HOLY CROSS ABBEY

reinhabiting place

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ABSTRACT

As a monastery living under the Rule of St. Benedict and as part of the 900-year-old Order of Cistercians of the Strict Observance (OCSO), the monks of Holy Cross Abbey (HCA) are pursuing sustainability not only to ensure that their traditions and spiritual way of life persevere, but also to foster a deeper stewardship of the land as "lovers of the brethren and of the place." As part of this sustainability initiative, HCA solicited the assistance of a team of graduate students from the University of Michigan's School of Natural Resources and Environment ("Michigan Team") under the guidance of Professor Andrew Hoffman. As part of this project, the Michigan Team used a systems perspective with the intention of encouraging a more holistic, integrative, and telescopic view of the monastery in its local, regional, and global contexts. To this end, the Team evaluated HCA's community sustainability as it specifically applies to the following topic areas: land use, energy, water, solid waste, toxics, economies, food, and buildings. Subsequently, synergistic recommendations were provided to help HCA become more sustainable. These suggested guidelines may also assist other monasteries and religious institutions as they initiate, evaluate, and/or modify their own sustainability efforts, thereby enhancing environmental stewardship throughout numerous communities and maximizing positive impact on society.

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EXECUTIVE SUMMARY

In early 2008, the monks of Holy Cross Abbey in Berryville, Virginia (HCA) began to evaluate their unique position in the local, regional, and global environment and to envision a more sustainable ecology, community, and economy. As a monastery living under the Rule of St. Benedict and as part of the 900-year-old Order of Cistercians of the Strict Observance (OCSO), the monks began to pursue sustainability not only to ensure that their traditions and spiritual way of life persevere, but also to foster a deeper stewardship of the land as "lovers of the brethren and of the place." As part of this sustainability initiative, HCA solicited the assistance of a team of graduate students from the University of Michigan's School of Natural Resources and Environment ("Michigan Team") under the guidance of Professor Andy Hoffman.

The methodology, analysis, and options proposed in this report were conceived from a systems perspective with the intention of encouraging a more holistic, integrative, and telescopic view of the monastery in its local, regional, and global contexts. However, while recognizing that HCA is part of a complex and inter-related system, we considered community sustainability as it specifically applies to the following topic areas: land use, energy, water, solid waste, toxics, economies, food, and buildings.

LAND USE

Property owned by HCA encompasses approximately 1,200 acres of karst terrain in the Shenandoah Watershed and includes three intermittent streams that drain to the Shenandoah River. A variety of ecosystem types and land uses exist on the property, such as farmland, forest, floodplain and the built environment. Each ecosystem type requires different management techniques, and each land use accomplishes a different objective.

Methodology

The Michigan Team evaluated HCA's land use to evaluate the community's impact on its physical environment. Data collection efforts and analysis involved historical research; literature review; water quality testing; a review of previous soil tests and a visual, spatial analysis using GIS data from the Natural Resource Conservation Service, Clarke County, the US Geological Survey, and the US Fish and Wildlife Service. In addition, a community map-survey was issued to gather information about community relationship to place, wildlife habitat, and places of interest.

Results

The land use analysis resulted in the following key findings:

- Current agricultural practices at the HCA property contribute to the degradation of soil integrity, soil biodiversity, and ground and surface water quality. Sinkholes located on parts of the property exacerbate these problems because they act as direct conduits of contaminants to the water table.

- Agricultural contaminants that threaten the property include nitrates from excess manure and fertilizer, heavy metals and bacteria from municipal sewage sludge, and harmful herbicides such as atrazine.

- The Shenandoah shoreline and streambanks suffer from erosion and sedimentation due to cattle grazing.

- Run-off of agricultural contaminants and eroded sediment occurs to the river. This run-off may harm the aquatic habitat in HCA's streams, the Shenandoah River, and, ultimately, the Chesapeake Bay. The 100-year floodplain is susceptible to contamination from HCA's septic systems, as well as from dilapidated structures containing contaminants such as lead paint.

- Waste deposited in streams and near Cool Spring inhibits natural hydrology and poses risks of water contamination.

- The Cool Spring infrastructure is old and rundown, and therefore inhibits community appreciation and enjoyment of this special life-giving feature of the landscape.

- Invasive plants on the property threaten biological diversity and ecosystem functioning.

- Many areas of lawn are unused and yet demand energy inefficient maintenance practices (such as mowing). These lawn areas reduce overall plant, insect, bird, and mammal biodiversity on the property.

- Many native woody trees and shrubs are located on the property, but there are relatively few native herbaceous perennials on the site.

- Overall, there is a small proportion of remnant forest habitat (13%) to developed land (87%), and poor habitat connectivity between existing forest patches. In addition, the floodplain forest is degraded due to cattle grazing and erosion caused by cattle traffic.

- The monastery lacks a formal enclosed cloister garden/fountain.

- Accessibility to the river and spring are limited by poorly maintained or non-existing trails.

- Agricultural biodiversity is poor due to use of monocultural production methods and the use of genetically modified corn.

- There are many underutilized spaces on the monastery grounds that could otherwise greatly enhance community well-being and enjoyment of the landscape.

- Proper stewardship of the entire acreage is beyond the current capabilities of the HCA community alone.

Options

Based on the land use analysis and research conducted on possible alternatives, the Michigan Team proposes the following recommendations for sustainable land use at HCA:

- <u>Restore the Shenandoah shoreline</u>. Prohibiting cattle access to this area, revegetating eroded banks, creating a riparian buffer at least 300’ wide, and monitoring restoration progress will help to restore the natural Shenandoah shoreline.

- <u>Restore the natural hydrology of streams</u>. Remove waste, prohibit cattle access, revegetate eroded banks, create a stream buffer at least 100’ wide, and monitor restoration progress.

- <u>Trail construction</u>. Construct a simple yet more formal trail along the shoreline, with access from the Bishop’s House, the Retreat House, and the Westwood House. Construct a more pedestrian-friendly trail that loops around Cool Spring and the adjacent pond. Pave the trail with ADA accessible paving material (such as crushed, decomposed granite).

- <u>Create buffers around sink holes</u>. Construct wide vegetated buffers around sinkholes with native perennial grasses to help filter pollutants directly en route to the water table, as well as to make them visible as a safety precaution. Treat surrounding land as ecologically sensitive areas.

- Restore Cool Spring. Resurrect Cool Spring as a critically important feature of the landscape, and beautify the human experience of it.

- Protect the water quality of Cool Spring. Protect the water quality of Cool Spring by constructing a wetland upgrade where there used to be a pond, and by designating surrounding land as an ecologically sensitive groundwater “recharge zone” where the use of toxics and/or septic discharge are strictly prohibited.

- Divert rainwater. Divert rainwater from all buildings, but especially from the Retreat House, into raingardens (depressed gardens lined with gravel beneath a layer of topsoil to promote on-site drainage, planted with native plant species which are both drought and flood tolerant).

- Prohibit the use of contaminants on the farm. Strictly prohibit the use of pesticides, herbicides, sewage sludge, excess artificial fertilizer and excess manure in current and future farm leases. Nitrogen applied—in the form of fertilizer or manure—should not exceed Virginia Cooperative Extension Service recommendations based on annual soil tests.

- Limit the use of traffic in the floodplain. Limit the use of vehicular or ATV traffic in the 100-year floodplain to prevent compaction on soil whose function of infiltrating floodwaters is ecologically significant.

- Use and promote organic farming techniques. Require current/future farm tenant to practice organic food production methods, which also strive to protect and/or enhance biodiversity and water quality through the use of best management practices. When the lease with the current farm tenant expires, consider providing a rare and valuable vocational opportunity for innovative, ecologically conscious young farmers by offering prospective tenants an affordable, yet fairly priced, lease.

- Create a new vegetable garden. Create a new vegetable garden maintained by organic agricultural methods that focus on improving soil organic content and biodiversity (compost produced at HCA can be used for this endeavor).

- Control invasive species. Remove and/or control the spread of invasive species on the property, especially Tree-of-Heaven, along the path to Cool Spring (which is aggressively outcompeting native plants and depleting valuable groundwater reserves in the spring recharge zone), and the Japanese honeysuckle that is scaling the large spring-fed sycamore near the main road.

- Create wildflower meadows. Convert some areas of lawn into no-mow wildflower meadows (which would only have to be mowed once a year, or maintained through annual or bi-annual prescribed burns).

- Use native plants. Use native plants adapted to the Shenandoah Valley ecosystem in all future plantings.

- Plant trees and construct a “greenbelt”. Plant more trees, especially along the road towards (and surrounding) the Retreat House, along the main road, and the road to Westwood House. In considering where to replant hardwood forest for the purpose of ecological restoration and/or sustainable forestry, increase the width of riparian and stream buffers first, then construct a “greenbelt” which will act as a habitat corridor to and from the floodplain forest.

- Conserve land. Place more land in conservation easement. Consider the option of a conservation burial ground to help protect land.

- Identify zones of ecological significance. Hire appropriate local ecologists/botanists/biologists to perform comprehensive botanical and habitat surveys of the property to identify zones of ecological significance.
- Enlist volunteers. Enlist the help of local volunteer or environmental groups to perform restoration work, as well as to conduct annual monitoring of biodiversity and water quality.
- Construct several gardens. Construct a prayer/healing garden in the footprint of the old sheep barn to be enjoyed by residents of the infirmary who may not be able to get very far outside. Construct a more formal cloister garden as a central, ceremonial gathering place. Enlist the help of lay Cistercians, volunteers, and/or local environmental groups to perform this work. Otherwise, consider donating land/conservation easements which are unable to be responsibly managed by HCA to a land trust/conservancy such as The Nature Conservancy.
- Use the landscape for education. Include educational and interpretive information in the landscape to educate guests, visitors, and community members about the history of the land, as well as sustainable land stewardship practices taking place at HCA.

Following these recommendations will provide significant environmental benefits. These efforts would help to protect and enhance ground and surface water quality, and would promote (unpolluted) groundwater recharge and protect and enhance biodiversity. These efforts also would protect soil fertility--soil is a virtually irreplaceable natural resource considering the time it takes for organic content and tilth (i.e., nutrients) to regenerate. HCA would reduce its energy footprint and sequester additional carbon to help offset global climate change. HCA would be able to grow its own food and even generate economic gain. The property would be protected from development and would become more beautiful and accessible to the community, which would increase the human connection to and enjoyment of the land and possibly even opportunities for relaxation and mental well-being. By sharing the principles and practices of land stewardship, HCA would be able to educate community members and visitors about the importance of sustainability.

HCA can implement these recommendations in phases. Many of the efforts will require ongoing effort and attention.

ENERGY

Current global energy consumption is unsustainable. Total global energy use has been rising at increasing rates since the industrial revolution and, in recent years, this trend has exploded. According to the International Energy Agency (IEA), an autonomous body charged with implementing an international energy program, the current consumption of energy resources by humans is heading towards a systematic crash. The IEA's report states that "the world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable—environmentally, economically, socially." While HCA is a small and isolated community, its consumption of energy resources connects the community to unsustainable energy practices around the world.

Methodology

The Team evaluated HCA's energy consumption and energy impact in three steps. First, we calculated HCA's aggregated energy consumption baseline by (1) aggregating the energy footprints of each Unit (i.e. residential, Retreat House, business, and farm); (2) disaggregating those footprints by fuel type and building area (not applicable to the consumption of gasoline); and (3) estimating the energy consumption by activity (not applicable to the consumption of gasoline). Second, we inventoried HCA's major: 1) electronics and appliances; 2) heating, ventilation and air condition (HVAC) units; and 3) building structures to estimate the energy used for specified activities within particular areas of the property. Finally, we assigned pollutant emission levels to each activity by using emission factors published by the US Environmental Protection Agency (EPA).

Results

The energy analysis resulted in the following key findings.

- In total, the community consumes an average of about 428,000 kWh of electricity, 2,300 gallons of propane, 18,600 gallons of heating oil and 1,100 gallons of gasoline per year. The total variable costs for these fuels equate to roughly $73,500 a year.
- In total, the community is responsible for an average of 570 tons of CO_2eq, 2.82 tons of SO2 and 0.76 tons of NOX per year.
- These emissions negatively impact social welfare and result in estimated soft costs that range from $5,000 to $32,500 each year.
- The space heating system for the Monastic Enclosure is extremely inefficient for two reasons: 1) the community's boilers are old and energy inefficient; and 2) the building envelope has low insulating capabilities and contains leaks throughout.
- HCA often purchases fuel (i.e. electricity and heating oil) for processes that could be carried out any time during the year (i.e. bakes and honey production) during months when input energy prices are typically high.

According to data from the World Resources Institute (WRI) and the Energy Information Agency (EIA), the average American consumes about 334 MMBtu per year. By contrast, the average HCA resident consumes about 269 MMBtu per year. It is not surprising that HCA members consume less energy because they lead a considerably different lifestyle than the average American when it comes to general activities involving consumption, like energy. However, this comparison could be misleading because the national statistic aggregates across all related activities (e.g. residential, commercial, industrial, etc.). In contrast, HCA fares worse when considering only residential activities. In fact, the average HCA member consumes about 110 MMBtu per year for household related activities (e.g. space heating and cooling, electronics, appliances, etc.), whereas the average Virginian resident averages about 42 MMBtu per year. In terms of carbon dioxide emissions, each HCA resident is accountable for 19.67 tons of CO_2eq annually, which is still higher than the national average (19.64 tons of CO_2eq per year)

Options

Based on the results of HCA's energy consumption baseline, the team concluded that there were numerous opportunities for reducing the community's energy use and the costs associated with that use. This section offers the HCA community various options for reducing the amount of energy consumed on the property. These options are categorized by the type of action taken and ordered from least to most capital intensive within each category. In addition to estimating energy and emission reductions for each option, the Team also estimated the total financial savings that the community would realize over the appropriate lifespan of each option. Notably, some of these options may never pay off, but the options nevertheless are attractive due to large reductions in the soft costs imposed on society from negative environmental impacts. These options include:

- Energy conservation behaviors. Adopt/continue energy conservation behaviors.

- Improve lighting systems. Improve lighting systems by converting to compact fluorescent lamps, installing occupancy sensors, increasing daylight in HCA's buildings, and/or installing daylighting controls.
- Increase appliance efficiency. Improve the use of appliances and electronics by installing smart power strips to reduce phantom loads and/or replacing old appliances with ENERGYSTAR® certified units according to recommended replacement schedules outlined in Chapter 2.
- Increase water heating efficiency. Improve water heating systems by insulating and/or replacing water heating units with more efficient units that use less energy.
- Increase heating/cooling efficiency. Improve heating and cooling systems by installing programmable thermostats to better control indoor climate (especially in low/no occupancy areas), switching to a forced air heating system for greater flexibility in climate control, replacing or retrofitting older boilers, and/or retrofitting buildings to better utilized free and clean energy by using passive solar design.
- Improve the building envelope. Improve the building envelope through weatherization (e.g., weather-stripping, caulking, etc.), improving roof and/or exterior wall insulation, and/or replacing single pane windows with double pane, low E windows (except the novitiate, where the glass dominated eastern wall should be replaced by triple pane, low E windows).
- Use renewable energy. Install on-site renewable energy (e.g. wind power and/or solar power).

WATER

The Earth's supply of fresh water is finite. While 70% of the Earth's surface is covered by water, only 2.5% of the water is fresh water. Of that 2.5%, nearly 70% is frozen in the polar icecaps and much of the remaining 30% is otherwise inaccessible to humans. Fresh water also is scarce in many areas of the world. While areas like Virginia have access to plentiful fresh water in most years, they are still susceptible to drought. Even so, globally, 1.2 billion people live in areas where water scarcity is a constant concern. Water supplies are further limited by pollution which can come from a variety of sources, including wastewater treatment systems, agricultural runoff, storm water runoff, and others.

At HCA, water used by the community is drawn from private wells. Because HCA draws its water from private wells, it does not pay for water access. Nevertheless, there is a strong environmental and economic rationale for encouraging the HCA community to conserve water. In sum, HCA should consider implementing water conservation measures for the following reasons:

- To avoid the financial cost of septic system replacement
- To avoid the financial cost To avoid the environmental cost of septic system pollution
- To avoid the cost of unnecessary energy expenditures related to hot water use
- To increase community resilience in anticipation of drought
- To take a leadership position, within the broader religious community, on an issue integral to sustainability

Methodology

In order to complete a full assessment of water use and water quality at HCA, the Team compiled inventories of all the components of HCA's water system, including wells, septic systems, water treatment systems, indoor fixtures and appliances, and outdoor fixtures. In addition, the Team collected flow rate data for indoor and outdoor appliances. This data was used in combination with data from a weeklong assessment of HCA community water use to estimate total, annual community water use. In addition, information about the location and purpose of specific wells and septic systems was used in conjunction with data on threats to water quality in order to create a plan for on-site water testing. This data was used to identify areas where the HCA community could reduce their water use.

Results

- There are nine wells on HCA's property supply water to HCA's facilities.
- Ultraviolet (UV) treatment systems are currently being used to treat water for the Bakery, Monastic Enclosure, Retreat House, and Westwood House.
- After use, wastewater is generally deposited into one of 11 septic systems onsite.
- HCA has a total of 256 indoor appliances and fixtures and 14 outdoor appliances and fixtures.
- The team calculated that the HCA community uses a total of 558,139 gallons of water per year. This level of use translates to 46,512 gallons of water per month, 10,733 gallons per week, and 1,529 gallons per day.
- Of the 558,139 total gallons of water used by the community annually, HCA residents are estimated to use 534,134 gallons (approximately 96%).
- For residents only, this number includes a per capita indoor water use of 68.7 gallons daily (excluding leaks). This level of water use does not compare favorably with the 59.8 gallons that are used daily, per capita, in an average, North American single-family home (excluding) leaks.

In terms of indoor water use, specifically, HCA residents actually use more water per capita than residents living in North American single-family homes on average (68.7 gallons per capita per day versus 59.8 gallons per capita per day). This finding suggests that there is ample room for HCA to reduce its water use.

Options

Based on the results of the water use and quality analysis, the Team offers the following options for conserving water, as well as monitoring and enhancing water quality.

- <u>Install new showerheads</u>. 2.0 gallon-per-minute (gpm) rated showerheads provide a relatively low cost way to conserve a substantial amount of water. In two locations, replacing showerheads provides a positive net present value.

- <u>Install sink faucet aerators</u>. 1.5 gpm rated sink faucet aerators provide a low cost way to conserve a substantial amount of water. In three locations, retrofitting faucet aerators provides a positive net present value.

- Install low-flow toilets. 1.28 gallon-per-flush (gpf) toilets have the potential to provide substantial water savings in a number of HCA locations.

- Install composting toilets. Composting toilets are an option to consider if new buildings are being designed. These systems can provide substantial water savings and nutrient recycling. However, they are not generally a good retrofit option due to design constraints.

- Install new urinals. 0.5 gpf urinals have the potential to provide substantial water savings in two HCA locations. Waterless urinals have the potential to provide even greater water savings than low flow urinals. However, before retrofitting waterless urinals, the HCA community should verify that the existing plumbing infrastructure is appropriate to accommodate the urinals.

- Install a high efficiency clothes washer. A modern, high efficiency clothes washer has the potential to provide moderate to substantial water and energy savings. However, new commercial clothes washers are quite expensive and residential washers may not have the load capacity that HCA requires.

- Install a high efficiency dishwasher. A high efficiency dishwasher has the potential to save a substantial amount of water in the refectory dishwashing room. The installation of a high efficiency dishwasher should also save the community a substantial amount of time.

- Install a graywater system. Graywater systems keep water out of septic systems. One type of graywater system uses graywater (wash water) for plant irrigation. Another type of system reuses graywater to flush toilets.

- Install drip irrigation systems. Drip irrigation systems are substantially more water efficient than sprinklers because they distribute water directly to the plant roots. A drip irrigation could effectively replace the sprinkler system now in use at the butterfly garden.

- Install flow meters. Flow metering would allow HCA to monitor the progress of its water conservation strategy.
- Adopt the following behavioral strategies for water conservation. 1) Watch out for leaking fixtures and fix leaks immediately when they are found. 2) Take short showers rather than baths. To encourage community members to adopt shorter showers, it may be useful to place a timer or sign in or near each shower as a reminder. 3) Turn the sink faucet off while brushing teeth, shaving, and scrubbing dishes. 4) Wash full loads of laundry or choose appropriate load-size setting. 5) Wash laundry with cold water.

- Develop a drinking water monitoring problem. A regular drinking water monitoring program would give the HCA community better information about the quality of its drinking water over time.

- Investigate septic system siting. Poor septic system siting can be a cause of water quality problems. The team's analysis indicates that one or more of HCA's septic systems could be located in a floodplain. HCA should consult a plumbing professional to determine whether current siting poses any risk to water quality.

- Develop a septic system maintenance program. A regular septic system maintenance program can help to increase the useful life of HCA's septic systems and help protect water quality.

SOLID WASTE

Most experts believe that humans generate roughly two billion tons of global municipal solid waste (MSW) every year, and annual worldwide production of MSW (i.e. trash) is predicted to grow to more than three billion tons within the next twenty years due to rises in global population and consumption. To manage this garbage, most countries primarily rely on incineration and/or landfilling, which are unfortunately connected to a number of environmental issues, such as the loss of resources, the pollution of groundwater and soil, and the production of greenhouse gases (GHGs).

A specific MSW management program at the national, regional, and even the local community level can be evaluated with regard to sustainability, based on whether its practices reflect the prioritized activities of integrated solid waste management (ISWM) and move a community toward "Zero Waste" status (a 90% or greater recovery/recycling rate). The ultimate goal is to eliminate waste by first maximizing waste prevention efforts, which is then followed by reuse and recycling/composting to the extent possible. Disposal is the last resort and should only incorporate non-recyclable and non-compostable items. If a waste management system, such as HCA's program, follows this framework, a relatively small amount of MSW will actually be placed in a landfill or incinerated, and the impacts to the environment and public health will be minimal.

Methodology

The Team conducted two MSW characterization studies, multiple qualitative interviews, and personal observations as part of this waste analysis. An open-ended sustainability questionnaire, which included inquiries about conservation behaviors, also was administered to HCA community members and full-time employees. The information was used to identify opportunities for the community to reduce its production of MSW.

Results

The Team's analysis revealed the following key findings:

- HCA generated 21,320 pounds of MSW in 2009, which is significantly lower than the amount of MSW produced by the equivalent number of "average" Americans in one year.

- From the total amount of MSW produced, HCA was able to recover 37 percent of it (7,878 pounds) through various recycling and diversion activities.

- HCA's recovery rate exceeded the national average (33%), but it fell short of meeting the recycling rates for the state of Virginia (38.5%) and Frederick/Clarke Counties (45%).

- Of the 13,442 pounds of MSW that HCA discarded (into a landfill), 68% of it was recyclable or compostable.

- There are over seven different, informal dump sites located on HCA's property.

- HCA has not adopted an official procedure for responsibly storing and disposing of electronic waste.

- The farm tenant burns some MSW (e.g. tire inner tubes and plastic buckets), which has serious, negative environmental implications.

- As a result of its current recovery activities, HCA avoided producing a net total of 8,670 pounds of carbon dioxide equivalents (CO_2eq).

Options

Based on the results of the analysis and research conducted on possible alternatives, the Michigan Team proposes the following options related to the sustainable management of solid waste at HCA:

- Contract for comprehensive recycling collection services. Contract with Waste Management to provide comprehensive (i.e., single-stream) recycling collection services on a weekly basis using an eight-yard dumpster (the same size as the current AWS dumpsters). This option would also entail discontinuing the existing cardboard recycling service while retaining AWS as the provider for monthly trash collection services.

- Implement a composting system. Build a three-bin composting system and compost all food waste and compostable materials produced on the property. The composting bin system could be built by HCA maintenance staff or local volunteers (e.g., the Boy Scout troop from the Shenandoah Area Council) primarily using second-hand materials. The Virginia Cooperative Extension (Clarke County office) will provide education regarding composting and any needed support.

- Discontinue burning trash at the farm headquarters. HCA should request that the farm tenant refrain from burning MSW at the farm headquarters and instead place recyclables and MSW in the appropriate dumpsters. As part of this option, HCA is encouraged to adopt an official policy prohibiting the burning of trash anywhere on its property (this could also be written into a new lease with the current or future farm tenant).

- Adopt/continue various waste prevention practices to limit total MSW produced. These practices include, but are not limited to: reducing the consumption of disposable goods by using and buying durable (or compostable) products, reusing paper and other packaging materials, buying in bulk, and repairing appliances and other products rather than replacing them.

- Develop a formal management system for e-waste. HCA should select a spacious indoor storage room that could temporarily house e-waste in a safe manner and that would limit the chance of damaging items and exposing harmful materials contained within the units. HCA is also encouraged to adopt an official policy that e-waste items be removed from the property after a certain span of time (e.g., every 3 months) by volunteers or the maintenance staff and donated or recycled.

- Develop a formal management system for pharmaceutical waste. Unused pharmaceuticals that have not yet expired can be taken to the Free Medical Clinic of Northern Shenandoah Valley, which can legally redistribute the medication to needy patients who cannot afford prescription drugs. Expired medication should be taken to the Leesburg Pharmacy, where it is picked up by a certified recycler who incinerates pharmaceutical waste—the most preferred disposal method for this type of waste according to the FDA and EPA.

- Remove and recycle waste from informal dump sites located on the property. HCA should work with local scrap collection companies and/or volunteers to assist with the removal, recycling, and appropriate disposal of all waste items contained at the known dump sites.

If all of these options are implemented, HCA could potentially divert up to 90% of its MSW from entering the Frederick County Landfill, thus achieving Zero Waste status and fully embodying the concept of sustainable waste management as espoused by the US Environmental Protection Agency's ISWM principles. In addition, HCA would avoid producing a total of 26,675 pounds of CO_2eq per year (possibly more depending on the waste prevention activities that are adopted), which is equivalent to avoiding the amount of carbon dioxide produced by consuming 1,235 gallons of gasoline.

TOXICS

It is impossible to know all of the effects that chemicals have on humans. Many of the chemicals that are commonly used in the home or found in surrounding landscapes are potentially harmful to humans and the environment. In addition to impacting the health of people indoors, the use of chemicals in the indoor environment can have environmental health impacts once they enter the outdoor environment. Chemicals improperly disposed of down the drain or in storm drains/sewers, can contaminate water supplies and be toxic to humans and animals. Other chemicals can disrupt endocrines (important hormones) in fish and amphibians.

Outdoors, the human and environmental health impacts of exposure to agricultural inputs, such as atrazine, biosolids, artificial fertilizers, and manure, depend on the inputs themselves. Health effects can include nervous system effects, skin or eye irritation, endocrine (hormone) system disruption, and cancer. Ground and surface water quality can be negatively affected by increased pollution levels. For animal species, effects may include mortality, diminished reproductive success, and sterility. Habitat destruction can also occur.

Methodology

To assess the use of chemicals used in the monastic enclosure, bakery, Retreat House and other buildings, the Team took a visual inventory of household cleaners/chemicals, pesticides/herbicides, maintenance products, and automotive products utilized at HCA. In addition to collecting a chemical inventory, the Team visually inspected the facility to identify the location of mold and various disposal areas. To explore what possible indoor pollutants are present, the Team hired a regional company, Hinson & Jung, LLC, to inspect for asbestos, lead paint, mold, and any other potential issues. To evaluate the potential for leakage from the underground storage tanks (USTs), we tested well water downstream of the USTs for oil and gasoline constituents.

Results

The results of our data collection efforts revealed the following:

- At the time of the inventory, HCA had over 100 products that contain potentially harmful ingredients.
- Potentially harmful ingredients can be found all over the property in paints, cleaners, solvents, and adhesives.
- The Monastic Enclosure has tiles and insulation that contain asbestos, a potentially carcinogenic substance.
- Lead paint, which is toxic, is peeling in several locations.

- A mold-like substance can be found in many locations in the Monastic Enclosure.

Options

HCA has several options for handling the toxics. The options include:

- Proper handling/removal of asbestos materials. As long as asbestos-containing products are undamaged, it is best to leave them alone. An initial site assessment should be done to identify all asbestos-containing products. If these products must be removed, a trained contractor should be used and should clean up the site appropriately. As noted in the indoor inspection, there is some damage to the floor tiles, which are likely to contain asbestos. These should be removed or covered up.

- Installation of a carbon monoxide detector. Hire a trained professional to inspect, clean, and tune-up the central heating system annually in order to discover and repair any leaks. To monitor carbon monoxide levels, HCA should install carbon monoxide monitors in various locations around the building, particularly near sleeping areas.

- Reduction of volatile organic carbon (VOC) emissions. First, to reduce formaldehyde levels, avoid purchasing pressed wood products containing phenol resins. Use air conditioning, dehumidifiers and increase ventilation to reduce emissions. When areas are repainted, low VOC paint should be used.

- Proper handling/removal of lead paint. Any paint used before 1978 likely has lead in it. If the paint is damaged and pieces or particles are peeling off, there is the risk that lead is being released into the environment. HCA should hire a trained professional to fix the areas that contain peeling paint.

- Reduction in use of insecticides/pesticides. The development of an integrated pest management (IPM) strategy that uses nonchemical based solutions can reduce the number of pests in HCA's buildings safely. Such a strategy involves implementing sanitation and structural improvements to prevent initial infestation. The next stage is to use mechanical (e.g., traps) or biological controls (e.g., plants) to eradicate the pest. The final stage is to use the least toxic pesticide possible following the application instructions carefully.

- Tests for radon. Radon testing should be done approximately once every 5 years. This can be done by a professional or by purchasing a self-home testing kit.

- Reduction of airborne particles. HCA should hire a trained professional to inspect, clean, and tune-up their central heating system each year and repair all leaks properly. Filters should be changed on central heating and cooling systems and air cleaners per manufacturer's directions.

- Reduction of household chemicals and cleaners. HCA should use all products according to manufacturer's directions and properly ventilate the areas of use. The community should only purchase quantities of chemicals that will be used soon and dispose of old/unneeded chemicals quickly and safely. HCA should also seek out environmentally friendly chemicals and cleaners. Chemicals and cleaners should be consolidated and stored in only a few sites to minimize the risks of accidental spills.

- Removing mold-impacted areas. These areas should be dealt with by cleaning with soap and water. Then, measures should be taken to ensure adequate ventilation which will mitigate mold growth. In some instances, more serious remediation efforts may be needed, including removal and replacement of contaminated areas.

- <u>Replacing underground storage tanks with aboveground storage tanks</u>. One of the best options for mitigating the potential for leakage from USTs would be to install aboveground storage tanks where you can see if any leaks are occurring.

BUSINESS

Sustainable businesses ensure (at a minimum) that their activities cause minimal harm, and do not deplete but rather restore and even enrich the natural environment. Sustainability makes companies viable for the long term by focusing management on principles that strengthen rather than undermine the company's roots in the environment, the social fabric, and the economy.

The main economic reason for business to embrace sustainability is that direct and measurable cost savings are possible. A less obvious economic justification for embracing sustainability is that developing and implementing a sustainability strategy can increase revenues. The market for green goods and services is large and growing. Finally, sustainable businesses often enjoy intangible benefits that may affect financial performance, including a competitive advantage and consumer goodwill.

Even though sustainable business can have significant economic benefits, in the final analysis some businesses adopt the sustainability agenda simply because "it's the right thing to do." Sustainable businesses reverse negative environmental, economic, and social impacts by creating healthy workplaces and reducing resource use and environmental damage.

Methodology

The Team adopted a modified "triple bottom line" (TBL) approach for evaluating the sustainability of HCA's business activities. TBL, which is often referred to as the three "Es" (economic prosperity, environmental quality, social equity) or the three "Ps" (profit, planet, and people), suggests that businesses should measure their success not only by the traditional metric of financial performance, but also by their impact on the environment and on the society in which they operate.

The Team evaluated financial performance by examining HCA's profitability by Unit (i.e. Bakery, Retreat House, Gift Shop, and Farm) and the profitability of each of the products produced by the Bakery. The Team also evaluated the future profitability of HCA's products by evaluating trends in sales, fixed and/or variable costs, and other key financial indicators. Finally, the Team considered qualitative factors, where relevant, to depict HCA's economic sustainability.

To assess HCA's environmental performance, the Team examined the environmental impact of the inputs and processes required for HCA to generate revenue from the activity. Specifically, the Team calculated the amount of energy required for upstream activities (obtaining ingredients and other inputs), manufacturing (operating appliances and the oven; supplying heat, space cooling, and light), and downstream processes (shipment of product to customers), and then determined the amount of carbon that resulted from the consumption of that energy.

To assess HCA's social performance, we evaluated the degree to which the work required to generate revenues are a drain on its aging population in terms of time and effort.

Results

The key takeaways from the business analysis follow:

- Profits from HCA's economic activities are declining rapidly, from a high of $174,000 in 2005 to just $32,000 in 2009. The Retreat House and the farm consistently generate a net loss. The bakery generates a profit, but bakery profits have declined dramatically over the past five years due primarily to declining fruitcake sales.
- The overall environmental performance "baseline" for HCA's current bakery products is 94 tons CO_2eq per year.
- HCA's fruitcakes are responsible for more carbon emissions in a year than any of HCA's other bakery products.
- Creamed honey also is responsible for a significant portion of HCA's bakery emissions (30 tons per year).
- Truffles are responsible for the least amount of emissions (less than 5 tons per year).
- At 9.5 to 10 lbs CO_2eq per sales unit, HCA's fruitcake, honeys, and fraters are more carbon-intensive than many common foods.
- Most of the emissions from HCA's bakery products result from manufacturing activities (primarily, electricity and heating oil used for lighting, space heating and cooling, operating the cool room and freezer, and to run appliances and the oven).
- With respect to HCA's social sustainability baseline, the bakery and gift shop demand the vast majority of the community's time (approximately 1,900 hours per year for each of these activities). The Retreat House and farm demand only a small fraction of the time spent at the bakery and gift shop.

Options

Based on the results of the analysis and research conducted on possible alternatives, the Team proposes the following options related to HCA's economies:

- Improve overall energy efficiency. At the Retreat House and gift shop, focus on conservation behaviors that address conventional energy uses such as light, heat, and space cooling. Actively invite retreatants to join HCA in these conservation practices by turning room lights off when not in use, keeping thermostats low in the winter and high in the summer, and taking shorter showers.

- Reduce energy consumption in the bakery. Investigate options such as sealing leaks, installing additional roof and wall insulation, eliminating summer bakes (if possible), and insulating the walls and ceiling of the ingredient storage room to reduce the huge amount of energy currently being consumed to heat and cool the bakery building (as discussed in Chapter 2).

- Reduce reliance on fruitcake sales. Prepare for a declining demand for fruitcake by focusing on creamed honey, which has more favorable margins and upward trending sales. Introduce new honey flavors and upgrade packaging to increase competitiveness.

- Introduce new bakery products. Focus on market segments with high growth potential, such as gourmet/specialty, organic, and gluten-free products. Balance the seasonality of fruitcake sales by developing products for events that occur early in the year, such as Easter and Mother's Day. Develop products that use locally grown and available ingredients (e.g., apples, peaches, tomatoes, and peanuts) to reduce the carbon footprint of the products sold.

- Partner with others to expand and modify economies. Find a partner or hire an employee to develop new products and find ways to more fully utilize the bakery's assets. Partner with a commercial baker who can use the oven in exchange for cash or personnel. Consider an arrangement with a private label manufacturer who can manufacture fruitcakes (as appropriate) and other bakery products for sale under the HCA label.

- Design and introduce more sustainable packaging. Consider the sustainability aspect of various packaging materials when reordering existing packaging and making future packaging decisions.

- Raise prices. Eliminate the range in the contribution amount that HCA suggests for retreats and suggest a single contribution that more than covers HCA's costs. Raise the price of fruitcake $2 per unit to better reflect market prices. Raise the rental rate per acre on the farm property to better reflect the rental market for agricultural land in northern Virginia and (more specifically) the Shenandoah Valley. Incorporate an annual percentage increase or rate schedule in any future farm leases that reflects anticipated increases in the market rate.

- Control costs. Reduce payroll expense to the fullest possible extent through flexible staffing and by reducing the weekday retreat by one day. Determine whether HCA currently is paying variable costs related to the tenant's farm operation and shift the burden of those costs to the tenant.

- Solicit additional funding for the Retreat House. Seek annual gifts from retreatants, create and solicit contributions to a building fund, and organize workshops and other themed events that are consistent with HCA's overall mission when Retreat House occupancy is low.

- Develop promotional programs for the gift shop. Display gift shop merchandise in public areas within the monastic enclosure (such as the lobby or library of the Retreat House and the foyer of the mansion), advertise in local and regional church bulletins, offer discounts on gift shop merchandise purchased before or at the conclusion of a retreat, create a book club for individuals that regularly attend retreats or patronize the shop, and/or establish a program for used book sales.

- Create a substantive Web site specifically for the gift shop. The Web site would provide substantive information about gift shop merchandise as well as basic information about shop hours and location, and might provide a platform for future online sales.

- Create areas for conservation burials. A 60-acre parcel at the southeastern end of the former Wynkoop Farm is a promising site because it can be reached from a separate entrance off Castleman Road and will not interfere with the community's daily routine. Construct walking trails and a non-denominational chapel to support the conservation burial services; restore the area to a natural forest as part of the conservation efforts

FOOD

There is a strong link between human and environmental health with respect to food production. A healthy environment is essential to producing nutritious fresh produce, which in turn is crucial for maintaining human health. In addition, the production of food can have a negative impact on the environment, mostly due to the large amounts of energy needed for large-scale food production, transportation, and consumption of that food. In addition to having a significant environmental impact, food production relates directly to a number of social issues including the use of illegal labor and worker health and safety. Food production and consumption also has profound economic implications. A few very large companies own most of the farmland and thus the profits are highly concentrated.

Methodology

To determine HCA's baseline food consumption patterns, the Team examined food purchases for the first and third weeks of January/February, and July/August. These months were chosen to represent seasonal variations in the food selection at HCA. After collecting the data, the Team coded each type of food to determine what food types HCA is purchasing (e.g., dairy, meat, produce). The Team used this coded data to identify the source of HCA's food and to estimate HCA's food budget, especially HCA's budget for produce.

Results

HCA purchases its food primarily from the following stores: Giant, Costco, Food Lion, Wal-Mart Supercenter, Martin's and Nalls Farm Market. By totaling up the purchases made during the sample purchasing weeks, the Team determined that 58 percent of food (by amount of money spent) is purchased at national/regional chains versus local markets/local farms. Fresh fruits and vegetables comprise a fairly significant portion of HCA's food budget (13%).

Options

Based on the information collected, we recommend the following options:

- Source food locally. One option is through a community supported agriculture share which entitles the shareholder to a portion of a farm's produce each week. Another option is to purchase food at local farmers' markets.

- Produce food at HCA. HCA could grow some of its own produce such as lettuce and tomatoes. Volunteers could help grow on a larger scale or greater variety.

BUILDINGS

Buildings and the built environment are responsible for a wide variety of impacts on human health and the environment. Principles of green construction can ameliorate these impacts. The term "green construction" refers to the practice of creating structures that are environmentally responsible and resource-efficient throughout a building's life-cycle (site selection, design, construction, operation, maintenance, renovation, and deconstruction). The overall goal of green construction is to create "a wonderful building – a building that is bright and well-lit, that is warm in winter and cool in summer, that is as comfortable as it is healthy, that is energy- and resource-efficient, that is functional and long-lived, and that promotes the well-being of its occupants and the earth."

Methodology

To evaluate building conditions and materials, the Team conducted an inventory of the buildings in the monastic enclosure and interviewed the Cellarer and other members of the community to understand the history and uses of buildings. Responses to the survey that the Team administered in August 2009 provided additional insight into the community's perspective on the community's buildings.

Results

The buildings in the monastic enclosure were constructed over many years. Some of the buildings were constructed as early as 1784, although most were constructed after the community moved to Virginia in the early 1950s. Although most of buildings generally are in good condition, some of the buildings have fallen into disrepair. Moisture and mold have been identified in the mansion, St. Joseph's Scriptorium, and old dormitory. In addition, a structural report prepared for HCA in January 2009 reported that in certain areas of the buildings the framing is inadequate to support the loading requirements. Exterior finishes, including certain areas of the cloisters, are in need of maintenance and paint.

Options

The Team developed a conceptual model of a new dormitory and cloister to illustrate how green building principles might be applied at HCA. The Team advocates for constructing the new dormitory in the basic footprint of the existing Old Dorm, if feasible, so that the foundation, subfloor, and perhaps even some wall materials could be incorporated into the new structure, and because preserving as much of the Old Dormitory as possible has sentimental appeal. The conceptual new dormitory includes the following green features:

- Roof and wall insulation with appropriate R-values, double- or triple-paned windows, and a thermally resistant roof system to maximize energy efficiency.
- Low-flow showerheads and faucets, high efficiency toilets and urinals, and/or even composting toilets to minimize water use.
- Interior finishes that are non-toxic and renewable (e.g., cork flooring, wool or other natural fiber carpets, and low-VOC, light-reflecting paint).
- Numerous windows so that residents can control airflow and temperature.
- Thick walls to provide heavy thermal mass for the building envelope and reduce heat loss.
- An open design, skylight, and glass façade to maximize daylight penetration and minimize the use of artificial lighting.
- A double glass façade that traps heat from the sun and uses the heated air to warm interior spaces in the winter and vents the heated air away from occupied spaces in the summer, thereby reducing the need for HVAC systems.

The new cloister consists of a covered walkway to replace the current cloister that connects the St. Joseph's Scriptorium, the mansion, and the Old Dormitory. At the northern end of the cloister, the walkway is partially enclosed to provide shelter and partially open and accessible to cloister area. Like the new dormitory, the new walkway at the northern end of the cloister includes several green features:

- Thick, insulated walls of the covered portion moderate the interior temperature without requiring an external energy source.
- The roof of the open section is pitched at a 15-20 degree angle and houses solar panels to generate electricity for interior and exterior lighting.

CONCLUSION

It is our hope that this report can help guide not only the HCA community and its guests, but also assist other monasteries and religious institutions. Ideally, these other religious institutions will find value in the content of this report as they initiate, evaluate, and/or modify their own sustainability efforts, thereby enhancing environmental stewardship throughout numerous communities, maximizing positive impact on society, and venerating God's gift of creation.

Throughout the process, the Team has endeavored to make connections between the global environmental challenges of our age and the unique challenges faced by the HCA community. Thus, it is the Team's great hope that this report will help the HCA community to more clearly understand its role within the global ecosystem, and from that understanding, to build a shared commitment to adjust daily habits, to mitigate environmental impacts through improved design and technology, to become more responsible consumers in the global marketplace, and to generate income in an ecologically responsible manner.

In reality, this project is only one of many steps in a long road toward sustainability. Considering this, we hope the proposed options will serve as a foundation for subsequent steps and the development of an implementation plan that will help HCA move toward a more sustainable future—one in which the community will be able to fully celebrate their role as stewards of the land and lovers of the place.

INTRODUCTION

We will find ecologically responsible methods of managing our land, buildings, industries, and other resources in order to promote the greatest good for all people, aware of the inseparable link between peace with creation and peace among men.

Strategic Plan of the Holy Cross Abbey, Berryville, Virginia (2009)

What is a sustainable monastery? In early 2008, the monks of Holy Cross Abbey in Berryville, Virginia (HCA) began to evaluate their unique position in the local, regional, and global environment and to envision a more sustainable ecology, community, and economy. As a monastery living under the Rule of St. Benedict and as part of the 900-year-old Order of Cistercians of the Strict Observance (OCSO), HCA began to pursue sustainability not only to ensure that their traditions and spiritual way of life persevere, but also to foster a deeper stewardship of the land as "lovers of the brethren and of the place."

To jumpstart its commitment to sustainability, HCA solicited the assistance of a team of graduate students from the University of Michigan's School of Natural Resources ("Michigan Team") under the guidance of Professor Andy Hoffman. This report presents a comprehensive summary of the research and analysis performed by the Michigan Team with respect to HCA's land use, energy consumption, water use and quality, solid waste management, toxic chemicals, economies, and buildings. In this report, we present an in-depth exploration of the meaning of sustainability in the context of a Cistercian monastery. Each chapter defines metrics for establishing HCA's current "baseline" sustainability and evaluating future progress toward achieving HCA's sustainability objectives in the core areas of land use, energy, water, solid waste, toxics, economies, food, and buildings. The report also presents concepts, ideas, options, and suggestions that might guide HCA's progress toward sustainability.

STEWARDSHIP OF THE EARTH: A SPIRITUAL MANDATE

HCA's commitment to sustainability is bolstered by recent initiatives of the Catholic Church. Pope Benedict XVI steadfastly supports environmental stewardship and urges all humanity to actively embrace a more sustainable way of life. For example, the Holy Father summoned all Catholics to "make decisions aimed at strengthening that covenant between human beings and the environment, which should mirror the creative love of God..." at the 2007 World Day of Peace celebration. To demonstrate the commitment of the Church, the current pope and his predecessor have promoted numerous efforts to "green" the Vatican.

The formal constitution that directs Cistercian life also underlies HCA's sustainability initiative. Section 27A of the OCSO Constitution states that "[t]he brothers are to be concerned about conservation of the environment and to manage natural resources prudently."[1] In fact, among all Catholics, Cistercians are known for forming the strongest bond with the land on which they live. Cistercian connection to the land has historically been realized through the practice of agriculture.[2] The concept of *ora et labora* (prayer and labor) expresses the notion that one can know God through both work (typically manual labor) and prayer, suggesting that establishing a healthy relationship with place can yield both physical and spiritual nourishment. "Loving place" is considered a responsibility and a mirror of spiritual commitment.

The nonmaterialistic monastic lifestyle, attained through vows of poverty, makes Cistercian communities ideal candidates for manifesting and modeling the principles of sustainability. To understand the Cistercian perspective on sustainability, the Michigan Team distributed a survey to OCSO houses in the United States as a part of this project. The objectives of the survey were (1) to provide HCA with valuable information about the sustainability initiatives that other Cistercian monasteries have attempted and/or are currently engaged in and (2) to aggregate the data and provide it to all OCSO houses in an attempt to galvanize collective support and potentially spur additional sustainability initiatives. The responses we received indicate that many OCSO houses perceive the following regarding the connection between Cistercian monasticism and sustainability:

- "The rule of St. Benedict contains within itself a degree of the rationale behind sustainability—the care of goods and property for the welfare and the spiritual and human needs of the community."
- "…[W]e believe that our land and the ecological environment is a gift from God and that in keeping with the Rule of St. Benedict, we are responsible to reverence this gift, and as good stewards, to enhance it for the benefits of the surrounding local community as well as for future generations."
- "We consider it our call and responsibility to respect, nurture, and care for our planet and the human family. Good stewardship is part of our Cistercian Constitutions and we reverence the presence of God in all of creation by this effort to be good stewards."
- "Our call as Christians asks of us a deep respect and love for all God's creation. We are all one in Christ and his presence fills every atom of the universe. So when we are invited to [demonstrate] good stewardship in our Constitutions, it is an invitation to live sustainably out of love."
- We are "entrusted by the Lord to be stewards of the manifold gifts He has given [and that] the land, water, minerals, and crops all are His creations, and with them comes a divine mandate to use them with care and profit."

Many of the OCSO houses have outwardly manifested their commitment to sustainability by installing renewable energy systems, practicing sustainable agriculture, and "greening" their buildings. A summary of the responses we received from the OCSO houses is included as Appendix 0-A.

As a community, the monks of HCA confirmed their commitment to be responsible caretakers of creation in a Strategic Plan that they developed to guide the future intentions of their community. According to the Strategic Plan, HCA intends to move forward with a plan to place a portion of their property in conservation easement (Direction 5.1); to solicit outside resources for advice and direction regarding ecologically minded management of their buildings, property, and practices (Direction 5.2); and to assess its physical plant, giving special attention to maximizing space use and minimizing harmful environmental impact, always honoring their tradition of Cistercian simplicity (Direction 6).

Individual monks, likewise, have expressed personal commitments to a more sustainable community. In response to a survey that the Michigan Team administered as part of this project, many members of the community perceived a strong linkage between the Cistercian Order and sustainability based on the following truths:

- Careful management of natural resources and mindfulness of land/water use has always been a valued part of Cistercian culture and history.
- Cistercian constitutions and statutes reflect conscientious management of land and the importance of being "lovers of the place."
- Embracing sustainability demonstrates a respect for God's divine creation.
- Using earth's resources wisely reflects Cistercians' commitment to living a life of simplicity and poverty.

Other monks were motivated not only by a moral obligation and the spiritual importance of environmental stewardship, but also by concerns about the community's economic sustainability and ability to recruit new vocations. (For a summary of HCA's motivations as expressed in responses to a survey administered as part of this project, *see* Appendix 0-B.)

The community at HCA is pursuing sustainability because they are inspired by “the divine presence of God inherent in the natural world.” When asked to describe the community’s motivation for this project, Fr. Robert Barnes (Abbot of Holy Cross Abbey) noted that “[w]e ourselves are an integral part of this creation, united by the Spirit of God in an impenetrable bond with all that God has entrusted in our care. Our lives as Cistercian monks commit us to the care of God’s creation.” Fr. James Orthmann echoed this sentiment, noting that “[t]he topography [of the land] is inseparable from our vocation, our life stages, our ups and downs; it can seem to be the externalization of our monastic journey.” HCA is committed to fostering a deeper stewardship of the land as “lovers of the brethren and of the place.”

Holy Cross Abbey

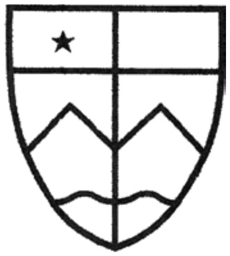
The monks of Holy Cross Abbey live on a 1,200-acre farm in Clarke County, Virginia, where rolling pastures descend to the Shenandoah River and are bordered by the Blue Ridge Mountains. Settlement in river valleys has been a Cistercian tradition since 1098, when the first Cistercian monastery was established in Citeaux, France. Architectural historian Terryl Kinder writes, “In some Cistercian valleys, the sun rises over the hills very late on a winter morning and disappears early in the afternoon, its rays barely touching the cloister garth. In these cases, the glance of the spirit is led inward and upward rather than outward and downward, and the effect might be described as more ‘interiorizing.’”[3]

The HCA property is part of the Shenandoah Watershed. Three intermittent streams drain into the Shenandoah River, which flows into the Potomac River, which finally empties into the Chesapeake Bay. The monks worked the land from the time the monastery was established in 1950 until the late 1970s, when they decided they no longer could continue to manage such a large acreage themselves, particularly with their aging population. Since the late 1970s, HCA has been leasing the land to a farm tenant who raises Black Angus cattle and practices conventional cultivation of corn, hay, and barley on 900 to 1,000 acres of the property.

Much American history is infused into the landscape at Holy Cross Abbey. HCA’s riverside property has been transformed from Native American hunting and fishing grounds, to early colonial plantation, to a Civil War battlefield, to the pastoral monastic retreat that it is today. Many artifacts have been discovered in the fields close to the river. A variety of Native American stone implements as well as battle relics (e.g., bullets, belt buckles, and buttons) are on private display in the Cool Spring Mansion. These relics serve as a tangible reminder of the presence of the Monacan and Manahoac Tribes who once hunted there and of the bloody Battle of Cool Spring that took place on July 17 and 18, 1864, just beyond where the current Retreat House stands.[4]

Although the landscape is dominated by pasture, there remain several patches of hardwood forest on site as well as a handful of traditionally cultivated areas near the monastic enclosure, gift shop, and Retreat House. A number of buildings are scattered throughout the property, as might be common on a large old farm in the area. Barely visible across the river is a residential subdivision and golf course that sprouted up in recent years. Overall, the setting is pastoral, peaceful, visibly sloped to the river, and framed by the omnipresent beauty of the Blue Ridge Mountains.

HCA’s signature emblem represents four key parts of their identity, two of which represent elements of their home landscape: the Shenandoah River and the Blue Ridge Mountains.



The star signifies Our Lady

The cross, the Abbey of the Holy Cross

The peaks, the Blue Ridge Mountains

The curve, the Shenandoah River

WHAT IS SUSTAINABILITY?

Sustainability has become a buzz word over the past decade or so. As a result of the widespread use of the term, a number of definitions have been developed. Some of the definitions are very resource-focused and anthropocentric, and other definitions focus more on ecosystems as a defining concept. Individual interpretations of this concept guide decision-making processes within emerging sustainability strategies.

Perhaps the most common definition of *sustainability* was coined by the United Nations World Commission on Environment and Development in 1987. This definition, which has become one of the most widely accepted (albeit very general) definitions of the term, states that sustainable development is development that "meets the needs of the present without compromising the ability of future generations to meet their own needs."[5] Visionary ecologist Aldo Leopold viewed sustainability even more generally: “A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise.”[6]

Several principles can be used to guide the development of a sustainability strategy. These principles can be summarized as follows:

- Capping principle: The capping principle provides that when human activities (such as extraction of natural resources or disposal of waste) are inherently constrained by biophysical conditions, humans should limit, or “cap,” those activities according to the level that preserves ecological functioning.
- Source principle: The source principle provides that when resources used by human populations come from a source that is inherently limited and has no substitutes, they should be absolutely preserved and protected. Once we consume them, they are gone and cannot be replaced.
- Intermittency principle: The intermittency principle provides that resources should be used according to nature’s rhythms and fluctuations of each others’ needs. At its essence, this principle encourages us to move more in sync with the cycles of nature.
- Precautionary principle: According to the precautionary principle, when an activity raises threats of harm to human health or the environment, preventative measures should be taken even if cause-and-effect relationships are not fully established scientifically.

HUMAN BEINGS AND THE ENVIRONMENT: CURRENT TRENDS

Global environmental mega-problems define the world in which HCA resides. Several of the most pressing problems include: global warming and climate change, toxics and pollution, water scarcity and degradation, depletion of natural resources, and habitat degradation and loss of biodiversity. These issues are summarized below in order to provide a context for this study.

Global Warming

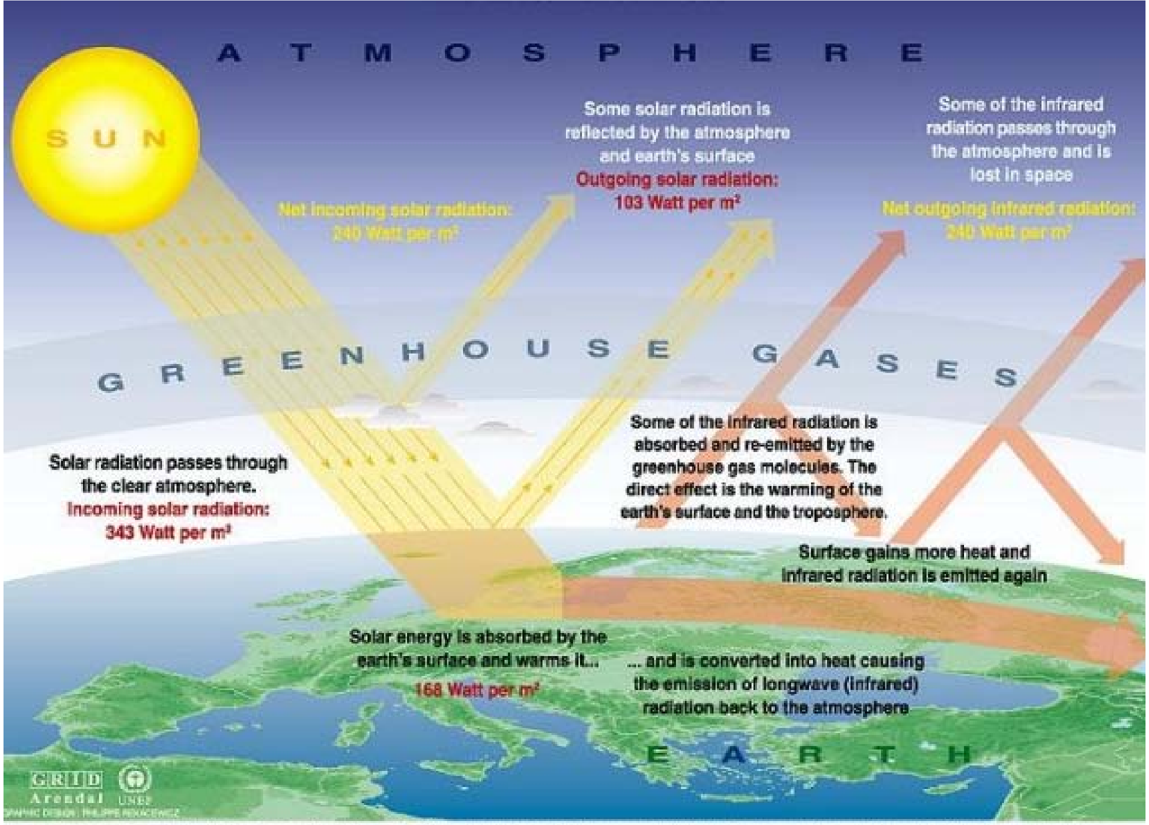
In recent years, global warming has topped the list of environmental issues. Global warming results when earth’s system of temperature control is forced out of equilibrium. Global warming is a concern because of its potentially harmful effects. Scientists predict that the increase in atmospheric temperature will potentially cause a rise in sea level, flooding, agricultural instability, the spread of disease, and even species extinction.

Global warming is caused by the greenhouse effect, which is a relatively simple concept. Earth maintains its temperature by absorbing radiation (a form of heat) from the sun and releasing its own radiation back into the atmosphere. Greenhouse gases (GHGs), such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), exist naturally in the earth's atmosphere and trap some of the radiation given off by the earth. In the past 50 or so years, increasing amounts of manmade GHGs have been emitted into the atmosphere from industry, vehicle exhaust, and other activities. The excess concentration of GHGs acts like a greenhouse in that it allows the same amount of solar radiation into the earth's atmosphere but less radiation out of the atmosphere. As a result, some of the earth's emitted radiation cannot escape and is causing the earth to overheat. Figure 1 graphically portrays the greenhouse effect.

The Intergovernmental Panel on Climate Change (IPCC) reports that emissions of GHGs from human-related activities are increasing at alarming rates—greater than the earth's capacity to absorb these gases. The IPCC also reports that the effects of global warming from these activities are tangible and easily observed. For example:

- Eleven of the previous twelve years leading up the IPCC's 2007 study were the warmest years ever recorded by instrument.
- Mountain glaciers and snow cover are receding at alarming rates.
- Global sea level rose 0.08 meters between the years 1961 and 2003, and could rise as high as 0.8 meters by 2100.

Figure 1: Diagram of the earth's greenhouse effect

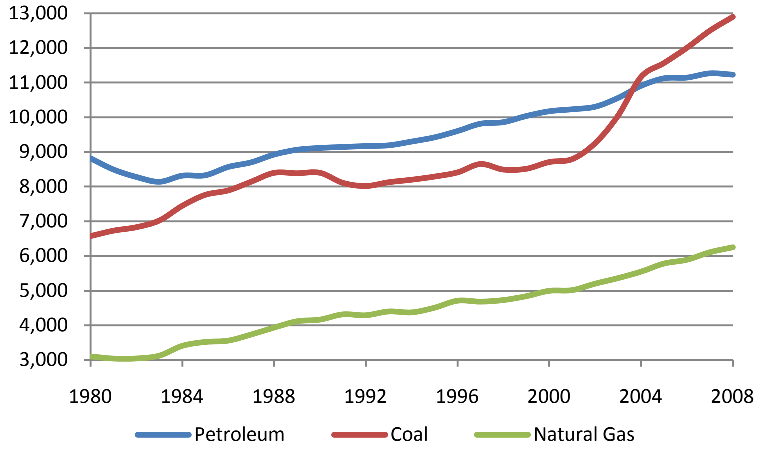


Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

Nearly all scientists agree that the consequences could be disastrous if these trends continue.[7]

Energy consumption is a major cause of anthropogenic GHG emissions, as measured in carbon dioxide equivalents (CO_2eq). As shown in Figure 2, the combustion of petroleum, natural gas, and coal in 2008 led to more than 3.3 billion metric tons of CO_2eq being emitted into the atmosphere, and the rates of emissions from energy consumption are increasing.[8] The combustion of coal alone causes about 42% of global GHG emissions and is expected to reach 45% by 2030.[9] Emissions from the consumption of petroleum and natural gas also are increasing.

Figure 2: GHG emissions (MMTCO_2e) from world consumption of fossil fuels



Source: EIA, Accessed at: http://www.eia.doe.gov/emeu/international/contents.html

Toxics and Pollution

Human activities result in the emission of many substances that can have a negative impact on human health and the environment. We use increasing amounts of chemicals for all of our activities (e.g., manufacturing, transportation, agricultural production) and inevitably release these chemicals into the air, ground, and water. Toxic chemicals can cause a wide range of health problems such as respiratory illness, diseases of the internal organs, and cancer. Inappropriate waste disposal methods lead to waste building up in various ecosystems, including the ocean, where it threatens biodiversity and species existence.

Smog is a particularly harmful type of air pollution that is formed by the burning of fossil fuels. There are two types of smog. The first type is *classic smog*, which is a combination of smoke (tiny particulate matter that is mainly derived from ash) and sulfur dioxide (SO_2) that collect in the lower levels of the atmosphere. The combustion of coal, which typically comprises 45 to 50 percent of all power generation in the US,[10] releases particulate matter such as silicon dioxide, calcium oxide, and traces of heavy metals. All of these pollutants can lead to serious human health conditions if inhaled. Combustion of high-sulfur coal also creates SO_2. SO_2 can react with oxygen and water vapor in the atmosphere to create acids such as sulfur trioxide, sulfuric acid, and sulfurous acid. When these compounds in the atmosphere cool, they can drop in the form of acid rain, which can cause significant health risks and damage to crops, soil, and buildings.[11]

The second type of smog is *photochemical smog*. Simplified, photochemical smog is created through a mixture of chemicals that is released into the atmosphere and changes in chemical composition when reacting with sunlight. The components of photochemical smog are emitted when fossil fuels are burned by industry and vehicles, and include chemicals such as nitrogen oxides (NO_X) and volatile organic compounds (VOCs). NO_X and VOCs can react with sunlight to create particulate matter and a low level of ozone, also known as tropospheric ozone. This particulate matter can irritate allergies and lead to conditions such as emphysema, bronchitis, and asthma.[12] Furthermore, the formulation of tropospheric ozone can be unhealthy to breathe and can damage crops, trees, and other vegetation.[13]

Water Scarcity and Water Quality Degradation

With 70% of the earth's surface covered by water, it is easy to take for granted the finite nature of fresh water supplies. However, only 2.5% of the earth's water supplies are fresh water. Of that 2.5%, nearly 70% is frozen in the polar icecaps, with much of the remaining 30% otherwise inaccessible to humans. In fact, only 0.007% of the earth's total water supply is accessible, fresh water.[14]

Arguably more important than total water supply, however, is the distribution of this supply. While areas like Virginia typically have access to an abundance of fresh water, it is estimated that 1.2 billion people around the globe live in areas where fresh water is scarce. Another 1.6 billion people lack the infrastructure to adequately access surface and groundwater supplies.[15] As populations in water-scarce areas grow, water stores are being depleted. For example, the Midwest depends heavily on the Ogallala Aquifer, a giant underground reservoir, for water. However, it is estimated that the Aquifer will be functionally depleted within 15 to 50 years.[16] Unfortunately, if the Ogallala does become depleted, it will take 6,000 years to recharge.[17]

Water supplies are further limited by pollution. According to a recent assessment by the EPA, in the U.S. alone, "44% of assessed stream miles, 64% of assessed lake acres, and 30% of assessed bay and estuarine square miles were not clean enough to support uses such as fishing and swimming."[18] These water supplies are contaminated by a variety of sources including wastewater treatment systems, agricultural runoff, storm water runoff, and others. Some water pollution—particularly issues arising from wastewater treatment systems—is directly related to water use. Other threats to water quality may stem from land use practices, solid waste disposal practices, and the use of toxics.

Depletion of Natural Resources

Almost all human activities result in the consumption of natural resources. The impact of consumption varies with its magnitude and intensity, and depends on whether a resource is renewable or non-renewable. Non-renewable sources are typically natural resources that cannot be replenished at a rate necessary to sustain their level of consumption. Such resources typically exist in a fixed amount or are consumed at a rate faster than the rate at which the earth can recreate them. Conversely, renewable sources are continuously recreated and are often components of the earth's natural cycles.[19] Based on the rate at which we are consuming some of the earth's non-renewable resources, it is possible that we will soon run out of many of them.[20]

Habitat Degradation and Loss of Biodiversity

Habitat degradation occurs when humans develop land for the purposes of agriculture, urban development, industrial production, or resource extraction (e.g., drilling for oil, mining for coal). All development displaces and disrupts native biotic communities and fragments the landscape into a matrix that is largely human-dominated, dotted with patches of remnant habitat. The amount of land that is developed is directly proportional to the percent of species that will be lost in the particular plot of land.[21] In other words, 50% development means that half of the species on that property will be lost. The loss of global biodiversity threatens food security and resource availability, and compounds the problems of water quality degradation, soil depletion and erosion, air pollution, global warming, and many others.

Emissions of pollutants to land, air, and water can also cause habitat degradation, even in remote locations. The deposition of atmospheric nitrogen particulates, which stems from automobile use in cities and on highways, can negatively affect distant and isolated habitats. For example, they can alter the soil chemistry in such a way that favors exotic plant invasion, which can displace a native ecosystem.

A Systems Approach

The word *ecology* in its barest sense means "the study of home" (Greek *oikos* = habitation).[22] Though the word *ecosystem* typically conjures an image of a strictly plant and animal community, human beings are beginning to adopt a more inclusive view of our place in the world. In the face of global environmental degradation, we have been made aware of the dangerous consequences of an anthropocentric worldview.

Recognizing that humans are an integral part of the environment helps us to recognize the reciprocal relationship between human health and environmental health. Ecologist Margaret Palmer believes that the "ecology of the future" must consider the human species as an integral component of earth's ecosystems.[23] Botanist and entomologist Douglas Tallamy has stated that "we must give up the old notion of preserving nature in its pristine form" and accept the need to redesign human habitat to accommodate the preservation of other species.[24] Pope Benedict XVI has said, "[t]he deterioration of nature is in fact closely connected to the culture that shapes human coexistence: when 'human ecology' is respected within society, environmental ecology also benefits."[25] Seeing human beings as part of one global ecosystem facilitates appropriate responsibility within local ecosystems and watersheds, and enables us to carefully manage our home turf, adjust our daily habits, make our livings with less impact, and become more responsible consumers in the global marketplace.

The systems orientation is helpful for "seeing wholes" and provides "a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots."[26] The approach involves dynamic thinking, the framing of problems in terms of patterned behaviors over time rather than on particular events, constant attention to a macroscopic view, and examination of how actions and results might be intertwined.

PROJECT ORGANIZATION

The Michigan Team kept a "systems" orientation in mind as we developed the scope for HCA's sustainability plan. We acknowledged, for example, that the built environment that the monks occupy is nested within an agricultural ecosystem, which is nested within a larger "natural" ecosystem. Furthermore, each sub-watershed on the property belongs to the Shenandoah Watershed, which ultimately belongs to the larger Chesapeake Bay Watershed. Land use directly correlates to water quality: nutrient runoff from the farm impacts the lives of fisherman in the Chesapeake Bay through the hypoxic aquatic condition it contributes to; unchecked energy consumption affects HCA's economic sustainability and contributes to the far-reaching social and environmental effects of global warming; the use of fruitcake ingredients grown by farmers in distant locales who choose to use pesticides has implications on the farmers' health, water quality, and adds to HCA's overall carbon/energy footprint. As Aldo Leopold put it, "The land is one organism."[27]

Thus, the methodology, analysis, and options proposed in this report were conceived from a systems perspective with the intention of encouraging a more holistic, integrative, and telescopic view of the monastery in its local, regional, and global contexts. However, while recognizing that HCA is part of a complex and interrelated system, we teased apart several aspects of the community for critical and thorough assessment. These categories include the following: land use, energy, water use and quality, solid waste, toxics, business, and buildings.

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LAND

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The property owned by the Holy Cross Abbey encompasses approximately 1,200 acres of karst terrain in the Shenandoah Watershed and includes three intermittent streams that drain into the Shenandoah River. Though the property should be viewed as a single ecosystem, a variety of ecosystem types and land uses exist on the property: farmland, forest, shoreline, and the built environment. Each ecosystem type requires different management techniques, and each land use accomplishes a different objective. However, accomplishing the overarching sustainability goals of site biodiversity, improved groundwater and surface water quality, and improved human health and wellbeing requires a solid understanding of the fundamental building blocks that all ecosystems share—soil, water, flora, fauna, and people.

This chapter describes how land use affects the soil, water, flora, fauna, and people at HCA as it meets or fails to achieve ecological ambitions and sustainability goals. We focus the discussion in this chapter on land use within three landscapes at HCA: the architectural landscape, the agricultural landscape, and the "natural" landscape. (We use the word *natural*, for lack of a better term, to describe those parts of the landscape where human presence is largely absent.) The first section explains why it is important to consider these three landscapes when evaluating the impact of HCA's various land uses. Subsequent sections explain the tools and techniques we used to evaluate HCA's land and property as well as our key findings and conclusions. The last section and the designs that accompany this report suggest options that HCA might consider for improving these landscapes. Throughout this analysis, we consider how land use affects the larger Chesapeake Bay watershed to which the HCA property and all of its smaller sub-watersheds belong (*see* Figure 3). However, the specific subject of water quality and water conservation is dealt with in Chapter 3.

CONTEXT: Landscape as Mirror

The landscape can be a telling mirror of human cultural values. If one were to compare the Great Serpent Effigy Mound in present-day Ohio with the artificially constructed Palm Islands in Dubai, one might, from a distance, notice similarities in these abstract earthworks. Upon closer examination, however, an observer of these landscapes would be able to discern some dramatic differences between them, and between the values and beliefs of the cultures that conceived of and constructed them.

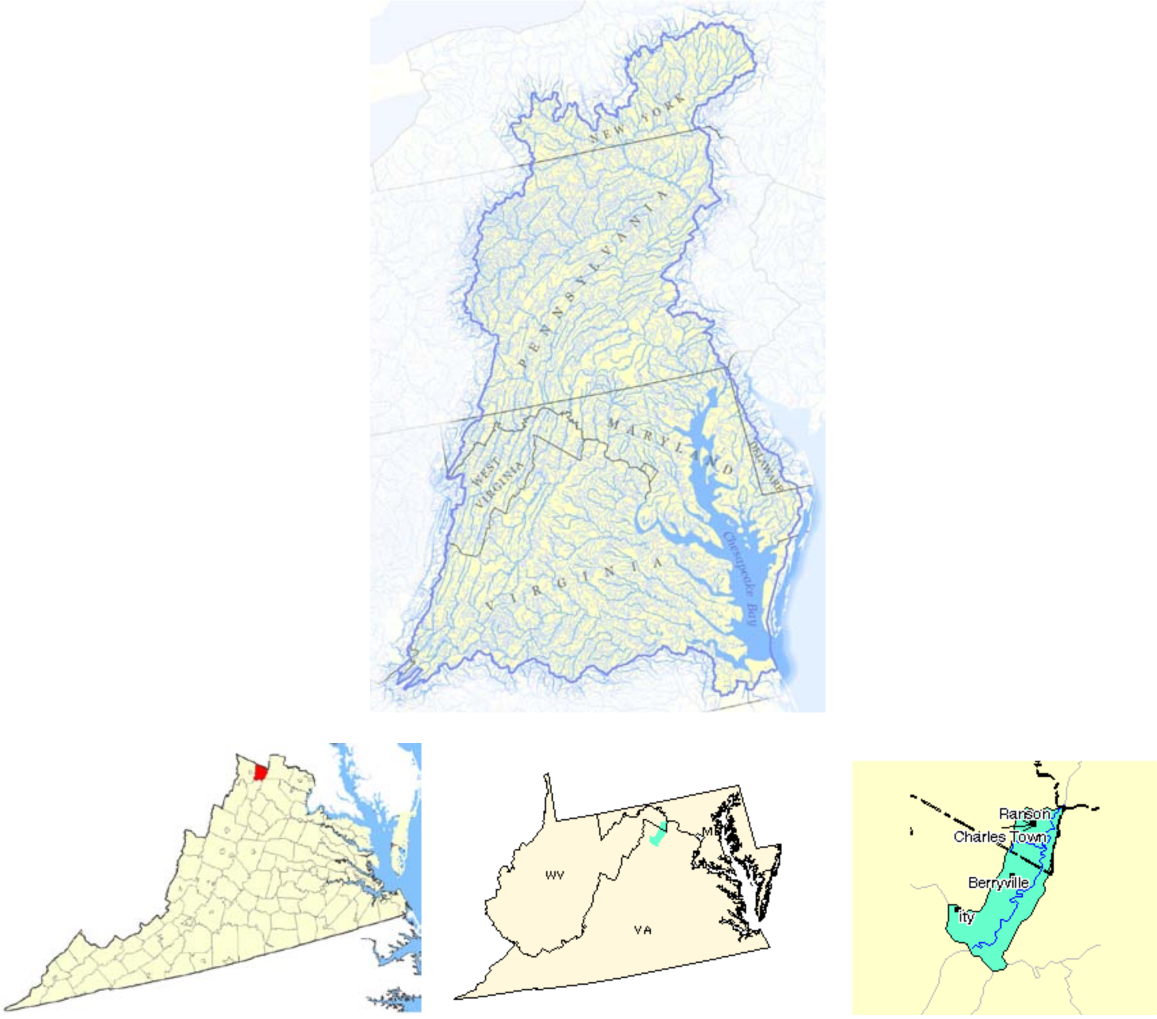
Figure 2: Palm Islands, Dubai[1]

Figure 1: Great Serpent Effigy Mound, Ohio[1]

While it is unfair to romanticize the land values of indigenous cultures without sufficient supporting historical evidence, many North American effigy mounds are believed to have been constructed for spiritual or religious purposes, based on the fact that many of them serve as burial sites and/or have some correlation to astronomy. Nobody will ever know why the Great Serpent Mound was built around 1070 BC, but it probably wasn't constructed for the primary purpose of economic gain. By contrast, Palm Islands was a development strategy intended to "solve Dubai's beach shortage" and maximize the amount of valuable, developable waterfront property.[1] Each frond of Palm Islands is a money-maker, lined with expensive homes, resorts, and upscale retail. Perhaps in the distant future, if global-warming induced floods erase all traces of Palm Island infrastructure, and if open pit mines revegetate and become soft and curious-looking “earth works,” future civilizations will view our landscape legacy as having been rooted in mysterious spiritual values, rather than in economic ones.

The landscapes we create and inhabit in the 21st century are largely a reflection of our motivation towards industrial progress and economic growth. Degraded shorelines, polluted rivers, hypoxic bays, contaminated “brownfields,” gaping pit mines, sprawling cities, toxic factory-style farms, and numerous capped landfills all speak for themselves. Dwindling natural resources and the loss of global biodiversity are finally having an effect on the world economy, food security, and human survival. As we remember that the economy is not something created solely by humans and that true wealth is rooted in a healthy planet, we are beginning to reconsider our approach to global land use and are changing the way we build cities, the way we farm, the way we protect, conserve, and restore natural areas, and even the way we construct small “in-between” spaces in the built environment and in our own backyards.

Figure 3: Shenandoah Watershed is part of the larger Chesapeake Bay Watershed[2]



The Architectural Landscape: The Importance of Backyard Decision Making

The built environment is the arena for habitual decision making and is a reflection of our relationship to the resources that feed, hydrate, bathe, shelter, educate, and sustain us on a daily basis. Cistercian architecture, with its simple, colorless, and cloistered aesthetic, has a tradition of supporting an austere, interior life.[3] The built environment, however, includes not only interior but also exterior spaces that have been designed, constructed, and cultivated and that are managed on a regular basis. Elements of analysis referring to this landscape will focus not on building architecture, but on the siting and landscape architecture of Holy Cross Abbey and its impacts on soil and water quality, biodiversity, and community health, wellbeing, and daily behaviors.

Scientists estimate that the loss of biodiversity in a given area is directly proportional to the amount of land that has been developed.[4] In other words, if 50% of a landscape is disturbed, 50% of the species existing there will be lost. It is more important than ever for land owners to practice conservation on even the smallest properties. We can no longer rely on the anomaly of privileged large-scale land conservations like those that occur in state and national parks and preserves.[5] Instead, this analysis will take a closer look at the ecological implications of traditional landscaping at HCA, including the use of lawn and exotic cultivars, and assess the potential for the grounds to serve conservation purposes in addition to being a beautiful backdrop for the monastery.

The sustainability of the built environment also hinges upon the potential for storm water to infiltrate the ground as close to where it falls as possible, without running off and causing unnecessary erosion, sedimentation, stream degradation, and nonpoint source pollution of ground and surface waters. Improved on-site storm water infiltration can also help remove water-borne toxins through plant uptake and contribute to groundwater recharge.[6]

The Agricultural Landscape: Why Sustainable Agriculture?

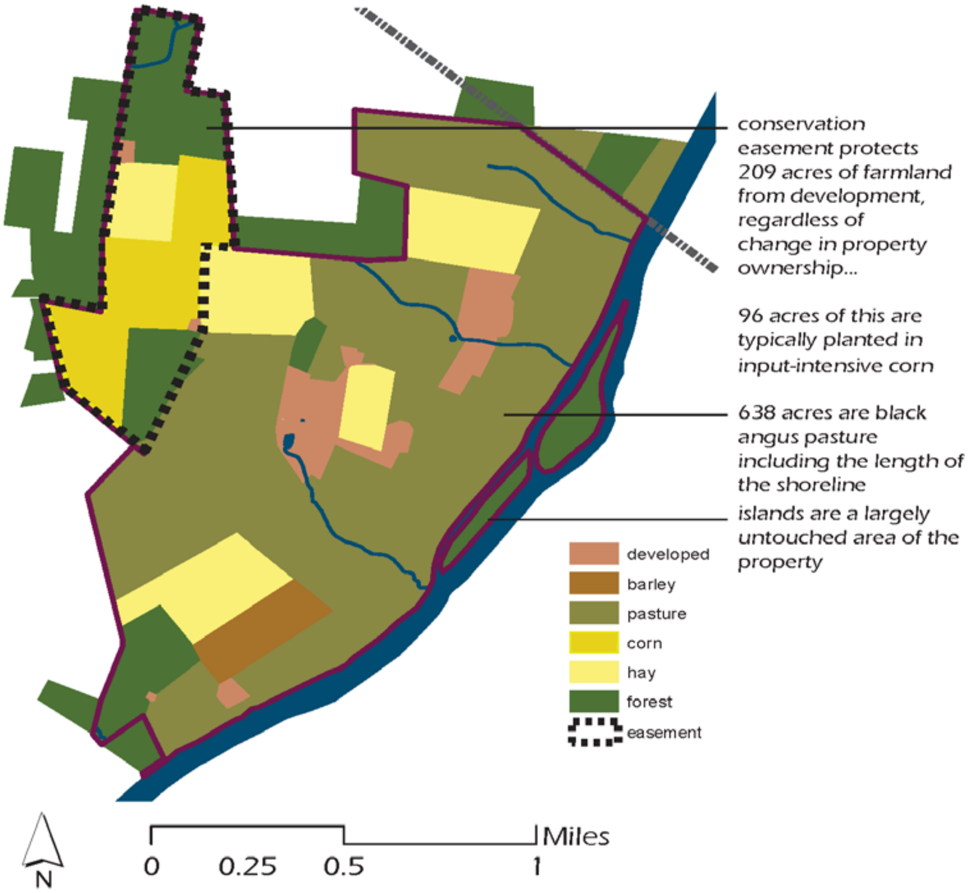
The farm can exist only within the wilderness of mystery and natural force. And if the farm is to last and remain in health, the wilderness must survive within the farm.

Wendell Berry*, The Unsettling of America*[7]

The rise of industrial agriculture has seen enormous parcels of arable land fall under the control of a small handful of "agribusinessmen," who in turn, under a rigid and outdated Federal Farm Bill, are dependent upon a small handful of large corporations that continue to secure economic gain through unsustainable farming practices. These large corporations use farming practices that demand monocultural production, global competition, heavy petroleum inputs, the use of toxic pesticides, herbicides, fungicides, and heavy-metal-laden municipal sewage sludge, feedlot-scale husbandry, unregulated animal sewage disposal, and the use of genetically modified organisms.[8] Among the dwindling population of "small farmers," which includes even those who cultivate as much as several hundred acres, economic strain has a strong influence over cultivation and husbandry practices. Many innovative methods of sustainable agriculture have been developed, and scientists have proven that organic farming can indeed "feed the world,"[9] but policy and legislation lags behind and does not yet support these practices. This fact, combined with the force of consumer preference for cheap—albeit environmentally costly—food, tells us that the detrimental effects arising from the practice of "conventional" agriculture is not entirely the fault of the individual farmer.

Farmers comprise only 2% of this country's population. On a regular basis, these farmers face not only financial stress but also unpredictable weather, machinery breakdown, and disease outbreaks. The existence of such federal programs as the Wetlands Reserve Program, the Conservation Reserve Program, and the Environmental Quality Incentives Program reflect a growing commitment to ameliorating environmental degradation within agricultural landscapes. However, these programs do not consider a farm to be one interconnected "agroecosystem" to which humans, crops, livestock, soil, water, natural vegetation, and wildlife all belong. Instead, today's conventional farming takes a linear, production line approach that is blind to many of the complex ecosystem processes that should factor into all decisions made on a farm. In the future, a process versus product approach to agriculture will consider the interrelatedness and importance of soil fertility, air and water quality, biodiversity, and community, regional, and global health as much as it considers commodity crop production yields. Farmers who view the farm more as a natural habitat for crops and livestock than as a factory will be inspired to choose to harness "ecosystem services" for fertility and pest control, rather than fossil fuel and man-made chemicals.[10]

Figure 4: 2009 Land Use



Source: Data from Clarke County, VA NRCS, USFWS

Clarke County has demonstrated an outstanding commitment to the preservation of agricultural land through the use of planning tools such as sliding scale zoning and conservation easements. Instead of accepting modern, large-scale agriculture as a "necessary evil" and as a given "ecological sacrifice zone,"[11] sustainability requires a more creative, collaborative, and holistic approach to both farming and conservation. Preserving land is only half the battle. The other imperative is to ensure that the land in easement is managed sustainably so that the agroecosystem at HCA remains viable for future generations of monks to "till it and keep it."[12] As Aldo Leopold put it:

> Conservation is a state of harmony between men and the land. By land is meant all of the things on, over, or in the earth. Harmony with land is like harmony with a friend; you cannot cherish his right hand and chop off his left. That is to say, you cannot love game and hate predators; you cannot conserve the waters and waste the ranges; you cannot build the forest and mine the farm. The land is one organism.[13]

The Natural Landscape: Sustainability through Appreciation

The leaf has its own texture and its own pattern of veins and its own holy shape, and the bass and trout hiding in the deep pools of the river are canonized by their beauty and strength.

Thomas Merton[14]

As noted earlier, we cannot "save the world" just by preserving our state and national parks. Individuals must accept their role in facilitating the healthy functioning of their own ecosystems and watersheds. Americans have either taken or modified for our own use between 95% and 97% of all land in the lower 48 states.[15] Similarly, 87% of the land at HCA is dominated by human use. Only 13% of the HCA property is natural landscape with which humans infrequently interact on a day-to-day basis.

As we protect ecology on our own square footage, we increase the resourcefulness of our home ecosystems. More energy in an ecosystem means that it will produce more ecosystem services, or, in other words, "make more fish, more lumber, and more oxygen, filter more water, sequester more carbon dioxide, buffer larger weather systems, and so on."[16] While this economic reasoning often can be an effective argument in our consumptive society, perhaps a more sure approach towards the protection and sustenance of the earth and its natural resources is a spiritual one. Thomas Berry suggests that "the universe itself, but especially the planet Earth, needs to be experienced as the *primary* mode of divine presence, just as it is the primary educator, primary healer, primary commercial establishment, and primary lawgiver for all that exists within this life community."[17] It might be said that true sustainability cannot be achieved until we value and appreciate the natural world for its *own sake*, and not just for how it can serve us.

Principles of Sustainable Land Use: What is Stewardship?

What does it mean to be a steward of the land? Twenty-first century stewardship requires a responsible relationship with the landscapes we inhabit as well as conscious consideration of those that sustain us from afar. With the industrialization of agriculture and increasing globalization, urbanization, and digitalization, our relationship to the natural world to which we belong has become largely invisible, indirect, and consequently nonreciprocal. For centuries, Cistercian monks have practiced agriculture within riparian ecosystems. Though there were ecological costs associated with the necessary draining of wetlands that made this possible, the monks' intimate relationship with the land perhaps instilled in them a sense of stewardship for the soil, water, flora, and fauna that directly sustained them. The monastic community at HCA has been inspired to reclaim the physical and spiritual stewardship of the beautiful terrain they reside in and of the waters that flow through it, even though they no longer physically sustain themselves by relying on the land. In the opening vision statement of HCA's Strategic Plan, the community states that they "[t]ake as a special imperative the imaginative care and safeguarding of the land entrusted to" them.[18]

What will this new "imaginative care" entail? Landscape architect and researcher Joan Nassauer states that landscapes are like children in that they "require tending, not making" and care that is "habitual, humble, intelligent, and vivid."[19] Intelligent care, she believes, depends in part upon "learning how to recognize what is ecologically healthy."[20] This requires the steward to educate him or herself and to seek guidance from contemporary scientific research in ecology.

Evidence-based landscape design, use, and management should be balanced with a great deal of respect, humility, careful observation, and wonder. In addition, a healthy relationship to place must span a hierarchy of spatial scales: the steward must care about the individual species as much as he cares about the health of the entire watershed that he belongs to, and he must be able to see the connectivity between the micro and the macro levels simultaneously.[21] Sustainable land management must exhibit foresight, with attention to the facilitation of ecological resiliency for generations to come, by striving to be adaptive in the face of change, whether that be change in the monastic community or in the climate.[22,23]

True care of the landscape will recognize that higher standards of ecological health can redefine our notion of beauty. A new "land ethic"[24] can become a new land aesthetic. The concept of "cultural sustainability" means that an educated steward whose notion of beauty is in part determined by knowledge of ecological function will be more likely to offer sustained care and attention to the landscape.[25]

This landscape evaluation for HCA has in part been guided by a newly established rating system for sustainable land use, as realized in a broad collection of guidelines and benchmarks that were recently published in the 2009 version of the Sustainable Sites Initiative (SSI). This rating system is to landscapes what LEED is to buildings, offering certification for sites that effectively facilitate “ecosystem services” such as storm water infiltration, the prevention of erosion, provision of wildlife habitat, and provision of dense, walkable, and accessible neighborhoods.[26] Ratings are based on a point system, such that sustainable site selection, planning, design, construction, and management are rewarded based on an estimate of their conservation or enhancement of ecosystem services. Though not all of the evaluative criteria apply to HCA, many of them do and have been considered in both the analysis and recommendations that follow.

Whether enacted with the assistance of community members or appointed surrogate caretakers, this new Cistercian stewardship will require sensitive observation, scientific consultation, outreach, financial support, manual labor, spiritual will, love, and a deeply felt sense of belonging. Its effects should include improved groundwater quality, improved water quality in the Shenandoah River and the Chesapeake Bay, greater biodiversity, cleaner air, enhanced carbon sequestration to help offset global warming, and improved human health and wellbeing.

METHODOLOGY

Valuation: Ecosystem Services

A new method for assessing the cost of degradation and therefore the value of ecological health employs the concept of financially quantifiable “ecosystem services.”[27] Scientists have formulated a method for attaching a dollar sign to phenomena such as clean air and water, stable and agriculturally productive soil, and biodiversity. By virtue of the fact that the HCA community is spiritually invested in the ecological health of its property, this landscape site analysis opted for a simpler, more qualitative approach that assumed the value of all ecosystem functions to be intrinsic and priceless.

As Wendell Berry described in his September 2009 article “Inverting the Economic Order,”[28] “the pricelessness of things should refer to things of absolute value, beyond and above any price that could be set upon them by any market. The things of absolute value would be fertile land, clean water and air, ecological health, and the capacity of nature to renew itself in the economic landscapes.”[29] Berry further shared that the “cultural precedent for this assignment of absolute value that is nearest to us” can be discerned from biblical writings, namely Psalm 24, which states that “The Earth is the Lord’s, and the fullness thereof…” and from Leviticus 25:23, which reads, “The land shall not be sold for ever: for the land is mine, for ye are strangers and sojourners with me.”[30]

Visual-Spatial Analysis

This land use analysis began with historical research, literature review, precedent study, and a survey of the sustainability efforts of other Cistercian monasteries in the country. Two site visits then allowed the opportunity for intensive observation, photography (~1,000 photos), mapping, inventory, and interview. Data considered were annual soil testing results provided by the farm tenant as well as water quality test results.

This analysis took a strong visual-spatial approach, which consisted of using and creating data layers with ARC GIS mapping software to document existing ecological and cultural patterns and processes both within and beyond the property boundaries. Soils data was gathered from the Natural Resource Conservation Service (NRCS). Other data was provided by Clarke County, the US Geological Survey (USGS), and the US Fish and Wildlife Service (USFWS). Data layers created by the Michigan Team include the following:

- HCA property boundary
- HCA sub-watersheds
- HCA 2009 land use
- Wells
- Septic tanks
- Septic leachfields
- UST’s
- Gas pumps
- Mowed areas
- Riparian buffers
- Sinkhole buffers
- Stream buffers
- Waste dump sites

Survey

A community map-survey was issued to gather information about the community’s relationship to place, wildlife habitat, and places of interest. A geographic survey was administered to the community, requesting participants to mark up a series of 3 maps of varying scales according to the following legend items:

- Where I walk
- Where I’d like to walk
- Where I sit
- Where I’d like to sit
- Bird sightings (list species)
- Animal sightings (list species)
- Favorite trees
- Areas to plant more trees
- Areas to conserve/protect
- Areas to clean up/improve
- Places held sacred by HCA
- Inaccessible areas
- Views that I enjoy
- Views that could be improved
- Other sites of interest

Eleven monks completed and returned a survey, which relayed information that has informed landscape recommendations for habitat preservation, grounds cleanup, ecological restoration, sacred space enhancement, contemplative garden and walking trail construction, etc.

Organization of Analysis

The land use analysis differs from other analyses in that it covers a wide plethora of subtopics. Several aspects of each of the following topics will be explored in this analysis:

- Soils
    - geology
    - taxonomy
    - contamination
    - erosion
    - compaction
    - drainage
- Hydrology
    - surface flow and drainage
    - storm water management
    - groundwater quality
- Flora
    - ecosystem integrity
    - invasive species
    - gardens and grounds management
    - lawn
    - agricultural biodiversity
- Fauna—wildlife habitat
- Human relationship to the land
    - human/auto traffic flows
    - sacred places
    - management

This analysis deliberately weaves these elements together in a dynamic web offered from a holistic, ecosystem-based point of view.

RESULTS

Soils

Soils are ecosystems in and of themselves. The soil food web is both one of the most important and one of the most invisible ecosystems in need of preservation. Life in the soil resides in the rhizosphere, or the root zone of plants, where in healthy soil billions of species of bacteria, fungi, insects, and macroinvertebrates feed on root exudates, organic matter, and each other. Some of these organisms form critically important symbiotic relationships with plants, improving their ability to uptake certain nutrients; others aerate the soil as they move through it, and most all of them generate soil fertility through the digestion of organic matter. Though organic content, or humus, is at best no more than 5% of the total soil composition in the upper horizon, it is the basis for survival of all life on earth.[31]

This section identifies the key characteristics of the soils and other subsurface features at HCA. We first describe the unique geology (karst) that underlies the property and is responsible for forming the natural spring for which the land was named by colonial settlers. We then describe the predominant soil types at HCA and the primary threats to soil health: soil contamination, erosion, drainage, and compaction.

Figure 5: A hard to miss sinkhole

Figure 6: A new sinkhole forming near the Retreat House

Source of photo in Figure 5: The Plain Dealer, “Sinkhole Closes Madison Avenue,” http://blog.cleveland.com/metro/2008/10/sink hole closes madison avenu.html

Karst: Porous Geology, Vulnerable Groundwater

Much of the subsurface of HCA’s property is characterized by karst--soluble carbonate limestone geology.[32] The limestone of the Shenandoah Valley is part of the “Great American Carbonate Bank,” which “formed over a time span of 70 million years as carbonates were deposited in a shallow tropical ocean along the southeast edge of North America.”[33] Today these carbonates (up to 3.5 kilometers in thickness) are either exposed or just under the surface, existing as karst. The stark geologic contrast between the fragile karst geology of the Shenandoah Valley and the robust, metamorphic stone of the Blue Ridge Mountains across the river was likely a determinant of colonial settlement patterns in this part of the Shenandoah Valley.

Karst terrain has been determined to be one of the most sensitive types of environments for human development. When acidic rainwater comes into contact with this limestone, it erodes, forming not only springs but sinkholes, caves, and sinking streams. See Figure 5: A hard to miss sinkholeFigure 6. Continually eroding conduits of open space in karst geology not only make building roads and structures risk-laden and difficult, but they make groundwater extremely vulnerable to direct pollution.[34]

As shown in Figure 7, runoff of polluted storm water, eroded sediment, toxic agricultural chemicals, nitrogen-rich manure and fertilizer, and leakages from septic systems and underground storage tanks into this Swiss cheese-like landscape all pose immediate and serious threats to the groundwater at HCA, which is the current drinking water source.

We identified areas of ecological concern at HCA's property by mapping the locations of known sinkholes on the property and considering them within the context of current land use and topography. The land in the conservation easement, on which corn was cultivated in 2009, has a considerably punctuated geology, allowing the chemicals and toxins that are known to have been applied to these acres (including the herbicide atrazine, a synthetic nitrogen fertilizer, and municipal sewage sludge) to leach directly into the water table. Water tests have shown that several wells on the property are contaminated with harmful nitrates, which likely come from runoff carrying fertilizer, sewage sludge, and cow manure, which can enter the groundwater through infiltration or, much more rapidly, through draining directly into these sinkholes. While tests conducted in February did not detect atrazine residue in the well water, we believe that if the test had been conducted in the spring (just after the herbicide was applied), it very possibly would have detected atrazine in HCA's water—especially if there was a heavy rain event after the application.

Figure 7: A sectional illustration of karst[35]

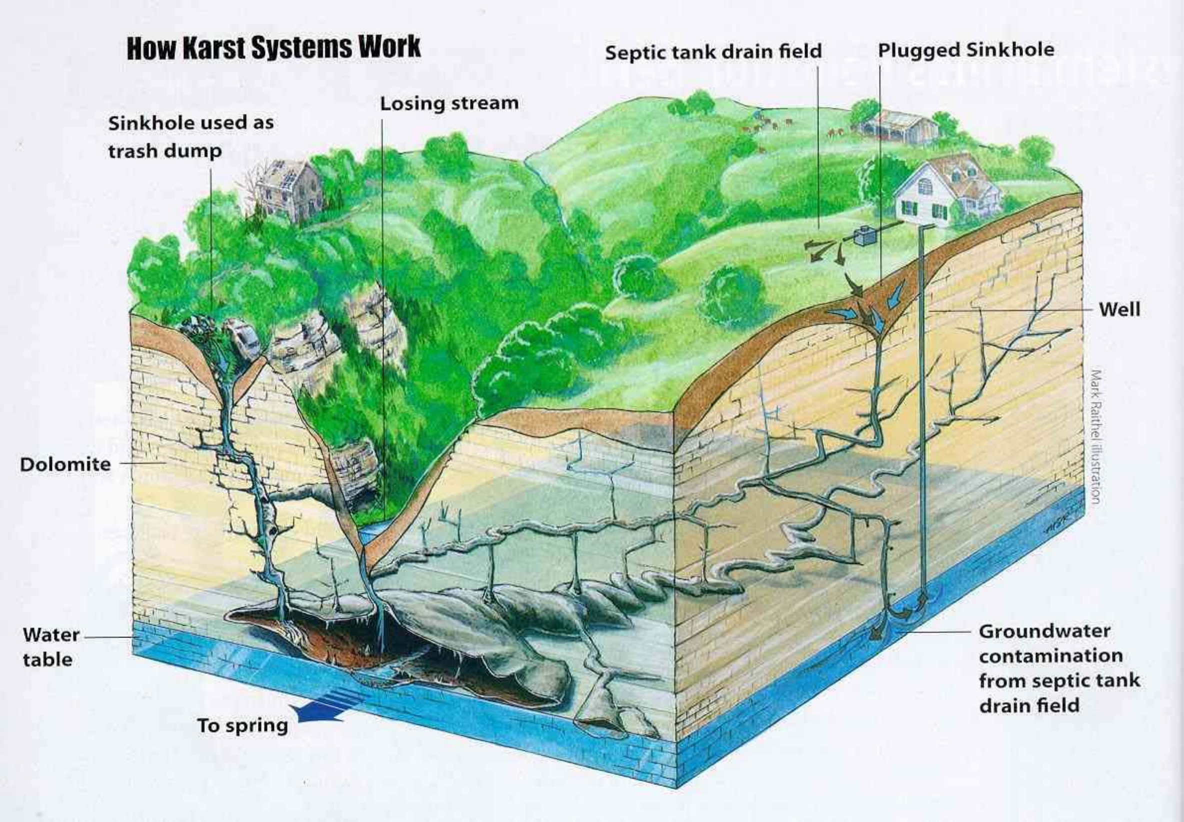
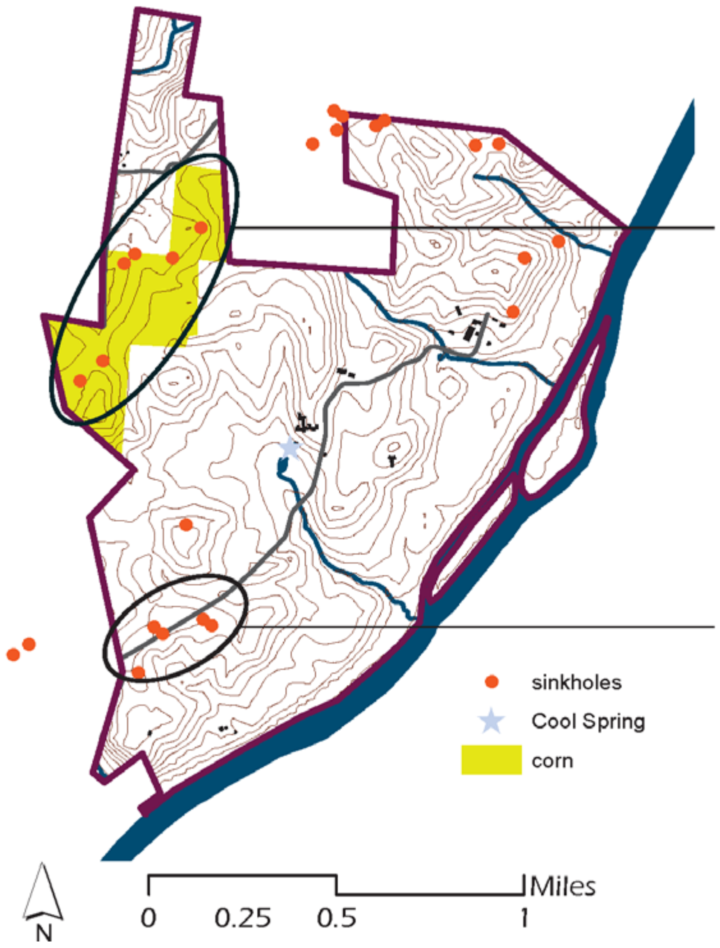


Figure 9: Sinkholes and land use



groundwater is directly exposed to all agricultral inputs, including atrazine, inorganic fertilizer, manure, and municipal sewage sludge, in this cropland perforated with sinkholes

road integrity may potentially be compromised in the future by further erosion of sinkholes

Source: Data from Clarke County, VA NRCS, USFWS

The Team identified areas of ecological concern at HCA's property by mapping the locations of known sinkholes on the property and considering them within the context of current land use and topography. The land in the conservation easement, on which corn was cultivated in 2009, has a considerably punctuated geology, allowing the chemicals and toxins that are known to have been applied to these acres (including the herbicide atrazine, a synthetic nitrogen fertilizer, and municipal sewage sludge) to leach directly into the water table. Water tests have shown that several wells on the property are contaminated with harmful nitrates, which likely come from runoff carrying fertilizer, sewage sludge, and cow manure, which can enter the groundwater through infiltration or, much more rapidly, through draining directly into these sinkholes. While tests conducted in February did not detect atrazine residue in the well water, we believe that if the test had been conducted in

Figure 8: Characteristic red soil at HCA

the spring (just after the herbicide was applied), it very possibly would have detected atrazine in HCA's water—especially if there was a heavy rain event after the application.

The map in Figure 9 depicts locations of known sinkholes (according to community members, the farm tenant, and Clarke County GIS data), the location of Cool Spring, and location of corn in 2009.

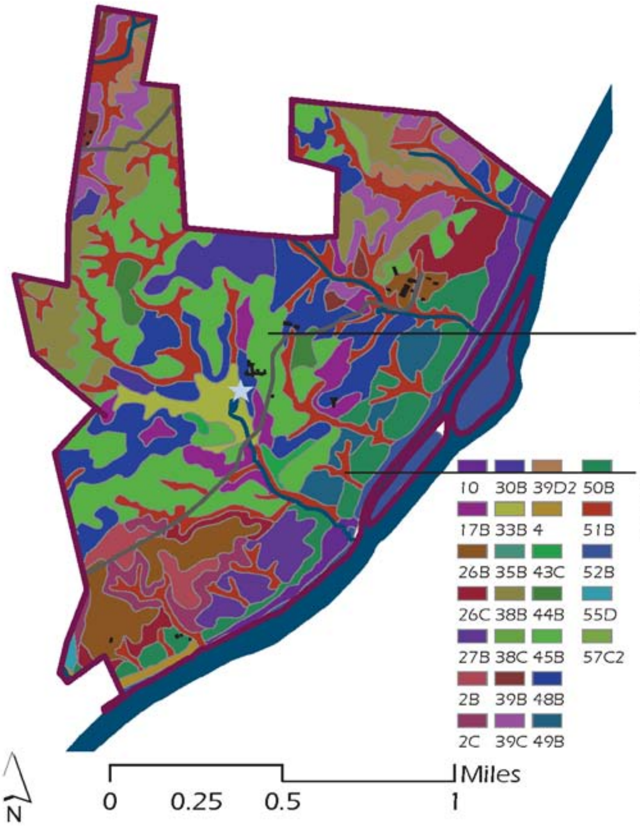
Soil Characteristics

Iron oxides give much of the soil at HCA its reddish color. Though local soils are commonly referred to as "Virginia Red Clay," the Natural Resource Conservation Service (NRCS)[36] map in **Figure 9:** Characteristic red soil at HCA

illustrates that there are many types of soil present on the property. The most predominant soil type on the property is Swimley Silt Loam (3%–8% slopes), a silty loam weathered from limestone and shale parent material, which is present on 16% of the property. It is followed by Timberville Silt Loam (0%–7% slopes), an alluvial floodplain soil, which is present on 15% of the property. The third most predominant type of soil is the Swimley-Rock Outcrop Complex (3%–8% slopes), which is present on 11% of the property. All of the other soil types occur in very small percentages across the property. (A taxonomy of soil types is included as Appendix 1-A.)

The general term *Virginia Red Clay*, though it may describe what the soil looks and feels like to the non-soil scientist, does not convey the true nature of these predominant soil types. A typical profile of Swimley Silt Loam, a "deep, well-drained soil,"[37] only exhibits true clay at 14 inches below the surface. It should be noted that NRCS data is interpolated from a scattered collection of sample sites, and is not necessarily up to date or exactly precise to any given location. A much more accurate measure of character and quality can be achieved through observation and testing of a soil pit dug on the location in question.

Figure 10: Soils



the predominant soil type is Swimley Silt Loam (45 B), with 3-8% slopes, which is a silty loam weathered from limestone

another predominant soil is Timberville Silt Loam (51 B), an alluvial floodplain soil

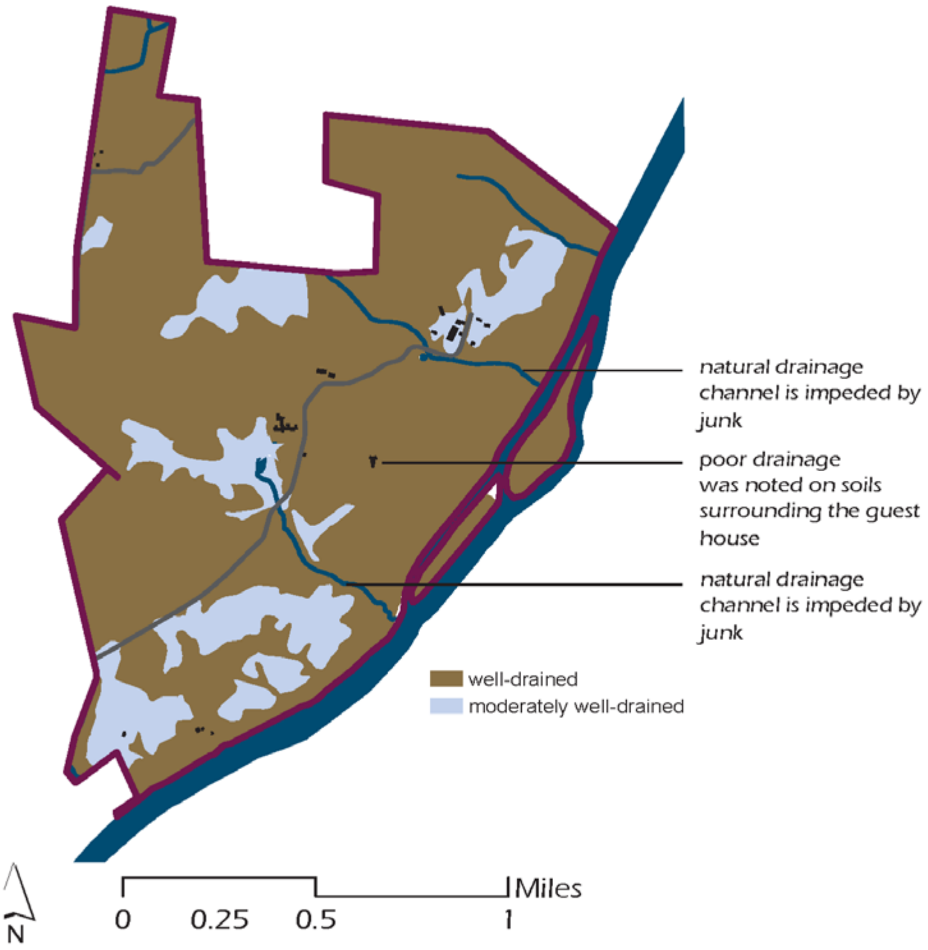
Source: Data from Clarke County, VA NRCS, USFWS. See Appendix for more soil information about soil taxonomy.

Soils at HCA are generally acidic in nature; the pH ranges from 4.6 to 7.5, with the average pH across the entire property being 5.5. When a soil's pH is away from the neutral 7.0, it inhibits the ability of a plant to uptake certain nutrients. The farm tenant's annual application of lime to the soil helps to reduce the acidity.

All of the soils at HCA are well drained with the exception of soils on roughly 15% of the property, which are moderately well drained (*see* Figure 10). The Swimley soils exhibit moderate shrink-swell potential, which can make roads and structures susceptible to buckling and heave.

There are no hydric soils present on the property, or soils that were formed under wet conditions that are well able to support hydrophytic vegetation. The existence of hydric soils is one factor to take into consideration when determining where to restore wetlands.

Figure 11: Drainage



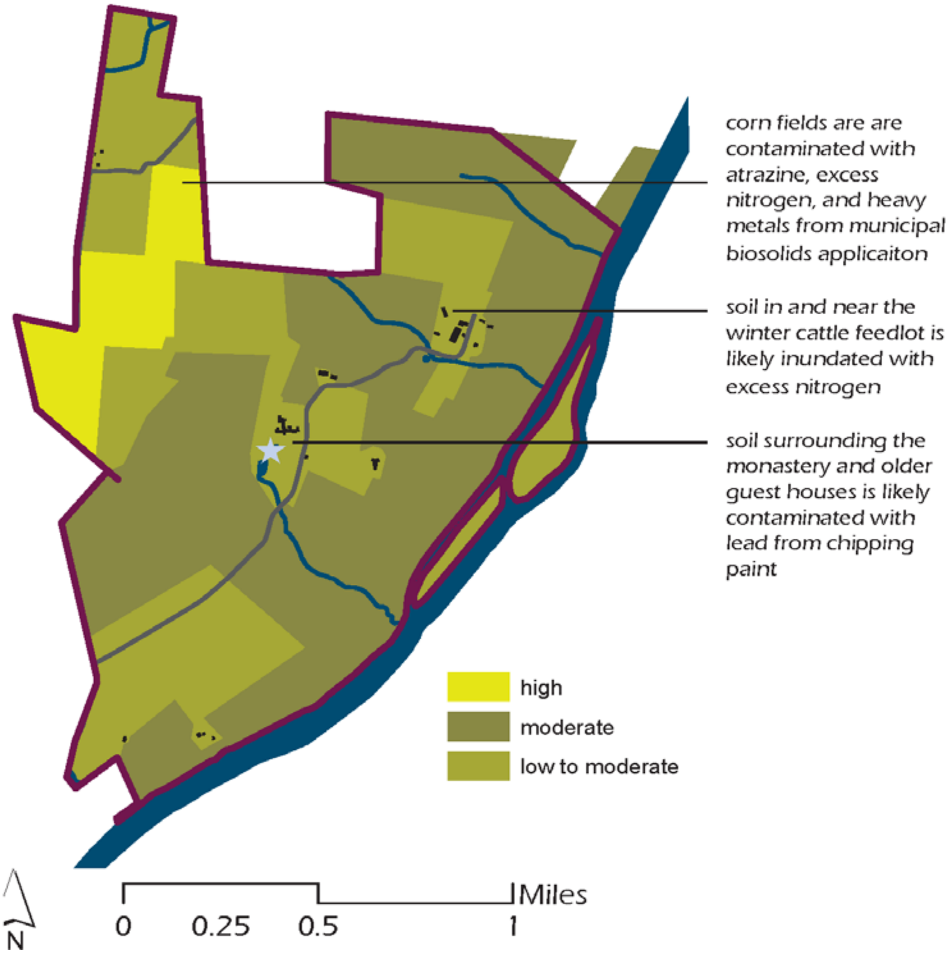
Source: Data from Clarke County, VA NRCS, USFWS

Soil Contamination

The primary threats to soil health in this land use analysis are the agricultural inputs that the farm tenant uses at the property. These farm inputs include atrazine, biosolids, sythetic fertilizers, and manure. Areas impacted by these inputs are shown in Figure 12. Though many of these contaminants most profoundly affect ground and surface water quality, they also affect soil health, fertility, and biodiversity. Other possible soil contaminants of concern in the built environment at HCA include sediments of aging, toxic building materials such as lead paint and asbestos, and possible septic tank and/or underground storage tank (UST) leakage. These issues will be dealt with in other sections of the analysis, though they should be taken into consideration if there is a desire in the future to cultivate any type of food-producing garden in proximity to any of the buildings on site.

Though we have created synthetic fertilizers, they are not without problems. Not only are they generated with the finite resource of fossil fuels, they directly contribute, through rampant over-application, to large hypoxic dead zones in receiving water bodies such as the Chesapeake Bay and the Gulf of Mexico. Synthetic fertilizers also can inadvertently cause the salinization of soils, rendering cropland unproductive.[38] There is simply no substitute for natural soil fertility—a relatively easy thing to maintain and enhance, but an impossible thing to create anew without the benefit of something like 10,000 years time. [39]

Figure 12: Soil Contamination



Source: Data from Clarke County, VA NRCS, USFWS

Atrazine

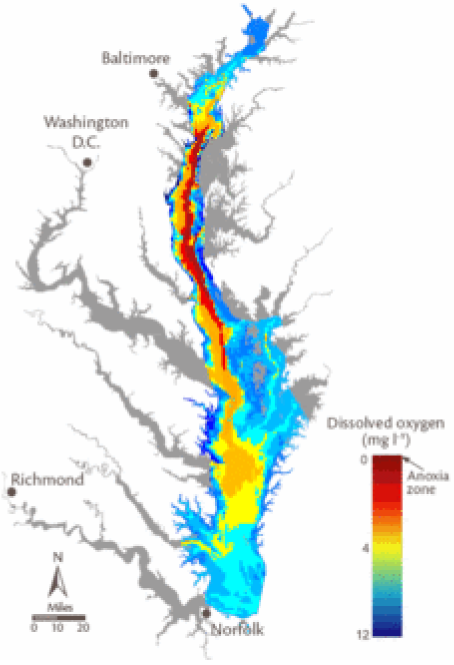
Atrazine is known to be used in the areas of the farm where corn has been cultivated (*see* Figure 13). The use of atrazine as an herbicide is a tradeoff for the practice of no-till agriculture, which greatly reduces soil erosion. Atrazine, banned in Europe because of its documented harmful effects on humans, is also detrimental to life in the soil. Scientists have proven that "the application of atrazine will decrease the biodiversity of soil microorganisms."[40] In one study, it was noted to decrease fungal diversity in the soil by 42%.[41] Soil biodiversity is important to the sustainability of all life. A healthy coniferous forest soil has been estimated to contain up to 40 miles of fungi (threadlike hyphae) in just one teaspoon, as compared to several yards typically found in agricultural soils.[42] The affects of atrazine on human health are discussed in detail in Chapter 3.

Figure 13: New corn emerging from an HCA field that was treated with herbicides in May of 2009

Biosolids

HCA's farm tenant has reported using municipal biosolids on his corn crops as a no-cost recycled input yielding nitrogen, phosphorous, and some trace elements. The application of municipal biosolids is "the primary source of heavy metals that are introduced to agricultural land."[43] When biosolids (or sewage sludge) from the municipal wastewater treatment plant are applied to the land, these "potentially harmful metals may inadvertently enter the human food chain."[44] Residual heavy metals include copper, cadmium, and zinc. These metals (along with E. coli) may induce concern for food safety and can also cause "phytotoxic responses in plants and soil biota."[45] The affects of biosolids on human health are discussed in detail in Chapter 3.

Figure 14: Red area designates hypoxic waters in the Chesapeake Bay in 2008



Source: Baltimore Sun, "B'More Green: Chesapeake Bay – An environmental blog for everyday living." http://weblogs.baltimoresun.com/features/green/chesapeake_bay/

Nitrogen

The farm tenant also reported that he spreads manure on his cropland at HCA every week. Excessive application of inorganic nitrogen fertilizer and build up or application of manure can also have detrimental affects on soil health. According to one study, excessive fertilizer and manure application can cause excessive salt and nitrate concentrations to accumulate, deteriorating soil quality.[46] Researchers have estimated that humans have doubled their rate of nitrogen input since 1975,[47] as only about half of what is applied to fields is actually taken up by plants.[48] While we do not know exactly how much nitrogen the farm tenant adds to the soil, it is common practice to be liberal in one's application, as a precautionary measure. Soil tests conducted by A&L Eastern Laboratories, Inc. recommended that 130 pounds per acre of nitrogen be applied to heavy feeder crops at HCA such as corn, and that 50 lbs/acre be applied to hayfields.

Nitrogen-laden runoff has a short route, both over land and underground, to the groundwater table and ultimately to the Shenandoah River. This runoff is currently contributing to the hypoxic dead zone in the Chesapeake Bay (this phenomenon is depicted in Figure 14 and described in further detail in Chapter 3). The human health effects relating to nitrate and nitrate pollution also are discussed Chapter 3.

Organic Production: A Bottom-Up Approach

Organic agricultural methods can be highly productive *without* requiring as many of the toxic inputs that are described above. The primary focus of organic agricultural methods is to care for and improve the organic content, biodiversity, and overall quality and fertility of the soil. Healthy soil promotes plant health in countless ways, which in turn makes them much less susceptible to pests and disease (which prey on weak hosts).[49]

Organic methods that focus on building soil-organic content not only avoid the use of toxic inputs, but promote carbon sequestration in the soil as well, which helps offset the effects of global warming.[50]

Soil Erosion

Soil erosion is a two-part problem. It results in loss of soil fertility and depth, and causes unwanted sediment pollution in receiving water bodies.[51] Soil is a resource that cannot be quickly restored. According to the 2009 version of the Sustainable Sites Initiative (SSI), it takes hundreds of years for organic content and biotic community to reaccumulate and render a soil productive.[52]

Though the farm tenant uses no-till agriculture on some of the cropland at HCA to minimize erosion, the practice of grazing cattle along the stream and riverbanks has caused severe erosion in these sensitive areas, resulting in the loss of precious organic topsoil, the destruction of habitat, and the introduction of harmful sediments and unwelcome agricultural inputs into the waters of the Shenandoah River (*see* Figure 15, Figure 16, Figure 17, and 18). This is significant because "many buffering processes known for riparian systems depend on soil organic matter" and because "enhanced levels of carbon can lead to enhanced denitrification and enhanced degradation of pesticides."[53]

Fine sediment produced by soil and gully erosion associated with cattle grazing and crop cultivation increases the turbidity of stream water and has a negative impact on aquatic species.[54] The culverts near the new hay barn and Westwood House were noted to be carrying sediment (and likely nutrient

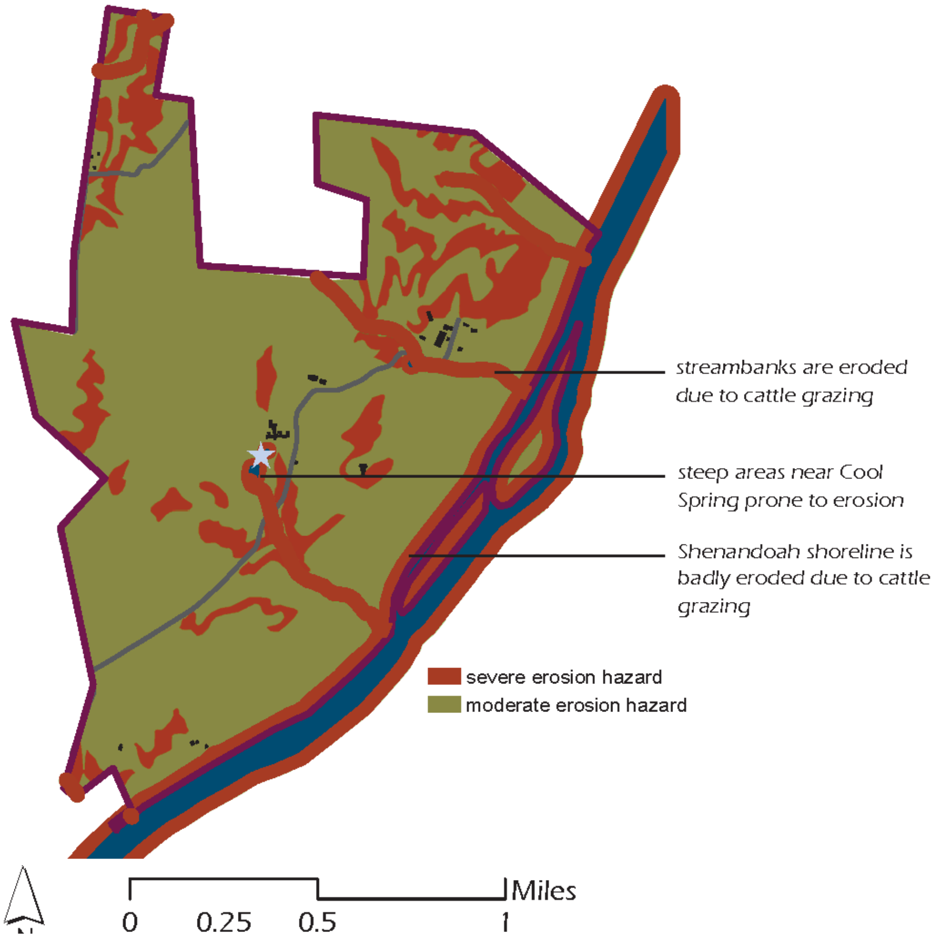
Figure 15: Erosion and manure on HCA property loading directly into the Shenandoah River

Figure 16: Erosion along the stream channel near the Westwood House

Figure 17: The shoreline east of Westwood House is badly eroded and needs restoration and stabilization

runoff from the feedlot slope) into the nearby receiving stream.

Figure 18 Erosion



Source: Data from Clarke County, VA NRCS, USFWS

Soil Compaction

Soil compaction can render the soil void of air pores and infiltration capacity, making a field functionally no different than a parking lot. Plant roots depend on porous soil to fulfill their needs for both oxygen and water. Uninhibited infiltration of rainwater is important for groundwater recharge, erosion prevention, and for the biological filtration/remediation of toxins through plant root uptake. Infiltration in the floodplain also serves important ecological functions.[55]

We observed compaction or soil-compacting activity in two areas at HCA. The first area was the two-track trail to Cool Spring, which is not necessarily of great concern. The second area was in the pasture along the Shenandoah shoreline/floodplain. The farmhand claimed that he drove up a pickup truck up and down in this area regularly, at least during the spring, to check on

Figure 19: Erosion associated with a makeshift culvert near the farm complex

young calves. Soil bulk density was not tested in these areas, but visual indicators such as poor plant growth and signs of heavy traffic suggest compaction.

Soil Drainage

Soil drainage is an important factor to consider when siting a septic system, a particular crop or plant species, or other land use that would be inhibited by either rapid drainage or ponding after rain events. Most of the soils at HCA, according to NRCS data, are relatively well drained. After several consecutive days of rainfall that occurred during the Team's May visit, some areas were noted to exhibit poor infiltration capacity, as visible by lingering standing water. In these areas, grade changes and/or specific plant species might be recommended to improve drainage. More information about poor drainage is provided in the Hydrology section of this chapter.

Figure 20: Poor drainage just outside the Retreat House

Figure 21: Storm drain pipe (lower right) causing mud and erosion behind the Retreat House

Hydrology

Land use largely determines water quality. Current agricultural practice at HCA ultimately contributes to enlarging the hypoxic "dead zone" in the Chesapeake Bay. Although many aspects of water at HCA are discussed in Chapter 3, we cannot keep the discussion completely separate from this section because water is so important to land use. In this section, we map and discuss current water sources at HCA, hydrologic flow, storm water infiltration and groundwater recharge, possible land-use related contamination of groundwater and surface waters, and floodplain function.

The Source: Cool Spring

The land at HCA was named after the source of water that made it so habitable in the first place: Cool Spring. Cool Spring likely formed due to erosion patterns in the existing karst terrain. Where the spring emerges from the earth, a pump house has been constructed. The pump house also houses the well that HCA currently uses as the main water supply for both the monastery and the bakery. As visible in the photo in **Figure 22: Historic Cool Spring infrastructure**

, remains of old spring infrastructure give a historic presence to the site, despite the fact that they are in disrepair. Pumping water uphill is a modern-day departure from the Cistercian tradition of siting monasteries for utilization of gravity-fed systems. This being said, the Cistercians historically have not been afraid to dramatically alter site hydrology, having "drained and reclaimed land, built dams, dug canals, deviated flooding, moved the river course, or created whatever innovative solution was necessary to make the site habitable.[56]

Figure 23: Historic Cool Spring infrastructure

Cool Spring water not only has a daily uphill journey, but also has an impeded downhill journey. Cool Spring Stream was informally dammed in four locations a number of years ago, unbeknownst to the community, by a monk who may have been trying to create a desirable trout habitat. Materials used in the informal dam include old railroad ties, plastic buckets, a mattress box spring, and other items. (See Chapter 4 for photos and more information.) The railroad ties likely were treated with coal tar creosote as a preservative and pose a threat to water quality; coal tar creosote contains leachates such as PAH, benzene, and toluene, is a known carcinogen, and may cause numerous other ill health effects in humans and wildlife.[57] These dams exist downstream from the Cool Spring well, but water that passes through them picks up yet another contaminant that ends up in the aquatic habitat of the Shenandoah River (which supplies drinking water to the city of Berryville). Perhaps of greater concern is the neglected appearance of the spring and its stream, which functions as the heart and the lifeblood of the property and the community.

Other notable water sources and features in the landscape include nine wells (one unused), sinkholes, two constructed ponds, several cattle troughs, three intermittent drainage channels, a cistern at the Westwood House, the Shenandoah River, and the 100-year floodplain.

Subterranean and Overland Hydrologic Flow

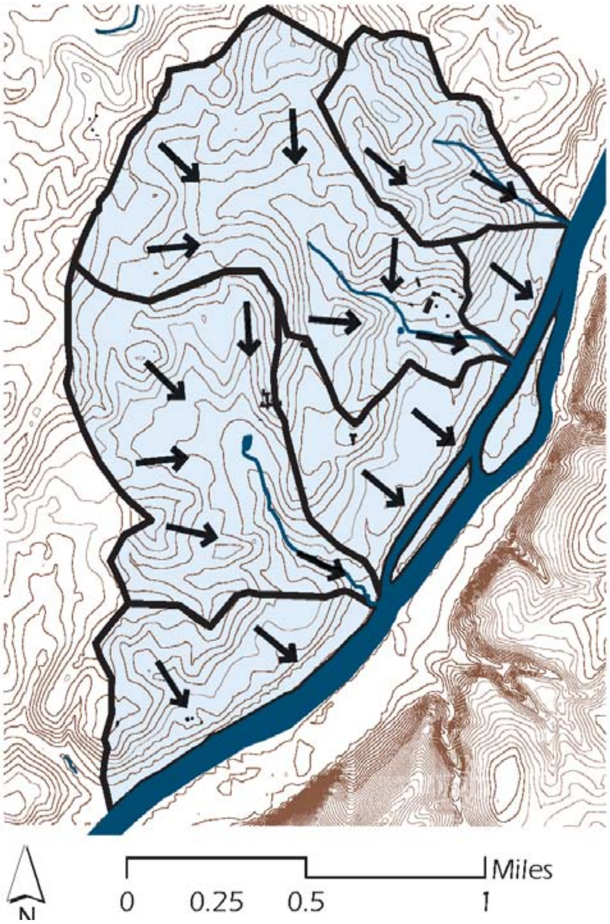
The flow map in Figure 23**: Overland Flow and Drainage Patterns**

depicts the movement of water over land. An understanding of where a raindrop travels after it hits the ground can yield much important information about the land use-related baggage it may be carrying when it enters groundwater or surface-water bodies. The six sub-watersheds shown in the map are smaller, distinct catchment areas within the HCA property boundary, delineated from 10-foot contour data provided by Clarke County. Data for subterranean flow mapped by the US Geological Survey (USGS), which describes water movements through the unique carbonate aquifer at HCA, was not available at the time of this study (but may soon be available).

Infiltration and Recharge

The Clean Water Act of 1972 focuses primarily on

Figure 22: Overland Flow and Drainage Patterns

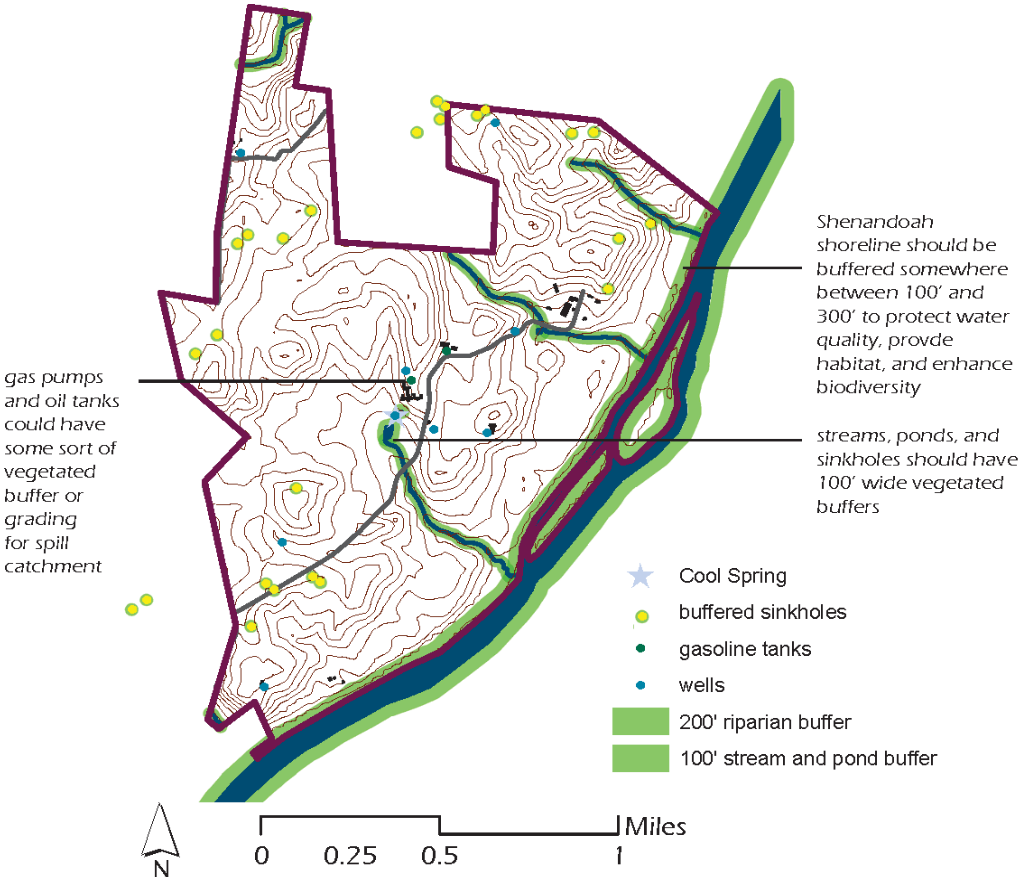


Source: Clarke County, VA NRCS, USFWS

curbing point-source pollution, such as pollution discharged directly by industry. More recently, legislation has begun to address the enormous problem of nonpoint source pollution, which occurs when contaminated storm water runoff from urban areas, roads, faulty septic systems, and farms is discharged into surface waters. Storm water runoff picks up contaminants as it flows across the land surface and causes pollution in rivers, lakes, and streams. In addition, at times of rapid flow, storm water erodes banks, deposits sediment, and destroys aquatic habitat.[58] On-site storm water infiltration is becoming an ever-increasing priority, and cities and home/property owners are being encouraged through tax incentives to capture and/or treat storm water where it falls through the use of green roofs, rain barrels, rain gardens, vegetated swales, cisterns, and other techniques.

HCA is not connected to a municipal drain and, being a rural site, is blessed with much permeable land surrounding their buildings. However, polluted nonpoint source storm water runoff, though not directly discharged into the Shenandoah through a pipe, is transported to the river through underground water movement which may indeed resemble a municipal drain. *See* Figure 24. Runoff at HCA during a given rain event contains agricultural toxins such as herbicides (atrazine), pesticides, bacteria and nitrates/nitrites from manure, nitrogen, and biosolids, heavy metals from biosolids, and other chemicals from lawn or farm fertilizers. Some polluted runoff at HCA slowly filters through vegetated terrain, but some of it shoots directly into the groundwater (which flows eventually into the river and

Figure 24: Water Quality Buffers



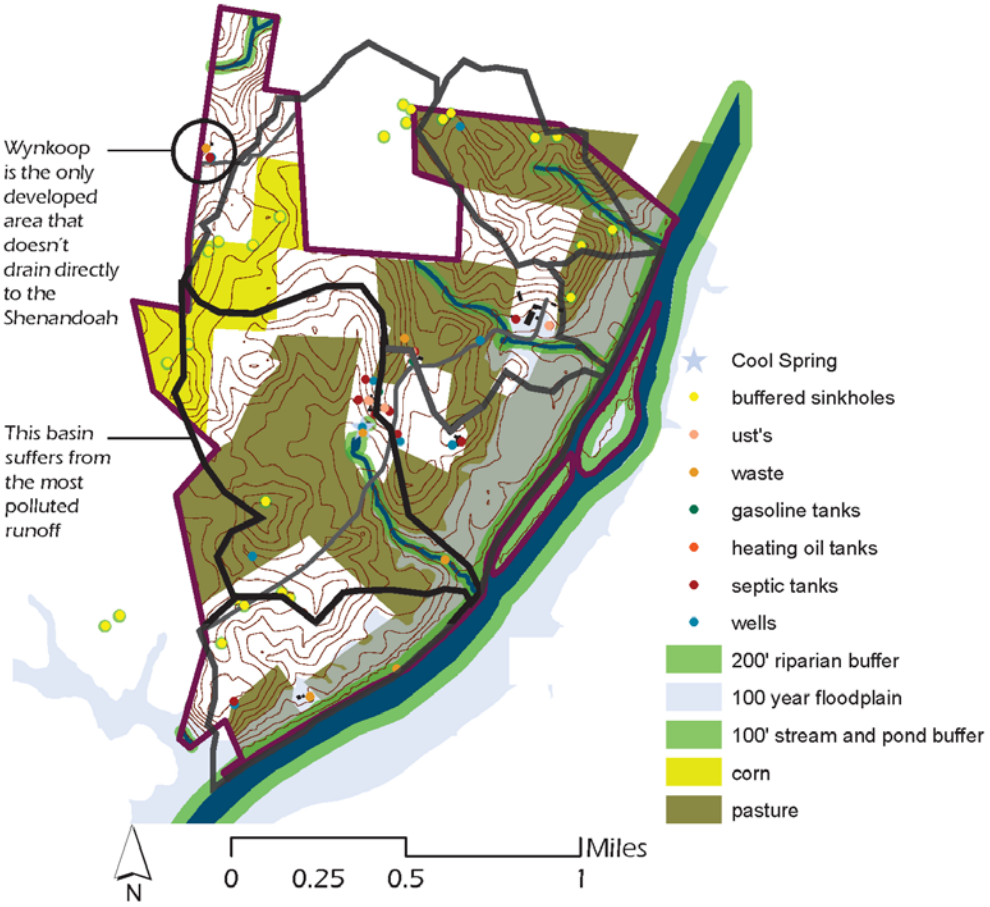
Source: Clarke County, VA NCRS, USFWS

ultimately into the Chesapeake Bay) through sinkholes. Heavy rain events also induce the more rapid discharge of septic effluent into ground and surface waters. Septic effluent is polluted with harmful bacteria and toxic cleaning chemicals and detergents.

Several storm gutters on the monastery buildings are directed immediately below ground (*see* Figure 26). Allowing the water to pass above ground and through the rhizosphere, or the root system of plants (if possible without causing ponding and icing due to heavier clay content in soils), may help filter any contaminants carried from roof shingles, roads, and other impervious areas of the property. *See* Figure 24: . Areas noted to suffer from poor drainage may benefit from enhanced infiltration through rain garden or bioswale construction.

Historically, Cistercians have been very creative and talented hydrological engineers. The photograph in Figure 26**:** depicts a storm water delivery system constructed into a monastery in Europe. Twenty-first century water quality issues could potentially inspire a renaissance of artful, functional storm water treatment systems at Cistercian monasteries around the world.

Figure 25: Non-Point Source Pollution



Source: Clarke County, VA NCRS, USFWS

Figure 28: A historic Cistercian approach to drainage at Fontfroide Abbey in Franc (it would be better if these gutters emptied into a vegetated area)

Source: Kinder, *Cistercian Europe*

Figure 26: A storm drain directed immediately underground at the monastery

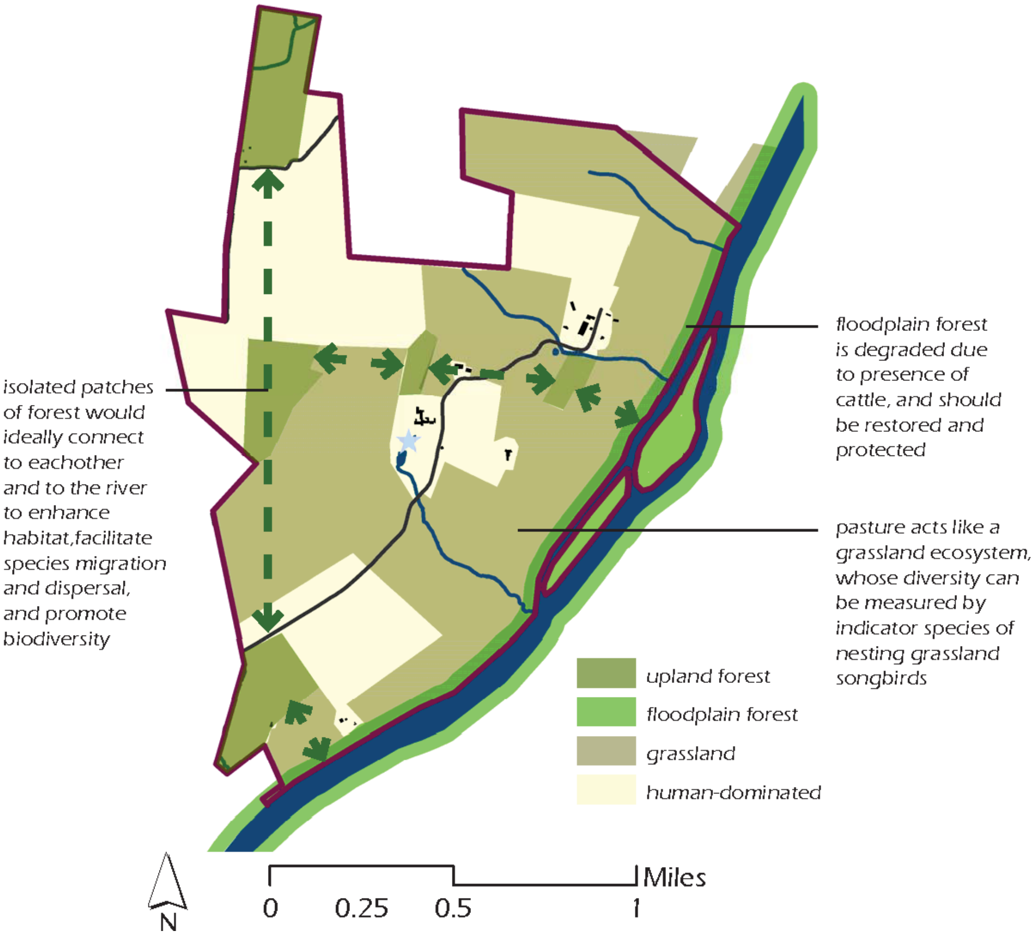
Figure 27: An unnecessary storm drain at HCA

Flora

"Plants are not optional."[59] Plants are the only organism on Earth that can capture energy from the sun through photosynthesis and, therefore, "feed the rest of us." Botanical biodiversity is threatened today by the invasion of nonnative species, the use of popular exotic cultivars in landscaping, and monoculturalism in both agriculture and in the planting of our favorite groundcover—turf grass. As one might imagine, poor plant diversity results in poor insect and animal diversity, and, overall, creates a dysfunctional ecosystem that acts as a *sink* rather than as a sustainable *source* of life.[60] As more source ecosystems are converted to sinks, rates of speciation and immigration are decreasing and rates of extinction and emigration are rising. Losses in plant biomass (quantity), health (quality), and diversity (sustainability) also result in the loss of ecosystem services, such as breathable air, clean water, carbon sequestration, soil preservation, food, timber, fiber production, and more. It has been estimated that over 70% of the forests along the eastern seaboard of the U. S. have been cleared.[61] Similarly, 87% of the once forested landscape at HCA has been developed.

Plant communities at HCA exist in several different types of ecosystems, as noted on the map in Figure 29. Along the river, there exists a degraded floodplain forest ecosystem, and upland, there remain several patches of remnant forest. These ecosystems as well as the landscape surrounding all of the built structures at HCA belong to one larger system that will be referred to as an "agroecosystem," after the dominant land use on the property.

Figure 29: Ecosystems


isolated patches of forest would ideally connect to eachother and to the river to enhance habitat,facilitate species migration and dispersal, and promote biodiversity

floodplain forest is degraded due to presence of cattle, and should be restored and protected

pasture acts like a grassland ecosystem, whose diversity can be measured by indicator species of nesting grassland songbirds

Source: Clarke County, VA NCRS, USFWS

Botanical biodiversity in natural areas can be measured by performing transect studies (i.e., by identifying rare indicator species through botanical survey). It was not within the scope of this project to undertake such an assessment. We offer our initial observations about biodiversity at HCA only to provide insight into basic levels of ecosystem integrity and to identify cultural values associated with vegetation at HCA.

Floodplain Forest

Healthy riparian ecosystems typically host a richly diverse and uniquely adapted population of plants. These plants, whether they belong to a wet prairie or to a floodplain forest, have evolved along a gradient of elevations to tolerate annual fluctuations of inundation, oxygen, nutrients, and light.[62] Some of this vegetation can act as habitat for both terrestrial wildlife and, when the system is inundated by floodwaters, as excellent breeding grounds for fish. Vegetation serves the critical functions of filtration and phytoremediation of the excess nutrients, pollution, and sediments that travel in overland flow. Vegetation also can prevent much of this contamination from entering rivers and streams. Furthermore, the roots of grasses, forbs, shrubs, and trees help hold the riverbank together, preventing unnecessary erosion and destruction of habitat. Floodplain ecosystems serve the important function of sediment and nutrient trapping during flood events, which themselves are "postulated to enhance biological productivity and diversity in the system."[63]

Though natural ecological processes (such as fire and flooding) have been suppressed by humans who naturally fear their destructive consequences, it is important for the integrity of these ecosystems to enable these processes as much as possible. Since most of the floodplain at HCA is pastured, there are no obstacles to floodwater inundation. Of concern, however, are contaminants that floodwaters may collect and disperse, such as agricultural toxins, harmful bacteria and nitrates from manure, and heavy metals (such as lead) that likely exist in two of the structures that may exist in the 100-year floodplain: the Westwood House and the Waterloo ruins.

Figure 30: Waterloo ruins in the 100-year floodplain pose a contamination threat

The floodplain forest at HCA is visible from a distance by the hauntingly beautiful white trunks of the many mature sycamores that follow the shoreline of the Shenandoah. The forest along the Shenandoah averages roughly 100’ along most of the length of the property and also exists on the islands in the river. However, research has shown that floodplain forest width is only one factor of a functional riparian buffer; microtopography (small variations in elevation that create unique microclimates for a greater diversity of vegetation) and physical heterogeneity may prove to be more important.”[64]

The floodplain forest at HCA is unable to act as a functional riparian buffer because it is permeated by cattle that have been grazing along all stream and riverbanks on the property for at least the last 30 years (*see* Figure 32). These cattle excrete manure directly into the river, graze on emergent vegetation, and trample, compact, and erode the riverbank.

Figure 32: Floodplain forest at HCA

Figure 31: Evidence of cattle grazing and erosion

Livestock grazing affects riparian vegetation by "reducing reproductive output of mature plants and by increasing mortality of seedlings and saplings."[65] This results in the alteration of species composition and diversity as well as the reduction of woody species. Excluding livestock in riparian areas and revegetating the streambank with fascines or other bank restoration methods can help improve the diversity, integrity, and functionality of a floodplain forest.

Remnant Forest

We have reduced the enormous land mass that, over millions of years, created the rich biodiversity we can still see today in this country on tiny habitat islands.

Tallamy, *Bringing Nature Home*[66]

Remnant patches of forest on HCA property indeed appear like small islands in a predominantly agricultural landscape. *Patch* is the term used by ecologists to describe fragments of habitat that once formed the ecological "matrix" or predominant fabric of land cover. [67] Patches can be reconnected by linear habitat "corridors" or greenways, which aid in species dispersal, migration, and survival. Patch diversity directly corresponds to patch size.

Existing forest remnants at HCA, such as the one near the main entrance, were noted to contain a number of (non-old-growth) native woody species including white oak, black walnut, sassafrass, black cherry, grape, and other species. However, small patches often suffer from inundation with invasive species due to their higher proportion of edge habitat to core habitat. Though edge habitats tend to harbor more biological diversity since they provide a kind of compromised living situation for species from two different ecosystems, they are also most appealing to opportunistic, invasive species.[68] This is often due to the fact that an edge (such as that between a forest and an agricultural field) has been created through human disturbance. Where soil has been disturbed, invasive plants (so named due to their ability to outcompete other species for habitat, water, light, and nutrients) are typically the first to move in.

Figure 33: A blend of native woody species at the forest patch near the main entrance, including white oak and dogwood

Thus, in the patch of forest near the main entrance at HCA, a number of invasive species including garlic mustard (*Alliaria petiolata*), tree of heaven (*Ailanthus altissima*), and multiflora rose (*Rosa multiflora*) were noted in fairly significant numbers, both on the edges and in the interior. A botanical survey would be necessary to more fully assess the ecological integrity of the remaining forest patches at HCA. For more information on rare and endangered native plants to Virginia, look on the Department of Conservation's website (http://www.dcr.virginia.gov/).

The importance of the smallest vegetated patches cannot be underestimated. The smallest patch, even a patch as minute as a planter in a parking lot, can function as an ecological stepping stone for a handful of plant and insect species and provide the ecosystem services of cleaner air and water and erosion control. We offer suggestions for enhancing patch connectivity to facilitate species dispersal, migration, and biodiversity[69] in the Options section of this chapter.

Invasive Species

The rampant transport of species through human agency in recent times is unlike any mass migration that has every occurred in nature since terrestrial life evolved.

Clewell and Aronson[70]

Invasive plants, many of which have been introduced through nursery trade, compete with, displace, and harm biotic communities. According to the authors of the Sustainable Sites Initiative, at least 5,000 plant species have escaped into natural ecosystems, resulting in millions of dollars in control costs.[71] A multitude of negative environmental effects are associated with the spread of native plants as they "competitively exclude, and hybridize with native vegetation, alter the frequency of wildfires and the availability of surface or ground water, decrease the diversity of soil biota, deplete soil nutrients, degrade aquatic habitats through soil erosion, increase the competitive pressure on endangered plant species, and degrade wildlife forage."[72] In turn, each of these consequences has a long list of cascading economic, social, and environmental consequences.

Because invasive plants are inedible to native insects, none of their photosynthetic work is shared with the rest of us. Insects are forced to travel elsewhere—to source ecosystems—to feed. As more and more soil is disturbed through development and agriculture, more and more source ecosystems are converted to sinks. Sooner or later there will be no "elsewhere" to travel to, unless we accommodate native plants in our own backyards, on our farms, and in our cities.

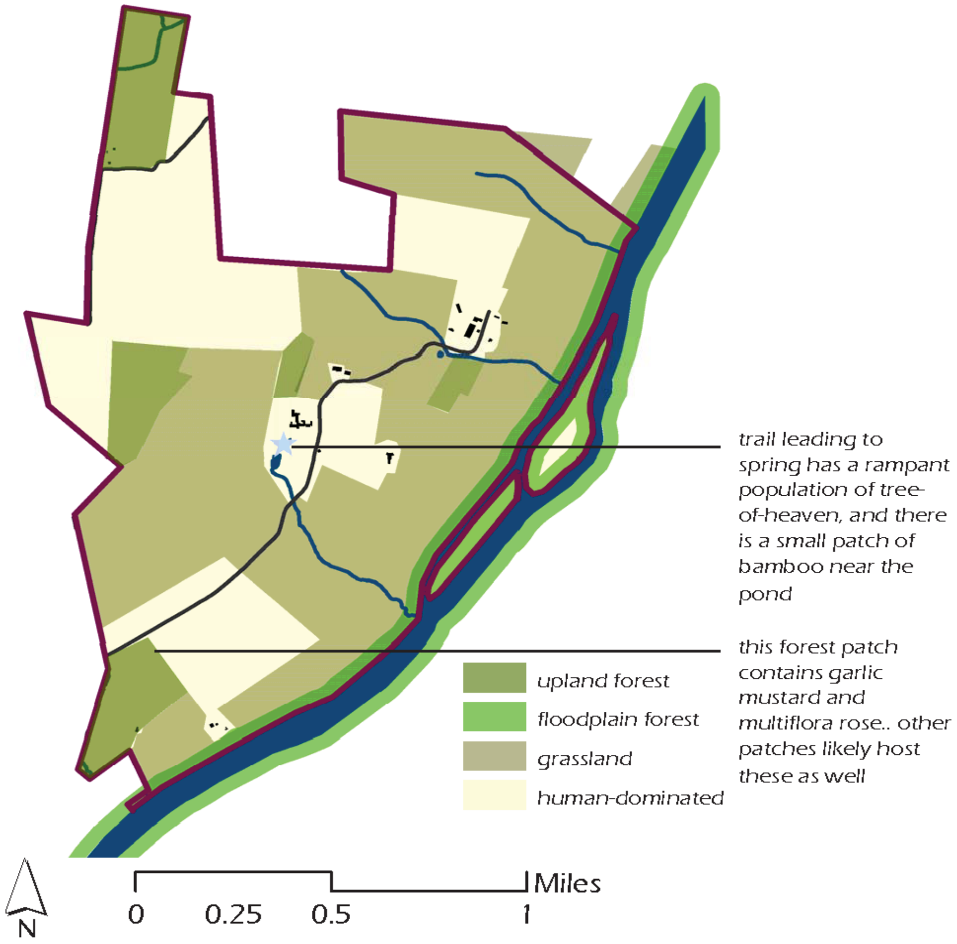
It is important to understand that any plant has the potential to become invasive under the right climatic conditions. Therefore, the scientific community considers it unsafe to take risks when it comes to choosing exotic cultivars for our gardens. Invasive plants noted to exist at HCA include:

- Garlic mustard (*Alliaria petiolata*)
- Tree of heaven (*Ailanthus altissima*)
- Multiflora rose (*Rosa multiflora*)
- Bamboo (*Phyllostachys spp*.)
- Japanese Honeysuckle (*Lonicera japonica*)
- Teasel (*Dipsacus spp.)*
- Siberian Elm (*Ulmus pumila*)
- Mile-a-Minute Weed (*Polygonum perfoliatum)*

Some locations where these species were identified are shown on the map in Figure 34. Photographs of some of these species are shown in Figure 35. Most likely, there are others as well. For a full list of invasive plants known to exist in Virginia, *see* Appendix 1-B.

Removal and control of invasive plants can be disruptive, cause unwanted erosion (especially if on a stream bank), and introduce herbicides into soil and groundwater. Some invasive species in forest or prairie ecosystems can be controlled by regular, prescribed burning, which is often considered the most preferable management technique, if feasible. Management of invasive species must include continual monitoring and control in order to validate removal efforts.

Figure 34: Invasive Species



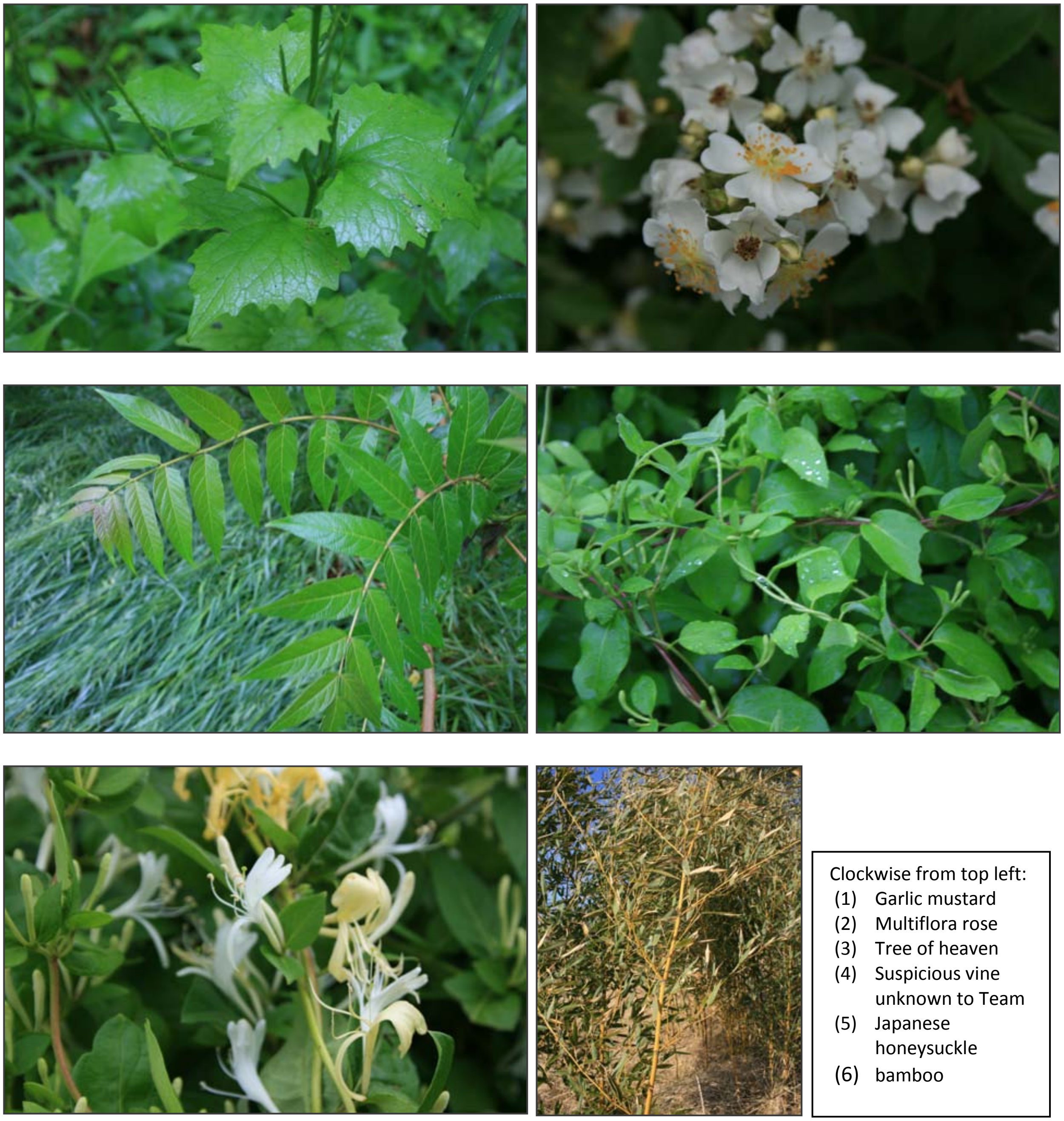
Ource: Clarke County, VA NCRS, USFWSA

Often, the control of invasive species requires a tandem effort to reintroduce native plants. Natives, which have adapted to local climate and site conditions, typically require fewer resources and less maintenance, provide food for insects (including important pollinators) and higher trophic levels, provide excellent storm water uptake and remediation through dense, fibrous root systems, and offer a sense of regional beauty. In the face of global climate change and as our typical USDA planting zones shift northwards, it is advisable to choose species with "phenotypic plasticity" that have a foot in both current and future zones.[73]

Gardens and Grounds

When planting a garden or designing a landscape, it is important to consider a plant for its beauty, its cultural value, and its ecological functions. In general, exotic cultivars (generally characteristic of a rural Virginia estate) are present but do not outnumber the native species gracing the grounds at HCA. Overall, many areas of the HCA have been tended to or cultivated by monks over the years, such as a spring ephemeral bulb "garden" in the woods behind the hermitage, an alleé of trees along the driveway, a pinewood plantation, and more, and there are several specific garden areas worth describing in detail.

Figure 35: Photographs of invasive species



Clockwise from top left:
(1) Garlic mustard
(2) Multiflora rose
(3) Tree of heaven
(4) Suspicious vine unknown to Team
(5) Japanese honeysuckle
(6) bamboo

The following are among the nonnative woody species that are present at the property:

- Japanese maple
- Boxwood
- Smoke tree
- Japanese yew
- Weeping cherry
- Siberian elm
- Ginkgo

The cultural importance of exotic woody and herbaceous plants on the grounds should be weighed against their ability or inability to serve the ecosystem. Woody natives planted (or preserved) on the grounds include:

- Silver maple (*Acer saccharinum)*
- White oak (*Quercus alba)*
- Black oak (*Quercus velutina)*
- Bur oak (*Quercus macrocarpa)*
- Eastern red cedar (*Juniperus virginiana)*
- Arborvitae (*Thuja occidentalis)*
- Dogwood (*Cornus spp.)*
- Sycamore (*Platanus occidentalis)*
- Tulip tree (*Liriodendron tulipifera)*
- Black walnut (*Juglans nigra)*
- Hawthorn (*Crataegus spp.)*
- Colorado blue spruce (*Picea pungens)*
- Cherry *(Prunus spp.)*
- Black locust (*Robinia pseudoacacia)*
- Flowering dogwood (*Cornus florida)*
- Sweet gum (*Liquidambar styraciflua)*

Butterfly Garden

This garden, located on the northern edge of the monastic enclosure, was gifted to the monastery by Virginia Marie Peterson in 1994. Designed with plants whose nectar is attractive to specific butterflies, this type of garden exhibits not only a beautiful array of flowering woody and herbaceous perennials, but also exemplifies a sense of care for nonhuman forms of life and sensitivity to the notion that we can play a positive role in our own immediate ecosystems (instead of a negative or even just a neutral role). Species present in May 2009 included mostly native plants with the exception of the butterfly bush and some of the lilies.

Figure 36: Flowering dogwood on monastery grounds in May

Figure 37: The butterfly garden in May

Cloister Garden

Historically, a covered well or running fountain at the center of a Cistercian cloister garden was typically conceived of as the "heart of the monastery."[74] Four-sided enclosed cloisters, or *claustrum*, were very common not only to the Cistercian order but to "all European religious orders," and were seen as "the single most inventive and enduring achievement of monastic building."[75] As noted in one resource that describes historic Cistercian structures:

> Cut off from the outside world both physically and spiritually, the central open court or garth served as a haven of tranquillity at the heart of the abbey complex. On all four sides were passages, usually covered with lean-to roofs, known as cloister walks, galleries, or alleys. Fronted by handsome rhythmic arcades of a generally uniform character, these walks served the practical function of linking church to chapterhouse, chapter-house to refectory, and so on. Moreover, they provided an ideal backdrop for processions and other ritual events.[76]

The historic Cistercian cloister was the site for rituals such as the Sunday rite of *benediction aquae*, in which the cloister and monastic buildings were blessed with holy water and salt, and *mandatum*, the weekly washing of brethrens' feet. It was also used for daily activities, such as reading (*lectio divina*), writing, washing, and shaving. Each side of the medieval cloister, according to Cistercian architectural historian Terryl Kinder, had an association with the mind, the body, or the spirit (*see*). Furthermore, it has been stated that "it is not unusual to find the courtyard and its central garden associated with the heavenly paradise."[77]

Only one of the monks who completed a community map-survey indicated the desire for a more traditional cloister garden. None of the surveys reported that anyone used the existing cloister garden for any of the purposes mentioned above or otherwise. Perhaps the lack of complete enclosure and the absence of a revered and/or functional water feature have prevented this space from acting as the central area of Holy Cross Abbey.

Figure 38: Fountain House, Poblet Monastery, Spain

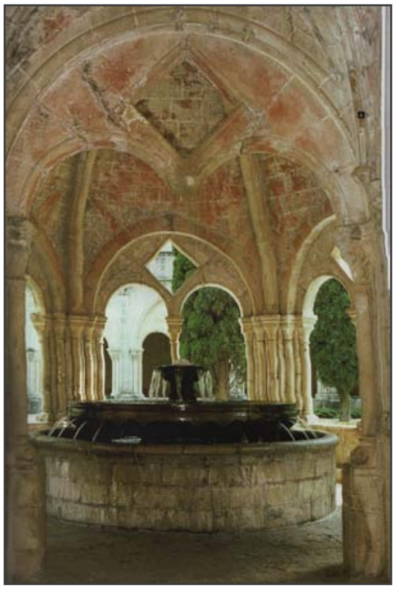
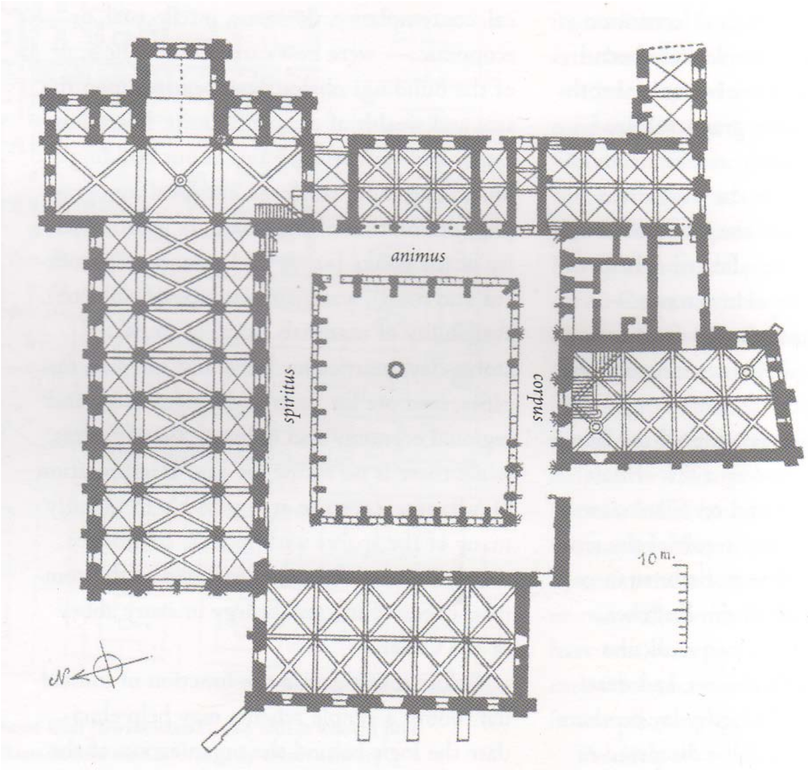


Figure 39: Cloister plan, Noirlac Monastery, France



Kinder, *Cistercian Europe*

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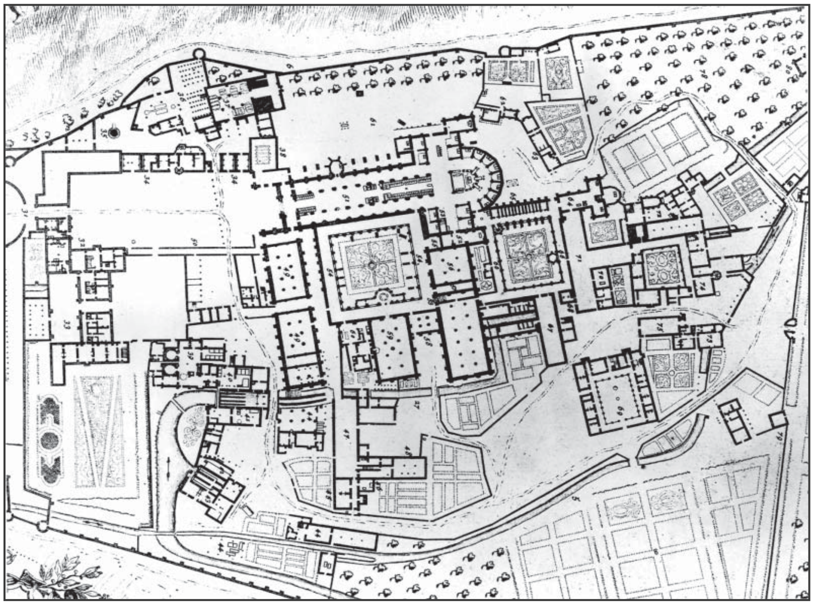
Figure 40: Many beautiful roses give the grounds a classic feel

Vegetable Garden and Old Orchard

Historically, Cistercians have exercised their self-sufficiency through diverse agricultural, silvicultural, aquacultural, and horticultural practices. The layout plan of the historic St. Gall monastery depicts a layout of this extensive productivity.

Figure 41: St. Gall grounds plan[78]



The monks at HCA downsized their food production efforts considerably in the 1980s, shifting from agricultural production to seasonal vegetable gardening. The old apple orchard west of the monastery buildings and south of the hermitage has suffered in health, productivity, and accessibility from years without pruning (Figure 42:). One of the most recent sites of a former vegetable garden at HCA is in the footprint of what was once a sheep barn, just north of the infirmary (Figure 42). Production ceased in that location as a result of the aging of the community and the shade of a large silver maple tree encroaching on the viability of the site. There are some espalier pear trees that remain around the perimeter. The monk who currently runs the gift shop also enjoys exercising his green thumb through edible container gardening (**Error! Reference source not found.**). Currently, there is some speculation regarding the best new site for a small vegetable garden.

Figure 43: The old orchard

Figure 42: Former vegetable garden

Lawn

Second only to paving in its impact on biodiversity is our love affair with sterile lawns […] If you are concerned about the human impact of climate change, reducing the amount of lawn you mow each week is one of the best things you can do to reduce your carbon dioxide emissions.

Tallamy, *Bringing Nature Home*[79]

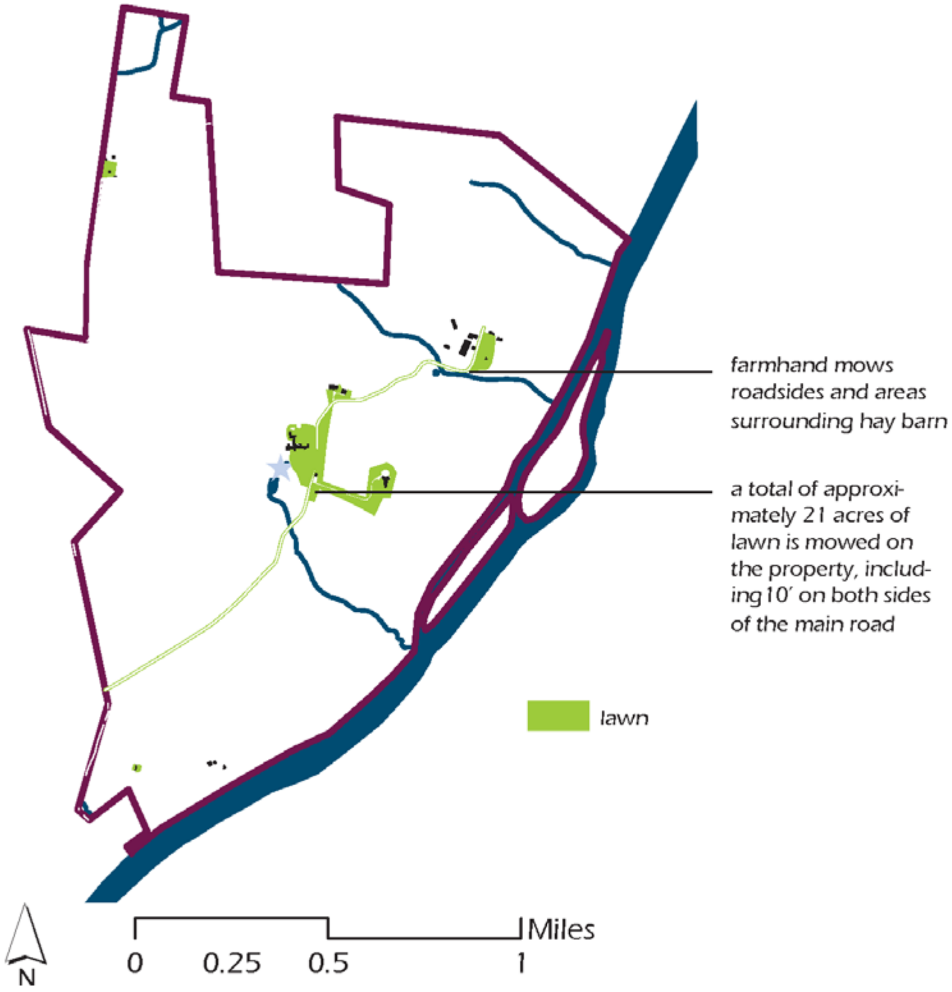
HCA currently mows roughly 21 acres of lawn on a regular basis (Figure 44). Monocultural lawns, which are comprised of a short list of turf grass species, consume and in a sense sterilize millions of acres of landscape in the US. While there is no replacement for all of the wonderful characteristics of a lawn that have granted them such beloved status, limiting turf to only those landscapes where it is truly called for, used, and appreciated is a key component of land use sustainability. One alternative to a traditional lawn is the "eco-lawn," which is seeded from grass mixes containing species which do not require mowing, fertilizer, or herbicide input. A native wildflower meadow also can make a beautiful lawn alternative that is supportive of backyard biodiversity (despite the fact that Virginia is not known for its prairies).

Figure 44: A vast expanse of lawn near the Retreat House

Figure 45: Lawn mowed over a new sinkhole near the Retreat House

Figure 46: A farmhand mows the edges of the road to the hay barn

Figure 47: Mowed Lawn



Source: Clarke County, VA NRCS, USFWS

Agricultural Biodiversity

Though an agroecosystem is typically composed of animals and food crop species that are mostly nonnative, it can still strive to be diverse and to mimic natural processes. We still have a lot to learn about "farming with the wild," but we know that creating farms that function as natural habitats "will require greater emphasis on diversification and resilience and less emphasis on simplification and short term fixes."[80] This can be achieved by:

- Diversifying crops and livestock
- Incorporating native plants into the landscape to serve as hosts for an array of organisms that offer pollination as well as natural pest control
- Restoring low areas to wetland habitats
- Leaving certain areas of pasture ungrazed and/or delaying hay harvest during the nesting season of grassland songbirds
- Protecting and enhancing remnant wood lots and hedgerows
- Cover-cropping, intercropping, and specialty cropping

- Practicing crop rotation
- Cultivating perennial polycultures as opposed to annual monocultures
- Introducing intensive rotational grazing, which mimics grazing patterns of migrating buffalo herds.[81]

Implementing the aforementioned actions can enhance the integrity of an agroecosystem, but avoiding other practices can advance the same goals. At HCA, one practice that should be avoided is the use of Bt corn, which was grown at HCA during the 2009 growing season. Bt corn is a genetically modified substance that has been engineered to contain Bt (the gene of the bacterium *Bacillus thurengiensis)* so that it contains a protein that kills certain corn pest larvae.[82] Bt corn not only harms corn pests, however; it also can harm native insects, including butterfly caterpillars, that may be feeding on native plants in areas near the crop where toxic pollen has drifted.

In addition to harming native insects, genetically modified organisms (GMOs) pose a threat to biodiversity. Once the GMOs are released into the gene pool, humans have little control over their tendency to outcompete and displace other organisms.[83] The benefits of biodiversity in agriculture have been laid out in a report by a task force of the Council for Agriculture Science and Technology (CAST), co-chaired by ecologist G. David Tilman and geneticist Donald N. Duvick, and may be consulted for further reading.[84]

Figure 48: Genetically modified corn grown at HCA in 2009

Holistic management, a process developed by Alan Savory in 1984, provides a conceptual framework and incentives for farmers and farm managers to make environmentally sound decisions that favor greater plant and animal diversity. This process (1) encourages farmers to develop a long-term vision for the landscape; (2) teaches recognition of ecosystem processes that healthy, sustainable farming systems depend upon, including the water cycle, the mineral cycle, plant succession, and energy flow; (3) places a high value on biological diversity both in crop systems and in areas on the land not used for farming; and (4) encourages practitioners to consider the effect of any proposed action or choice of enterprise upon the quality of life for the community as well as for themselves.[85]

Fauna

Wildlife habitat can be described as a place where an organism feeds, rests, and breeds. As mentioned earlier, the number of species present on a site directly corresponds to how much land has been disturbed or is dominated by humans. At HCA, 87% of the landscape is human-dominated, which means that there are about 87% fewer species at that location than there were before the land was settled. Riparian ecosystems are typically home to an incredible diversity of flora and fauna. Studies have reported that vertebrate animal species using riparian zones during their life stages were about 70% of all vertebrate species in the district.[86] The fact that most of the 100-year floodplain is used as pasture therefore plays a large role in the diminished biodiversity present on HCA property. Fencing the floodplain from cattle and improving connectivity between forest patches, widened hedgerow corridors, and the river will improve wildlife habitat and migration.

It was beyond the scope of this project to make a rigorous assessment of wildlife biodiversity on the property. Through observation, interviews, and community survey results, Table 1 represents species, noted by common name, that have been sited at unknown dates. The location at HCA where the species have been sited are shown on the map in Figure 56.

Table 1: Fauna observed at HCA

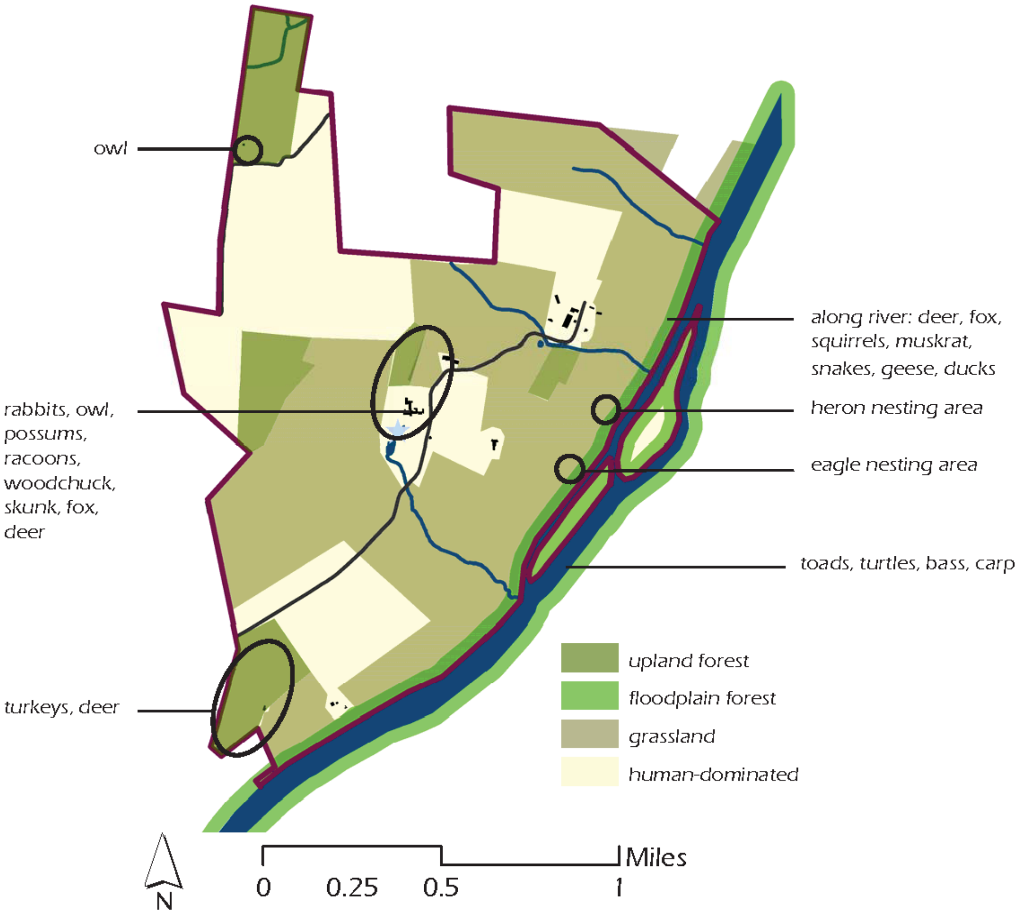
	Mammals	
white-tailed deer	woodchuck	mole
red fox	opossum	chipmunks
rabbit	skunk	black bear (rare)
squirrel	muskrat	
	Birds	
meadowlark	bluebird	crane
warbler	seagull	whippoorwill
cardinal	pigeon	duck
bluejay	robin	Canadian goose
downy woodpecker	mockingbird	Carolina wren
flicker	brown thrasher	bluebird
red-headed woodpecker	hummingbirds	heron
yellow-bellied	thrush	wild turkey
woodpecker	robin	pheasant
pileated woodpecker	swallow	bald eagle
sparrow	turkey vulture	barn owl
mourning dove	killdeer	bobwhite kestrels
phoebe	red-winged blackbird	hawks
starling	goldfinch	
	Fish	
	carp	
	bass	
	Reptiles and Amphibians	
	toads	
	turtles	
	black snakes	
	garter snakes	

At least one state-listed threatened species, the bald eagle, inhabits the HCA property. Bald eagles are reported to nest at a known location along the river near Retreat House. For a list of state and federal threatened and endangered species, visit the Virginia Department of Game and Inland Fisheries website (http://www.dgif.virginia.gov/).

Often, rare and endangered plant and animal species are considered to be "indicator species," signaling high-quality habitat whose preservation should be a high priority.[87] Animals that may be used as indicators for diversity in agroecosystems like those that function at HCA might include grassland songbirds such as the bobolink, the eastern meadowlark, and the dickcissel. Ecological and cultural harmony can exist if agricultural activity is conducted in a way that does not disturb the nesting of these birds in pasture and croplands, but rather is respectful and timed accordingly, through delaying or alternating years of cutting hay. Additionally, daily or regular monitoring for indicator species could be incorporated into an overall landscape agenda for HCA.

Ecologists used to prioritize the preservation of a "keystone" species. Keystone species are organisms without which an entire ecosystem might collapse. The presence of these species, as opposed to that of so-called "redundant" species, was viewed to have a large effect on an ecosystem relative to its abundance within that system. Typically, these organisms act to control potential dominant species, provide critical resources, act as mutualists, and modify the environment.[88] In North America, the grizzly bear and the beaver are considered keystone species, worthy of targeted restoration effort. However, ecologists are coming to a new consensus that "the keystone status of a species is entirely context dependent,"[89] meaning that in the face of climate change, for example, one should not put all of their eggs in one basket when it comes to preservation, but rather cast the net widely, considering the notion that *all* organisms in an ecosystem could play a critical function in its sustainability.

Figure 49: Known habitat



Source: Clarke County, VA NCRS, USFWS

Figure 51: A garter snake sunning itself outside the monastery

Figure 50: A red fox traversing a pasture near the Shenandoah River

Black Angus

The predominant megafauna at HCA are, by far, Black Angus cattle. The farm tenant currently manages a cow-calf operation with approximately 600 head of cattle. The cattle are grazed on long rotations in the warm season and corralled in a feed lot during the winter. While corralled in the feed lot, they eat a combination of hay and semi-fermented corn plant/kernel from a trench silo. Since much of the pasture at HCA borders two streams and the Shenandoah, most of the cattle drink directly from these surface-water bodies. Otherwise, there are several troughs containing water pumped from nearby sources. The beef that feed on the Virginia grass does not remain in the local food shed. Instead, when the cattle are four years old, they are sent to an Amish feedlot in Pennsylvania, where they are fattened prior to slaughter and distribution. While the meat remains in the national market, the hides are sent to Japan.

The farm tenant practices rotational grazing, though not at such a pace that its beneficial effects can be realized. By contrast, at a nearby farm in Swoope Virginia, farmer Joel Salatin practices what he calls "grass farming." Salatin realized that pasture grown as a perennial prairie polyculture is the most ecologically and agriculturally sound method available, and greatly benefits his family, the cows, the consumers, and the environment by using this method.[90]

The affect that cattle have on landscape pattern and process is profound and far-reaching. Many conservationists today promote vegetarianism, having concluded that beef production is highly resource consumptive, waste productive, and environmentally degrading relative to its nutritional value/necessity for the large human population that exists today. Grazing inhibits forest regeneration, compacts the soil, and erodes stream banks, causing the loss of organic topsoil

Figure 53: A cow in Cool Spring Stream

Figure 52: Grazing at Polyface Farms, Swoope, VA

and disruptive sedimentation in aquatic habitats.[91] Cow manure contributes to excess nitrogen in the soil, which can pollute drinking/groundwater as well as surface waters and contribute to hypoxia in the Chespeake Bay. Cattle in the landscape can disrupt native wildlife by disturbing their habitat and by dominating consumption of forage, especially when pastures are overgrazed.[92] Cattle that are fed corn inherit the poor ecological footprint that modern maize production generates through its excessive inputs of petroleum-based fertilizers and toxic pesticides and herbicides, among other things.[93]

In America, the cow is not necessarily considered sacred, but the hamburger (to the non-Cistercian, nonvegetarian population) is. This is not to say that there is no place for beef production in North American culture, or that there are no methods of husbandry that are more ecologically sound. The Salatin family, mentioned above, has been perfecting the art of management-intensive rotational grazing, which mimics native buffalo grazing patterns and aims to resonate with the animals' core instincts and needs as well as the natural flow of the ecosystem processes. The following quote from their farm's Web site illustrates their approach to grazing:

> Herbivores in nature exhibit three characteristics: mobbing for predator protection, movement daily onto fresh forage and away from yesterday's droppings, and a diet consisting of forage only—no dead animals, no chicken manure, no grain, and no fermented forage. Our goal is to approximate this template as closely as possible. Our cows eat forage only, a new pasture paddock roughly every day, and stay herded tightly with portable electric fencing. This natural model heals the land, thickens the forage, reduces weeds, stimulates earthworms, reduces pathogens, and increases nutritional qualities in the meat.[94]

Furthermore, research has shown that limited riparian grazing (meaning for two days twice a year) can actually benefit riparian ecosystems by creating a gentler slope of the stream bank and by adding an appropriately sized dose of nutrients to the soil.[95]

Human Presence in the Landscape

The last building block of the landscape (or three landscapes) at HCA is humans. Everyone at HCA—the monks, Retreat House guests, employees, Lay Cistercians, farm tenant and farmhands, and visitors—plays a part in how this ecosystem functions. One might view the whole of the property at HCA as a *Cistercian ecosystem*, which would take into account how Trappist spirituality, religious culture, horarium, business practice, work ethic, land ethic, hospitality, isolation, self-sufficiency, community personality, and agricultural tradition are woven into every pattern and process within this piece of the Shenandoah Valley.

There is no question that HCA is a beautiful place. Currently, however, the landscape at HCA appears to be more affected by a combination of benign neglect and ecologically destructive agricultural practices than it is by direct, intentional stewardship. This reality is likely due to the age of the population. The elderly monks are stretched thin by the demands of managing even basic daily responsibilities. During both Team visits, in March and in May, it was rare to *see* any of the community members outside (though perhaps they were kindly trying stay out of our way!). It *see*ms unlikely that the following quote from St. Benedict's rule was the reason for this: "If it can be done, the monastery should be so situated that all the necessaries, such as water, the mill, the garden, are enclosed, and the various arts may be plied inside of the monastery, so that there may be no need for the monks to go about outside, because it is not good for their souls."[96] We ruled out through interviews with several disabled monks that there were significant obstacles to accessibility on the grounds. Still, it may be that the desire to enjoy and actively steward the land is present in their hearts, but in some ways, for many, beyond their current physical capabilities.

The results listed in this section collect simple observations that might yield insight on how the landscape and built environment at HCA reflect community culture and vice versa. "Cultural sustainability" at HCA requires that this Cistercian ecosystem truly reflects community values, and in such a way that deep care is continually and incessantly inspired by the very appearance of the landscape. Moreover, we offer the following observations to enable community members to analyze themselves. We can only guess as to how the “lay of the land” and community interaction and presence within it reflects or fails to reflect core values, principles, and commitments.

Roads, Trails, Auto/Pedestrian Traffic Patterns, and Maintenance Access

Considering the size of the property and how alluring the Shenandoah shoreline is, few trails exist at the property to facilitate unhindered exploration of the landscape. Though many in the community have expressed that they do not mind (and at times even enjoy) traversing barbed wire fences and inhabited pastures, others (including Retreat House guests) may feel unwelcome or cautious about freely roaming the grounds or walking the length of the river, perhaps in search of communion with the divine in the natural world. Another popular destination, the pond near Cool Spring, has a sloped and unmaintained two-track trail lined with invasive tree of heaven and bordered by tall grasses that likely harbor ticks during the warm season.

Figure 54: One edge of the Retreat House grounds (the river is close but visibly unapproachable)

Figure 55: Path to Cool Spring is overgrown, sloped irregularly in places, and lined with invasive trees

The entrance to the property sits at a dangerous intersection. The entrance is located along a gradient that offers a poor view of oncoming traffic travelling at varying speeds from the south. Furthermore, according to Clarke County GIS data, numerous sinkholes exist near the entrance, which, in the future, could undermine the structural stability of the road. Night visibility is also poor down Cool Spring Lane, but could be greatly improved with the installation of solar-powered driveway lamps.

Retreat House guests mainly travel between the Retreat House, the gift shop, the chapel, and occasionally the river. Friends and family of the monks typically reside at the Westwood House, which exists partially in the floodplain, near the main hay barn. The farm tenant and his farmhands regularly traverse the property both on- and off-road by pickup truck and four-wheeler. Daily rounds are made through the pastures via pickup truck to check on cattle, especially young calves in the spring that may be administered antibiotics in the case of an illness. Business deliveries are made to and from the monastic enclosure on a somewhat regular basis. The monks move throughout the grounds as necessary to follow the horarium; for solo retreats at the Bishop’s House, Wynkoop House, or the hermitage; and beyond as they please and/or are able.

There are no known inhibitions to maintenance access for wells, septic systems, or energy sources. There is a gas tank in the main parking lot of the monastic enclosure, which has on rare occasion been stolen from.

Contemplative Spaces, Gardens, and Sacred Spots

The most visible sitting area on the grounds is a large patio decked with handsome hand-crafted wooden chairs. The patio overlooks the revered cemetery, the Retreat House, and the Blue Ridge Mountains beyond, but is not used as much as it used to be because a large shade tree that used to stand next to the patio died and was cut down.

A few chairs and benches have been placed at various spots throughout the grounds in a casual manner. As mentioned above, the cloister garden at HCA is atypical for a monastery as it is three-sided and without a gathering point (such as a fountain or desks) in place for reading. The vegetable garden beds in the footprint of the former sheep barn are no longer used as they are shaded by a large silver maple tree. This area, graced with the gorgeous butterfly garden and retained by the former northern wall of the barn, has great potential for reuse as a prayer or "healing garden," or as simply a comfortably shaded patio. The monks in the infirmary, whose lives are framed by walls, have the benefit of neither a greatly pleasing view nor an adjacent medicinal herb garden, as was customary in medieval Europe. Healing gardens, which are specifically designed to ease suffering associated with illness, pain, or disability, are increasingly being constructed by hospitals and other medical facilities. A healing garden may be appropriate for the aging community at HCA.

There is a small memorial for the soldiers who died in the Battle of Cool Spring along the road to the Wynkoop House, but there is no memorial or other marker on the property where the battle actually took place.

The majestic sycamore could be described as HCA's signature tree. Many sycamores near the river, described as "witness trees" for having lived through the Civil War Battle, have large hollows in their trunks that sometimes make amenable habitat for small animals, such as fox. A grand sycamore rising up out of a rock outcrop east of the hermitage is a beloved sitting spot. Another tree has fallen alongside Cool Spring and re-sprouted from its horizontal stature. A "grandmother" sycamore tree, which is located close to the Cool Spring and whose roots are fed directly by Cool Spring water, stands along the north side of the main road at the point where water flows through a culvert beneath the road to the stream beyond. This robust and lovely tree, whose growth has many stories to tell about the history of the land, is hidden by an invasive vine that is quickly scaling its way up to the canopy.

Figure 56: Poor visibility at intersection of Cool Spring Lane and Castleman Road

Figure 57: Patio overlooking the cemetery and the mountains

Figure 58: Holy Cross Cemetery

Several other specimen trees exist on the HCA property. There is a collection of seven large, healthy oak trees across the road from the "grandmother" sycamore. Young, recently planted tulip trees line both the main road and the road to the retreat house. Overall, there is an extremely low density of trees planted on the property. Those that do exist seem to help define which spaces are held sacred and are a part of what make the property so unquestionably beautiful. The preservation and enhanced visibility of these specimen trees could become a prominent stewardship priority.

Figure 62: A newly emerged sycamore leaf

Figure 63: Two graceful oak trees in a fine morning mist rising from the river

Figure 64: A stand of seven oaks near the intersection of Cool Spring Lane and Cool Spring stream

Figure 59: Spring-fed sycamore along the main lane

Figure 60: One of many tulip trees at HCA in bloom last May

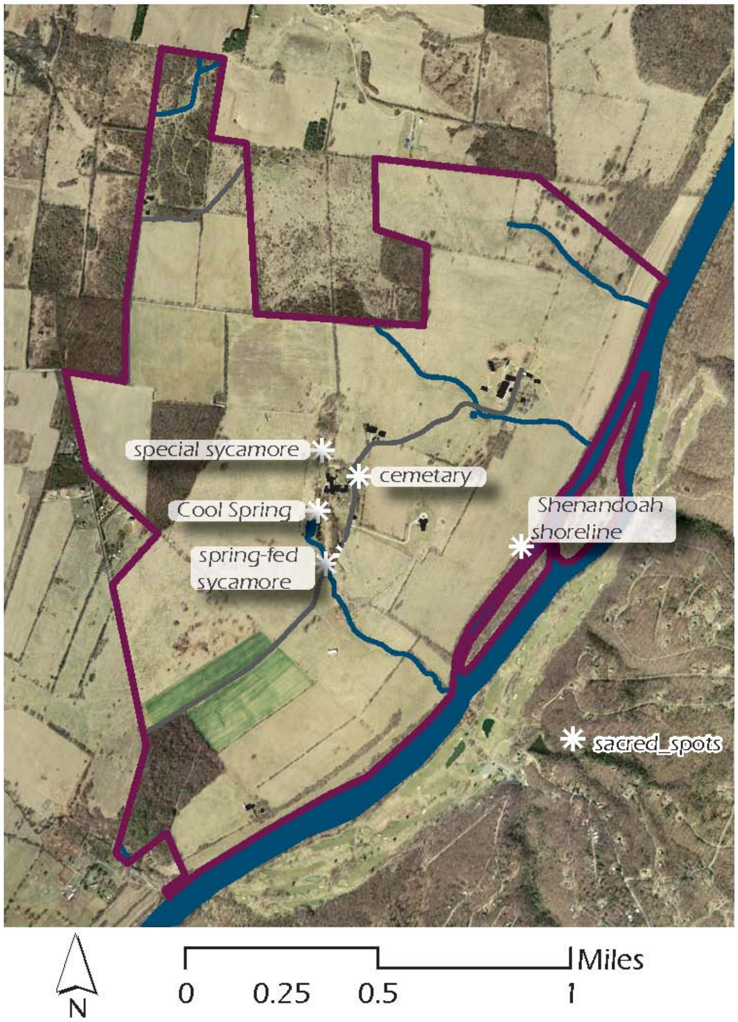
Figure 61: Sassafrass along the forest edge near the main entrance

Figure 65: Misty sunrise over the pasture

Figure 66: One of many "witness trees" along the river

Figure 67: Left, many shades of green at the river's edge. Right: Sunrise in the floodplain forest

Figure 68: Some Sacred Spots, Among Many



Source: Clarke County, VA NRCS, USFWS

Management and Maintenance

Let him take charge of everything.

Rule of Saint Benedict, Chapter 31

In the Cistercian order, the monk appointed as cellarer is responsible for all the grounds and all the maintenance on the property. Historian Terryl Kinder relates that "[the demands of the Cellarer], both moral and practical, were [are] truly formidable."[97] Though the cellarar can delegate responsibilities to a degree, he bears a privileged yet enormous burden throughout the duration of his life. This position requires technical and ecological knowledge, and demands both complex decision making and manual labor.

In the fall of 2009, HCA successfully granted a conservation easement for roughly 200 acres of its property. The conservation easement will prevent this land from being developed, regardless of transfer of property ownership.

In the past, Cistercian monks were dedicated to being self-sufficient and did not *see* k help beyond the walls of the monastic enclosure. However, today's aging communities may find that in order to adapt and sustain their order in the 21st century, reaching out to the broader community—especially for help with ecological restoration, conservation, ongoing stewardship, and monitoring—may be necessary.

OPTIONS: SUSTAINABLE LAND USE

Based on the land use analysis and research conducted on possible alternatives, we propose the following recommendations for sustainable land use at HCA:

- Remove all waste from informal dump sites located on the property, especially those located in the 100-year floodplain (*see* Chapter 4 for details).
- Restore the Shenandoah shoreline by prohibiting cattle access to this area, revegetating eroded banks, creating a riparian buffer at least 300' wide, and monitoring restoration progress.
- Restore the natural hydrology of streams by removing waste, prohibiting cattle access, revegetating eroded banks, creating a stream buffer at least 100' wide, and monitoring restoration progress.
- Construct a simple yet more formal trail along the shoreline, with access from the Bishop's House, the Retreat House, and the Westwood House.
- Construct wide vegetated buffers around sinkholes with native perennial grasses to help filter pollutants directly en route to the water table and to make them visible as a safety precaution. Treat the surrounding land as ecologically sensitive areas.
- Resurrect Cool Spring as a critically important feature of the landscape and beautify the human experience of it.
- Protect the water quality of Cool Spring by constructing a wetland upgrade where there used to be a pond and by designating surrounding land as an ecologically sensitive groundwater "recharge zone" where the use of toxics and/or septic discharge is strictly prohibited.
- Construct a more pedestrian-friendly trail that loops around Cool Spring and the adjacent pond, and pave the trail with ADA accessible paving material (such as crushed, decomposed granite).
- Divert rainwater from all buildings (especially the Retreat House) and into rain gardens (depressed gardens lined with gravel beneath a layer of topsoil to promote on-site drainage, planted with native plant species which are both drought and flood tolerant).
- Strictly prohibit the use of pesticides, herbicides, sewage sludge, excess artificial fertilizer, and excess manure in current and future farm leases—nitrogen applied in the form of fertilizer or manure shouldn't exceed VA Cooperative Extension Service recommendations based on annual soil tests.
- Limit the use of vehicular or ATV traffic in the 100-year floodplain to prevent compaction on soil whose function of infiltrating floodwaters is ecologically significant.

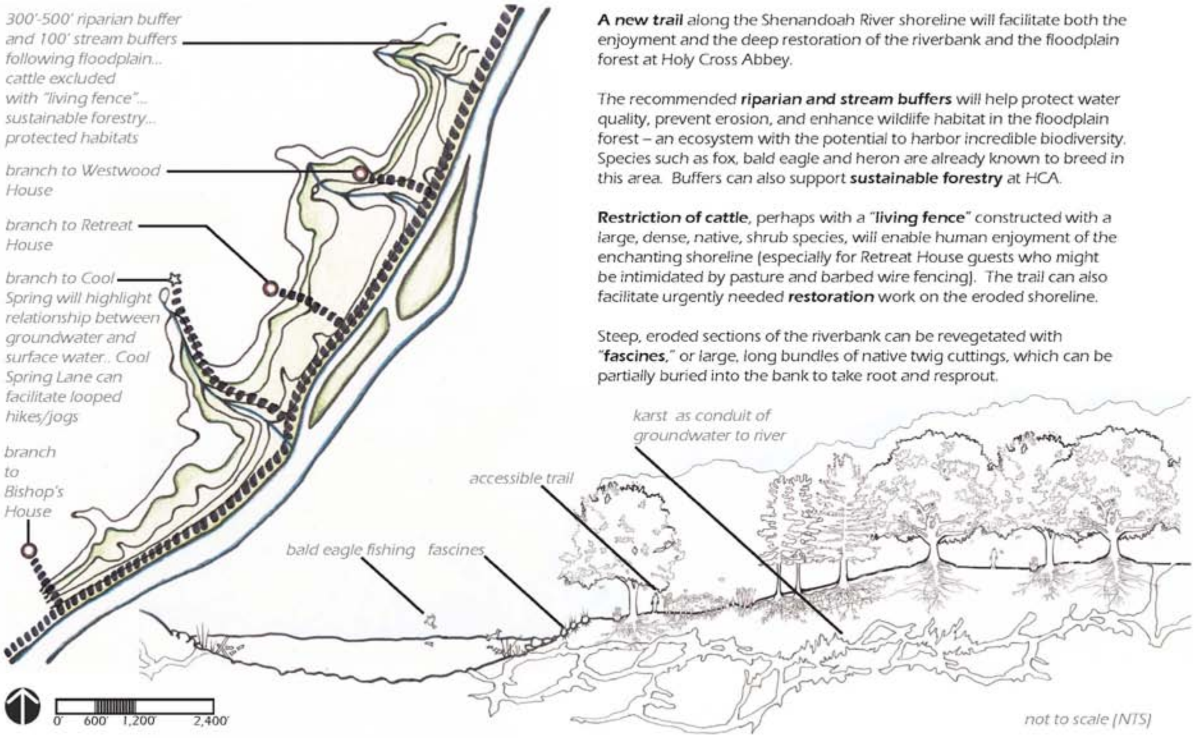
- Require current/future farm tenant to practice organic food production methods, which also strive to protect and enhance biodiversity and water quality through the use of best management practices.
- When the lease with the current farm tenant expires, consider providing a rare and valuable vocational opportunity for innovative and ecologically conscious young farmers by offering prospective tenants an affordable (yet fairly priced) lease.
- Create a new vegetable garden maintained by organic agricultural methods that focus on improving soil organic content and biodiversity (this can be assisted by use of compost produced at HCA (*see* Chapter 4)).
- Remove and/or control the spread of invasive species on the property, especially tree of heaven along the path to Cool Spring (which is aggressively outcompeting native plants and depleting valuable groundwater reserves in the spring recharge zone) and the Japanese honeysuckle that is scaling the large spring-fed sycamore near the main road.
- Convert some areas of lawn into no-mow wildflower meadows (which would only have to be mowed once a year, or maintained through annual or bi-annual prescribed burns).
- Use native plants adapted to the Shenandoah Valley ecosystem in all future plantings.
- Plant more trees, especially along the road towards (and surrounding) the Retreat House, along the main road, and along the road to Westwood House.
- In considering where to replant hardwood forest for the purpose of ecological restoration and/or sustainable forestry, increase the width of riparian and stream buffers first, then construct a “greenbelt” which will act as a habitat corridor to and from the floodplain forest.
- Place more land in the conservation easement.
- Hire appropriate local ecologists/botanists/biologists to perform comprehensive botanical and habitat surveys of the property to identify zones of ecological significance.
- Enlist the help of local volunteer or environmental groups to perform restoration work and to conduct annual monitoring of biodiversity and water quality.
- Construct a prayer/healing garden in the footprint of the old sheep barn to be enjoyed by residents of the infirmary who may not be able to get very far outside.
- Construct a more formal cloister garden as a central, ceremonial gathering place.
- Consider the option of a conservation burial ground to help protect land.
- Include educational and interpretive information in the landscape to educate guests, visitors, and community members about the history of the land and about the sustainable land stewardship practices taking place at HCA.
- Either enlist the help of lay Cistercians, volunteers, and/or local environmental groups to perform this work or consider donating land/conservation easements that are unable to be responsibly managed by HCA to a land trust/conservancy, such as The Nature Conservancy.

Following these recommendations will help protect and enhance ground and surface water quality, promote (unpolluted) groundwater recharge, protect and enhance biodiversity, provide carbon sequestration to help offset global climate change, protect land from development, reduce HCA's energy footprint, protect soil fertility (a virtually irreplaceable natural resource considering the time it takes for organic content and tilth to regenerate), beautify the environs, facilitate more opportunity for human connection to and enjoyment of the land, promote greater accessibility to sites of interest, provide food, provide economic gains, promote relaxation and mental wellbeing, and educate community members and visitors about the principles and practice of sustainable land stewardship. HCA can implement these recommendations in phases. Many of these efforts will require ongoing effort and attention.

Details for most of these recommendations are depicted in the design booklet that accompanies this report. Designs are also included below, in smaller format.

Due to the complexity and variability of many of these recommendations, cost estimates have not been provided. Relevant contact information that may further the execution of these actions and practices is provided in Appendix 1-D.

AS ABOVE... SO BELOW...



A new trail along the Shenandoah River shoreline will facilitate both the enjoyment and the deep restoration of the riverbank and the floodplain forest at Holy Cross Abbey.

The recommended **riparian and stream buffers** will help protect water quality, prevent erosion, and enhance wildlife habitat in the floodplain forest – an ecosystem with the potential to harbor incredible biodiversity. Species such as fox, bald eagle and heron are already known to breed in this area. Buffers can also support **sustainable forestry** at HCA.

Restriction of cattle, perhaps with a "**living fence**" constructed with a large, dense, native, shrub species, will enable human enjoyment of the enchanting shoreline (especially for Retreat House guests who might be intimidated by pasture and barbed wire fencing). The trail can also facilitate urgently needed **restoration** work on the eroded shoreline.

Steep, eroded sections of the riverbank can be revegetated with "**fascines**," or large, long bundles of native twig cuttings, which can be partially buried into the bank to take root and resprout.

AS ABOVE... SO BELOW...

Cool Spring lies at the **heart** of the property. The purity of its waters, as they emerge from below the Earth, is a reflection of human relationship to the land above. Special care should be given to the **"recharge zone,"** or the area of land upslope of the spring, such that maximum infiltration is allowed to occur, carrying an absolute minimum of contaminated agricultural runoff. Reconstructing a small **pond or wetland** at its historic location would help protect spring water quality.

A new, more **accessible trail** paved with decomposed granite will facilitate looped access to the spring and pond, and **connect** with a trail following Cool Spring stream down to the Shenandoah.

A band of **invasive** Tree-of-Heaven currently lines the eastern loop of the trail. **Removal and control** of these trees, as well as the bamboo near the pond, will enhance the biodiversity and beauty of the area, and protect the natural hydrologic regime.

Creative **renovation** of spring infrastructure will facilitate **reverence, appreciation, and enjoyment** of this unique **life source** and **defining feature** of the landscape. See precedent images on following page.

SHENANDOAH SHORELINE RESTORATION AND WALKING TRAIL

BEFORE: MANURE, EROSION AND SEDIMENTATION

AFTER: A SOFT AND STABLE SHORELINE, THE FOREST REGENERATING

Arrowwood Viburnum

Silky Dogwood

Lurid Sedge

living willow fence

live fascines

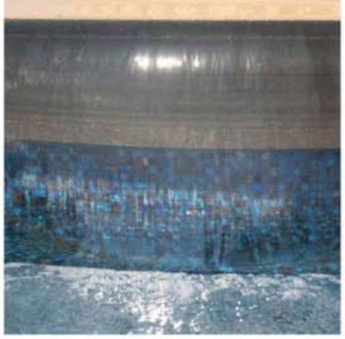
COOL SPRING RENOVATION, RESTORATION AND WALKING TRAIL

holy well, Gleninagh, Ireland

holy spring, Warwickshire, England

sacred fountain, Machu Picchu

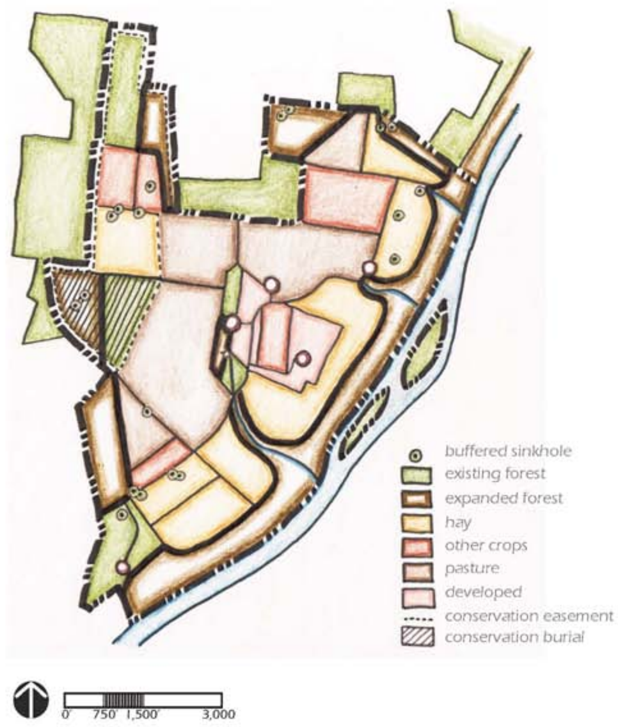
reflecting pool, Baha'i Temple, Chicago



Holy Spring Temple, Bali

Tanner Springs Park, Portland, Oregon

AS ABOVE...
SO BELOW...



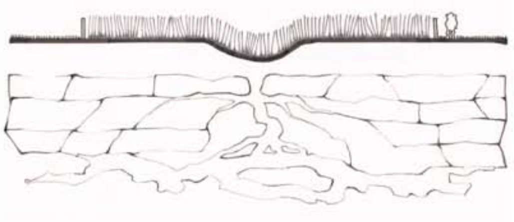
Efforts towards **sustainable forestry** at Holy Cross could yield both economic and ecological benefits. Forest restoration/hardwood cultivation should aim to **expand the riparian and stream buffers** on the property, as well as to **create a greenbelt** around the agricultural land, which creates a continous corridor of **habitat linking** to the floodplain forest along the river. This will facilitate the dispersal and migration of new and existing plant and animal species, and promote biodiversity at Holy Cross.

Ecologically speaking, **hay** is a relatively gentle crop, which should be employed adjacent to the riparian and stream buffers to aid in the filtration of agricultural runoff, as well as in fields which contain sinkholes.

To protect groundwater quality, **sinkholes should be buffered** with a band of native grasses, and fencing to exclude cattle in pastured areas.

All land use planning should consider how what is happening above ground affects what is happening below, in the water table.

a sinkhole buffer planted with native grasses and fenced in pastured areas will help protect groundwater



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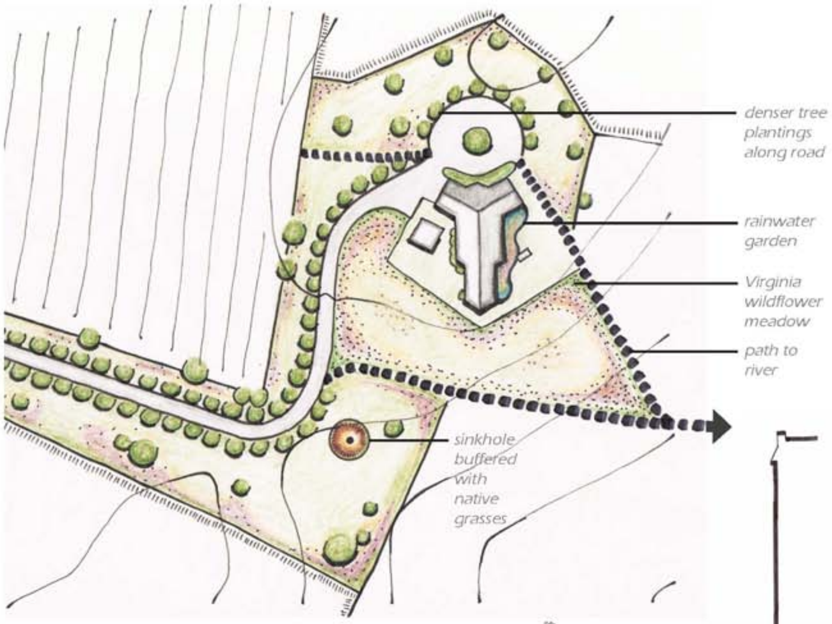


The expansive **lawn** around the Retreat House requires extensive human labor and energy inputs. Lawn here and elsewhere on the property where it is not "used" can be replaced with **wildflower meadows**.

Removing turf grass and seeding and/or planting the area with a mixture of appropriate **native grasses and perennials** can enhance the **beauty and biodiversity** of this peaceful landscape, attracting birds, butterflies, and other insects that may contribute to natural pest control in adjacent agricultural areas.

Maintenance of the meadow would require mowing just **once a year** and/or **prescribed burning.**

A **raingarden** on the east side of the Retreat House can capture and "clean" all stormwater runoff from the building. This would help prevent **erosion** that presently occurs beyond the fenceline where a large gutter releases discharge.

Raingardens are simply depressed gardens, typically 6" to one foot below grade. They can be lined with gravel below the topsoil to improve drainage. Species planted should be tolerant of both "wet feet" and drought conditions.

a raingarden on the east side of the Retreat House will capture and clean stormwater with a pleasing array of native plants

SUSTAINABLE LAND USE: FORESTRY AND RESTORATION


BEFORE: CATTLE HAVE UNRESTRICTED ACCESS TO RIVER AND STREAMS


AFTER: AN EXPANDING RIPARIAN BUFFER

NO-MOW MEADOWS


BEFORE: ENERGY INTENSIVE, MONOCULTURAL TURFGRASS


AFTER: AN EASY TO MAINTAIN, RICH AND INSPIRING LANDSCAPE


Early Goldenrod


Spiderwort


Blazing Star


Little Bluestem


annual prescribed burn

AS ABOVE...
SO BELOW...

hardwood nursery for sustainable forestry, ecological restoration, and "memorial tree" production for the conservation burial ground

three four-season hoophouses, a tool shed, vegetable beds, and an herb garden, located in a central location between the Monastery and the Retreat House

The agricultural field closest to the monastery can be utilized for **hardwood production** if the community chooses to pursue **forestry, restoration**, and/or the creation of a **conservation burial ground.**

A **garden**, cultivated by the community and/or lay Cistercians, Retreat House guests, or other volunteers, could provide fresh, healthy "carbon-free" food, as well as an opportunity to bond with place.

Simple "**hoophouses**" can extend the seasonal production of fruits and vegetables or act as a hardwood nursery.

The garden space depicted in the illustration is very **large**, and might represent a **long-term** development.

Since the well at the Gift Shop is contaminated, water used to irrigate food would have to be **treated**.

All production methods on the following page are hypothetical.

AS ABOVE...
SO BELOW...

grounds can accomodate 1,000 burials per acre

two sinkholes should be buffered and avoided

shelter with vista towards mountains

chapel and gathering area, trailheads

a variety of trails

some may prefer to bury their loved one in a forested area, others to "plant" them along with a tree in the former agricultural field as part of a restoration plan

A **conservation burial ground** would best occupy this 60 acre parcel bordering Castleman road, which is part of the new conservation easement. This area, though it may contain **sinkholes**, has sufficient depth to bedrock and water table, as well as soils not too heavy in clay content, according to NRCS data.

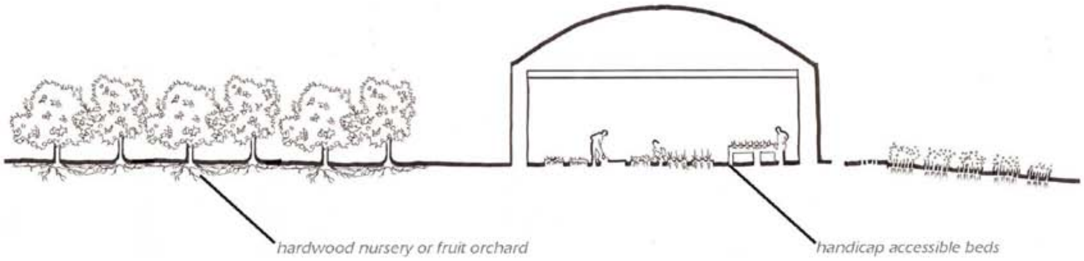
Two **ridges** would offer prime locations for a visitor center/chapel and a small shelter with a view. **Multiple trails** could be traversed by foot or a small vehicle.

Reforestation and restoration would likely require a full-time **steward** on site.

Locations of **flat gravestones** would be documented with **GPS** coordinates.

The **beauty and tranquility** of the site, met with Cistercian hospitality and spiritual tradition, would, in the opinion of the Team, make this a **desirable resting place**. The burial ground would also help restore **ecological health** to a sensitive landscape, and **honor the civil war soldiers** who died here.

HARDWOOD NURSERY AND FOOD PRODUCTION



shiitake mushrooms grow easily on oak logs

a hoophouse can extend seasonal production

hardwood seedlings

http://texasforestservice.tamu.edu/

CONSERVATION BURIAL GROUND

procession

Cinnamon Fern

forest burial

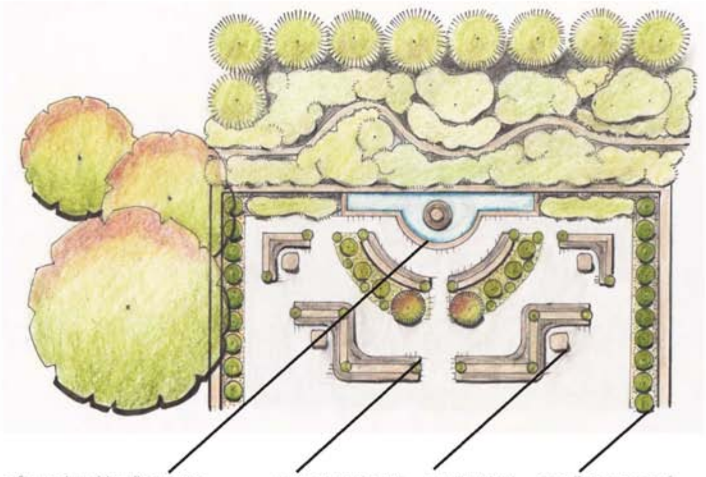
Cucumber Magnolia

gravestone

Bloodroot

http://www.memorialecosystems.com/

AS ABOVE...
SO BELOW...



a fountain with a limestone sculpture or a statue of the Virgin Mary will rest inside a long reflecting pool extended from the old wall of the sheep barn

two passageways lend a feeling of privacy and discovery to the innermost sitting area

small tables/ desks will support outdoor reading

espalier pears and apples will help frame and enclose the garden

A **prayer garden** tucked into the footprint of the old sheep barn would **complement** the beauty of the butterfly garden, and offer community members a comfortable and tranquil outdoor space in which to **read, pray, or hold community gatherings or rituals**. A small fountain with a reflecting pool could contain either a simple **stone** sculpture which spoke of the underlying topography, or a statue of the **Virgin Mary**.

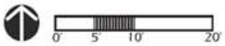
This space could be designated as **silent**, or as a more casual "public" space.

A **native plant** pallette would limit the need for much irrigation, but necessary water could be harvested from a **greywater cistern** or a series of **rainbarrels** attached to the monastery.

Tiered entrances will make the innermost sitting area feel **private and sacred**. Ample sitting areas – some sunny, some shaded, will offer community members a wide array of **choices** and **views.** Benches will have comfortable **back support.**

This space should be easily **accessible** to all community members, especially those unable to travel very far from the **senior wing or infirmary**.

This underutilized space has the potential to become a very **healing, contemplative** environment.



SILENT PRAYER GARDEN

BEFORE: SHEEP BARN TURNED VEGETABLE GARDEN

AFTER: A CONTEMPLATIVE AND HEALING SPACE

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ENERGY

2

Global energy consumption is unsustainable. Total global energy consumption has been rising at increasing rates since the industrial revolution and has exploded in recent years. According to the International Energy Agency (IEA), an autonomous body charged with implementing an international energy program, the current consumption of energy resources by humans is heading towards a systematic crash: "The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable—environmentally, economically, socially."[1] These energy systems must be completely overhauled in order to prevent such a crash. Individuals and communities must better understand their role in these systems and how they can help improve them. According to IEA, "The future of human prosperity depends of how successfully we tackle the two central energy challenges facing us today: securing the supply of reliable and affordable energy; and effecting a rapid transformation to a low-carbon, efficient and environmental benign system of energy supply."[2]

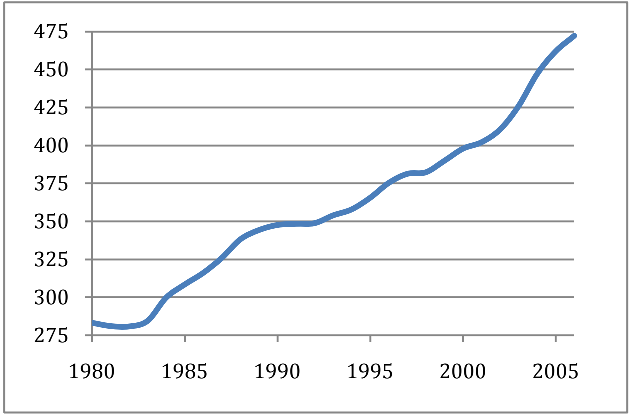
This chapter evaluates HCA's energy consumption and the impacts of that consumption. The first section describes unsustainable trends with regard to current energy consumption and identifies important principles for implementing sustainable energy systems. In the second section, we explain the methodology used for calculating HCA's energy baseline and estimating areas of high energy use. In the third section, we present the results of the tests and analysis used to summarize the community's energy consumption habits and associated financial and environmental impacts. We conclude this chapter by offering options for reducing HCA's energy consumption and estimating the potential improvements and financial savings that could result from implementing those options.

CONTEXT: UNDERSTANDING ENERGY SYSTEMS

Identifying the Problem

The US Department of Energy defines energy as "the ability to do work or the ability to move an object."[3] In developed countries, energy is intertwined with almost every aspect of modern society and is used to provide important services such as lighting, appliances and electronics, communication, heat, and mobility. The delivery of energy for end-use consumption is often very complicated, costly, and dependent on limited resources. The combined production, delivery, and consumption processes that enable end-use consumers to achieve their energy-use goals is called an *energy system* (see Box 1 in Appendix 2-A for further explanation). Due to the interconnected nature of energy systems, producers, distributors, and consumers of energy all have significant impacts on these systems.

Figure 1: Total energy (quadrillion Btu) consumed worldwide by year



Source: EIA, *International Energy Annual*, 2006

As Figure 1 shows, worldwide energy consumption has increased by almost 70% since 1980. This trend is expected to continue because world energy demand is forecasted to increase by 45% by 2030, or roughly 2.5 times more energy than was consumed in 1980.[4]

Over the last five years, the United States alone consumed an average of about 100 quadrillion (quad) British thermal units per year, or about 20% of total worldwide energy consumption.[5] A British thermal unit (Btu) measures the amount of energy needed to raise the temperature of one pound of water by one degree Fahrenheit. To put US energy consumption in perspective, the 100 quads of energy consumed by Americans each year could raise the temperature of the 15 trillion gallons of water in the Chesapeake Bay by 800 degrees Fahrenheit.[6]

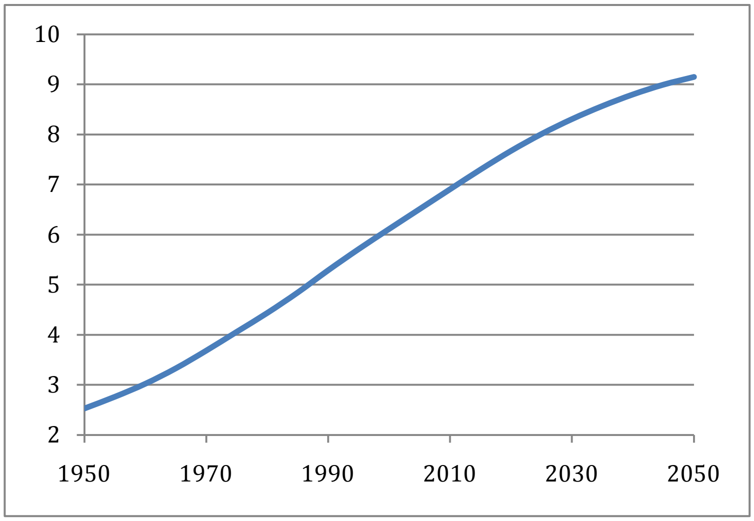
Drivers of Energy Consumption and Recent Trends

Unlike the production and distribution networks for many other goods and services, many energy systems are global in nature. Such a global network creates many degrees of separation between the end-use consumer (in this case, HCA) and the impacts of energy production, such as pollution and price increases. Because energy systems are global in nature, events in other areas of the world (e.g., a war in the Middle East or a lack of pollution standards in a developing country) can impact the HCA community. To better understand HCA's position within this global system, this subsection evaluates the three key drivers of energy consumption: population growth, growth in disposable income, and energy prices.

Population Growth

Global energy consumption is increasing because the human population is growing at an increasing rate. As Figure 2 shows, the United Nations Population Division (UNPD) projects that the world's population in 2050 will be more than three times greater than it was in 1950. Over this 100-year period, the world's population is expected to grow by about 6.62 billion people. The UNPD also forecasts that the US population will increase by 86.3 million people from 2010 to 2050.[7] With the average American currently consuming about 335 million Btu (MMBtu) per year, this population increase will cause the US alone to consume an additional 29 quads of energy per year, or a little less than a third of the country's current energy consumption.[8] To put this US trend in perspective, the additional amount of energy that is projected to be consumed in 2050 would equate to about 253 billion gallons of gasoline.[9] Fossil fuels are limited resources and the explosion in energy consumption due to population increases is unsustainable.

Figure 2: Past and projected world population (in billions) by year



Source: UN, *World Population Prospects*, 2008

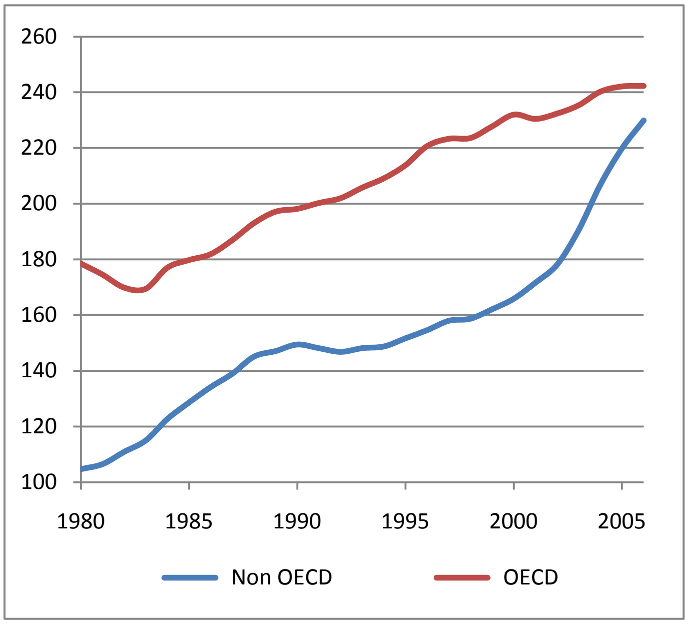
The prospects for institutionalizing an energy system overhaul currently look bleak because of the potential for a future explosion of population growth in less-developed countries. The current trends in energy consumption in developing nations (such as India and China) could cause total worldwide energy consumption to explode at rates much greater than the steady rates of increase presented in Figure 1. According to the Population Reference Bureau (PRB), the populations of the most-developed countries—specifically, countries that are members of the Organization for Economic Cooperation and Development (OECD), such as the United States, Canada, Australia, Japan, and Western European nations—are expected to grow by only 5% between now and 2050. The populations of developing nations, by contrast, which currently comprise about 87% of all non-OECD countries, are expected to grow by 47% over that same period.[10]

Large population growth in tandem with increased energy consumption per capita in developing countries could cause worldwide energy consumption to grow exponentially. As shown in Figure 3 on the next page, energy consumption in OECD countries has been growing at a constant rate and may begin to level out. Conversely, energy consumption in developing nations has increased exponentially since 2000. Developing countries have been experiencing their own industrial revolution, and it is expected that the energy per capita for those nations will continue to grow. Such consumption trends will probably cause total worldwide energy consumption to explode by 2050.

Growth in Disposable Income

In general, there is a strong correlation between increased energy consumption and increased wealth.[11] According to the Energy Information Administration's 2001 Residential Energy Consumption Survey, energy per capita in the US has increased as wealth has increased.[12] This correlation is intuitive because individuals or households that become wealthier are then more able to consume costly products that use significantly more energy. This trend is especially true in the US, which has experienced increasing trends in both wealth accumulation and energy consumption. Examples of trends in disposable income in the US that drive up energy consumption include:

Figure 3: Total energy (quads) consumed by developed (OECD) and developing (non-OECD) countries by year



Source: EIA, *International Energy Annual*, 2006

- Personal Transportation: Vehicle miles traveled for personal transportation increasing and the average vehicle occupancy is decreasing. This implies that more individuals own cars and drive their cars more often and over greater distances. In 2006, personal transportation from cars and light trucks consumed 17.3% of total US energy consumption. This reflected a 16% growth in energy consumption for these vehicles since 1996, or a 1.5% growth each year.[13]

- Size of Residential Housing: Increasing income typically results in larger homes. The average number of people per household in the US has decreased from 3.37 in 1950 to 2.62 in 2005. Yet, the size of the average US single-family house increased by 148% over that same time period (and 62% since 1970), causing the average area per household member to increase by 188 percent. Considering that Americans spend 90% of their time indoors, this increase in area per household member directly results in more energy consumption per person from area lighting and indoor space heating and cooling.[14]

- Use of Appliances and Electronics: It is no surprise that as household income increases, the average household consumes more energy-intensive electronics and appliances.[15] Such devices mostly consume energy in the form of electricity. In total, these products comprise about 42% of the average US household's total consumption of electricity.[16]

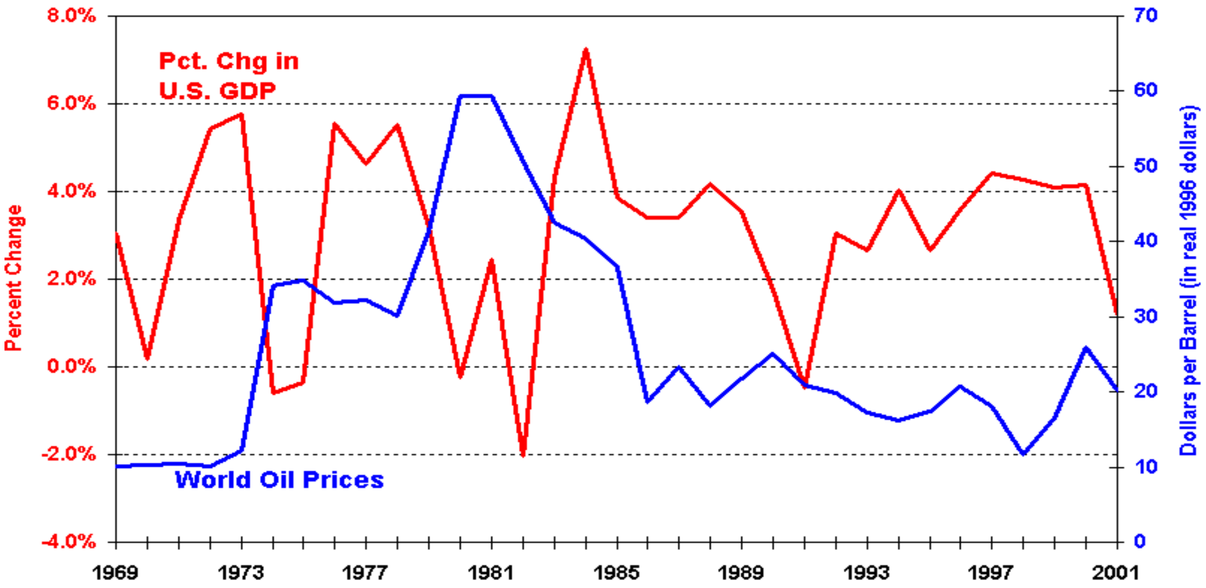
- Food Consumption: A strong positive correlation exists between increasing wealth and increasing food consumption.[17] However, this relationship is not necessarily linear since wealthy individuals eventually reach a point of satiation and choose not to consume additional food products. As a household's wealth increases, so does its ability to consume food products, such as beef, that are energy intensive to produce and considerably more expensive to consume. In fact, much of the food consumed by the average American is energy intensive to produce, process, package, transport, and store. In addition, most of the energy used to produce food in the US is from the consumption of nonrenewable fossil fuels. One source estimates that every unit of caloric energy in the food consumed by the average American takes 7.4 units of fossil fuel energy to produce, deliver, and store.[18]

Energy Prices

Energy consumption is probably the most influential component of both the world and US economies. Large or small, all manufacturing, retail, and service businesses rely on end-use energy products. As a crucial production input, the price of energy highly influences the cost of producing and selling commercial products (e.g., HCA's fruitcakes or honey). Some fossil fuels, such as natural gas and crude oil, are subject to high price volatility. Businesses, like HCA's bakery, that rely on these fuels are vulnerable to this volatility. Such volatility greatly impacts profit margins because it is often difficult to raise and lower the price of a consumer product (e.g., fruitcakes or honey) in accordance with fluctuating energy input prices. Therefore, unexpected and drastic increases in energy prices cause short-run profits to fall, sometimes drastically.

The price of oil typically is a good predictor of the short-term economic outlook. One study concluded that five of the six recessions in the United States between 1947 and 1975 followed periods of dramatic increases in the price of crude oil. (The average lag between an increase in crude oil prices and a recession was about nine months.)[19] Recent recessions (in 1990 and 2008) as well as the economic downturn in 2001 followed a very similar trend. Figure 4 below shows how the percentage change in US gross domestic product (GDP) typically decreases (red line) as world oil prices increase (blue line). As shown in this graph, very large spikes in oil price can lead to negative economic growth (negative percentage change in GDP), or a shrinking of the US economy. Conversely, US GDP typically grows as world oil prices decrease. Becoming less dependent on nonrenewable fossil fuels will provide businesses with greater price stability for inputs and could lead to greater economic security.

Figure 4: World oil prices and US GDP: An inverse relationship



Source: EIA, *U.S. Short-Term Energy Outlook*, 2008

Sustainable Energy Systems

The United Nations Development Program (UNDP) defines a sustainable energy system as "energy produced and used in ways that support human development over the long term in all its social, economic and environmental dimensions."[20] In the context of energy consumption, sustainability comprises three major components: *access, reliability, and impact*. This subsection briefly explains these components, or pillars, of energy systems and their importance for sustainability.

- Access: A sustainable energy system must be available to all users. In a sustainable world, everyone has a right to energy and society has a moral obligation to provide energy to each of its members. Restricting the use of adequate infrastructure for the transmission and distribution of energy and unaffordable consumption costs impedes this access.

- Reliability: Energy must be available when needed. An energy system is not sustainable if the lights in a building do not turn on and/or gasoline stations have no fuel for cars. Energy reliability is challenged when infrastructure is poor or inefficient, or the supply of energy sources is limited or restricted.

- Impact: The processes within an energy system and the consumption of end-use energy products must not detrimentally impact the environment. An energy system is not sustainable if extraction of energy resources or consumption of energy harms the environment.

No current energy system in the world is sustainable within the context of these three pillars. Energy systems that rely on fossil fuels—such as those that produce electricity and energy carriers such as gasoline, heating oil, propane, and natural gas—are the least sustainable. Fossil fuel energy sources offer limited access due to increasing energy costs and incomplete infrastructure, have reduced reliability due to resource limitations and political instability, and cause social disparity and environmental degradation.

Supply of Energy Sources

Sustainable energy systems ensure that energy will be available for both the current population and future generations. However, fossil fuel energy sources such as coal, crude oil, and natural gas are nonrenewable, and oil reserves are very limited in supply. Energy analysts currently predict that conventional global oil production will peak between 2010 and 2050.[21] Although the specific timing of peak oil remains highly controversial, the scary reality is that oil is a limited resource that is being consumed at exorbitant and continually increasing rates.

The currently vast and increasing use of these nonrenewable resources, in concert with an exploding world population, is inherently unsustainable. The use of energy from renewable sources such as the sun, wind, water, and biomass is crucial for meeting the energy demands of future generations.

Security of Supply

Sustainable energy systems come from a supply that is not subject to disruption. The supply of many sources of energy is not secure because those sources are unevenly distributed throughout the world and often are housed in countries that are politically unstable. Political instability can lead to supply shortages that directly hinder the reliability of an energy system. The supply of fossil fuels such as oil (and to a lesser extent, natural gas) has been interrupted due to political instability.

The heavy concentration of oil reserves in the politically unstable Persian Gulf region is of particular concern. The physical disruption in oil supply in the 1970s and 1980s led to multiple oil shortages and very high energy prices in the

US. Additionally, 42% of the world's oil reserves are controlled by the Organization of Petroleum Exporting Countries (OPEC), which can restrict supply through cartel agreements in order to artificially inflate the price of oil. Although supply security has improved for the US since the last supply shocks and OPEC's power has decreased over the last decade, political conflict could easily change the country's recent supply-side fortunes.[22]

The supply of energy from fossil fuels can also be disrupted by natural disasters. Hurricanes Katrina and Rita and other storm surges and high winds in the Gulf of Mexico have damaged thousands of miles of oil and natural gas pipelines in recent years. According to one source, almost 20% of US refining capacity was disrupted by the Gulf hurricanes, causing fuel prices to skyrocket.[23] Energy users that rely less on fossil fuels—especially oil—can make their operations less vulnerable to political and storm-related disruptions.

The security of the supply of energy resources is also being disrupted by a surge in demand from developing countries. It has been predicted that OECD countries, which accounted for 70% of the worldwide energy market in the 1970s, will see their market share for energy resources drop to less than 50% in coming years. This decrease in market share is not due to less energy consumption in OECD nations, but rather will be caused by a surge in demand from developing countries such as China, India, and Brazil. Increased demand from developing countries is beginning to put a strain on energy supply systems and could lead to disruptions for even the best energy customers, including the US. Untimely disruptions, like those experienced in the 1970s and 1980s, would have significant consequences as lacking energy inputs would trickle down throughout the economy.[24]

Cost of Consumption

A sustainable energy system must deliver affordable energy so that all members of society have the ability to purchase the energy they need. The prices of most nonrenewable energy inputs, when indexed for inflation, are rising considerably worldwide. Basic economic theory predicts that this trend will continue because as supply decreases and demand increases for these inputs, the price of those energy inputs will have to increase. As prices increase for end-use energy products, consumers on the margins will not be able to afford to use as much (or potentially, any) energy. Lack of access due to rising energy costs is not sustainable.

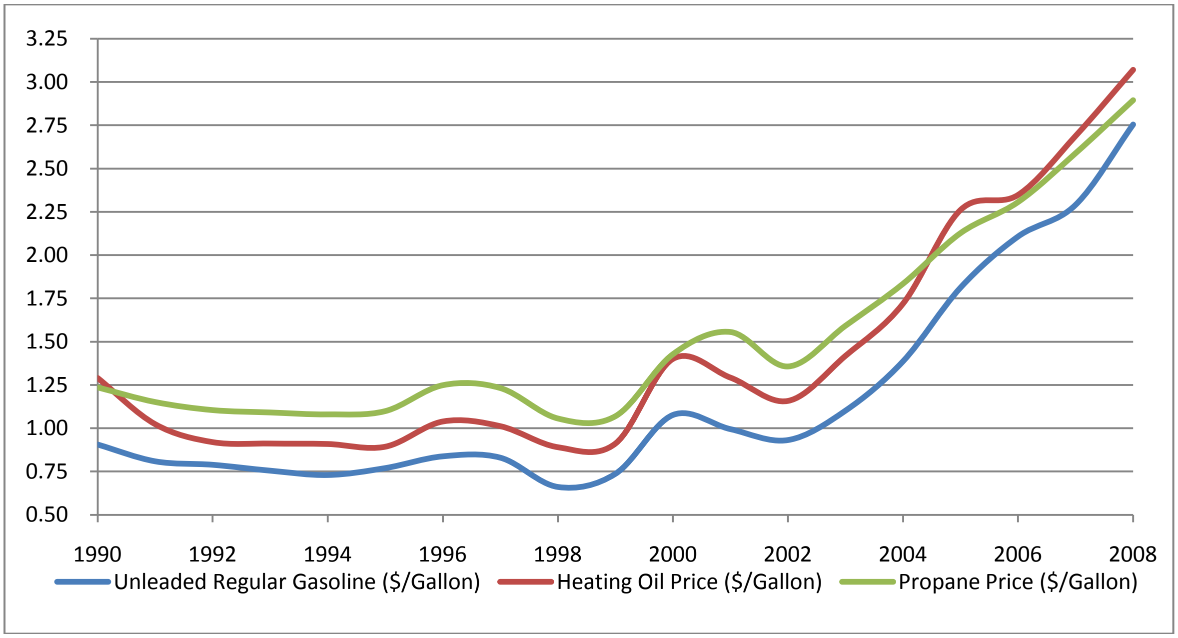
The trend of increasing prices for energy products affects all nonrenewable sources of energy. Most noticeably, the quickly diminishing production of oil significantly impacts the price of petroleum products worldwide and even HCA's local markets (see Figure 5 on the next page). HCA consumes large quantities of gasoline, propane, and heating oil, and the price that the community pays for energy now is twice as much as it paid in 2000. (Importantly, summary data indicating prices for petroleum products in Virginia was available only up to 2008. Other data suggests that prices peaked in 2008 and subsequently have decreased. However, the recent downward trend in prices probably will be short lived.)

Prices for other fossil fuels are also rising. In Virginia, the price of natural gas, which generates about 7% of the electricity purchased by HCA, increased from $4.66 per cubic foot in 2000 to $10.85 per cubic foot in 2008,[25,26] an increase of roughly 230%. Even coal prices, which generally have been stable when adjusted for inflation, have spiked. Since 2000, the average price of coal supplied to electric generators increased by about 70%.[27] Increases in the price of natural gas and coal have affected the price of electricity in Virginia, and unlike petroleum prices, the cost of electricity has not decreased since 2008. See Figure 6 on the next page.

Social Disparities

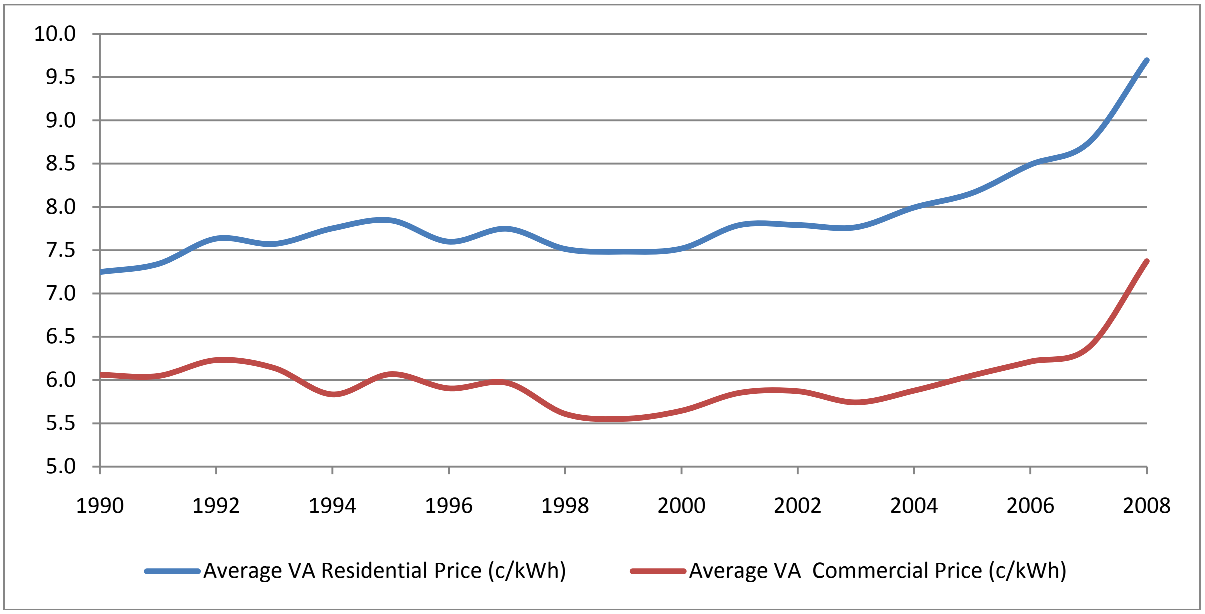
Lacking adequate energy access and reliability often perpetuates the poverty cycle for many of the world's poor. Energy is needed to generate sources that provide for people's basic needs, such as food, water, clothing, medical care, warmth, and shelter. Energy also powers key institutions (e.g., government and education) that are needed for reversing the cycle of poverty. High prices and poor energy infrastructure in developing countries hinder a poor individual's access to energy. Likewise, unequal distribution of energy resources within a developing country perpetuates large disparities between the wealthy elite and poor masses. According to the UNDP, 2 billion people are without clean, safe cooking fuels and 1.7 billion are without electricity.[28] As Figure 7 shows, people in less-developed areas of the world use less energy than those in more-developed areas, some by an order of magnitude.

Figure 5: Prices for petroleum products in Virginia ($/gallon)



Source: EIA, Energy Price Data

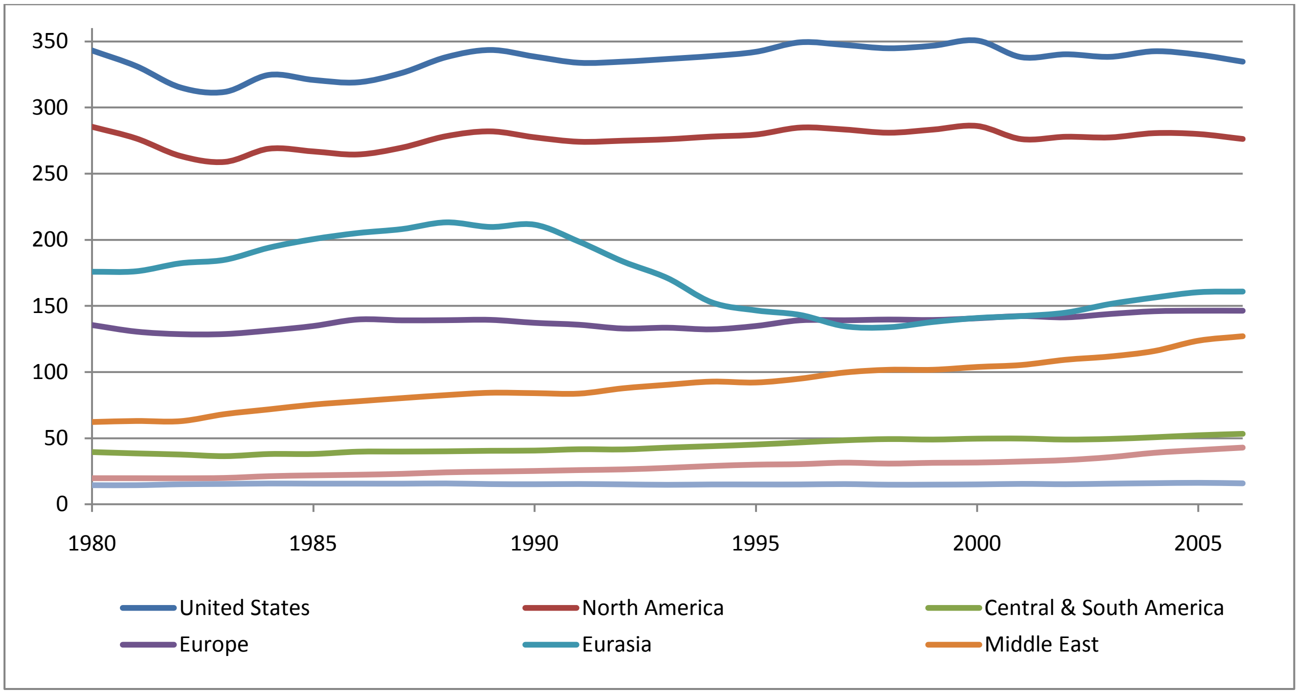
Figure 6: Electricity prices in Virginia (cents/kWh)



Source: EIA, Energy Price Data

Poor energy infrastructure and access even affects the world's most developed nations, such as the US. The poor in industrialized nations are not necessarily energy depressed in the absolute sense; poor individuals in the US use 1.65 times more energy than the average person in developing countries. Still, as best stated by the UNDP, "Despite this apparent energy affluence of the poor in industrialized countries relative to the masses in developing countries, their economic plight cannot be ignored."[29] Energy disparity tends to exacerbate poverty in well-developed countries "through the disconnection of energy services or the absence in cold countries of universal affordable warmth."[30] Furthermore, the poor in industrialized countries must spend a larger, and unsustainable, fraction of their income on energy, which ultimately perpetuates their economic condition.

Figure 7: Per capita energy consumption (million Btu) by area of the world



Source: EIA, International Energy Annual, 2006

Environmental Degradation

A truly sustainable energy system would not pollute the environment or disrupt natural systems. Sustainable energy production and consumption might even create positive impacts, such as using industrial waste to generate electricity or using waste cooking grease to power vehicle motors. The side effects of energy systems are called "externalities." Externalities occur when specific activities (e.g., energy production and consumption) cause external impact but the "cost" of the impact is not captured in market transactions. Pollution from electricity production is a classic example of an externality. The pollution that results from electricity generation (and causes things like global warming, acid rain, and poor human health) is not captured in the retail price of electricity. As a result, the price of a kWh is actually lower than it would be if the externality were included; we would have to pay more for electricity if the costs associated with pollution were accounted for in the price.

The extraction of energy also causes negative externalities. Although less common now than in the past, mismanaged wells and pipelines can lead to disastrous oil spills. Coal mines also are extremely taxing on the environment; coal mining can level mountains, destroy landscapes, and pollute nearby rivers and lakes. Even some renewable resources can have damaging effects on the environment. Large dams can destroy river habitats and prevent necessary water resources from reaching areas downstream. Even wind turbines—the symbol of clean renewable energy—can kill birds and bats.

Because externalities are difficult to quantify, markets fail to properly account for them in the price of energy. Purchasing sustainable energy, therefore, is more complicated than simply choosing the cheapest source. In fact, the cheapest source is many times the one with the worst impact on the environment. In today's wave of environmentalism, the type of energy we use and how much we consume reflects more than our savvy in market transactions; it also reflects our values towards social and environmental goals. Many people now consider potential environmental impacts when purchasing energy, rather than simply the energy's retail cost.

METHODOLOGY

Four categories of activities at HCA consume energy: (1) residential activities within the monastic enclosure; (2) activities directly related to the Retreat House; (3) business activities, both industrial and office related, that occur within the monastic enclosure, bakery, and gift shop; and (4) farm-related activities. For simplification, we call these categories "units" (e.g., business unit). This section explains the methodology we used to estimate the energy consumption and environmental impacts associated with these units. For purposes of this analysis, we focus on the monastic enclosure, the Retreat House, and the business units. We did not focus specifically on farm-related energy consumption and technologies because HCA generally cannot alter the practices of the farm tenant.

Factors Affecting HCA's Energy Consumption and Its Impact

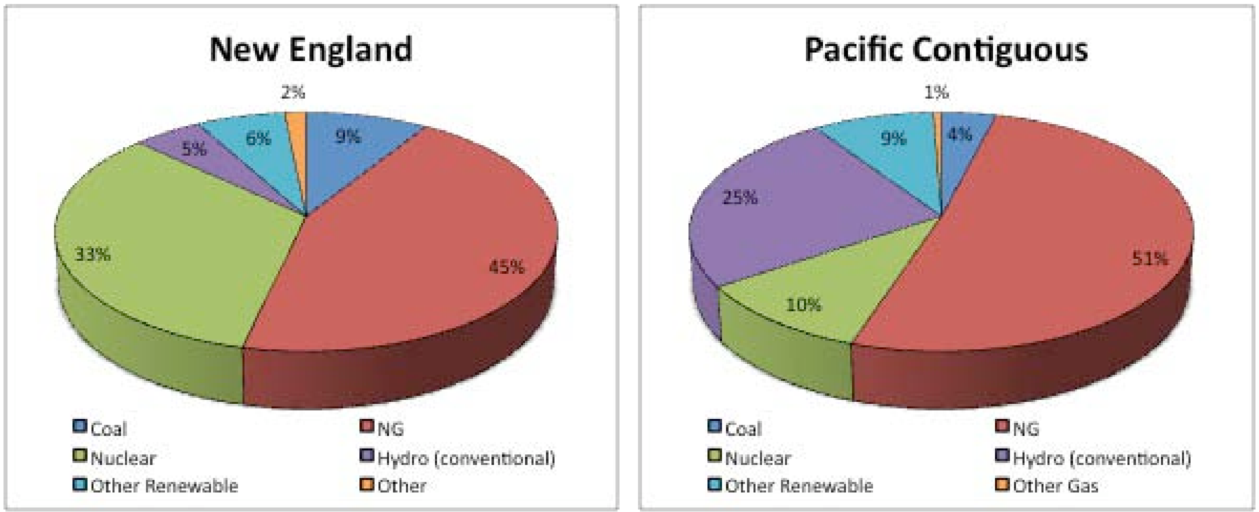
There are three factors that influence HCA's energy consumption and the impact it has on the environment. First, the energy use habits of community members and employees greatly impact the amount of energy consumed by HCA. In fact, changing the community's habits would be a very cost-effective way of reducing energy use. Encouraging the monks who do not already do so to create habits such as turning the lights off when leaving a room, using less hot water, lowering the thermostat temperature during sleeping hours, and reducing vehicle miles traveled can greatly reduce the amount of energy consumed by the community.

Energy efficiency also greatly affects HCA's energy use. For example, energy-efficient electronic devices (e.g., appliances, electronics, etc.) reduce energy consumption compared to standard models that are less efficient. Likewise, the structure of each building's exterior envelope also can reduce energy consumption through gains in energy efficiency from adequate insulation.

A third factor that influences the HCA's energy impact is the type and source of energy consumed. Two people in different regions of the country can consume the same amount of electricity (measured in kilowatt-hours or kWh) but cause different impacts on their respective local environments. For example, Figure 8 shows the different energy mix in New England compared to the Pacific Contiguous states. In general, generators in the Pacific Contiguous states use a greater percentage of renewable resources and cleaner burning fossil fuels (e.g., natural gas), and therefore have a lower environmental impact. Additionally, the higher percentage of nuclear power found in New England causes negative impacts due to the disposal of nuclear waste. As a general rule, the source of energy consumed is more important than the quantity of energy consumed. No community can completely reduce energy consumption by changing personal habits or improving energy efficiency; everyone must consume some energy. Therefore, it is important to purchase energy from clean and reliable sources.

We evaluated HCA's energy consumption and energy impact in three steps. First, we calculated HCA's aggregated energy consumption baseline. Second, we inventoried HCA's major electronics and appliances; heating, ventilation, and air conditioning (HVAC) units; and building structures to estimate the energy used for specified activities. Finally, we assigned pollutant emission levels to each activity by using emission factors published by the US Environmental Protection Agency (EPA).[31] The results of this analysis provide the community with detailed information for the energy consumption and emission output for each activity, allows HCA to recognize the most energy-intensive and environmentally degrading activities, and enables HCA to evaluate the cost effectiveness of alternative strategies. Each of these steps is described in detail in the following subsections.

Figure 8: Comparing generation portfolios for two US regions



Source: EIA, *Electricity Data*, 2009

Energy Consumption Baseline

An energy consumption baseline helps to identify the habits, devices, and property areas that consume the most energy at a given facility and attempts to explain the identified energy patterns. An energy consumption baseline is crucial for identifying energy-reducing strategies that are cost effective and that efficiently reduce the individual or community's impact on the environment. Once a baseline is established, a cost-benefit analysis can be performed to evaluate the feasibility of various reduction strategies and to make value comparisons over a range of potential options.

Defining HCA's Energy Systems

HCA's total energy consumption comprises multiple energy systems, which complicated the task of calculating HCA's energy consumption baseline. In total, HCA's property has 16 electric accounts, eight fuel oil tanks for space heating, three propane tanks for food preparation, and two gasoline tanks. These energy systems are described below.

Monastic Enclosure

Unlike most households, the community stores and consumes multiple sources of energy within the monastic enclosure. HCA uses electricity for common purposes such as powering electrical devices, refrigeration equipment, and space cooling. In addition, HCA stores and consumes fuel oil for space heating, propane for commercial-level food preparation, and gasoline for transportation. HCA has completed several additions to the monastic enclosure over the past many years. As a result, electric meters and fuel oil tanks are shared in an overlapping nature.

Business Unit

Activities within the business unit take place in three locations. Fruitcakes and honey are produced in the bakery but stored in the basement of the monastic enclosure. Retail operations take place in the gift shop, and office operations occur in all three locations. In instances where two units overlap (e.g., storing bakery products in the monastic enclosure), allocation for each unit was difficult, if not impossible. To prevent double counting errors, we assigned the energy consumed to the business unit according to where in the building the activity took place. For example, the Team designated the monastic enclosure as residential, and thus, all business operations that occurred within that building (i.e., office activities and product storage) were allocated to the residential unit.

Retreat House Unit

For purposes of this energy analysis, we did not calculate a complete energy baseline for the Retreat House. There were two reasons for this decision. First, the Retreat House is a newer building on the property and it has considerably better insulation and windows, newer appliances, and more efficient systems for space heating and cooling than the other buildings. Second, community members spend little (if any) time at the Retreat House. Visitors and their energy-use habits influence most of the unit's energy footprint and the impacts associated with that footprint. Aside from educating these visitors on the importance of energy-efficient practices, there is little the HCA community can do to alter the energy consumption of this unit. Therefore, the Team concluded that this unit had the least potential for significant value added. However, the Team did estimate the amount of power used by visitors for lighting because there are easy and cost-effective ways for the community to reduce this power load, despite the habits of their guests.

Calculating HCA's Energy Consumption Baseline

To simplify the results of the energy consumption baseline and to better evaluate areas of efficient energy reduction, the Team calculated the baseline for each unit three different ways: (1) by aggregating the energy footprints of each unit; (2) by disaggregating those footprints by fuel type and building area (not applicable to the consumption of gasoline); and (3) by estimating the energy consumption per activity (not applicable to the consumption of gasoline). The third series of calculations were completed using the appliance, electronic, and building inventories and will be addressed in the next subsection.

Aggregating HCA's Energy Baseline

Because we were working with an energy baseline as complicated as HCA's, it was important to first understand the community's total average energy consumption. We used electricity, propane, fuel oil, and gasoline bills dating back to 2003 to estimate the community's average annual consumption of each fuel type, and we used the average annual consumption to calculate the resulting environmental impacts. (The methodology for estimating the resulting environmental impacts is addressed later in the Methodology section.) Since fuels are sold according to different units of energy, all averages were converted into British thermal units (Btu) to compare the total consumption and cost per Btu for each fuel type. Indexing the use of each fuel into a common denominator allowed the Team to recognize potential inefficiencies from the use of particular fuel types and target more detailed analysis for those fuel types.

Assigning Energy Consumption to Building Areas

We assigned energy use to areas of the building according to fuel type so that we could disaggregate the community's use by unit. In the case of the monastic enclosure, which has multiple energy accounts, we further disaggregated each building's energy consumption data according to specific building areas. This method made it easier to target specific areas within the monastic enclosure that consume large amounts of energy. Dividing the energy consumption by area according to fuel type made it easier to pair inventoried activities to energy consumed and was especially important for identifying energy-intensive activities in the multiple additions of the monastic enclosure. Maps 1–4 in Appendix 2-B are visual examples of how the Team divided sections of the monastic enclosure according to fuel type.

Dividing energy consumption by area according to fuel type also allowed the Team to associate varying energy use with specific activities that are associated with the appliance, electronic, and building inventories. For example, by evaluating HCA's monthly consumption of electricity for a specified building or building area, we were able to parcel out the community's base load consumption from common electronics like appliances and lighting (which remains fairly constant throughout the year) from the community's peak consumption for specialized activities, such as space heating and cooling and commercial activities.

Energy Inventories

The Team conducted three separate inventories to accurately pair the disaggregated energy footprints of each building and building area to the activities that occur in those areas. The first inventory recorded all major appliances and electronics that consume electricity (e.g., clothes washers and dryers, refrigeration units, water heaters, and bakery mixers). The purpose of this inventory was to gather as much information as possible on the power requirements and time of use for each device. In addition to recording the location of each appliance (which could then be paired with the electric account for that area of the building), the Team recorded the wattage used by the device. Our Team also recorded the brand and model of each device in case we would need to contact the manufacturer for additional information (e.g., the average cycle time for a specific clothes washer). Exhibit 1 in Appendix 2-C shows examples of the various methods we used to calculate the energy consumed by multiple devices, along with a rating that explains the expected accuracy of those calculations.[32]

The second inventory was focused on the monastic enclosure and recorded all energy-consuming HVAC units used for space heating and cooling. The monastic enclosure is heated by multiple boilers that are located throughout the building and cooled in select locations by air conditioning powered by electricity. All of HCA's boilers are fueled by heating oil. For boilers, the Team identified each unit's annual fuel utilization efficiency (AFUE), which is a measurement of fuel efficiency. The higher the energy factor, the less fuel is wasted when running the boiler. For example, a boiler with an AFUE of 85% uses less fuel to produce the same heat output as a boiler with an AFUE of 55%. For air conditioning units, the team recorded the Btu per hour rating of each unit in addition to each unit's energy factor. This rating is a measurement of the unit's average energy output each hour. In addition to recording each unit's energy factor and output, the Team also mapped out the areas of the buildings served by each unit. Doing so allowed the Team to calculate the energy used for HVAC per square foot of living area, which helped us identify areas of inefficient energy use.

Lastly, the Team conducted a building material inventory to evaluate the building envelope of the monastic enclosure. The purpose of this inventory was to estimate the transfer of heat that passes through exterior walls, floors, and ceilings and to target areas where the building structure could be improved. For this inventory, we recorded the insulating R-value for each exterior wall, floor, and ceiling and recorded the size and insulating value of doors and windows. The R-values were estimated by measuring the thickness and type of insulation used and recording the material used in constructing the building envelope.[33] The team input the data from the building envelope inventory into a HVAC computer modeling program to estimate the average hourly heat loss and heat gain for each area of the monastic enclosure as-built.[34] The results of the HVAC modeling were then used to estimate the amount of energy needed to heat and cool the various building areas of the monastic enclosure.

Energy Consumption from Lighting

Without a device that can record the total power used when a light fixture or series of lights are turned on, the Team had to make a general estimation. According to the US Energy Information Administration (EIA), lighting comprises about 9% of an average residential household's power consumption.[35] EIA also estimates that 28% to 58% of the power consumed in commercial buildings with similar building activity to the monastic enclosure, such as religious worship and lodging, is from lighting.[36] California's Department of General Services estimates that when averaging across commercial and residential structures, lighting comprises 30% to 50% of a typical building's total power needs.[37]

Estimating the power consumed from lighting in the monastic enclosure was very difficult without advanced monitoring equipment. The monastic enclosure is not an average residential building because it also hosts business and healthcare activities. Such nuances for this unit imply that the average residential data reported by EIA should be interpreted as a low-end estimate. To correct for this problem, we assumed that lighting comprises 15% to 45% of the total power load within the monastic enclosure and reported low- and high-end estimates for energy consumption as a result of this range.

The power consumption for lighting the Retreat House, which is essentially a commercial lodging unit, was fairly easy to estimate. The EIA reports that 58% of the power used by lodging buildings is from lighting. To be conservative, the Team lowered this to 45% (which also is the high-end estimate for the monastic enclosure). The purpose of lowering EIA's reported percentage was to compensate for the fact that the Retreat House has compact fluorescent light bulbs and occupancy sensors installed in some areas of the building, which would cause the total percentage of power designated to lighting to decrease.

Estimating the amount of power used for lighting in HCA's business unit was also difficult. However, the accuracy of this estimate was less important than for the former units because lighting for business activities, especially in the bakery, comprises a small amount of total power consumed. Based on average electric consumption from commercial buildings that are similar to the bakery (e.g., warehouses and production facilities) and the gift shop (e.g., retail stores), EIA data suggests that about 23% of the electricity used in the bakery and 64% of the electricity used in the gift shop is from lighting.[38] Due to the high electricity use in the bakery for fruitcake and honey production and in the gift shop from the heat pump, using these percentages would grossly overestimate the actual power used for lighting these facilities. Without better data, the Team estimated the actual power consumption for lighting by subtracting power estimates of other processes from the total load for each building. We used these results to estimate the total power consumed from lighting for these units, then used those results to estimate the cost savings that could be realized from light bulbs that consume less power, such as compact fluorescent lamps (CFLs) and light-emitting diodes (LEDs).

Energy Consumption from Large Appliances and Electronics

The electricity consumption of large appliances and electronics can be calculated by multiplying the average power used by the product (measured in kilowatts (kW)) by the period of time the device was in operation (measured in hours). The Team was able to estimate the average power consumed by each device by taking a power reading using a device called a Kill-A-Watt (this device is available for purchase on the Internet and in hardware stores for about $40). Knowing the power consumption of each device, the Team then estimated the average amount of time each unit would operate in a year. This is a difficult and, at times, an inexact process.

Energy Consumption from Space Heating and Cooling

Space heating and cooling is a large consumer of energy for most residential and commercial buildings. There are many different systems heating and cooling any given building, so it is important for the community to understand how the community's space conditioning systems achieve these goals before calculating the amount of energy designated for those activities. Boxes 2 and 3 in Appendix 2-A give a high-level overview of the heating and cooling systems that are used by HCA. This section explains the methodology for estimating the energy consumption that results from the use of those systems.

Unit Efficiency vs. Building Envelope

The amount of energy used for space heating and cooling depends on two very important factors: (1) the energy efficiency of the HVAC unit and (2) the construction of the building envelope. The estimated energy lost from unit inefficiencies was estimated by using energy efficiency information recorded by the HVAC inventory. The estimated energy consumed as a result of the building's insulating capacity was determined by using the information gathered by the building material inventory. Each process is explained in greater detail below:

- Unit Efficiency: The efficiency, or energy factor, of the unit that is heating or cooling the space can greatly impact the amount of energy that is being consumed by a building. As the efficiency of the unit increases, a higher percentage of the per-unit energy consumed is used for adding or removing heat from the space. This means that there is less wasted energy and ultimately less energy used to do the same job. It is possible to estimate the average amount of energy used by each HVAC unit annually by knowing the total amount of energy used, as designated by an electric or fuel oil bill, and the energy factor of each HVAC unit consuming the energy.
- Building Envelope: The building construction greatly affects total energy consumption because this factor controls how much air infiltration there is in the building. According to the laws of thermodynamics, the temperature of two adjacent areas—in this case indoor and outdoor areas—will always move towards one equilibrium temperature. In doing so, air in areas of higher heat will move to areas of lower heat. The purpose of heating or cooling the interior of a building is to maintain a temperature difference between the inside and outside of the building (cooler in the summer, warmer in the winter) by limiting the transfer of high heat to low heat. Exterior walls, floors, ceilings, doors, and windows all act as buffers that prevent this type of heat transfer. However, different materials have different levels of ability to resist heat transfer. The ability of a material to resist heat transfers is measured by an R-Value. The higher the R-Value, the greater the insulating ability of the material and the less heat transfer will occur.

Estimating Heating Oil Consumption Patterns

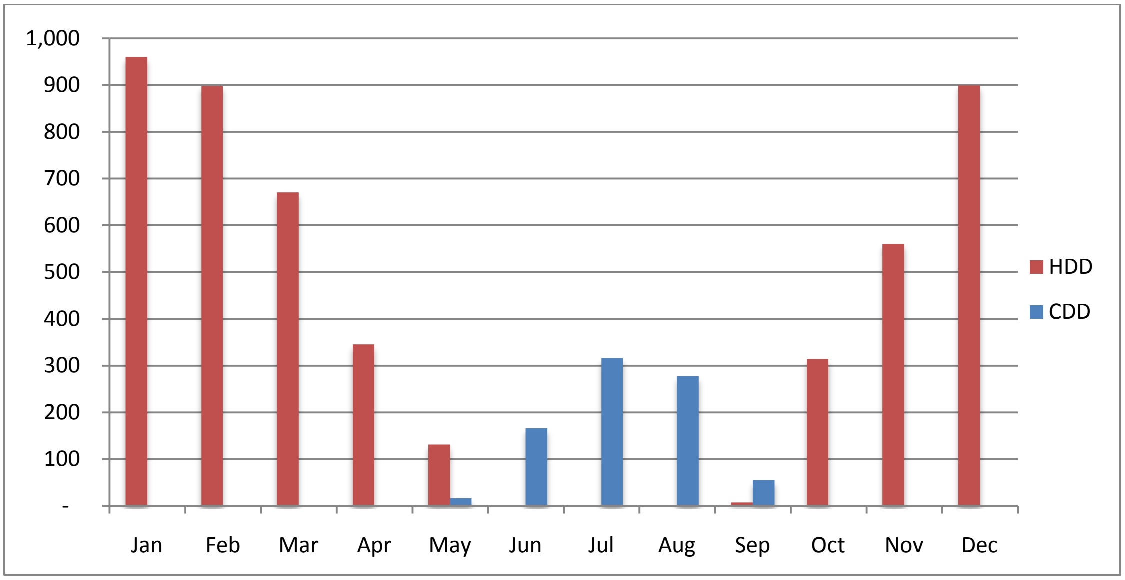
All space heating within the monastic enclosure is generated from boilers that run on fuel oil. Estimating the total annual energy consumed from each boiler was a difficult task for three reasons. First, as Map 5Map 6 in Appendix 2-B show, there are areas of the monastic enclosure where one tank services multiple boilers that heat different building areas. It is very difficult to estimate the percentage of oil used by each boiler that shares a tank without being able to know how often each boiler runs. Second, the AFUE is infrequently labeled on older boilers and the efficiency of these units can worsen over time. When the actual AFUE was unknown, the Team used industry averages of boilers according to the age of the unit, as designated by the US Department of Energy (DOE).[39] Finally, boilers that burn fossil fuels also consume electricity. Such boilers use electricity to: (1) power a blower fan that draws combustion air through air intake slots; (2) drive the oil pump, which transports the fuel from the underground tank to the boiler; and (3) to produce an electrical spark that ignites the combustion within the boiler.[40] It is also very difficult to calculate the total electricity used to carry out those processes.

To simplify the energy consumption baseline for each boiler that serves the monastic enclosure, the Team created separate methodologies for individually estimating the annual oil and electricity consumed for each boiler. Since we used the same methodology for calculating the electricity consumption for HCA's heating and cooling systems, this component of the energy consumption baseline is covered in the next subsection. The Team followed the steps below to estimate the fuel oil use of each boiler.

- Understand fuel oil usage: Before determining the average amount of fuel used by a particular unit, the Team first had to understand the overall consumption patterns at the monastery. The best way to do this was to divide the average annual consumption according to use by month. However, calculating the monthly consumption of fuel oil is difficult. Unlike consumption measurements of natural gas and electricity, which are tracked by metering devices, the daily or even monthly usage of fuel oil is unknown. Quarles, HCA's oil supplier, bills the community on the day it delivers for the amount of fuel that they used to fill the tank. This differs from the per-unit-use billing system often associated with electric or natural gas consumption. Lacking per-unit-use data, the Team was unable to determine when the oil was used and how much was burned on a particular day.

  The Team addressed this stock and flow problem in three steps. First, the Team identified how many days were between deliveries and how many of those days fell into each month. Exhibit 2 in Appendix 2-C is an example of this method using the delivery data for the House 1 fuel oil tank. The Team then divided the total amount of fuel oil according to the number of days in each month. This is exemplified in Exhibit 3 in Appendix 2-C. However, this method for assigning oil consumption by month is flawed because the majority of HCA's fuel use occurs during winter months. We used data for local heating degree days (HDD) and cooling degree days (CDD) to adjust the numbers in Exhibit 3 to reflect the reality that most, if not all, of the fuel oil used by HCA is consumed during colder months. Figure 9 shows a breakdown of heating degree days and cooling degree days for Berryville, VA. HDDs and CDDs are indexes that measure how much a building would have to be heated or cooled during the course of a year. These specific calculations are based on the assumption that the indoor air temperature would remain at 65 degrees Fahrenheit. Table 1 shows the percentage of HDDs and CDDs that each month comprises for the total number of HDDs and CDDs. To better estimate the average amount of fuel oil used each month, the Team totaled the assigned gallons for all the months in each year and then reassigned the amount of oil used each month according to the percentage of heating HDDs that each month typically experiences.

Figure 9: Average heating and cooling degree days for Berryville, VA



NOAA National Climatic Data Center

Table 1: Number of HDD and CDD and percent of total by month

	Average Temperature	HDD	% Total HDD	CDD	% Total CDD
Jan	34	960	20%	-	0%
Feb	33	898	19%	-	0%
Mar	43	671	14%	-	0%
Apr	53	346	7%	-	0%
May	61	132	3%	17	2%
Jun	71	-	0%	167	20%
Jul	75	-	0%	316	38%
Aug	74	-	0%	278	33%
Sep	67	8	0%	55	7%
Oct	55	314	7%	-	0%
Nov	46	561	12%	-	0%
Dec	36	900	19%	-	0%
Total		**4,788**		**833**	

NOAA National Climatic Data Center

1. <u>Integrate building inventory into HVAC modeling:</u> Since it was impossible to know the operation time for each boiler, and thus impossible to calculate the total number of gallons of oil used to fuel each unit, the Team took a backwards approach by estimating the average annual heat loss in one hour. To do this, we entered the information gathered by the building inventory into an HVAC modeling program. The results of the modeling were used to estimate total heat loss, in Btu, for each area of the monastic enclosure.

2. <u>Assign a heating load for each unit:</u> Having an estimate for the total heat loss per hour for each building area allowed the Team to estimate the operation time for each boiler. However, estimating operation time according to this methodology required us to also know each unit's AFUE, which gives the heat output per unit of energy input. By knowing the installation year for each boiler, the Team assumed that each unit had an AFUE consistent with the American Council for an Energy-Efficient Economy's (ACEEE) and Department of Energy's (DOE) estimates for units made in those years.[41] Using these assumptions, which could be flawed, it was possible to calculate the annual use of oil for each unit by assuming that the percentage of the total heat loss of the area serviced by each boiler was equal to the percentage of the total amount of fuel used in the average year.

Estimating Electricity Consumption Patterns

Estimating the amount of electricity consumed by boilers, window air conditioning units, and central air conditioning units is even more difficult than estimating the amount of fuel oil used to run those units. Whereas the fuel oil housed in underground tanks is only used for heating purposes, the electricity used within the monastic enclosure can be attributed to a wide array of activities. However, by using the heat gain and loss estimates from the HVAC model, the Team was able to use these per-unit-of-time estimates and the Btu outputs of each heating and cooling unit to calculate a reasonable estimate for the total operation time for each unit. Additionally, by knowing the electric power requirements of each HVAC unit, the Team was able to multiply a unit's power consumption by the total operational time to get the total amount of energy consumed by each unit. According to EIA's 2001 Residential Energy Consumption Survey, 10.1% of the average American household's electricity is consumed for space heating and 16% is consumed for space cooling.[42] Although HCA is not representative of the average American household, the Team did use these averages as guidelines for understanding the results of the above methodology.

Due to the uncertainty of this methodology, we also made some back-of-the-envelope calculations to verify the magnitude of its results. Specifically, the Team used the EIA's average household electricity percentages in a second method for calculating the electricity consumption for space heating and cooling. This methodology assumed that the month of April did not use any space heating or cooling units. This is a fairly reasonable, although inaccurate, assumption because April has mild temperatures and HCA uses the least amount of electricity for heating and cooling, on average, in this month. Setting April as a baseline, any additional electricity consumption above that month's consumption was assumed to be for either space heating or cooling. As Table 2 shows, any additional electricity consumption above the April baseline in warmer months was assumed to be for space cooling. Likewise, any additional electricity consumption above the baseline for colder months was assumed to be for space heating. It is important to note that there is no air conditioning served by electricity account 34300-1, which is why those months record less electricity than the base month. Additionally, the positive readings in May and October were not counted towards the total amount of power used for space cooling. The resulting breakdown, 8% of total electricity for heating and 15% for cooling, was very similar to EIA's estimated residential averages. The results from this method were a few percentage points lower than the first method, and thus, the Team feels confident in them.

Heating and Cooling in the Bakery and Retreat House

Calculating the amount of energy used for space heating and cooling at the bakery and Retreat House was considerably easier than for the monastic enclosure. We estimated the bakery's use of oil by first estimating the amount of oil used by the oven during the course of a year and then subtracting that fraction from the total number of gallons consumed. When calculating the cooling load for the bakery, the Team used a similar approach to the one that was used for the monastic enclosure. The Retreat House uses oil only to fuel a boiler for space heating. We were unable to calculate a cooling load for the Retreat House due to time constraints and lack of data.

Table 2: Assigning electricity use for space heating (red) and cooling (blue)

	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh
Account #	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
34100-1	1,415	1,218	1,764	-	147	1,652	1,854	2,803	2,570	755	589	1,408
34200-1	1,767	729	1,239	-	318	2,439	4,551	4,850	3,571	1,576	693	1,816
34300-1	504	384	445	-	8	(121)	(117)	(141)	(144)	5	(2)	527

	kWh	kWh	%	%
Account #	**Total Heat**	**Total A/C**	**% Heat**	**% A/C**
34100-1	6,394	9,635	9%	14%
34200-1	6,244	16,988	6%	16%
34300-1	1,858	-	45%	0%
	14,495	**26,622**	**8%**	**15%**

Source: HCA

Energy Consumption from Water Heaters

Due to on-site time constraints and lacking data, the Team only estimated the amount of energy used for hot water in the monastic enclosure. All hot water that is consumed in the monastic enclosure comes from conventional storage water heaters, the most popular system used for household water heating. Box 4 in Appendix 2-A provides a detail explanation of how this system works and compares it to other water heating systems. This system can be fueled either by electricity or fossil fuels (such as natural gas or fuel oil). HCA uses three storage water heaters in the monastic enclosure, two of which are powered by electricity and the other runs on fuel oil. Map 9 and Map 10 in Appendix 2-B show where these units are located as well as the areas of the monastic enclosure that they serve.

Estimating the energy consumption of a storage water heater can be difficult because the device requires energy to heat the water that is being stored even when that water is not being consumed. Therefore, calculating the total amount of energy consumed by a water heater is more complicated than just multiplying its recovery efficiency, which is the amount of energy consumed to heat one gallon of water to a specified temperature, by the number of gallons of hot water consumed. It is important to also consider the standby losses (the percentage of heat loss per hour from the stored water compared to the heat content of the water) and the cycling losses (the loss of heat as the water circulates through a water heater tank, and/or inlet and outlet pipes) for each unit.

Estimating the energy consumption from the two electric water heaters was considerably easier than estimating the amount of oil consumed by the third unit. Both of the electric water heaters are fairly new and have EnergyGuide Labels issued by the Federal Trade Commission (FTC) that provided an energy factor, or overall energy efficiency, for those units. Specifically, the EnergyGuide Labels provided an estimated amount of kilowatt-hours (kWhs) used by each unit in one year under average household conditions. The Team used those ratings as a baseline for the total electricity consumed by those units at HCA. We then multiplied those ratings by a weighting index that adjusts each unit's average annual kWh consumption to the unit's likely use at HCA. For example, the unit that heats the water for the North West Dormitory and Senior Wing supplies more hot water than the unit designated to the Old Dormitory and Mansion, and therefore was assigned a higher weighted index. The weighted index was calculated using the results from the water consumption survey.

Estimating the amount of fuel oil used to power HCA's third storage water heater was more difficult because the unit is a converted boiler that is over 30 years old. Since the unit is very old, there is no recorded energy efficiency information on the unit. Therefore, the Team was forced to make some assumptions to estimate the unit's average annual energy consumption. First, we assumed an energy factor of 0.55, which is consistent with older boilers.[43] Second, we assumed that the 300-gallon oil unit had a demand of about 2.5 times more than the 120-gallon electric units. To calculate the annual energy used, the Team first averaged the kilowatt-hour consumption ratings found on both of the electric units' EnergyGuide Labels and converted that number to Btu. Next, we increased that number by 35% because the average electric water heater has an energy factor of 0.90, which is 35% higher than the 0.55 rating for a water heater running on fuel oil. The Team then divided that number by the average heat content of fuel oil (138,500 Btu per gallon) to get the total number of gallons used under average household conditions. Finally, the Team multiplied the estimated number of gallons under average household conditions by that unit's weighted index to estimate the actual number of gallons the unit requires to supply the community's hot water demands.

Estimating Environmental Impact

As explained in the Context section of this chapter, energy systems are often very damaging to surrounding ecosystems. We evaluated the environmental impact of HCA's energy use by focusing on certain types of air pollution that result from HCA's energy consumption: global warming and smog. This section outlines the methodology we used to calculate the amount of air pollution that results from HCA's energy consumption.

Upstream vs. Downstream

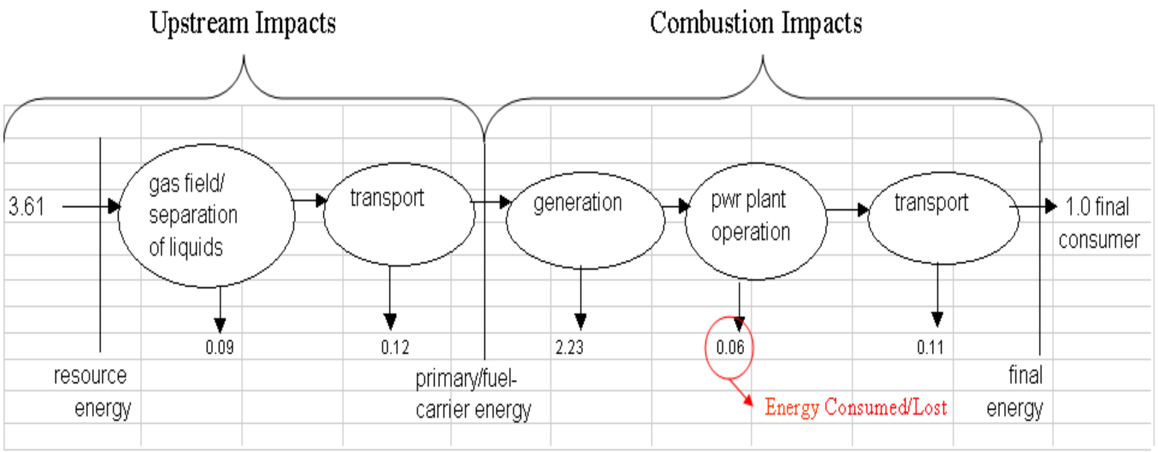
The total fuel cycle impact from the consumption of fuel has two stages: (1) "upstream" emissions, which are associated with the extraction, processing, and delivery of the fuel; and (2) "downstream" emissions, which are associated with the combustion and/or use of the fuel on-site. Classifying emissions as upstream or downstream is not an exact science. Typically, upstream and downstream emissions are distinguished by the state in which the fuel is being used.

Fuel oil used for heating can be used to illustrate these concepts. The upstream impacts associated with delivering one gallon of fuel oil to a specified boiler include the emissions associated with extracting the oil, transporting the oil through pipelines, and any storage processes that occur along the way. By contrast, the downstream impact includes the emissions resulting from the combustion of the oil in the boiler.

Distinguishing the upstream and downstream emissions that result from the use of electricity is more difficult. The upstream impacts of delivering one kWh of electricity to a HCA building are associated with the extraction of the fuel (coal, natural gas, oil, biomass, etc.) used by the electricity generator, the refining of the input fuel (if applicable), and the transportation of that fuel to the generator. The downstream impacts are associated with the actual combustion of the fuel at the generator to produce each kWh. The delivery of each kWh to the facility is also considered in the combustion phase because line loss (the loss in electrical energy as electricity is carried over power lines) must be included to properly calculate the incremental fuel burned by the generator to account for the fractional kWh that is lost during the delivery of each kWh consumed on-site.

Figure 10 provides a simplified example of energy accounting by demonstrating the energy losses associated with the delivery of one kWh of electricity. In this example, 3.61 kWh of fuel would be required to deliver 1 kWh of electricity to the end-use facility, resulting in an efficiency of about 27 percent. All emissions associated with the energy losses in each delivery stage must be accounted for and totaled for that 1 kWh of energy delivered.

Figure 10: Energy accounting example



Source: Keoleian, 2007

Global Warming Potential

According to the Integrated Panel on Climate Change (IPCC), there are over 60 known greenhouse gases, all of which are summarized in Data Table 1 of Appendix 2-D. Each of these gases has a different global warming potential (GWP) based on each molecule's residency in the atmosphere and its ability to absorb and reemit radiation. The GWP of a molecule acts as a weighted index, or impact multiplier, that allows us to compare the severity of impact from one molecule (e.g., CO_2) with another (e.g., CH_4). In this example comparison, methane's (CH_4) longer residency time and greater ability to absorb and reemit the long-wave radiation that is emitted from the earth causes its GWP to be 25 times greater than the warming potential of carbon dioxide (CO_2). Table 3 summarizes the GWP factors, as designated by the IPCC, for all the gases reviewed in this report. By knowing the total amount of each gas emitted, one can use the GWP factors to index the estimated impact of all of the gases emitted by converting them to carbon dioxide equivalents (CO_2eq). This aggregated and indexed number is what most people refer to as a "carbon output" or "carbon footprint" when that impact is assigned to a specific plot of land.

Table 3: Global warming potential factors for greenhouse gases reviewed in this report

Industrial Designation or Common Name	Chemical Formula	Atmospheric Lifetime (years)	100-yr GWP Factor
Carbon dioxide	CO_2	N/A	1.0
Methane	CH_4	12.0	25.0
Nitrous oxide	N_2O	114.0	298.0

Source: IPCC, Fourth Assessment Report

Smog Potential

In addition to greenhouse gases, HCA emits air pollutants that contribute to the formation of smog. When HCA consumes electricity, heating oil, propane, and gasoline they emit NO_X, which can lead to photochemical smog. Furthermore, the community's consumption of electricity also results in SO_2 emissions from coal-burning power plants, which can lead to classic smog. Similar to GHG calculations, the easiest way to calculate and compare the SO_2 and NO_X emissions for those fuels is to convert the aggregated amount of each fuel used into Btu and multiply that number by the emissions factor for the average combustion of each fuel type, as designated by the EPA. Table 4 provides the EPA's estimated emissions per MMBtu from the average combustion of each fossil fuel. For HCA's emissions from its electricity consumption, PJM reported that each kWh generated in 2008 emitted an average of 0.007 pounds of SO_2 and 0.002 pounds of NO_X.[44]

Table 4: NO_X and SO_2 emission factors for the combustion of fossil fuels

Fuel	g SO_2/MMBtu	g NO_X/MMBtu
Heating Oil	0.5126	0.0722
Propane	0.0004	0.0469
Gasoline	0	0.1225

Source: EPA, *AP 42*, 2010

Emissions from Buildings

HCA's building operations comprise the greatest source of the community's greenhouse gas emissions and air pollutants. The carbon output from the buildings results from two main types of activity: building construction and facility use. The first source of impact includes all GHGs emitted throughout the material production and construction phases. Due to time constraints and limited data, this analysis ignores GHGs emitted from construction, which comprise a small proportion of a building's total life-cycle emissions, and focuses on emissions associated with the use of each building. Typically, the greatest contributor to a building's carbon footprint is its use of energy from fossil fuel sources.

The GHGs emitted by the buildings owned and operated by the HCA community come from three sources: electricity, fuel oil, and propane. We only calculated the upstream emissions of the energy consumed by a building when the immediate upstream processes and delivery were well defined.[45] The methodology for estimating the impacts of each fuel type according to upstream and downstream stages for HCA's buildings are explained below:

Emissions from electricity consumption: All facilities evaluated in this report use electricity from the PJM Interconnection electrical grid. Although Allegheny Power bills HCA for its electricity consumption, some of that power may not come from Allegheny Power generators. It is impossible to locate the specific source of each delivered kWh because many generators feed the electric grid.[46] Therefore, we calculated the emissions per kWh from the grid by calculating the weighted average for the aggregated emissions from all fuel inputs used to generate all of the electricity that is fed into the grid and dividing that number by the total number of kWh generated.

Table 5 shows the percentage breakdown, by fuel type, for the total generation that was supplied by the PJM Interconnector in 2008. Since we used annual averages for electricity consumption, as determined by time-series data dating back to 2003, we assumed that each kWh would be generated based on the most recent reported breakdown. Using EPA emission factors, specified according to fuel and combustion type, it is possible to estimate the total carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions for each kWh consumed based on this breakdown. Using the most recent GWP factors from the IPCC (see Table 3), those emissions could be converted to carbon dioxide equivalents. However, PJM tracks their emissions and reported that each kWh generated in 2008 emitted and average of 1.2195 pounds of CO_2eq.[47]

Table 5: PJM's reported 2008 electric grid breakdown by generation fuel type

Fuel	Percentage
Coal	55.6%
Gas	6.8%
Nuclear	34.9%
Oil	0.3%
Renewable	2.4%

Source: PJM Interconnector, 2009

Emissions from fossil fuel consumption: Estimating the upstream emissions associated with the distribution of fuel oil, gasoline, and propane can be difficult and system specific. For the purpose of this report, the Team only accounted for GHGs emitted during the on-site combustion of those fuels and did not account for the upstream emissions associated with the production and delivery of those fuels. We converted the aggregated amount of each fuel used into Btu and then multiplied that number by the emissions factor for the average combustion of each fuel type, as designated by the EPA. Table 6 provides the EPA's estimated emissions per MMBtu from the average combustion of each fuel type.

Table 6: Greenhouse gas emission factors for the combustion of fossil fuels

Fuel	lbs CO_2eq/MMBtu
Heating Oil	161.29
Propane	137.34
Gasoline	155.20

Source: EPA, *AP 42*, 2010

RESULTS

The energy analysis resulted in the following key findings:

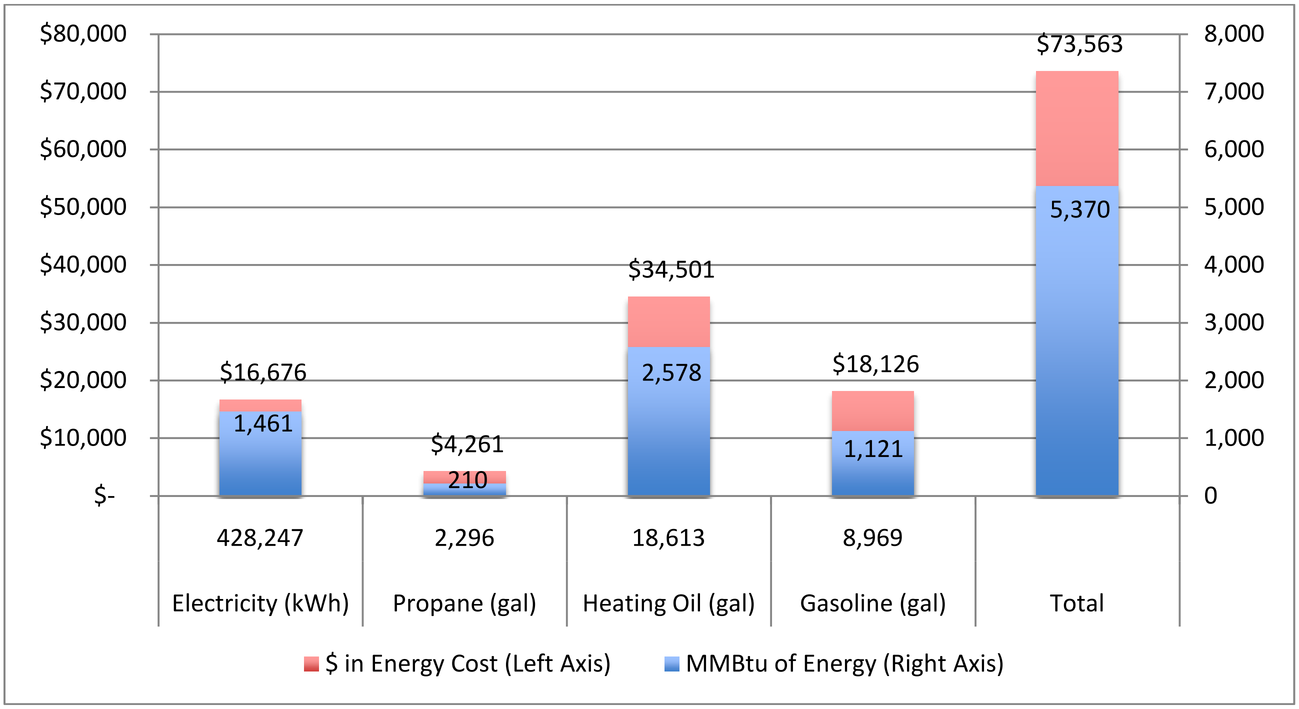
- In total, the community consumes an average of 428,000 kWh of electricity, 2,300 gallons of propane, 18,600 gallons of heating oil, and 1,100 gallons of gasoline per year. The total costs for these fuels equate to roughly $73,500 a year.
- In total, the community's energy consumption emits an average of 570 tons of CO_2eq, 2.82 tons of SO_2, and 0.76 tons of NO_X per year. These emissions negatively impact social welfare and result in estimated soft costs that range from $5,000 to $32,500 each year.
- The space heating system for the monastic enclosure is extremely inefficient for two reasons: (1) the community's boilers are old and energy inefficient; and (2) the building envelope has low insulating capabilities and contains leaks throughout.
- HCA often purchases fuel (e.g., electricity and heating oil) for processes that could be carried out any time during the year (e.g., baked goods and honey production) during months when input energy prices are typically high.

HCA's Aggregated Energy and Carbon Baseline

For a community of 20 residents, four full-time employees, and four part-time employees, HCA's annual energy consumption is relatively low. Figure 11 on the next page summarizes HCA's energy consumption in Btu and cost according to each fuel type used by the community. According to data from the World Resources Institute (WRI) and the EIA, the average American consumes about 334 MMBtu per year.[48] By contrast, the average HCA resident consumes about 269 MMBtu per year. It is not surprising that HCA members consume less energy because they lead a considerably different lifestyle than the average American when it comes to general activities involving consumption, like energy. However, this comparison could be misleading because the national statistic aggregates across all related activities (residential, commercial, industrial, etc.). When compared to the average Virginia household, which comprises an average of 2.54 people, HCA's energy efficiency when undertaking household tasks is relatively poor. The average HCA member consumes about 110 MMBtu per year for household-related activities like space heating and cooling, electronics, appliances, and more. The average Virginia resident averages about 42 MMBtu per year.[49,50]

Moreover, the volume of air emissions that result from HCA's energy consumption is also poor compared to national averages. The EIA estimates that the average US citizen is responsible for about 19.64 tons of CO_2eq each year.[51] Table 7 shows HCA's aggregated annual emissions averaged over 5 years. When all of the carbon emissions are allocated to HCA's full-time residents, each member is accountable for 28.52 tons of CO_2eq each year. Even if emissions attributable to part-time and full-time lay employees are subtracted, the resulting annual per-capita output of 19.67 tons of CO_2eq is still higher than the national average. In addition to its carbon output, HCA directly emits 1.32 tons of SO_2 from the combustion of fossil fuels and indirectly emits an average of 1.5 tons of SO_2 from its use of electricity. HCA also directly emits 0.33 tons of NO_X emissions from the combustion of fossil fuels and indirectly emits 0.43 tons of NO_X from its use of electricity each year, for a total of 0.76 tons of NO_X.

Figure 11: HCA's average annual energy consumption and costs by fuel type



Source: HCA

Air emissions impose social costs to society when they cause environmental problems such as global warming and smog formation. In order to properly compare these environmental costs with the benefits of using energy, economists have attempted to place a monetary value on the negative impacts caused by air pollution. Table 7 summarizes the estimated per-ton costs of emitting each pollutant. Due to the subjective nature of these analyses and the large range of accepted values that result, Table 7 shows the low and high ends of the estimated aggregated costs associated with HCA's annual emissions. Although these costs are not tangible in that they do not show up on an accountant's balance sheet, any reductions in these emissions would benefit society and therefore should be included when evaluating the potential costs associated with HCA's energy use. To make the results of the analysis easier to interpret, we separated these costs (also known as soft costs) from the tangible costs (or hard costs) that are represented on a balance sheet. When combining the hard costs from Figure 11 and the soft costs from Table 7, we find that the total cost associated with HCA's annual energy consumption ranges from about $78,000 to $106,000 per year.

Table 7: HCA's aggregated air emissions and soft costs

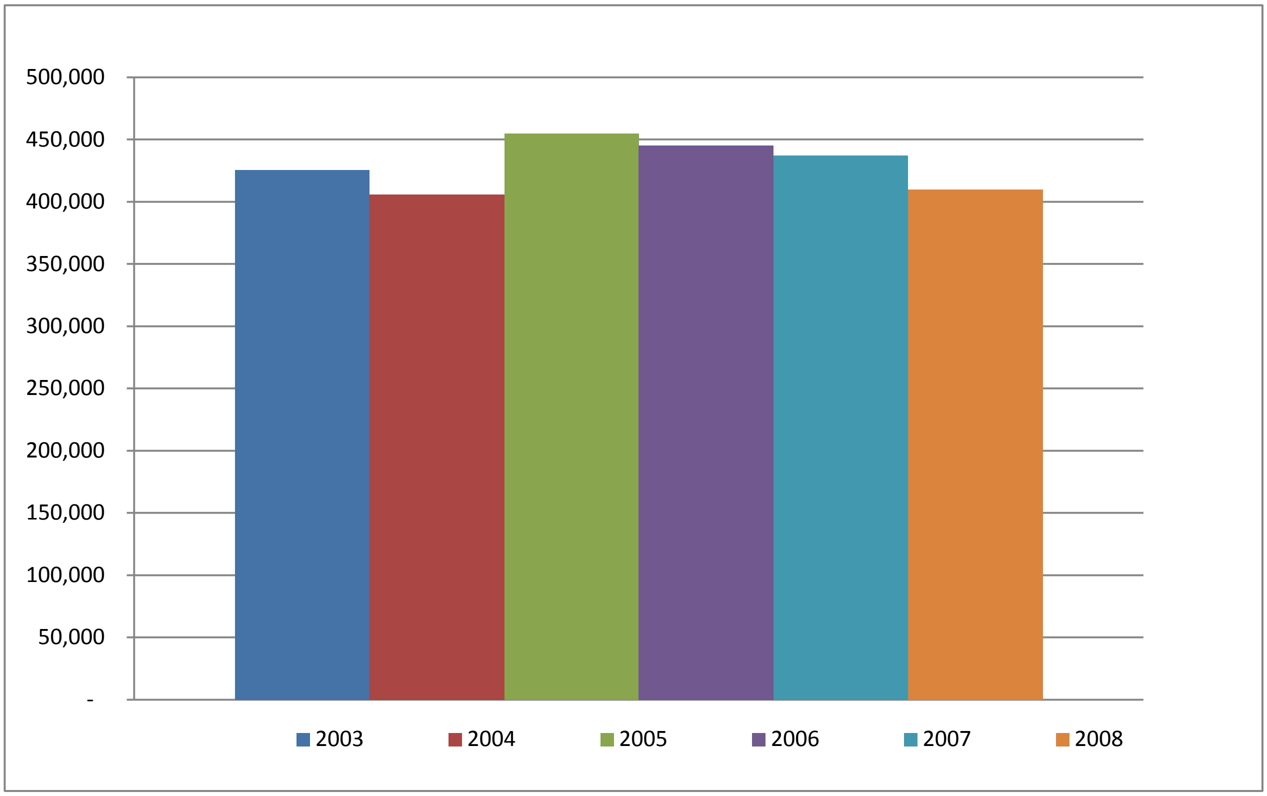
Substance	Emissions (tons/year)	Impact Cost Range ($/ton)	Low Estimate for Social Cost ($/year)	High Estimate for Social Cost ($/year)
SO_2	2.82	$91 - $6,800	$257	$19,179
NO_X	0.76	$2,090 - $10,000	$1,592	$7,616
CO_2eq	655	$5.50 - $10	$3,603	$6,550

Based on the methodology outlined in this chapter, this section disaggregates the results presented above in two ways. First, the Team presents HCA's aggregated energy trends by fuel type to identify periods of excess consumption and to identify times of the year when flexibility in the time of use for certain fuels could save the community money. Second, the Team disaggregates the community's energy consumption according to property unit (residential, business operations, and Retreat House). The purpose of presenting the results in this manner is to help the community identify areas of the property that are less efficient in energy consumption and target specific activities within those units that should be prioritized for changing energy use habits or infrastructure.

Aggregated Trends for Electricity Use

As Figure 12 shows, HCA's annual electricity consumption is fairly stable from year to year and has been decreasing slightly over the last four years. The use of electricity typically comprises about 27% of the community's total energy consumption in Btu. As shown in Figure 13 on the next page, HCA's monthly consumption of electricity is also relatively stable. The community's use of electricity follows typical trends associated with space heating and cooling, as electricity consumption increases in summer months to power the community's central air conditioning systems and increases in the winter months to power the electric motors running the community's boilers and space heaters.

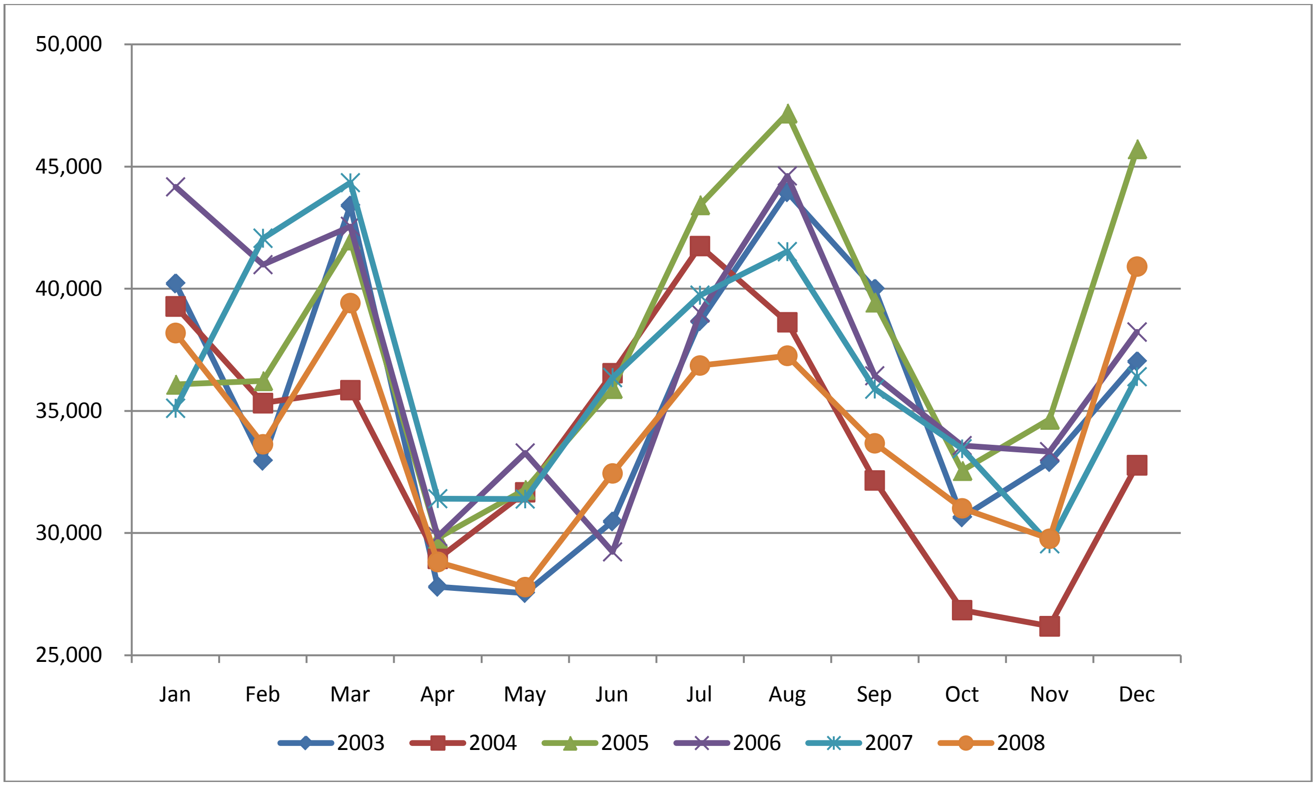
Figure 12: HCA's aggregated electricity consumption by year



Source: HCA

Increased production of fruitcakes and honey probably explains the peaking electricity consumption in other months (e.g., March). The high electricity consumption in the summer months is also due to increased production of fruitcakes and honey.

Figure 13: HCA's monthly electricity consumption by year

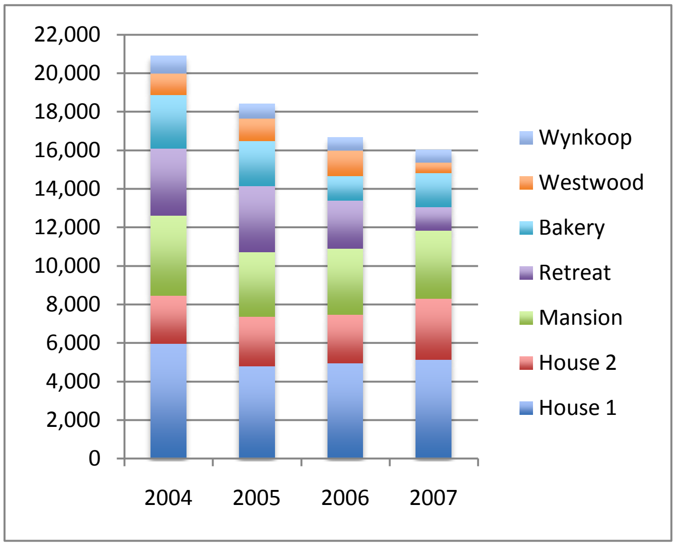


Source: HCA

Aggregated Trends for Heating Oil Use

Comprising 48% of HCA's total energy consumption in Btu, heating oil is by far the largest component of the community's energy portfolio. As Figure 14 shows, the community's use of heating oil has been decreasing. We do not know if this trend has continued because we were only able to gather complete data for the years 2004 through 2007 due to long gaps in scheduled deliveries of the oil to certain buildings on the property. Figure 14 also points out changes in the use of heating oil on the property. For example, the amount of heating oil used to heat the monastic enclosure, which includes the House 1, House 2, and Mansion tanks, is increasing. Conversely, the use of heating oil is decreasing for Wynkoop, Westwood, and the Retreat House. The use of heating oil in the bakery was decreasing until the surge in 2007.

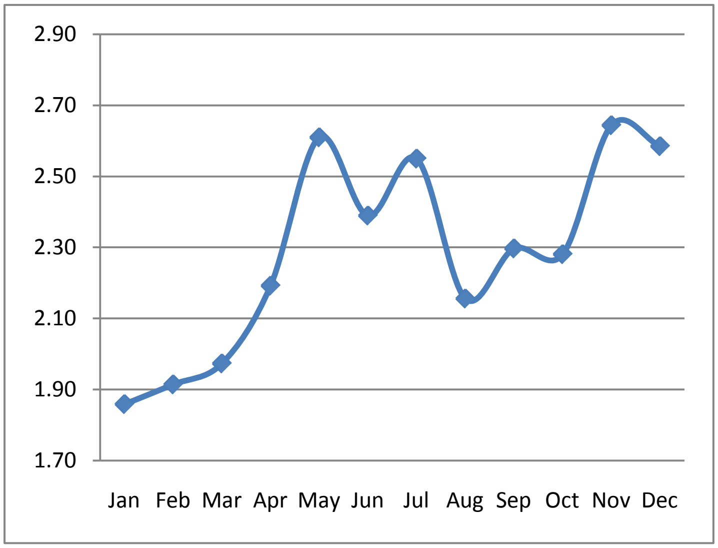
Figure 14: HCA's aggregated heating oil consumption (gallons) by year



Source: HCA

The price of fuel oil typically increases in the summer months and the early months of the heating season. As Figure 15 shows, the average increase in heating oil prices is quite dramatic over those periods. Given that the community has large underground oil tanks, HCA has the capacity to hedge against high oil prices by purchasing large quantities of oil during lower-priced seasons. As Table 8 shows, HCA currently purchases 38% of its fuel oil during the more expensive months (i.e., May, June, July, September, and October). Filling the oil tanks during cheaper months could significantly lower operating costs. It is important to note that heating oil, a derivative commodity of crude oil, can fluctuate in price quite a bit. Purchasing this fuel oil in the early months of the year may not always be the best option. However, recent trends do suggest that prices peak in the summer and early heating months.

Figure 15: Average price ($/gallon) of heating oil by month (2003-2009)



Source: HCA

Table 8: HCA's heating oil purchases by month (2003-2009)

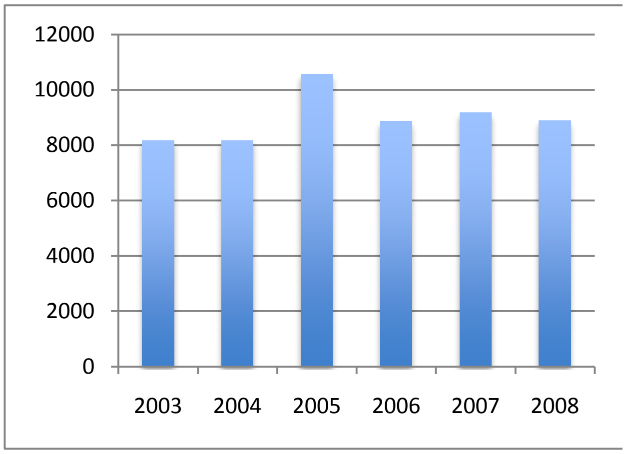
Month	Number of Orders	Percentage of Total
January	18	20%
February	2	2%
March	11	13%
April	5	6%
May	3	3%
June	3	3%
July	0	0%
August	21	24%
September	18	20%
October	7	8%
November	0	0%
December	0	0%

Source: HCA

Aggregated Trends for Gasoline Use

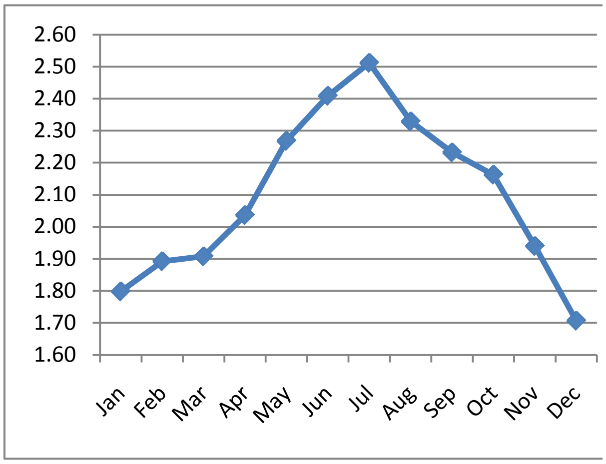
Gasoline consumption by HCA is another large energy expense and comprises about 21% of total energy consumed by the community. As Figure 16 shows, gasoline use at the monastery has increased slightly since 2003, with a large surge in consumption in 2005. Similar to heating oil, gasoline is a byproduct of crude oil and fluctuates in price. Despite those fluctuations, the price of gasoline is typically much higher in summer months than in winter months (see Figure 17). HCA's use of gasoline in those months is low compared to other months, so the community is not significantly impacted by the price premium. However, gasoline is expensive in general so reducing vehicle miles traveled anytime of the year will lower operation costs.

Figure 16: HCA's gasoline consumption (gallons) by year



Source: HCA

Figure 17: Average price ($/gallon) of gasoline by month (2003-2009)



Source: HCA

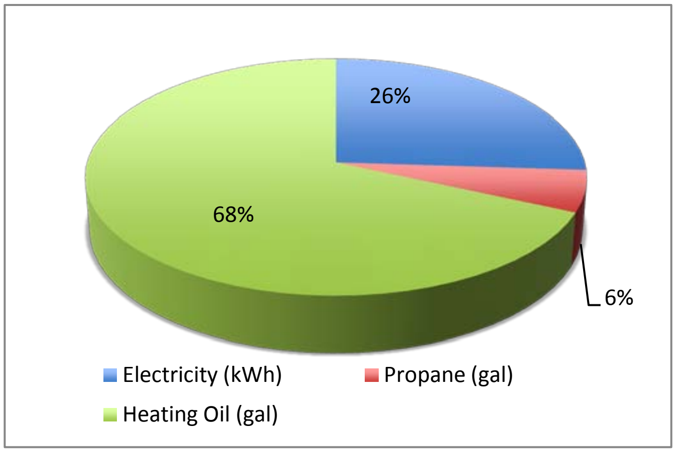
Aggregated Trends for Propane Use

HCA also uses propane for cooking (e.g., stoves) and for the commercial clothes dryer in the laundry room. Propane, which is a cleaner-burning and cheaper fuel, comprises only 4% of the community's total Btu consumption. Propane prices greatly fluxuate, which makes proposing a purchasing strategy difficult. Since this fuel is by far the least used by HCA, the Team did not focus on the community's consumption of propane and would not recommend making the reduction of propane consumption a top priority.

Monastic Enclosure

The monastic enclosure uses more energy than any other unit on HCA's property. Specifically, the amount of energy consumed in this unit comprises 43% of the total energy consumed by the community and 55% of all energy consumed by buildings on the property. As Figure 19 shows, the majority of the energy consumed by this unit is from heating oil, which is used for space heating and water heating. According to the University of Michigan's Center for Sustainable Systems, water and space heating typically comprises about 38% of the average household's total energy consumption, which is considerably lower than the percentage of total energy consumed by HCA. Electricity typically comprises 42% of the average household's energy consumption. This share is significantly larger than the portion of electricity that comprises the monastic enclosure's energy portfolio. Since the residents of the monastic enclosure typically use less electricity from the use of electronics and appliances than the average US citizen, these large discrepancies highlight large inefficiencies in HCA's water and space heating systems. These discrepancies also

Figure 18: Energy consumption within the monastic enclosure by fuel type



indicate that there could be problems with the insulating capabilities of the building's envelope. The following sections break down the Team's findings by energy use category.

Lighting

The Team estimated that HCA uses about 26,500 kWh to 79,700 kWh of electricity and spends about $1,000 to $3,000 per year to artificially light the monastic enclosure. This is a conservative range using the average consumption rates for lighting outlined in the Methodology section. Lighting configurations and resident habits that are specific to the HCA community could cause the actual energy consumption for lighting to be outside of this range. This building unit uses both florescent and incandescent lights. Whereas florescent light bulbs are energy efficient, incandescent light bulbs are not. After taking an inventory of all lighting fixtures in the monastic enclosure, the Team estimated that about 65% of all lighting is from incandescent light bulbs. The community's high use of incandescent lighting serves as an opportunity for reducing HCA's electricity and associated costs.

Appliances and Electronics

Estimating the total amount of electricity used by appliances and electronics was very difficult since we were not able to record device activity with an electricity monitor, as this device was uninstalled after causing a malfunction of the church lights. Due to the secluded and simple lifestyle of HCA's residents, the Team assumed that the electricity consumption from appliances and electronics per resident is considerably lower than that of the average American, and therefore spent less time analyzing this energy use category. However, the Team did identify devices that consume a large amount of electricity. Table 9 shows the results of this inventory and the estimated costs associated with the use of each device.

Although the devices in Table 9 use a considerable amount of electricity, they represent only 5.7% of the unit's total electricity consumption. There are many other smaller electrical devices scattered throughout the unit that, in aggregate, consume much more electricity. Determining the electricity consumption of those devices would be very time consuming and outside of the scope of this project. Despite this lack of information, HCA's habits when using electronics and appliances can greatly impact the total amount of electricity consumed by this unit. In general, the community should attempt to turn off all devices when possible and install power strips that eliminate standby power.

Table 9: Summary of large electronics and appliances within the monastic enclosure

Building Area	Electric Account	Appliance Type	Brand	Number of Units	Estimated Annual Energy per Unit (kWh)	Estimated Annual Cost
Infirmary Wing	34200 1	Refrigerator	Whirlpool	2	420	$31
Dining Area	34200 1	Refrigerator	Hobart	1	2,498	$92
Dining Area	34200 1	Freezer	Larkin	1	3,425	$126
Dining Area	34200 1	Refrigerator & Freezer	Unknown	1	1,239	$45
Laundry	34100 1	Clothes Washer	Whirlpool	1	886	$35
Laundry	34100 1	Clothes Washer	Wascator	1	524	$20
Boiler Room	34100 1	Clothes Washer	Kenmore	1	743	$29
Throughout	All Accounts	Desktop Computer	Varied	30	299	$365
Total					**10,034**	**$743**

Space Heating and Cooling

Space heating and cooling comprises more than 75% of total energy consumed by the monastic enclosure when accounting for both heating oil and electricity use for those activities. The percentage of energy consumed by space heating, which accounts for about 70% of this unit's total energy use, is more than twice as high as the average US residence.[52] Space heating dominates the unit's energy consumption for two reasons. First, the boiler system used for heating the monastic enclosure is old and very inefficient. In comparison, the cooling systems installed in the unit are newer and much more efficient, and thus, represent a more typical energy load for carrying out their purpose of space cooling and conditioning. Second, the patchwork structure of the monastic enclosure's building envelope also causes a large discrepancy between the energy used for space heating and cooling. Tables 10 and 11 summarize the results of the HVAC modeling for the monastic enclosure.

Table 10 shows the estimated heat loss in Btu per hour for all major residential areas. The large range of heat loss amongst areas is not surprising considering that the monastic enclosure is actually a number of separate buildings that are connected. Some areas of this unit, such as the business and infirmary wings, are very well insulated and use considerably less energy for heating. Conversely, areas like the Sacrament Chapel are poorly insulated and have large areas of single-paned windows. These areas consume an incredible amount of energy for heating per square foot. The unit's cooling loads are much lower for similar reasons. For the most part, the spaces conditioned by the unit's cooling systems are areas of new construction that have double-paned windows and proper insulation. These areas include the business and infirmary wings, the chapter room, and the senior wing. Table 11 shows the estimated heat gains per major area of conditioned space.

Table 10: Results of heat loss modeling by fuel oil tank

Heating Oil Account	Ft^2	Total Btu/H Heat Loss	Btu/H per Ft^2
House 1 Tank			
Church	3,587	62,323	17.37
Chapter Room Area	1,332	35,530	26.67
Abbot Office Area	581	22,277	38.34
Below Church	3,645	49,903	13.69
Lower Library Area	2,258	22,279	9.87
Sacristy	352	6,745	19.16
Sacristy Stairwell	225	6,945	30.87
Laundry	446	45,643	102.34
Bakery Storage Room	3,274	12,270	3.75
Elevator Lobby Area (Basement)	857	7,955	9.28
Business Offices	1,376	18,610	13.52
Elevator Lobby Area (Ground)	857	9,316	10.87
Kitchen	1,376	22,266	16.18
Refectory/Dishwashing Area	3,284	33,610	10.23
Infirmary	3,284	43,745	13.32
Elevator Lobby Area (Upper)	857	10,653	12.43
Total/Average	***27,591***	***410,070***	***14.86***

House 2 Tank			
Novitiate Basement	148	363	2.45
Novitiate Area	1,194	19,628	16.44
Sacrament Chapel	636	390,940	614.69
Changing Room	148	7,444	50.30
Novitiate Hall	585	8,845	15.12
NW Dormitory	3,474	48,657	14.01
NW Wash Area	985	11,298	11.47
Senior Wing	1,836	40,337	21.97
Total/Average	***9,006***	***527,512***	***58.57***

Mansion Tank			
Mass Crypt/Secretary	385	24,303	63.12
St. Joes	1,099	62,459	56.83
Mansion 1st Floor	1,710	80,204	46.90
Mansion 2nd Floor	1,710	95,463	55.83
Mansion Basement	1,710	57,287	33.50
Old Dorm Basement	2,082	63,204	30.36
Old Dorm Ground Floor	2,082	89,628	43.05
Total/Average	***10,778***	***472,548***	***43.84***

Grand Total/Average	**47,375**	**1,410,130**	**29.77**

Table 11: Results of heat gain modeling by cooling system

Account	**Ft^2**	**Total Btu/H Heat**	**Btu/H per**
Church and Chapter Room			
Church	3,587	33,281	9.28
Chapter Room Area	1,332	11,120	8.35
Sacristy	352	6,745	19.16
Total/Average	***5,271***	***51,146***	***9.70***

NW Dorm and Senior Wing			
Novitiate Hall	585	3,433	5.87
NW Dormitory	3,474	19,714	5.67
Senior Wing	1,836	20,145	10.97
Total/Average	***5,895***	***43,292***	***7.34***

New Wing			
Bakery Storage Room	3,274	741	0.23
Elevator Lobby Area (Basement)	857	2,098	2.45
Business Offices	1,376	5,194	3.77
Elevator Lobby Area (Ground)	857	3,734	4.36
Kitchen	1,376	11,198	8.14
Refectory/Dishwashing Area	3,284	13,971	4.25
Infirmary	3,284	20,320	6.19
Elevator Lobby Area (Upper)	857	4,536	5.29
Total/Average	***15,165***	***61,792***	***4.07***

Grand Total/Average	**26,331**	**156,230**	**5.93**

Heating the monastic enclosure is very expensive. The Team estimated that the boiler system consumes about 22,000 kWh each year, or about 12% of this unit's total power load. It costs HCA more than $800 per year just to run the electric motors for the boiler system. Also, the boilers consume about 11,500 gallons of heating oil per year, which equates to an average annual cost of more than $21,000. The unit's heat gain is much less than its heat loss, and air conditioning is only in certain locations. Under these conditions, the monastic enclosure uses an annual average of almost 27,000 kWh for air conditioning, which equates to about $1,000 a year.

Water Heating

Each resident in the monastic enclosure consumes about 160 MMBtu of energy per year for water heating, which accounts for about 7% of the total energy used by this unit. At first glance, this percentage seems low compared to the average US household's, in which water heating comprises about 12% of the total energy consumed on-site.[53] However, the average resident in the Middle Atlantic region of the country consumes a little over 3 MMBtu of energy if the household is using an electric water heater and a little over 13 MMBtu of energy if the household uses a water heater fueled by oil.[54] The estimate for HCA's residents is consistent with this range, considering that about 65% of the hot water use comes from the community's two electric water heaters and about 35% comes from a converted boiler. The fact that water heating comprises a small percentage of the total energy consumed within the monastic enclosure further supports the Team's assumption that the unit's space heating systems are very inefficient.

Environmental Impact

The environmental impact caused by the monastic enclosure is large. Table 12 and Table 13 break down those impacts according to use of fuel oil and electricity within this unit. The most striking result found by the Team's assessment of the monastic enclosure is that the unit's extremely inefficient heating systems and poorly insulated building envelope generates a large proportion of the property's total emissions. Based on these results, we have determined that each resident of the monastic enclosure is, on average, responsible for 13.63 tons of CO_2eq, 0.07 tons of SO_2, and 0.01 tons of NO_X each year. These per-capita figures demonstrate that the habits of the HCA community and its residential building contribute to a majority of the air emissions created by the property. In total, the estimated soft costs associated with these emissions range from $2,200 to $12,600 per year.

Table 12: Environmental impact from combustion of fuel oil in the monastic enclosure

Fuel Oil	Tank	Gallons	Tons CO_2eq	Tons SO_2	Tons NO_X
Boilers					
Aldrich Company	House 1	2,683	38.63	0.19	0.03
Weil-McLain 1	House 1	1,689	24.32	0.12	0.02
Weil-McLain 2	House 2	3,576	51.48	0.25	0.04
Burnham Commercial	Mansion	2,623	37.76	0.19	0.03
Water Heater					
Aldrich Company	House 1	872	12.56	0.06	0.01

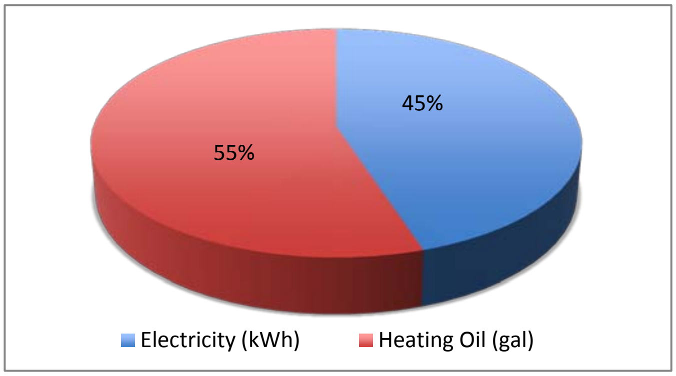
Table 13: Environmental Impact from Use of Electricity in the Monastic Enclosure

Electricity	Electric Account	kWh	Tons CO_2eq	Tons SO_2	Tons NO_X
Boilers					
All Electric Motors	All	14,495	8.84	0.05	0.01
Water Heaters					
A.O. Smith	34300 1	949	0.58	0.003	0.001
Bradford White	34100 1	10,437	6.36	0.04	0.01
Air Conditioning					
All A/C Units	All	26,622	16.23	0.09	0.03
Appliances & Electronics					
All Large Units	All	10,034	6.12	0.04	0.01
Lighting					
All Lighting	All	15,934	9.72	0.06	0.02
Remaining Electricity					
All Excess Consumption	All	98,569	60.10	0.34	0.10

Business Operations

For the purpose of this analysis, the Team assumed that HCA's business operations are housed in two buildings: the bakery and the gift shop. Although some business activities occur within the monastic enclosure (e.g., storing fruitcakes and housing business offices), it was difficult to separate the energy used for those operations from the energy used for residential purposes. Under this designation, we found that HCA's business operations consume about 12% of the total energy used on the property. This overall consumption includes about 22% of the total electricity and about 12% of the total heating oil consumed on the property. The gift shop, which is heated by a heat pump that is powered by an electric motor, operates completely on electricity. On average, the gift shop's electricity consumption equates to almost 24,000 kWh (81 MMBtu) per year. The bakery uses electricity for lighting and machinery and heating oil for heating and fueling the fruitcake oven. The average annual energy consumption for the bakery is split evenly between electricity (about 71,000 kWh or 243 MMBtu per year) and heating oil (about 2,100 gallons or 297 MMBtu per year). Figure 19 shows the percentage breakdown of the bakery's energy consumption. The following sections disaggregate the energy consumed by the business unit according to activity.

Figure 19: Energy consumption within the bakery by fuel type



Source: HCA

Establishing energy trends for the business unit was difficult when it came to measuring oil consumption but very easy when it came to measuring electricity consumption. In addition to space heating, the bakery uses fuel oil for baking fruitcakes. It consumes a large amount of this resource during high production months (e.g., in the summer). Unlike in the analysis for the monastic enclosure, the Team could not assume that the bakery's oil consumption aligned with the location's heating and cooling degree days. Thus, the Team was unable to provide trend data for the bakery's consumption of fuel oil. Conversely, monthly electric data from HCA's power bills provided easy trend analysis. Figure 20 shows how electricity consumption changes throughout the year for both the bakery and the gift shop. Being heated by a heat pump, the gift shop is heavily reliant on electricity and experiences peak demand in colder months. The bakery, on the other hand, experiences its peak load during summer months when space cooling and refrigeration demands increase and in months with increased production (e.g., March and the summer months).

Figure 20: electricity consumption (kWh) by business activity and month

Source: HCA

It is important to note that disaggregating the unit's energy use according to business process was extremely difficult, and the Team's approach for generating the process-related results was inexact and often relied on heroic assumptions. The Team's inability to gather reliable data was the main reason for this difficulty. For example, we were unable to find energy use data for the oven or to explain the large amount of electricity consumption that was recorded from two fruitcake bakes. Therefore, the process-related results presented below should be considered as rough estimates and are presented with a low level of confidence.

Lighting

Lighting for HCA's business unit is relatively insignificant. All lighting in the bakery is from fluorescent ballasts, and thus is fairly energy efficient. With a maximum power of 0.5 kW (when all lights are turned on), the energy consumption from lighting at the bakery seems insignificant when compared to the maximum power that is generated by the lights in the monastic enclosure, which equates to about 26 kW. Based on the Team's estimated occupancy hours, the amount of electricity consumed for lighting at the bakery is estimated to be between 1,000 kWh and 2,000 kWh per year. Such power consumption only equates to about $35 to $70 per year. The amount of electricity consumed for lighting at the gift shop is considerably less, and the Team did not allocate time to estimate the power load needed for lighting at that unit.

Machinery and Oven

A significant share of the bakery's energy consumption is from the machinery and oven used to produce HCA's baked goods and other food. A typical fruitcake bake uses electricity to power industrial appliances, electric motors, fans, and the oven. By analyzing power meter readings taken at various times during two bakes, the Team determined that the total amount of electricity consumed during a typical fruitcake bake is about 1,000 kWh. In 2009, the community held

15 bakes, which would have resulted in a total of about 15,000 kWh for the year. The total amount of electricity consumed from making fruitcakes equates to about $550 per year.

Each bake also consumes oil for fueling the oven. It is estimated that the oven uses a little more than five gallons of oil per bake, or almost 80 gallons per year. It is important to note that the oven model used at the bakery has been discontinued and the Team was unable to gather accurate data, although one technician we contacted estimated that the oven utilizes 145,000 to 180,000 Btu per hour. Therefore, it is possible that the actual number of gallons used by the oven could be higher than we estimated—maybe even significantly higher. At these estimates, the amount of oil consumed for producing fruitcakes equates to about $150 per year.

Honey production also uses a significant amount of energy. Unlike fruitcake production, which consumes both electricity and fuel oil, HCA's honey production only requires electricity. The Team estimates that about 350 kWh of energy is consumed during each day of honey production, which results in about 9,500 kWh per year.

Space Heating and Cooling

Space cooling at the bakery presents a unique problem because of the need for the building to maintain large temperature differences in adjacent rooms. The ingredients and batter used to make the fruitcakes must be stored in a cool room so they do not spoil. However, the room containing the oven is adjacent to this storage room, and the oven room can get very hot. To further exacerbate the problem, a poorly insulated sliding door serves as the only thermal mass resisting heat gain from the oven room to the ingredient storage room. Thus, the air conditioning unit cooling the ingredient room often competes with the high heat radiated by the bakery oven, especially during hot summer days. This condition, in tandem with the high cooling loads needed to store the ingredients during the summer months, causes the amount of power used for space cooling to be high. Depending on the year and the amount of bakes, we estimate that the annual cooling load could range from 25,000 kWh to 45,000 kWh, which equates to between $900 and $1,750 per year.

Space heating is a large consumer of energy at both the bakery and the gift shop. Due to the relatively poor insulation, the bakery uses a considerable amount of energy for heating. In total, the Team estimates that the bakery consumes about 2,100 gallons of oil for space heating, which equates to about $3,900 a year. Additionally, the bakery consumes almost 4,000 kWh of electricity per year to power the heating system, which amounts to about $145. The heating system for the gift shop is power entirely by electricity. We estimate that the heat pump at the gift shop consumes an average of 5,000 kWh per year. Heating the gift shop costs the community around $200 a year.

Environmental Impact

When compared to the monastic enclosure, the business unit's impact on the environment from airborne emissions is relatively low. Most of those impacts are from bakery processes. Table 14 summarizes all air emissions from the business unit for an average year. Although a fraction of the community's residential impact, these impacts are significant for the size of bakery's production capacity. As Table 14 also shows, the total estimated soft costs burdening social welfare could be valued at more than $5,000. When compared to the total average annual energy costs for the business unit, which is about $7,600, the soft costs associated with the use of that energy are high.

Table 14: environmental impact from energy consumed by the business unit

Fuel	tons CO_2eq	tons SO_2	tons NO_X	Combined Soft Costs ($)
Electricity	58	0.33	0.10	$560 to $3,825
Heating Oil	24	0.15	0.02	$190 to $1,460
Total	**82**	**0.49**	**0.12**	**$750 to $5,285**

Retreat House

We estimate that HCA uses almost 40,500 kWh of electricity and spends about $1,500 per year to artificially light the Retreat House. As in the monastic enclosure, lighting configurations and visitor habits could cause the actual energy consumption for lighting to be higher or lower than this estimate. This unit uses both florescent and incandescent lighting, but compact fluorescents and motion detectors are already strategically located in the unit's halls to reduce current power consumption. However, this strategy is not used in guest rooms or other areas of the building. After taking an inventory of all lighting fixtures in the Retreat House, the Team estimated that about 62% of all lighting is from incandescent light bulbs. Such a high use of incandescent lighting serves as an opportunity for reducing HCA's electricity and associated costs.

The aggregated environmental impact from Retreat House operations is on par with the business unit. Table 15 summarizes these results. Due to lacking information, the Team was unable to disaggregate these impacts according to specific processes and operations.

Table 15: Environmental impact from energy consumed by the Retreat House

Fuel	tons CO_2eq	tons SO_2	tons NO_X	Combined Soft Costs ($)
Electricity	54	0.31	0.09	$510 to $3,550
Heating Oil	29	0.18	0.03	$240 to $1,800
Propane	50	0.0003	0.03	$340 to $800
Total	**132**	**0.49**	**0.15**	**$1,090 to $6,150**

OPTIONS

Based on the results of HCA's energy consumption baseline, the Team concluded that there were great opportunities for reducing the community's energy use and the costs associated with that use. This section offers the HCA community various options for reducing the amount of energy consumed on the property. These options are ordered from least to most capital intensive. In addition to estimating energy and emission reductions for each option, the Team also estimated the total financial savings that the community would realize over the appropriate lifespan of each option. Some of these options may not result in a noticeable hard cost reduction for the community, but the options nevertheless are attractive due to the large reduction in soft costs imposed on society from negative environmental impacts.

A summary of the options presented in this section is listed below.

- Option 1: Adopting/continuing energy conservation behaviors
- Option 2: Improving lighting systems by converting to compact fluorescent lamps, installing occupancy sensors, increasing the amount of natural daylight that is able to enter HCA's buildings, and/or installing daylight controls
- Option 3: Improving the use of appliances and electronics by installing smart power strips and/or replacing old appliances with ENERGYSTAR® Units
- Option 4: Improving water heating systems by insulating or replacing water heating units

- Option 5: Improving heating and cooling systems by installing programmable thermostats, switching to forced air with individual room thermostats, replacing or retrofitting older boilers, and/or retrofitting buildings for passive solar design
- Option 6: Improving the building envelope by improving weatherization, roof insulation, and/or exterior wall insulation, and/or replacing single-pane windows
- Option 7: Install on-site renewable energy sources (e.g., wind power and/or solar power)

A Note on the Financial Analysis

Due to many variables relating to the installation and initial purchase costs associated with many of the options in this section, we were not always able to take these costs into consideration. We provide unit and installation costs when possible, and sometimes present a range of costs. However, upfront costs for any energy-saving project are an important component of the decision-making process for accepting that project. Instead of making bold assumptions regarding upfront costs, we converted the estimated stream of savings expected for each year into one monetary value that is measured in today's dollars (also known as the present value (PV) of the stream of savings realized by implementing a particular option). When evaluating the financial viability of an option, the community should receive professional estimates on installation and unit costs and subtract those costs from the option's PV. If the resulting number is positive, then that option is financially viable and should be implemented.

Estimating the PV of a stream of savings is based on assumptions that have a strong impact on the results of the estimates. Key variables that must be assumed in any PV analysis include: (1) the life of the project in years; (2) an appropriate risk factor (e.g., discount rate) for making any capital outlays, which usually includes the forgone opportunity to invest those outlays in lower-return, but risk-free investments; and (3) inflation rates for prices of energy inputs, such as oil and electricity. The life of the project varies by the type of project and estimated life of the units installed. For example, the optimal project life for a refrigerator may be 10–12 years, meaning that a new refrigerator should be replaced every 10–12 years.

The risk factor also varies among projects. Projects with high initial capital outlays and less certain results should have higher discount rates than projects with lower outlays and more certain results. For example, some of the building-related options presented below require large capital outlays, and the results of those projects are uncertain because they are estimated using computer modeling. These projects were assigned a higher discount rate (15%) than low-cost and low-risk options like light bulb replacements (6%). Table 16 summarizes the Team's discount rate assumptions.

Lastly, the future price of energy inputs greatly influences the financial savings that would be realized upon the completion of a project. The Team based the cost of each energy input on averaged costs paid by HCA over the last five years. Using this data, the Team used a price of $1.85 per gallon for oil and a price of $0.039 per kWh for electricity. Based on the EIA's conservative projections of local energy prices, the Team assumed that oil prices would increase at a rate of 1.5% per year and electricity prices would increase at a rate of 0.3% each year.[55] These percentages could increase significantly if global oil prices spike again or if the US Congress passes climate change legislation.

Table 16: Discount rate assumptions by type of project

Project Type	Nominal Discount Rate	Real Discount Rate Used to Calculate Oil Savings	Real Discount Rate Used to Calculate Electricity Savings
Low-cost, low-risk	6.0%	4.4%	5.7%
Medium to large capital outlays with high certainty in energy savings	8.0%	6.4%	7.7%
Large capital outlays and/or energy savings based on computer modeling	15.0%	13.3%	14.7%

Option 1: Adopt/Continue Energy Conservation Behaviors

According to a survey that was administered to the HCA community, most members attempt to reduce their use of energy via various activities ranging from choosing shorter washer and dryer cycles for laundry to combining trips when leaving the property. Despite some of these important and commendable efforts, there are still additional behaviors that HCA members can adopt to conserve energy. In light of this, the Team proposes the following:[56,57]

- Set the thermostat to 68 degrees (or lower) during the day and 60 degrees (or lower) at night during winter months (discussed in detail in Option 5).
- Use ceiling fans and open windows when possible instead of using the air conditioner.
- Set the air conditioner to 75–78 degrees and raise it to 82 degrees when people are not around (discussed in detail in Option 5).
- Turn the water heater down to 120 degrees.
- Insulate the water heater with an insulating jacket (discussed in detail in Option 4).
- Wash laundry in cold water.
- Use a line or a drying rack to hang dry clothes instead of using the electric dryer.
- If a dryer is used, only dry full loads and like materials (e.g., don’t mix towels and sheets) and use dryer balls (see http://www.simplygoodstuff.com/dryer_magic-dryerballs.htm).
- Turn off computers at night and use standby/sleep settings; ideally, setting computers to standby after 15 minutes of inactivity is optimal.
- Turn off lights when lighting is not needed and place small signs by light switches to remind users to flip the switch off when they exit the room.
- Assign someone to ensure that specific appliances are turned off at the end of the evening.
- Use task lighting rather than overhead lighting when possible.
- Clean refrigerator heating coils once a year.
- Keep the refrigerator temperature between 35 and 38 degrees for maximum efficiency and safety.

- Lower window shades or curtains on the south side of all applicable facilities to block the sun in the summer and raise them to allow solar gains in the winter.
- Use the smallest possible cooking appliance when warming up or cooking individual-sized portions of food (e.g., microwave, toaster oven, table-top grill, etc.) rather than a full-sized oven.
- Weather strip doors and windows (discussed in detail in Option 6).
- Clean the furnace and air conditioning air filters every month while in use.
- Unplug electronics that are not used regularly to avoid phantom load energy loss and plug other more frequently used items into an easily-accessible power strip that can be turned off (discussed in detail in Option 2).
- Check vehicle tire pressure once a month and inflate if necessary to manufacturer's standards. Placing a small sign or note on the dashboard would help remind drivers to check the tire pressure during the first week of each month.
- Turn off the car and refrain from idling if parked for more than ten seconds.
- Warm up vehicles for only 30 seconds during the winter season (applicable to modern cars).
- Combine errands to limit the number of vehicular trips.
- Conduct regular maintenance on all vehicles.
- Buy energy-saving products when possible.

Option 2: Improve Lighting Systems

Artificial lighting at HCA consumes a lot of power and is a major cause of the site's emission of greenhouse gases and air pollutants. Luckily, improving the efficiency of lighting systems is often inexpensive and easy to do, and usually results in a quick financial payback. Other than changing the community's lighting use habits, there are three actions HCA can take to significantly reduce its power demand from lighting. These options are summarized below.

Convert to CFLs

Compact fluorescent lamps (CFLs) are excellent substitutes for the traditional incandescent light bulb. As Table 17 shows, CFLs typically use only about 25% to 35% of the power needed to power an incandescent bulb and have a lifespan that is about 10 times longer.[58] Although the average CFL can be anywhere from two to four times more expensive than the average incandescent, the incredible energy savings that can be realized by converting to CFLs often results in a payback time of no more than 2 years (when assuming an 8% interest rate on the investment). Since more than 60% of lighting in both the monastic enclosure and the Retreat House is from incandescent lights, the Team calculated the potential financial savings and reduction in environmental impact that could be achieved by changing all of these units to CFL lights. Included in the environmental impact are the Team's estimates of the savings in soft costs associated with reducing greenhouse gases and air pollutants. Table 18 and Table 19 summarize the results of this option.

Table 17: Comparing incandescent bulbs and compact florescent lamps (CFLs)

Incandescent Bulbs (watts)	Compact Florescent Lamps (watts)	Minimum Light Output (lumens)
40	9 – 13	450
60	13 – 15	800
75	18 – 25	1,100
100	23 – 30	1,600
150	30 – 52	2,600

Source: DOE

Table 18: Financial results achieved by replacing incandescent light bulbs with CFLs

Building Unit	Estimate Range	% Power for Lighting	Assumed Life of Option	Assumed Unit and Installation Cost[59]	Estimated Annual Savings	PV of Energy Savings	NPV of Energy Savings
Monastery	Low	15%	5	$491	$514	$3,460	$2,969
Monastery	High	45%	5	$491	$1,543	$7,321	$6,830
Retreat House	No Range	45%	5	$316	$240	$1,803	$1,487

Table 19: Environmental benefits from lighting replacements when accounting for externalities

Option	CO_2eq Reduced (tons)	NO_x Reduced (lbs)	SO_2 Reduced (lbs)	Low PV Soft Costs	High PV Soft Costs	Low NPV Soft Costs	High NPV Soft Costs
Monastery (Low)	8.04	26.38	92.32	$3,780	$5,676	$3,289	$5,185
Monastery (High)	24.13	79.13	276.97	$8,281	$13,971	$7,791	$13,480
Retreat House	3.75	12.29	43.02	$1,952	$2,836	$1,636	$2,520

Install Occupancy Sensors

Occupancy sensors are devices that replace standard light switches to automatically turn on lights in a room when people are present and turn off lights when people are not present. Aside from providing a convenient service of controlling a room’s lighting, occupancy sensors remove the need for a household or community to change its lighting habits because this change would be absorbed by the system of sensors. According to the DOE, there are two main types of occupancy sensors: (1) ultrasonic sensors that detect sound made by occupants and (2) infrared sensors that detect occupant heat and motion.[60] The appropriate sensor can differ according to the room since certain appliances and other activities that give off heat or make sound could trigger or distort one type of sensor but not another. Therefore, further consultation from lighting installation experts should be considered if this option is attractive.

According to the National Electrical Manufactures Association, occupancy sensors, when used appropriately, can reduce the amount of power used for lighting by 17 to 60 percent.[61] Higher savings are most realized in areas of infrequent or unpredictable traffic, such as restrooms and halls.[62] Thus, HCA is probably already experiencing large savings at the Retreat House, where occupancy sensors have been installed. The financial savings and the avoided soft costs from environmental externalities that would be realized by installing occupancy sensors more than compensate for the cost of installing these systems, which is typically about $50 to $150 per unit.[63] Due to high uncertainty in potential reductions from the installation of occupancy sensors, the Team did not estimate the savings that could be realized from this option.

Increase Exposure to Daylight

Light from the sun is free and clean. Better utilizing daylight throughout HCA's buildings would reduce both the financial costs and environmental impact that electricity use for artificial lighting imposes. Furthermore, studies have shown that improved daylight exposure indoors, in addition to reducing energy consumption, also improves an individual's productivity and overall mood.[64] Increasing indoor exposure to daylight requires a thoughtful design that best utilizes the sun's position and movement to maximize the total amount of lumens available throughout a given day. Skylights are often the best solution since they allow sunlight to penetrate the indoor space from an elevated location (which usually maximizes the amount of lumens received in that space) even as the position of the sun changes. Skylights typically provide 30% more sunlight than a standard window of the same area.[65]

Without expert energy modeling and consultation, it is difficult to estimate the net effect that increased daylight exposure would have on a building's overall energy performance. Installing skylights or increasing window area often conflicts with the goal of reducing energy for space heating and cooling, as the insulating capacity of glass and transparent plastics is considerably lower than that of heavily-insulated exterior walls and ceilings. Conversely, skylights that can open often help reduce cooling loads by allowing warm interior air to escape thought the roof and draw in cooler air from ground levels.[66] Skylights can be as little as $150 to $250 per unit (installation costs not included) for small tubular models and as much as $1,200 to $5,000 per unit for models that include highly insulating glass, remote control venting options, and built-in blinds.[67] Due to uncertainty in design conditions and installation requirements, the Team did not estimate the potential energy savings that could be realized by implementing this option.

Install Daylighting Controls

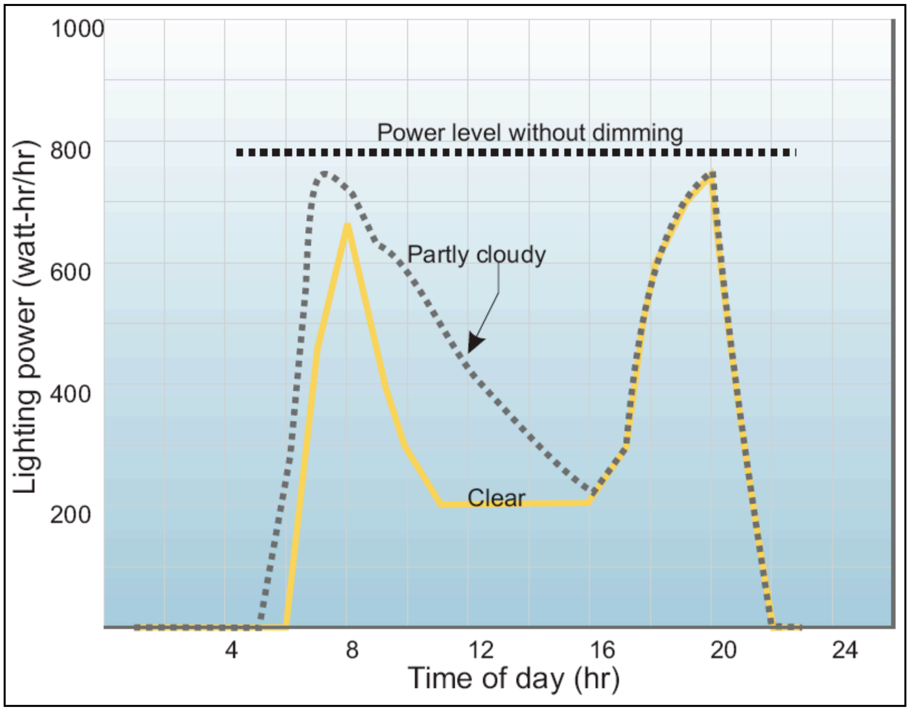
Daylighting controls are devices that adjust the amount of illumination provided by artificial lighting in accordance to the amount of daylight that is available in an interior space. These controls, which include devices like automatic light dimmers and switches, use sensing devices (such as photocells or photosensors) to minimize the amount of artificial light being used within a space. Switches can automatically turn lights off when a certain threshold of sunlight is detected whereas dimmers reduce the level of illumination, which lowers the power consumed by lighting fixtures as sunlight exposure within an interior space increases. Figure 21 provides a visual example for how much electricity an automatic dimmer could save during hours of peak sunlight, even on cloudy days. According to the New Buildings Institute, daylighting controls can "easily save 10%—50% of annual lighting energy."[68] This option can be implemented in concert with the option to increase exposure to daylight or act as a stand-alone project for interior spaces with currently sufficient exposure. Like with occupancy sensors, the amount of power saved by daylighting controls is highly dependent on site conditions, and this high level of uncertainty made it impossible for the Team to accurately estimate the energy and cost savings from the implementation of this option.

Option 3: Improve Use of Appliances and Electronics

Install Smart Power Strips

Many appliances and electronics consume power even when they are turned off. This wasted energy, also called a phantom load, adds up over time. Smart power strips can be used to reduce phantom loads by sensing when an appliance or electronic is in an idling mode and shutting off the power supply to that appliance automatically. Some power strips even come with occupancy sensors that automatically power a device on when the room is occupied and off when it is not. Manufacturers of smart power strips claim that these units pay for themselves within six weeks.[69]

Figure 21: Comparing the power output of a lighting system with and without dimming controls



Source: New Buildings Institute, 2010

Replace Old Appliances with ENERGY STAR® Units

The use—not the purchase—of most appliances accounts for the majority of the financial cost and environmental impact associated with that appliance. When evaluating the life cycle of most appliances, the use phase dominates because the energy used to power the unit's electric motors and provide hot water (e.g., in clothes washers) is very costly and environmentally damaging. A decision based on the life cycle approach, which evaluates the unit's total financial cost and environmental impact from cradle to grave, would determine that appliances should be replaced more often than most people think. Shorter replacement schedules are suggested because the technology curve for these products is steep, so advances in energy efficiency happen often. As a result, it is better—from both a financial and an environmental standpoint—to replace large appliances often with newer ENERGY STAR® rated units. It is important to keep in mind that replaced appliances should be disposed of in a manner that is consistent with the recommendations outlined in Chapter 4 (solid waste) of this report. Below are suggested replacement schedules for large appliances:[70]

- Refrigerators: Replace every 14 years
- Clothes washers: Replace every 11 years
- Dishwashers: Replace every 10 years
- Room air conditioners: Replace every 9 years

Option 4: Improve Water Heating Systems

Since three separate water heaters heat the water within the monastic enclosure, updating HCA's water heating system should be relatively easy. This heating system varies widely in its performance, and the Team's recommendations are more focused on improving these target areas than replacing the entire system. For example, the two electric units are fairly new and towards the top end of the efficiency spectrum for similar models of their size. Conversely, the large oil unit in the boiler room is very inefficient, and replacement should be considered. Below are some options for improving the performance of the monastic enclosure's water heating system.

Insulate Water Heating Units

Conventional hot water storage units lose a lot of energy storing hot water so that it is available when demanded. These losses occur when heat escapes through the walls of the unit's storage tank and energy must be consumed to reheat the stored water. Wrapping a unit's storage tank and hot water pipes with R-24 or higher insulation can reduce storage energy losses by 25% to 45% and reduce total energy consumed for hot water heating by 4% to 9%.[71] Pre-cut jackets can be purchased at hardware stores for $10 to $20, and installing a jacket is fairly easy.[72] As Table 20 shows, wrapping each storage tank in the monastic enclosure would more than pay for itself in one year.

Table 20: Financial results from wrapping water heater tanks

Water Heater	Energy Unit	Units Reduced (4%)	Units Reduced (9%)	Low Estimate of Annual Savings	High Estimate of Annual Savings
Aldrich Company	Heating Oil Gallons	35	79	64.56	145.26
A.O. Smith	kWh	37.95	85.39	1.48	3.33
Bradford White	kWh	417.49	939.34	16.28	36.63

Replace Water Heating Units

In addition to insulating HCA's hot water heaters, replacing those units with more efficient models provides another option for reducing energy from hot water heating. According to the EIA, water heaters powered by electricity are more efficient than those that burn oil.[73] Since two of the units in the monastic enclosure are powered by electricity, converting those to the highest-rated ENERGY STAR® unit would result in minor benefits with large costs. Conversely, replacing the oil-burning unit in with an ENERGY STAR® electrical storage unit would result in large financial gains (see Table 21). However, electricity in HCA's region of the country is more environmentally damaging per Btu than heating oil. Therefore, this option would result in a negative environmental impact (see Table 22).

Less conventional systems should also be considered for heating water in the monastic enclosure. One option would be to replace those units with ENERGY STAR® tankless models. These units heat the water when demanded, which eliminates the wasted energy that results from storing hot water. This option would result in both financial and environmental benefits for the unit in the novitiate basement, but would still result in a net negative environmental impact for the oil-burning unit. Another option would be to heat water through thermal heating supplied by solar panels. These systems are expensive to install and must have a backup water heating system during times of low solar radiation. Due to the solar fluctuations in the Berryville area, the Team estimated that the existing systems, which would be used as backups, would be used too often to make this option viable for significantly reducing environmental impact and financial costs. Based on these results, the team would recommend that HCA should not implement a solar water heating system unless that system is integrated with an on-site solar power generation system.

Table 21: Financial results from water heater replacements

Water Heater	Location	Option	Assumed Life of Option	Assumed Unit and Installation Cost[74]	Estimated Annual Savings	PV of Energy Savings	NPV of Energy Savings
Aldrich Company	Old Boiler Room	ENERGY STAR® Electrical Storage	20 Years	$1,025	$623	$4,815	$3,790
Aldrich Company	Old Boiler Room	ENERGY STAR® Tankless	20 Years	$2,075	$1,164	$8,263	$6,188
Aldrich Company	Old Boiler Room	Solar Water Heater	20 Years	$12,000	$898	$6,196	($5,804)
A.O. Smith	Mansion Basement	ENERGY STAR® Electrical Storage	20 Years	$1,025	$2	$19	($1,006)
A.O. Smith	Mansion Basement	ENERGY STAR® Tankless	20 Years	$2,075	$21	$210	($1,865)
A.O. Smith	Mansion Basement	Solar Water Heater	20 Years	$12,000	$6	$62	($11,938)
Bradford White	Novitiate Basement	ENERGY STAR® Electrical Storage	20 Years	$1,025	$20	$205	($820)
Bradford White	Novitiate Basement	ENERGY STAR® Tankless	20 Years	$2,075	$230	$2,314	$239
Bradford White	Novitiate Basement	Solar Water Heater	20 Years	$12,000	$60	$600	($11,400)

Table 22: Environmental benefits from water heater replacements when accounting for externalities

Water Heater	Location	Option	CO$_2$eq Reduced (tons)	NO$_x$ Reduced (lbs)	SO$_2$ Reduced (lbs)	PV of Low Estimate for Soft Costs	PV of High Estimate for Soft Costs	NPV of Replacement with Low Soft Costs	NPV of Replacement with High Soft Costs
Aldrich Company	Old Boiler Room	ENERGY STAR® Electrical Storage	(5.75)	(50.80)	(177.77)	($581)	($5,733)	$3,209	($1,943)
Aldrich Company	Old Boiler Room	ENERGY STAR® Tankless	2.70	(23.09)	(80.77)	($81)	($2,272)	$6,107	$3,916
Aldrich Company	Old Boiler Room	Solar Water Heater	5.42	0.01	0.03	$187	$340	($5,617)	($5,463)
A.O. Smith	Mansion Basement	ENERGY STAR® Electrical Storage	0.03	0.09	0.33	$3	$19	($1,004)	($988)
A.O. Smith	Mansion Basement	ENERGY STAR® Tankless	0.33	1.07	3.75	$30	$210	($1,834)	($1,655)
A.O. Smith	Mansion Basement	Solar Water Heater	0.10	0.32	1.11	$9	$62	($11,929)	($11,876)
Bradford White	Novitiate Basement	ENERGY STAR® Electrical Storage	0.32	1.04	3.65	$30	$204	($791)	($616)
Bradford White	Novitiate Basement	ENERGY STAR® Tankless	3.60	11.80	41.29	$334	$2,311	$573	$2,550
Bradford White	Novitiate Basement	Solar Water Heater	0.93	3.06	10.72	$87	$600	($11,313)	($10,800)

Option 5: Improve Heating and Cooling Systems

HCA's inefficient heating and cooling systems comprise the second largest source of wasted energy and emission of greenhouse gases and air pollutants. Only HCA's poor building structure and insulation (which also affects the heating systems) accounts for a greater amount of energy wasted and pollutants emitted. (Due to the magnitude of its impact, building structure was separated from this section and will be addressed in the following option.) Similar to lighting, the amount of waste produced by heating and cooling systems can be reduced through habitual and technological improvements. Furthermore, technological improvements in heating and cooling systems, like lighting, usually result in significant savings and a positive net present value when converting these savings to today's dollars and subtracting the installation costs associated with these technology upgrades. However, unlike lighting, the efficiency of heating and cooling systems and the actual savings realized by improving this efficiency depends on multiple factors and can vary greatly depending on site conditions and community use. In addition to this variability, options for upgrading space heating and cooling technology often require a large capital outlay for the unit and system installation, which makes the payback time significantly longer than other options. With these conditions in mind, the Team identified four options for reducing the energy load demanded by HCA's heating and cooling systems. These options are summarized below.

Install Programmable Thermostats

Most households often overheat or overcool their living space as a result of poor system monitoring. For example, buildings are often heated uniformly, but many rooms or sections of a building are low-use and low-occupancy areas that are only utilized at certain times of the day. Heating those spaces uniformly with high-use and high-occupancy areas is a waste of heating energy. At HCA, the Mansion, church, and business areas of the monastic enclosure serve as a good example of overheating as these building areas have zero occupancy during sleeping hours. Retrofitting the heating system to substantially lower the space heating needs for these areas during these times would save a significant amount of energy and money. This concept also can be applied to space cooling in the church, chapter room, and business areas. Even in areas of the building where residents sleep, the heating requirements should be considerably lower, especially if individuals use additional blankets for layering. Sleeping conditions can be quite comfortable at 60 degrees Fahrenheit, or even less, if optimal bedding is used.

Like with lighting systems, changing an individual's energy habits for space heating and cooling can be difficult. Although a simple task, manually turning down all building thermostats is often forgotten, especially in a building as large and complex as the monastic enclosure. According to the DOE's Office of Energy Efficiency and Renewable Energy, turning back a building's thermostat 10–15 degrees Fahrenheit for 8 hours saves, on average, 5%–15% of the energy used for heating.[75] According to this statistic, HCA could save 530 to 1,585 gallons of heating oil each year, which would result in a financial savings of about $975 to almost $3,000 per year through proper use of programmable thermostats in the monastic enclosure. Programmable thermostats vary from $30 per unit to as much as $300 per unit. Although these costs seem high, the typical payback for these units is only one to two years.[76]

There are two major drawbacks to programmable thermostats as they would relate specifically to HCA. First, it is difficult to adequately control the specific area heating requirements for buildings that have old boiler systems, like the monastic enclosure.[77] As displayed in Map 5 and Map 6 in Appendix 2-B, three boilers control three large areas of the monastic enclosure. All of those areas contain rooms of consistent occupancy during the day and house sleeping occupants during the night. Although programmable thermostats could reduce the heating requirements for each of these large areas during sleeping hours, the limitations of the boiler systems would prevent HCA from reducing heating loads in low-occupancy areas during the day. One way around this problem would be to relocate residents in the old dorm to the North West Dormitory. This would provide HCA the opportunity to significantly lower heating requirements in the east wing of the monastic enclosure (highlighted in green in Map 5 and Map 6) by substantially reducing the nighttime temperature in that area.

The second drawback is that boiler systems typically have long response times. Older boiler systems like HCA's can take as long as a few hours to reach optimal temperatures, especially when temperatures are significantly lowered during the night. Traditional programmable thermostats can struggle in this type of environment because setting the appropriate temperatures for given times throughout the day can be difficult. However, with trial and error, a programmable thermostat can work quite well. Alternatively, there are more expensive thermostats that can track the performance of a heating system and automatically turn the boilers on to achieve comfortable temperatures during the programmed time.[78]

Switch to Forced Air with Individual Room Thermostats

Replacing HCA's radiant baseboard heating system with a forced-air system would result in some major drawbacks, such as a large capital outlay and increased dust accumulation. However, a forced-air system provides a very important advantage as it can easily control air flow and thus better control where the heat output is going in the building. When combined with a system of programmable and room-specific thermostats, a forced-air system can optimally control the heating loads of individual rooms, which could reduce a building's overall heating load by much more than the 5%-15% reductions mentioned in the previous section.

A forced-air system also can respond much more quickly to programmed temperature changes than a radiant baseboard system. There is a common misconception that programmable thermostats make furnaces work harder than normal when warming a room back to a comfortable level. But according to the DOE:

> The fuel required to reheat a building to a comfortable temperature is roughly equal to the fuel saved as the building drops to the lower temperature. You save fuel between the time that the temperature stabilizes at the lower level and the next time heat is needed. So, the longer your house remains at the lower temperature, the more energy you save.[79]

The actual amount of energy used by a well-designed forced-air system depends on site conditions and maintenance. Furthermore, the installation costs are difficult to quantify, especially since the new system could be integrated into the existing ductwork in areas of the monastic enclosure that are serviced by central air conditioning. This high level of uncertainty made it impossible for the Team to accurately estimate the energy and cost savings from the implementation of this option.

Replace or Retrofit Older Boilers

If replacing the current radiant baseboard heating system with a forced-air system proves to be too expensive or difficult, replacing HCA's older boilers with higher-efficiency boilers could be a good option. Specifically, the two boilers in the main boiler room were installed in the 1970s and probably have an AFUE of around 60 percent or less. These systems currently waste about a third (or 3,400 gallons) of the heating oil used for space heating. By installing one of the newer ENERGY STAR® boilers, which can reach an AFUE of 90% or more, about half of the oil wasted from the current system inefficiencies could be saved. Table 23 and Table 24 summarize the potential savings and environmental benefit that could be achieved by replacing the current boilers in the monastic enclosure with ENERGY STAR® boilers that have a 90 AFUE rating.

Another potentially less capital-intensive option would be for HCA to retrofit its existing boilers. Well-made older boilers, if properly retrofitted and commissioned annually, can achieve a 5%–20% savings in fuel use.[80] According to these percentages, this option could reduce oil consumption by 530 to 2,115 gallons per year and lead to an annual financial savings of $775 to $3,900. The energy and financial benefits associated with boiler retrofits are difficult to quantify without a complete diagnostic from a trained professional. However, the following bullets outline the average costs and energy savings associated with the most common types of boiler improvements:

- Vent dampers: If any of the boilers at HCA do not have a vent damper, this addition to the system could be a viable option. Vent dampers reduce chimney losses by closing the vent of a boiler when the unit is not firing. Larger units typically benefit more than smaller from this option. The cost of implementing this option varies depending on the unit and site conditions.[81]
- Barometric flue damper: It is common for too much heat to be lost up the chimney. A barometric flue damper, which costs less than $100, limits chimney losses and can reduce oil consumption by 5 percent.[82]
- Replacing oil burners: The current oil burners used by HCA's boilers may be inefficient. Replacing the burner, which costs about $500 per burner, can save a considerable amount of fuel. Flame retention burners, which prevent airflow escape through the chimney when the unit is not firing, can reduce oil consumption by up to 20 percent.[83]

Table 23: Financial results from boiler replacements or retrofits

Boiler Make	Location	Assumed Life of Option	Assumed Installation Cost[84]	Estimated Annual Savings	PV of Energy Savings	NPV of Energy Savings
Aldrich Company	Old Boiler Room	25	$8,000	$1,493	$10,728	$2,728
Burnham Commercial	Mansion Basement	25	$6,000	$873	$6,277	$277
Weil-McLain 1	Old Boiler Room	25	$6,000	$934	$6,713	$713
Weil-McLain 2	Novitiate Basement	25	$6,000	$1,191	$8,558	$2,558

Table 24: Environmental benefits from boiler replacements or retrofits when accounting for externalities

Boiler Make	CO_2eq Reduced (tons)	NO_x Reduced (lbs)	SO_2 Reduced (lbs)	Low PV Soft Costs	High PV Soft Costs
Aldrich Company	9.01	0.008	0.008	$11,320	$11,844
Burnham Commercial	5.27	0.005	0.005	$6,623	$6,946
Weil-McLain 1	5.64	0.005	0.005	$7,083	$7,426
Weil-McLain 2	7.19	0.006	0.006	$9,030	$9,455

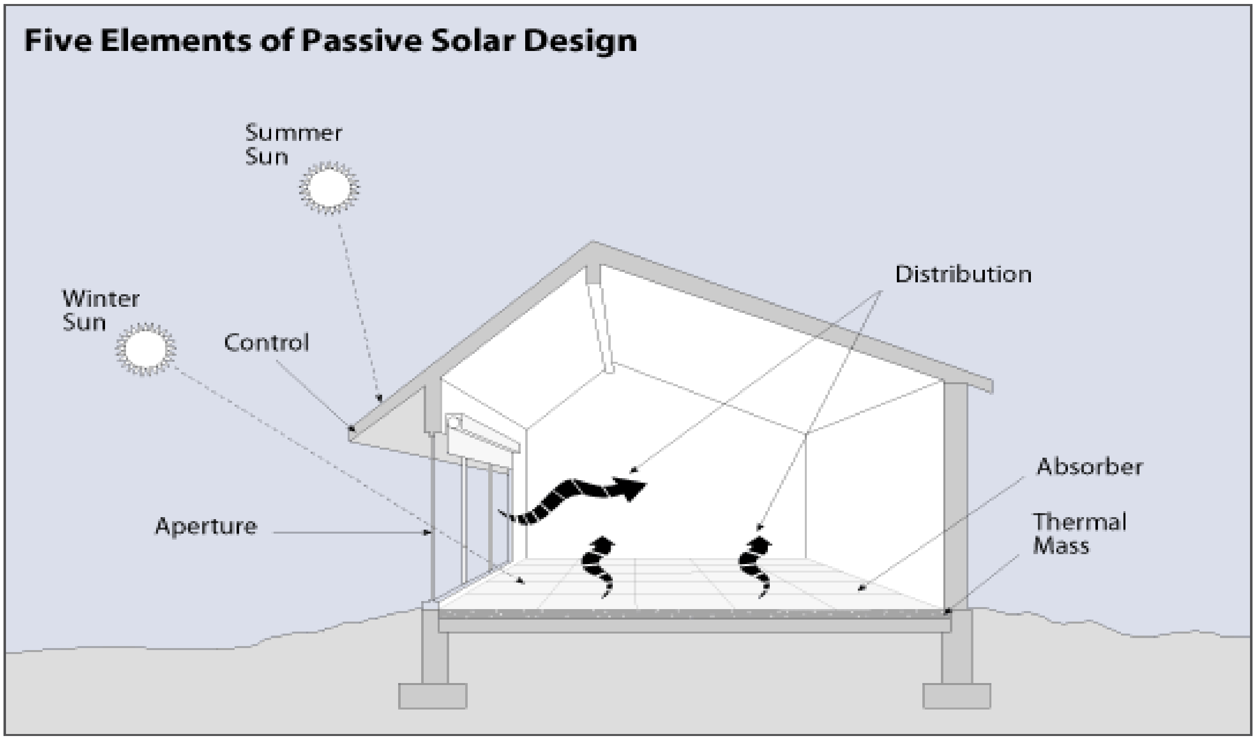
Retrofit Buildings for Passive Solar Design

Buildings can also be retrofitted to use passive solar design. This technique alters a building's windows, walls, and floors to better "collect, store and distribute solar energy in the form of heat in the winter and reject solar heat in the summer."[85] Lower heating loads are a major advantage of this design. To best utilize solar energy from passive design, a building should meet the five criteria outlined below and illustrated in Figure 22.[86]

- Aperture: The aperture, or large window area, should face south and experience no or little shade from 9 a.m. to 3 p.m. during the winter months.

- Absorber: The interior space needs to have a hard and dark surface, usually a floor or wall, that sits directly in the path of sunlight and absorbs the heat from the solar radiation.
- Thermal mass: Below the absorber material must be a thermal mass that is able to retain the heat that is absorbed.
- Distribution: The design of the interior space must be able to transfer heat collected from the sunlight evenly throughout the space through methods of heat conduction, convection, and radiation. Fans, ducts, and blowers can be installed to aid the proper transfer of heat throughout the space.
- Control: The control is used to adjust the space to better adapt for the changing position of the sun. In the summer, the sun is at a higher angle and a roof overhang or other shading device can be used to block direct sunlight and reduce the amount of radiation absorbed and distributed in the interior space. Conversely, in the winter, the sun is at a lower angle and the radiation from the sun can be absorbed and distributed throughout the interior space.

Figure 22: An illustration of the five elements of passive solar design



Source: DOE, 2010

Option 6: Improve the Building Envelope

While improving the overall efficiency of heating and cooling systems is an important and cost-effective way to reduce HCA's total energy consumption, improving the building structure is also necessary to reduce heating and cooling loads. As demonstrated by the heat gain/loss modeling, HCA could significantly reduce oil consumption for space heating and electricity for space cooling by improving building envelopes. Such reductions would be especially high for the monastic enclosure and bakery units. The following subsections offer four options for improving the building envelopes of these units. These options are ordered from least to most expensive, but it is important to note that these options vary considerably with regard to their benefit-to-cost ratios and some result in greater overall costs. However, all of the options presented below would result in substantial reductions in energy consumption, which is environmentally beneficial. Lastly, it is important to note that these costs and benefits cannot be summed across options if multiple options are implemented in the same unit. For example, if the community decides to implement more than one option in the monastic enclosure, then the costs and benefits will be lower per option than the sum of the individually listed results of each option presented in this section. When combining multiple options, there are synergies that could reduce installation costs and system overlap that could make realized energy savings lower.

Improve Weatherization

Weatherization techniques (e.g. sealing air leaks in the building envelope with caulk, weather stripping windows and doors) are very cost-effective methods for reducing the amount of energy needed to support adequate space heating and cooling loads. Air leaks can be detected through infrared testing, and weatherization can be completed without the need for contracted work. The materials needed to properly seal the average leaky house cost about $50 to $350, which translates to about $0.02 to $0.14 per square foot of living area.[87,88] According to these cost figures, a high-end cost estimate for weatherizing the monastic enclosure would be about $6,600. When assuming a project life of 40 years, the financial savings of about $1,700 per year would result in a positive net present value and a payback time of less than 6 years. In addition to financial savings, this option would reduce annual CO_2 emissions by 10.93 tons, annual NO_X emissions by 2.67 pounds, and annual SO_2 emissions by 9.38 pounds, which would result in an estimated present value environmental benefit of $425 to $1,515.

This option would apply to other building units as well, but limited data prevented the Team from estimating the financial and environmental costs and benefits of implementing this option in those units. The Team expects that weatherizing the very leaky bakery could result in higher emission reductions and financial savings per area than the estimated results for the monastic enclosure.

Improve Roof Insulation

A large proportion of heat in any interior space is lost through the ceiling because warm air rises. Heavily insulating all attic space within the monastic enclosure to an R-Value of 57 could reduce HCA's heating load by 7% during the winter months. The Team's energy modeling suggests that HCA experiences high levels of heat gain through the ceilings of certain areas that are cooled in the summer months (especially the church). Insulating these areas would reduce HCA's cooling load by about 10%. Unlike weatherization, attic and roof insulation can be expensive, especially if installed by a contractor. Although the per-unit cost of insulating attics can be costly, especially if the insulation is made from green materials, HCA's onsite property management team could easily install the insulation. The Team estimated the cost of additional ceiling insulation by using RSMeans' localized per-area construction data. Tables 25 and 26 summarize the financial and environmental results of this option.

Improve Exterior Wall Insulation

According to our energy model, the exterior walls of the monastic enclosure serve as the largest source of heat gains and losses throughout the unit. Better insulating these walls would provide HCA with the greatest potential for reducing heating and cooling loads within the monastic enclosure. However, retrofitting existing walls for improved insulation depends on the type of structure and can be difficult and costly. Such retrofits are complicated by the fact that the monastic enclosure has two main types of wall structures—standard wood framing and masonry block—either one or two blocks wide. Being a building that is comprised of multiple additions, the methods of insulation are different throughout. For example, the west wing, which includes the refectory, kitchen, infirmary, and business offices, is well insulated with double-block walls that have either R-5 or R-11 board insulation between the two blocks. On the other hand, HCA's oldest buildings (like the Mansion) have little to no insulation within their wood frames. Consequently, the heat loss and gain within the monastic enclosure varies considerably.

Table 25: Financial results from increased ceiling insulation for the monastic enclosure

Area	Assumed Life of Option	Current R-Value	Option New R-Value	Assumed Installation Cost[89]	Estimated Annual Savings	PV of Energy Savings	NPV of Energy Savings
Infirmary	40 years	38	57	$1,576	$42	$311	($1,265)
Chapter Room Area	40 years	19	57	$1,332	$69	$505	($827)
Church	40 years	22	57	$3,587	$245	$1,754	($1,833)
Sacristy	40 years	19	57	$352	$9	$74	($278)
Abbot Office Area	40 years	19	57	$581	$25	$186	($395)
Novitiate Area	40 years	11	11	$0	$0	$0	$0
Novitiate Hall	40 years	19	57	$585	$17	$121	($464)
NW Wash Area	40 years	11	11	$0	$0	$0	$0
NW Dormitory	40 years	38	57	$1,668	$25	$180	($1,488)
Senior Wing	40 years	19	57	$1,836	$7	$49	($1,787)
Mass Crypt/ Secretary	40 years	0	57	$1,101	$87	$652	($450)
St. Joes	40 years	0	57	$3,143	$249	$1,861	($1,282)
Mansion	40 years	0	57	$4,891	$388	$2,896	($1,995)
Old Dorm	40 years	44	57	$791	$10	$78	($713)
Total				**$21,443**	**$1,173**	**$8,668**	**($12,775)**

Table 26: Environmental benefits from increased ceiling insulation when accounting for externalities

Area	CO_2eq Reduced (tons)	NO_x Reduced (lbs)	SO_2 Reduced (lbs)	PV of Low Estimate for Soft Costs	PV of High Estimate for Soft Costs	NPV of Replacement with Low Soft Costs	NPV of Replacement with High Soft Costs
Infirmary	0.32	3.15	11.03	$38	$181	($1,227)	($1,084)
Chapter Room Area	0.52	2.66	9.32	$29	$133	($798)	($694)
Church	2.56	7.17	25.11	$202	$930	($1,631)	($903)
Sacristy	0.00	0.70	2.46	$2	$12	($276)	($265)
Abbot Office Area	0.15	1.16	4.07	$6	$29	($389)	($366)
Novitiate Area	-	-	-	$0	$0	$0	$0
Novitiate Hall	0.15	1.17	4.10	$6	$29	($458)	($435)
NW Wash Area	-	-	-	$0	$0	$0	$0
NW Dormitory	0.22	3.34	11.67	$42	$200	($1,446)	($1,288)
Senior Wing	0.06	3.67	12.85	$50	$240	($1,738)	($1,547)
Mass Crypt/ Secretary	0.53	2.20	7.71	$21	$94	($429)	($356)
St. Joes	1.50	6.29	22.00	$153	$710	($1,129)	($572)
Mansion	2.34	9.78	34.23	$363	$1,701	($1,632)	($294)
Old Dorm	0.06	1.58	5.53	$10	$48	($703)	($665)
Total	**8.42**	**42.89**	**150.10**	**$921**	**$4,305**	**($11,855)**	**($8,470)**

Table 27: Financial results from increased wall insulation (Option 1) for the monastic enclosure

Area	Insulation Type	Assumed Life of Option	Current R-Value	New R-Value	Assumed Installation Cost[90]	Estimated Annual Savings	PV of Energy Savings	NPV of Energy Savings
Church	Board	40 years	5	11	$8,439	$1,769	$3,248	($6,670)
Chapter Room Area	Board	40 years	0 - 11	11	$1,607	$2,011	$1,060	$405
Abbot Office Area	Board	40 years	0	11	$1,630	$1,882	$488	$252
Below Church	Board	40 years	0	11	$3,968	$3,751	$1,188	($217)
Lower Library Area	Board	40 years	0 - 11	11	$2,832	$1,348	$848	($1,484)
Sacristy	Board	40 years	0	11	$257	$352	$287	$95
Sacristy Stairwell	Board	40 years	11	11	$0	$0	$0	$0
Laundry	Board	40 years	0	11	$4,061	$4,690	$1,216	$628
Bakery Storage Room	Board	40 years	5	11	$3,759	$250	$1,220	($3,509)
Elevator Lobby Area (Basement)	Board	40 years	11	11	$0	$0	$0	$0
Business Offices	Board	40 years	5	11	$2,594	$223	$842	($2,371)
Elevator Lobby Area (Ground)	Board	40 years	11	11	$0	$0	$0	$0
Kitchen	Board	40 years	5	11	$2,881	$605	$1,109	($2,275)
Refectory/ Dishwashing Area	Board	40 years	5	11	$3,509	$736	$1,351	($2,773)
Infirmary	Board	40 years	5	11	$3,358	$704	$1,293	($2,654)
Elevator Lobby Area (Upper)	Board	40 years	11	11	$0	$0	$0	$0
Novitiate Basement	Board	40 years	5	11	$129	$3	$42	($127)
Novitiate Area	Board	40 years	5	11	$826	$72	$268	($754)
Sacrament Chapel	Board	40 years	5	11	$2,847	$158	$924	($2,689)
Changing Room	Board	40 years	5	11	$15	$2	$5	($14)
Novitiate Hall	Board	40 years	5	11	$447	$47	$172	($399)
NW Dormitory	Board	40 years	5	11	$5,380	$568	$2,070	($4,811)
NW Wash Area	Board	40 years	5	11	$921	$83	$299	($839)
Senior Wing	Board	40 years	5	11	$3,032	$349	$1,275	($2,683)
Mass Crypt/ Secretary	Blown	40 years	0	11	$152	$312	$275	$161
St. Joes	Blown	40 years	0	11	$538	$2,651	$976	$2,113
Mansion 1st Floor	Blown	40 years	0	11	$905	$4,238	$1,642	$3,333
Mansion 2nd Floor	Blown	40 years	0	11	$764	$3,761	$1,386	$2,997
Mansion Basement	Blown	40 years	0	11	$746	$3,674	$1,354	$2,928
Old Dorm Basement	Blown	40 years	0	11	$748	$3,691	$1,358	$2,942
Old Dorm Ground Floor	Blown	40 years	0	11	$1,042	$5,139	$1,891	$4,097
Total					**$57,389**	**$43,069**	**$28,088**	**($14,319)**

Table 28: Environmental benefits from increased wall insulation (Option 1) when accounting for externalities

Area	CO_2eq Reduced (tons)	NO_x Reduced (lbs)	SO_2 Reduced (lbs)	PV of Low Estimate for Soft Costs	PV of High Estimate for Soft Costs	NPV of Replacement with Low Soft Costs	NPV of Replacement with High Soft Costs
Church	1.63	1.0195	3.5726	$85	$252	($6,585)	($6,418)
Chapter Room Area	1.86	1.1598	4.0640	$101	$302	$505	$707
Abbot Office Area	1.52	0.0014	0.0097	$56	$124	$307	$375
Below Church	3.03	0.0027	0.0193	$111	$224	($106)	$7
Lower Library Area	1.09	0.0010	0.0069	$40	$95	($1,444)	($1,389)
Sacristy	0.37	0.4203	1.4718	$18	$68	$113	$162
Sacristy Stairwell	-	-	-	$0	$23	$0	$23
Laundry	3.79	0.0034	0.0241	$139	$274	$767	$903
Bakery Storage Room	0.20	0.0002	0.0013	$8	$36	($3,501)	($3,473)
Elevator Lobby Area (Basement)	-	-	-	$0	$23	$0	$23
Business Offices	0.18	0.0002	0.0011	$7	$35	($2,364)	($2,337)
Elevator Lobby Area (Ground)	-	-	-	$0	$23	$0	$23
Kitchen	0.56	0.3491	1.2231	$24	$74	($2,252)	($2,202)
Refectory/ Dishwashing Area	0.68	0.4245	1.4874	$29	$89	($2,744)	($2,684)
Infirmary	0.65	0.4057	1.4216	$28	$85	($2,626)	($2,569)
Elevator Lobby Area (Upper)	-	-	-	$0	$23	$0	$23
Novitiate Basement	0.00	0.0000	0.0000	$0	$23	($126)	($104)
Novitiate Area	0.06	0.0001	0.0004	$2	$26	($751)	($727)
Sacrament Chapel	0.13	0.0001	0.0008	$5	$31	($2,684)	($2,658)
Changing Room	0.00	0.0000	0.0000	$0	$23	($14)	$9
Novitiate Hall	0.05	0.0542	0.1899	$2	$26	($397)	($373)
NW Dormitory	0.59	0.6493	2.2736	$32	$111	($4,779)	($4,701)
NW Wash Area	0.07	0.0001	0.0004	$3	$27	($836)	($812)
Senior Wing	0.40	0.5816	2.0364	$23	$88	($2,660)	($2,595)
Mass Crypt/ Secretary	0.25	0.0002	0.0016	$10	$39	$170	$200
St. Joes	2.14	0.0019	0.0136	$79	$165	$2,192	$2,278
Mansion	3.43	0.0031	0.0218	$125	$250	$3,459	$3,584
Mansion	3.04	0.0027	0.0193	$111	$225	$3,108	$3,221
Mansion	2.97	0.0027	0.0189	$109	$220	$3,037	$3,148
Old Dorm	2.98	0.0027	0.0190	$109	$221	$3,052	$3,163
Old Dorm	4.15	0.0037	0.0264	$152	$299	$4,249	$4,395
Total	**35.82**	**5.0899**	**17.9251**	**$1,410**	**$3,520**	**($12,909)**	**($10,799)**

Table 29: Financial results from increased wall insulation (Option 2) for the monastic enclosure

Area	Insulation Type	Assumed Life of Option	Current R-Value	New R-Value	Assumed Installation Cost[91]	Estimated Annual Savings	PV of Energy Savings	NPV of Energy Savings
Church	Board	40 years	5	19	$9,148	$2,536	$3,469	($6,613)
Chapter Room Area	Board	40 years	0 - 11	19	$2,093	$2,311	$1,146	$219
Abbot Office Area	Board	40 years	0	19	$2,123	$2,007	$488	($116)
Below Church	Board	40 years	0	19	$5,168	$4,030	$1,188	($1,138)
Lower Library Area	Board	40 years	0 - 11	19	$3,689	$1,576	$848	($2,113)
Sacristy	Board	40 years	0	19	$335	$376	$301	$41
Sacristy Stairwell	Board	40 years	11	19	$1,397	$115	$446	($1,281)
Laundry	Board	40 years	0	19	$5,290	$5,003	$1,216	($287)
Bakery Storage Room	Board	40 years	5	19	$4,075	$435	$1,220	($3,640)
Elevator Lobby Area (Basement)	Board	40 years	11	19	$2,114	$189	$729	($1,925)
Business Offices	Board	40 years	5	19	$2,812	$460	$916	($2,352)
Elevator Lobby Area (Ground)	Board	40 years	11	19	$1,879	$167	$648	($1,711)
Kitchen	Board	40 years	5	19	$3,123	$868	$1,185	($2,255)
Refectory/ Dishwashing Area	Board	40 years	5	19	$3,804	$887	$1,394	($2,917)
Infirmary	Board	40 years	5	19	$3,641	$1,009	$1,380	($2,632)
Elevator Lobby Area (Upper)	Board	40 years	11	19	$1,879	$167	$648	($1,711)
Novitiate Basement	Board	40 years	5	19	$140	$5	$42	($135)
Novitiate Area	Board	40 years	5	19	$895	$103	$268	($792)
Sacrament Chapel	Board	40 years	5	19	$3,086	$268	$924	($2,818)
Changing Room	Board	40 years	5	19	$17	$2	$5	($15)
Novitiate Hall	Board	40 years	5	19	$484	$68	$184	($416)
NW Dormitory	Board	40 years	5	19	$5,832	$794	$2,200	($5,037)
NW Wash Area	Board	40 years	5	19	$999	$118	$299	($880)
Senior Wing	Board	40 years	5	19	$3,287	$459	$1,247	($2,828)
Mass Crypt/ Secretary	Blown	40 years	0	19	$175	$364	$275	$190
St. Joes	Blown	40 years	0	19	$619	$2,829	$976	$2,209
Mansion 1st Floor	Blown	40 years	0	19	$1,042	$4,755	$1,642	$3,713
Mansion 2nd Floor	Blown	40 years	0	19	$880	$4,013	$1,386	$3,133
Mansion Basement	Blown	40 years	0	19	$859	$3,920	$1,354	$3,061
Old Dorm Basement	Blown	40 years	0	19	$862	$3,938	$1,358	$3,076
Old Dorm Ground Floor	Blown	40 years	0	19	$1,200	$5,483	$1,891	$4,283
Total					**$72,944**	**$49,256**	**$31,274**	**($23,688)**

Table 30: Environmental benefits from increased wall insulation (Option 2) when accounting for externalities

Area	CO_2eq Reduced (tons)	NO_x Reduced (lbs)	SO_2 Reduced (lbs)	PV of Low Estimate for Soft Costs	PV of High Estimate for Soft Costs	NPV of Replacement with Low Soft Costs	NPV of Replacement with High Soft Costs
Church	10.04	0.0090	0.0638	$367	$690	($6,245)	($5,923)
Chapter Room Area	9.16	0.0082	0.0582	$335	$631	$553	$849
Abbot Office Area	1.62	0.0015	0.0103	$60	$130	($56)	$15
Below Church	3.26	0.0029	0.0207	$119	$239	($1,019)	($899)
Lower Library Area	1.27	0.0011	0.0081	$47	$107	($2,066)	($2,006)
Sacristy	2.76	0.0025	0.0175	$101	$206	$142	$246
Sacristy Stairwell	0.09	0.0001	0.0006	$4	$29	($1,278)	($1,253)
Laundry	4.05	0.0036	0.0257	$148	$291	($139)	$5
Bakery Storage Room	0.35	0.0003	0.0022	$13	$46	($3,627)	($3,594)
Elevator Lobby Area (Basement)	0.75	0.0007	0.0048	$28	$72	($1,897)	($1,853)
Business Offices	1.18	0.0011	0.0075	$43	$101	($2,308)	($2,251)
Elevator Lobby Area (Ground)	0.67	0.0006	0.0042	$25	$67	($1,687)	($1,645)
Kitchen	3.44	0.0031	0.0219	$126	$251	($2,129)	($2,004)
Refectory/ Dishwashing Area	3.52	0.0031	0.0223	$129	$256	($2,788)	($2,661)
Infirmary	4.00	0.0036	0.0254	$146	$288	($2,485)	($2,344)
Elevator Lobby Area (Upper)	0.67	0.0006	0.0042	$25	$67	($1,687)	($1,645)
Novitiate Basement	0.00	0.0000	0.0000	$0	$23	($135)	($113)
Novitiate Area	0.08	0.0001	0.0005	$3	$28	($789)	($764)
Sacrament Chapel	0.22	0.0002	0.0014	$8	$37	($2,810)	($2,781)
Changing Room	0.00	0.0000	0.0000	$0	$23	($14)	$8
Novitiate Hall	0.48	0.0004	0.0031	$18	$55	($398)	($362)
NW Dormitory	5.62	0.0050	0.0357	$205	$396	($4,832)	($4,642)
NW Wash Area	0.10	0.0001	0.0006	$4	$29	($877)	($851)
Senior Wing	3.25	0.0029	0.0206	$119	$238	($2,709)	($2,589)
Mass Crypt/ Secretary	0.29	0.0003	0.0019	$11	$42	$201	$232
St. Joes	2.29	0.0020	0.0145	$84	$174	$2,293	$2,384
Mansion 1st Floor	3.84	0.0034	0.0244	$141	$278	$3,854	$3,991
Mansion 2nd Floor	3.24	0.0029	0.0206	$119	$238	$3,252	$3,371
Mansion Basement	3.17	0.0028	0.0201	$116	$233	$3,177	$3,294
Old Dorm Basement	3.18	0.0029	0.0202	$117	$234	$3,193	$3,310
Old Dorm Ground Floor	4.43	0.0040	0.0282	$162	$317	$4,445	$4,600
Total	**77.01**	**0.0690**	**0.4896**	**$2,823**	**$5,815**	**($20,865)**	**($17,873)**

When creating these scenarios, the Team did its best to maximize energy savings while at the same time minimizing installation costs. Increasing insulation for wood-framed walls is fairly easy and cost effective because contractors can inject expanding foam into spaces between studs without gutting the inside of the wall. For single- and double-block walls, increasing insulation is more expensive because insulation cannot be blown into existing seems. For these walls, the Team assumed that HCA would install thin board insulation and then apply drywall over top. It is important to note that the cost assumptions used by the Team for this option were conservatively high. It is also important to note that the benefit-to-cost ratio varies considerably among different areas of the unit. Whereas implementing this option in all areas would further reduce HCA's environmental impact, it may not make sense in many areas where the additional funds used to increase insulation could be used towards another project that yields a greater financial benefit and/or greater reduction in environmental impact. Table 27 through Table 30 summarize the financial and environmental results for both scenarios of this option.

Exterior wall insulation also would greatly improve the Bakery's heating and cooling performance. The Bakery uses a large amount of energy for heating and cooling a space that is used infrequently when compared to other units, such as the Monastic Enclosure. In fact, the Bakery, which consumes on average about 64 kBtu per square foot, uses about 30% more energy per area than the Monastic Enclosure (49 kBtu/ft[1]). This is alarming because a large majority of that energy is being consumed for space heating and cooling, and not for the actually manufacturing of HCA's business products.

Unlike with the Monastic Enclosure, the Project Team was unable to estimate the heat loss and gains through computer modeling. Without this information, the Team could not estimate the actual amount of energy that would be reduced by improving insulation. Regardless, the Team does expect that a sizable net present value would result from the financial savings that could be realized by those improvements. Using crude estimates for heating oil at the Bakery, the Team estimates that this unit has similar, if not worse, heat loss and gain ratios than the poorest insulated areas of the Monastic Enclosure. This inefficiency is not only environmentally harmful, but also adds to unit production costs.

When considering the option of better insulating the bakery, the community should also consider better insulating all walls of the Ingredient Storage room. The currently poor level of insulation creates unnecessary stress for the air conditioning unit that cools this room because this system must compete with the intense amount of heat emitted by the oven in the adjacent room. This stress magnifies in the summer when temperatures are high from both the oven and the outside ambient temperature. Insulating this room at a very high R-value would significantly reduce the amount of heat that is exchanged with the outside and adjacent oven room. Reducing this exchange in turn would significantly lower the cooling loads for that area and result in a reduction of electricity, and its associated emissions, used to cool that room.

Replace Single-Pane Windows

Whereas windows reduce a building's energy demand by providing indoor space with natural light, windows negatively impact its energy efficiency through heat gains and losses. Having little thermal mass when compared to walls, windows provide little resistance to heat and highlight the tradeoff between increasing natural light and decreasing heating and cooling loads. Heat can pass through windows in three ways: (1) direct conduction through the glass or outlining frame caused by temperature differences between the inside and outside air; (2) radiation from the sun and residents within the space that can pass through the glass; and (3) air leakage around the window frames that allows warm air to escape the interior space in the winter and enter that space in the summer.[92] As mentioned above, weatherization can resolve the third cause of heat flow. Therefore, only the first two will be addressed in this portion of Option 6.

The U-factor of a window, which is simply the inverse of an R-value, rates the energy efficiency performance of windows. Being the inverse of the R-value, a lower U-factor indicates a more energy-efficient window. Below are factors that influence the U-factor of a window:

- Number of panes: The number of panes a window has the most significant factor for reducing conduction and improving the U-factor. Thermal resistance increases as the number of panes increases, which lowers the window's U-factor.[93]

- Glass coating: Thin coatings to the glass glazing can be used to reduce thermal conduction. Low-E, which is a microscopically thin layer of metal or metallic oxide, is a common coating used to reduce radiative heat flow by reflecting internal radiation back into the space in the winter and solar radiation away from the space in the summer.[94]

- Insulating gases: The space between two panes of glass acts as a buffer for thermal exchange. High reflectivity of radiation between two panes of glass can excite molecules within that space and create a protective layer that can reduce thermal conduction. Filling this space with gases like argon, krypton, sulfur hexafluoride, and carbon dioxide can better achieve this goal. Gas fills typically only add a few dollars to the price of a window, and the financial savings realized through the additional reduction in energy consumption easily recovers this premium. It is important to note that gas fills work best with Low-E coating.[95]

- Frame material: Heat can move through the frame of a window by thermal conduction. Different materials provide different levels of thermal resistance, which can cause windows to vary significantly by U-factor. Wood, fiberglass, and vinyl frames are better thermal resistors than metal frames. However, metal frames usually wear better and have a longer lifespan.[96]

When comparing the U-factors of windows, it is important to make sure that the National Fenestration Rating Council (NFRC), which assigns ratings according to the window's entire performance, conducted these ratings. All windows that are qualified by EPA's ENERGY STAR® program have a NFRC label.[97]

Aside from those installed during the recent construction in the west wing of the monastic enclosure and the chapter room, the windows in this building unit are old, energy inefficient, and in need of replacement. Many of these windows are only single paned, and those that are double paned do not have insulating gas fills. Furthermore, all windows outside of the areas excluded above do not have low-E coatings and the frames of many of these windows are damaged to the point where weatherization could be ineffective. In addition to reduced energy efficiency, poorly insulated windows can lead to other problems such as moisture penetration and mold build up. Given these observations, the Team recommends that HCA upgrade single-paned and deteriorating windows to new double-paned windows and replace the large window area in the Sacrament Chapel with triple-pane glass. Tables 31 and 32 outline the installation costs as well as the financial savings and environmental benefits from the resulting energy reductions.

Table 31: Financial results from upgrading windows in the monastic enclosure

Area	Replacement Type According to Panes	Assumed Life of Option	Assumed Installation Cost[1]	Estimated Annual Savings	PV of Energy Savings	NPV of Energy Savings
Church	Single to Double	30 years	$4,559	$165	$1,196	($3,363)
Chapter Room Area	None	30 years	$0	($0)	($0)	($0)
Abbot Office Area	Single to Double	30 years	$802	$9	$68	($734)
Below Church	Single to Double	30 years	$2,330	$49	$363	($1,967)
Lower Library Area	Single to Double	30 years	$2,179	$15	$109	($2,071)
Sacristy	None	30 years	$0	$0	$0	$0
Sacristy Stairwell	Single to Double	30 years	$551	$17	$121	($430)
Laundry	Single to Double	30 years	$251	$8	$56	($194)
Bakery Storage Room	None	30 years	$0	$0	$0	$0
Elevator Lobby Area (Basement)	None	30 years	$0	$0	$0	$0
Business Offices	None	30 years	$0	$0	$0	$0
Elevator Lobby Area (Ground)	None	30 years	$0	$0	$0	$0
Kitchen	None	30 years	$0	$0	$0	$0
Refectory/ Dishwashing Area	None	30 years	$0	$0	$0	$0
Infirmary	None	30 years	$0	$0	$0	$0
Elevator Lobby Area (Upper)	None	30 years	$0	$0	$0	$0
Novitiate Basement	None	30 years	$0	$0	$0	$0
Novitiate Area	Single to Double	30 years	$852	$15	$108	($744)
Sacrament Chapel	Single to Double & Double to Triple	30 years	$1,202	$1,019	$7,484	$6,281
Changing Room	Single to Double	30 years	$601	$8	$61	($540)
Novitiate Hall	Single to Double	30 years	$401	$9	$65	($336)
NW Dormitory	None	30 years	$0	$0	$0	$0
NW Wash Area	Single to Double	30 years	$526	$7	$53	($473)
Senior Wing	Single to Double	30 years	$2,455	$14	$98	($2,357)
Mass Crypt/Secretary	Single to Double	30 years	$1,102	$28	$205	($897)
St. Joes	Single to Double	30 years	$902	$7	$53	($849)
Mansion 1st Floor	Single to Double	30 years	$2,405	$19	$141	($2,264)
Mansion 2nd Floor	Single to Double	30 years	$1,804	$14	$106	($1,698)
Mansion Basement	Single to Double	30 years	$1,954	$41	$304	($1,650)
Old Dorm Basement	Single to Double	30 years	$2,305	$71	$522	($1,783)
Old Dorm Ground Floor	None	30 years	$0	$0	$0	$0
Total			**$27,179**	**$1,517**	**$11,112**	**($16,067)**

Table 32: Environmental benefits from window replacement when accounting for externalities

Area	CO_2eq Reduced (tons)	NO_x Reduced (lbs)	SO_2 Reduced (lbs)	PV of Low Estimate for Soft Costs	PV of High Estimate for Soft Costs	NPV of Replacement with Low Soft Costs	NPV of Replacement with High Soft Costs
Church	1.27	1.45498	5.09510	$97	$349	($3,266)	($3,014)
Chapter Room Area	-	-	-	$0	$0	$0	$0
Abbot Office Area	0.06	0.00005	0.00035	$2	$26	($732)	($708)
Below Church	0.30	0.00027	0.00190	$11	$42	($1,956)	($1,925)
Lower Library Area	0.09	0.00008	0.00057	$4	$28	($2,067)	($2,042)
Sacristy	-	-	-	$0	$0	$0	$0
Sacristy Stairwell	0.10	0.00009	0.00063	$4	$29	($426)	($401)
Laundry	0.05	0.00004	0.00029	$2	$25	($192)	($169)
Bakery Storage Room	-	-	-	$0	$0	$0	$0
Elevator Lobby Areas (bsmt, gnd & upper)	-	-	-	$0	$0	$0	$0
Business Offices	-	-	-	$0	$0	$0	$0
Kitchen	-	-	-	$0	$0	$0	$0
Refectory/ Dishwashing Area	-	-	-	$0	$0	$0	$0
Infirmary	-	-	-	$0	$0	$0	$0
Novitiate Basement	-	-	-	$0	$0	$0	$0
Novitiate Area	0.09	0.00008	0.00057	$4	$28	($740)	($715)
Sacrament Chapel	6.15	0.00551	0.03912	$223	$426	$6,504	$6,708
Changing Room	0.05	0.00005	0.00032	$2	$26	($538)	($514)
Novitiate Hall	0.07	0.09069	0.31757	$3	$28	($333)	($308)
NW Dormitory	-	-	-	$0	$0	$0	$0
NW Wash Area	0.04	0.00004	0.00028	$2	$25	($471)	($448)
Senior Wing	0.12	0.19261	0.67433	$5	$34	($2,352)	($2,323)
Mass Crypt/ Secretary	0.17	0.00015	0.00107	$6	$33	($891)	($864)
St. Joes	0.04	0.00004	0.00028	$2	$25	($847)	($824)
Mansion 1st Floor	0.12	0.00010	0.00074	$4	$30	($2,260)	($2,234)
Mansion 2nd Floor	0.09	0.00008	0.00055	$3	$28	($1,695)	($1,670)
Mansion Basement	0.25	0.00022	0.00159	$9	$39	($1,641)	($1,611)
Old Dorm Basement	0.43	0.00038	0.00273	$16	$51	($1,767)	($1,732)
Old Dorm Ground Floor	-	-	-	$0	$0	$0	$0
Total	**9.48**	**1.7455**	**6.1380**	**$404**	**$1,252**	**($15,664)**	**($14,816)**

Option 7: Install On-site Renewable Energy

The energy analysis up to this point emphasizes the reduction of fossil fuel consumption to reduce financial costs and environmental impact. Although efforts to reduce energy consumption are important, it is also important to realize that HCA will never be able to completely eliminate the community's energy needs. In addition to implementing energy-reducing efforts, HCA should peruse methods for consuming clean renewable energy. There are many options for integrating renewable energy into HCA's energy-use habits (e.g., using biofuels for transportation, retrofitting buildings for geothermal heating and cooling systems, and purchasing green power from the community's electric utility), but the Team focused this evaluation on assessing the feasibility of installing on-site wind and solar power units.

Wind Power

The kinetic motion of wind can serve as a natural and potentially large source of energy without emitting greenhouse gases or air pollutants that are typically associated with the combustion of fossil fuels. Depending on the unit's capacity, wind turbines can generate large amounts electricity through a very simple mechanical process. Specifically, the blades of the turbine rotate as the wind blows, which rotates a shaft that spins a generator. The simplicity of these mechanisms makes wind turbines practical in windy areas.

Installing wind power units can be a difficult and time-intensive process. The Michigan Team is not qualified to recommend wind as an option, but we did identify key components within the process of wind development and composed an initial resource analysis that the community should keep in mind. These components are described below.

Wind Resource

In order for a turbine to be both successful at producing power and financially viable, there must be a strong resource of wind at the location. A strong resource of wind is defined by two factors. First, the wind must be strong enough to rotate the unit's blades. As wind velocity increases, the number of blade rotations increases, and therefore, the amount of power generated increases. Second, the wind resource should be fairly constant. The less intermittent the resource is, the more reliable the turbine will be to meet the community's power demand.

This second point is important because power generated from wind does not vary with demand (as inlike a coal or natural gas power plant). Instead, power demand is met according to the ebbs and flows of the wind resource. This important distinction is made clear with a simple example. Imagine a turbine that produces 100,000 kWh of power per year, which is equivalent to a little less than 25% of HCA's total power demand. However, HCA would not be able to consume all of that power because a large percentage would be generated at night when the community is sleeping. Therefore, a considerable amount of that power could go unused. Understanding the timing of when the wind resource is available is crucial for wind development and was estimated by the Team.

Turbine Capacity

A turbine's capacity is the maximum amount of power it can produce at a given moment in time. For example, a 10 kW turbine can produce a maximum of 10 kWh of electricity in one hour. Turbines only operate at capacity when wind conditions are at optimal levels, and this rarely (if ever) occurs. Therefore, the capacity factor (which is the percentage of capacity at which a turbine operates) is a more effective measure. Typical capacity factors in the US range from 20% to 40%, and this all depends on the strength of the wind resource.[98]

Wind Power Density

Wind turbine models have different optimal wind speeds to maximize overall efficiency. A wind power density (WPD) curve rates this efficiency by measuring the amount of power produced by the turbine at different wind speeds. Smaller turbines typically have flatter WPD curves and are more efficient at lower wind speeds, whereas larger turbines have steeper WPD curves and are more efficient at greater wind speeds. The optimal unit is chosen according to the efficiency WPD rating at the average wind speed for a given area.

Turbine Height

The height of a turbine is key because the turbine's tower accesses the wind resource. Typically, although not always, wind speeds increase as the tower height increases. Therefore, two turbines made from the same manufacturer that have the same capacity will probably have different capacity factors at different heights. The height of a turbine can create a lot of controversy because of bird migration patterns, scenic views, and zoning ordinances.[99] These are all issues that HCA would be required to investigate before pursuing wind as an option for renewable power generation.

Using US National Renewable Energy Laboratory (NREL) data from two wind farms within a ten-mile radius of HCA and wind density data from multiple wind turbine manufacturers, the Team was able to estimate the amount of power that could be generated by a variety of turbines that differ by capacity and height. It is important to note that wind resources can vary by location and can change significantly even within a few hundred yards. The estimates provided by the Team should be considered crude and used only for informational purposes. If the community decides to pursue wind power, a more detailed analysis by trained professionals will be required. These analyses are expensive, as a wind feasibility study can cost around $20,000.[100]

After accounting for these factors, we found that HCA does have a legitimate, although low, wind resource. Tables 33 and 34 show how HCA's estimated wind resources, measured in meters per second (m/s), change according to tower height, month, and time of day. Wind speeds of 7 m/s or more (red) are preferable for producing power, but speeds of 6 to 7 m/s (pink) and 5 to 6 m/s (orange) are also viable. It should be noted that HCA's wind resources are weakest during midday hours in the summer months, which unfortunately corresponds to HCA's highest electrical demand time.

As Virginia residents, the HCA community can benefit from net metering, which means that the community's power utility will credit any power HCA feeds back into the grid.[101] This provision would assure HCA that all of the power produced by an on-site wind turbine—even power that is generated during low- or no-demand periods of the day—would be removed from the community's electric bill. Unlike more progressive states, however, HCA would not be paid for the power that fed back into the grid. It is important to note that net metering has a capacity constraint of 10 kW for residential facilities and 500 kW for nonresidential facilities.[102] With both residential and business activities taking place on the property, it is unclear as to which classification HCA would fall under.

Based on the above conditions, the Team estimated the potential power generation of three common models (i.e., a 10 kW Bergey BWC Excel-R unit, a 20 kW Tairui Windpower unit, and a 35 kW Endurance G-3120 unit), at five different tower heights. Assuming a real discount rate of 14.7% and an installation cost of $4,000 per kW of capacity, Table 35 below summarizes the financial results of these simulations and Table 36 summarizes the environmental benefits from those options.[103] The estimated hourly electricity generation for each of these options is presented in Data Tables 2 through 7 in Appendix 2-D. It should be noted that all options would result in a negative net present value because of the area's limited wind resource. Although financially costly, this resource could significantly reduce HCA's environmental impact from energy consumption. For example, installing a 40-meter Endurance G-3120 unit could reduce HCA's energy-related CO_2 emissions by about 75 tons, or about 13% of HCA's total carbon output. Such reductions are significantly large.

Table 33: HCA's estimated average hourly wind speed (m/s) at a tower height of 30 meters

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
0	7.78	6.48	6.38	6.23	5.99	5.39	5.00	5.20	5.68	6.42	7.09	7.00	**6.22**
1	7.90	6.59	6.56	6.46	6.23	5.69	5.41	5.42	5.72	6.44	7.18	6.93	**6.38**
2	7.99	6.84	6.63	6.68	6.52	5.93	5.65	5.72	5.87	6.43	7.25	7.10	**6.55**
3	7.73	6.84	6.58	6.60	6.59	5.98	5.55	5.72	5.77	6.23	7.12	7.13	**6.49**
4	7.64	6.83	6.56	6.68	6.62	5.86	5.55	5.61	5.86	6.20	7.13	7.23	**6.48**
5	7.52	6.83	6.47	6.75	6.62	5.74	5.61	5.59	5.82	6.18	7.00	7.18	**6.44**
6	7.45	6.80	6.47	6.70	6.52	5.78	5.53	5.56	5.78	6.03	6.88	7.08	**6.38**
7	7.33	6.79	6.41	6.61	6.44	5.73	5.51	5.45	5.73	5.98	6.68	7.02	**6.30**
8	7.24	6.76	6.35	6.49	6.32	5.67	5.48	5.40	5.71	5.99	6.47	7.03	**6.24**
9	7.24	6.73	6.29	6.32	6.21	5.60	5.29	5.36	5.59	6.09	6.41	7.13	**6.19**
10	7.11	6.64	6.16	6.29	6.12	5.45	5.09	5.26	5.52	5.97	6.52	7.17	**6.11**
11	7.03	6.52	6.05	6.34	5.91	5.06	4.62	4.96	5.44	5.76	6.61	7.08	**5.95**
12	6.85	5.91	5.75	5.98	4.92	4.14	3.76	4.06	4.77	5.58	6.52	7.07	**5.44**
13	6.96	5.71	5.50	5.63	4.11	3.52	3.25	3.37	4.04	5.19	6.69	7.51	**5.12**
14	7.23	6.08	5.62	5.44	4.19	3.42	3.30	3.32	3.79	4.72	6.70	7.91	**5.14**
15	6.89	5.99	5.60	5.30	4.41	3.62	3.44	3.47	3.72	4.60	6.07	7.38	**5.04**
16	6.52	5.83	5.40	5.28	4.58	3.88	3.53	3.46	3.89	4.53	5.43	6.52	**4.90**
17	6.27	5.73	5.40	5.40	4.79	4.11	3.71	3.48	3.98	4.53	5.00	5.94	**4.86**
18	6.22	5.64	5.56	5.58	5.04	4.35	3.93	3.42	4.00	4.61	4.89	5.79	**4.92**
19	6.39	5.52	5.71	5.74	5.17	4.65	4.16	3.42	4.01	4.86	5.08	5.82	**5.04**
20	6.83	5.63	5.83	5.90	5.26	4.69	4.32	3.72	4.33	5.09	5.39	6.04	**5.25**
21	7.23	5.75	5.87	5.97	5.29	4.72	4.34	4.01	4.58	5.25	5.86	6.36	**5.44**
22	7.50	5.95	6.00	5.96	5.50	4.95	4.47	4.35	4.98	5.78	6.45	6.96	**5.74**
23	7.72	6.31	6.28	6.08	5.75	5.04	4.54	4.91	5.60	6.51	6.93	7.14	**6.07**
Avg.	**7.19**	**6.28**	**6.06**	**6.10**	**5.63**	**4.96**	**4.63**	**4.59**	**5.01**	**5.62**	**6.39**	**6.90**	**5.78**

Source: NREL, *Eastern Wind Dataset*, 2007

Table 34: HCA's estimated average hourly wind speed (m/s) at a tower height of 9 meters

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	6.25	5.20	5.13	5.00	4.81	4.32	4.01	4.18	4.56	5.16	5.69	5.62	**4.99**
1	6.34	5.29	5.27	5.19	5.01	4.57	4.34	4.35	4.59	5.17	5.77	5.56	**5.12**
2	6.41	5.49	5.32	5.36	5.23	4.76	4.53	4.59	4.71	5.16	5.82	5.70	**5.26**
3	6.20	5.49	5.28	5.30	5.29	4.80	4.46	4.59	4.63	5.00	5.72	5.72	**5.21**
4	6.13	5.48	5.26	5.36	5.31	4.70	4.45	4.50	4.70	4.98	5.72	5.80	**5.20**
5	6.04	5.48	5.20	5.42	5.31	4.61	4.50	4.49	4.67	4.96	5.62	5.76	**5.17**
6	5.98	5.46	5.19	5.38	5.23	4.64	4.44	4.46	4.64	4.84	5.52	5.68	**5.12**
7	5.89	5.45	5.15	5.31	5.17	4.60	4.42	4.38	4.60	4.80	5.36	5.63	**5.06**
8	5.81	5.43	5.10	5.21	5.07	4.55	4.40	4.34	4.58	4.81	5.19	5.64	**5.01**
9	5.81	5.40	5.05	5.08	4.98	4.50	4.25	4.30	4.49	4.89	5.15	5.72	**4.97**
10	5.71	5.33	4.94	5.05	4.92	4.37	4.08	4.22	4.43	4.79	5.23	5.76	**4.90**
11	5.64	5.23	4.86	5.09	4.74	4.06	3.71	3.98	4.37	4.63	5.31	5.68	**4.77**
12	5.50	4.74	4.62	4.80	3.95	3.33	3.02	3.26	3.83	4.48	5.23	5.67	**4.37**
13	5.59	4.59	4.42	4.52	3.30	2.83	2.61	2.71	3.24	4.17	5.37	6.03	**4.11**
14	5.80	4.88	4.52	4.36	3.36	2.75	2.65	2.67	3.04	3.79	5.38	6.35	**4.13**
15	5.53	4.81	4.50	4.25	3.54	2.91	2.76	2.79	2.99	3.69	4.87	5.93	**4.04**
16	5.23	4.68	4.33	4.24	3.68	3.12	2.84	2.78	3.12	3.64	4.36	5.23	**3.94**
17	5.03	4.60	4.34	4.33	3.84	3.30	2.97	2.79	3.20	3.64	4.02	4.77	**3.90**
18	4.99	4.53	4.46	4.48	4.04	3.49	3.15	2.74	3.21	3.70	3.93	4.65	**3.95**
19	5.13	4.44	4.58	4.61	4.15	3.73	3.34	2.74	3.22	3.90	4.08	4.67	**4.05**
20	5.48	4.52	4.68	4.74	4.22	3.77	3.46	2.98	3.47	4.08	4.33	4.85	**4.22**
21	5.81	4.61	4.71	4.79	4.25	3.79	3.49	3.22	3.68	4.21	4.70	5.11	**4.36**
22	6.02	4.78	4.81	4.78	4.41	3.98	3.59	3.49	4.00	4.64	5.18	5.59	**4.61**
23	6.19	5.06	5.04	4.88	4.62	4.04	3.65	3.94	4.50	5.23	5.56	5.74	**4.87**
Avg	**5.77**	**5.04**	**4.86**	**4.90**	**4.52**	**3.98**	**3.71**	**3.69**	**4.02**	**4.51**	**5.13**	**5.54**	**4.64**

Source: NREL, *Eastern Wind Dataset*, 2007

Table 35: Financial results of wind power simulations

Model	Capacity (kW)	Height (meters)	Estimated Annual Generation (kWh)	% HCA Total Annual Demand	Annual Savings	PV of Annual Savings	Estimated Installation Cost	Net Present Value
Bergey BWC Excel-R	10	18	3,898	0.92%	$121	$809	$40,000	($39,191)
Bergey BWC Excel-R	10	43	6,933	1.64%	$215	$1,439	$44,000	($42,561)
Tairui Windpower	20	18	16,466	3.90%	$509	$3,419	$80,000	($76,581)
Tairui Windpower	20	43	22,479	5.32%	$696	$4,667	$88,000	($83,333)
Endurance G-3120	35	30.5	106,687	25.27%	$3,301	$22,151	$140,000	($117,849)
Endurance G-3120	35	40	122,583	29.06%	$3,793	$25,451	$154,000	($128,549)

Table 36: Environmental benefits of wind power simulations

Model	Height (m)	CO_2eq Reduced (tons)	NO_x Reduced (lbs)	SO_2 Reduced (lbs)	PV of Low Estimate for Soft Costs	PV of High Estimate for Soft Costs	NPV of Replacement with Low Soft Costs	NPV of Replacement with High Soft Costs
Bergey BWC Excel-R	18	2.38	0.004	0.014	$143	$992	($39,047)	($38,199)
Bergey BWC Excel-R	43	4.23	0.007	0.024	$255	$1,765	($42,306)	($40,796)
Tairui Windpower	18	10.04	0.016	0.058	$605	$4,192	($75,976)	($72,390)
Tairui Windpower	43	13.71	0.022	0.079	$826	$5,722	($82,506)	($77,610)
Endurance G-3120	30.5	65.05	0.107	0.373	$3,922	$27,159	($113,927)	($90,691)
Endurance G-3120	40	74.74	0.123	0.429	$4,507	$31,205	($124,042)	($97,344)

Solar Power

Like wind, the sun provides free, clean, and renewable energy. When using solar power, radiant energy from the sun must be converted to electrical power by semiconductors called photovoltaics (PVs). Also similar to wind, the efficiency of this conversion is low—even lower than wind. The conversion efficiency of current PV technology is between 5% and 18%. Despite the low conversion efficiencies of PV panels (i.e., arrays), solar radiation is the largest source of energy on earth. In fact, the amount of solar energy that reaches the earth is 15 orders of magnitude larger than the total amount of global electricity consumed. Furthermore, sunlight is most available during periods of peak power demand (i.e., summer afternoons that require heavy air conditioning loads), making solar-powered units an attractive option for powering most daily activities.[104] Combining wind power, which typically blows more heavily in the mornings and evenings because of changes in air pressure, and solar power, which is greatest during the middle of the day, is a good strategy for assuring that the community would have renewable energy throughout the day.

There are many other benefits to installing PV arrays on-site. Unlike wind turbines, arrays do not require moving parts to generate electricity. Without moving parts, solar arrays require very little, if any, maintenance after installation. PV systems are easier to install and provide greater flexibility for customized needs. As a system of individual arrays, the capacity of a PV system can be scaled up or down by simply adding or subtracting individual panels. Panels also can be disjointed, which allows system owners to place panels in convenient, yet power optimizing, areas of their property. Additionally, PV arrays are less obtrusive than wind turbines, making it easier to blend them into the building's décor and bypass the many problems wind turbines face with zoning ordinances and community objections.

Table 37: Financial results of solar power simulations per solar array

Model	Array Capacity (kW)	Array Efficiency	Estimated Annual Array Generation (kWh)	% HCA Total Annual Demand	Annual Savings Per Array	PV of Annual Savings	Estimated Installation Cost Per Array	Net Present Value Per Array
Sharp Solar, Model# 39614	0.170	12.68%	235	0.06%	$9	$62	$1,360	($1,298)
Green Brilliance GB54P6-190	0.188	13.10%	290	0.07%	$11	$77	$1,500	($1,423)
Green Brilliance GB72P6-260	0.260	13.68%	376	0.09%	$15	$99	$2,080	($1,981)

However, PV systems also have major drawbacks. Most importantly, solar arrays are very expensive. Systems with a capacity of 10 kW or less typically cost about $8 per watt of installed capacity.[105] This is significantly more than the per-watt installation cost of smaller wind turbines, which average around half that cost. Reliability also is a problem. Although considerably more consistent than wind, the sun is an intermittent source of power, and a cloudy day could significantly reduce the amount of power generated by a PV system. It is important to note that battery storage is often a reasonable option for mitigating part of the intermittency problems associated with solar power, but these systems are expensive. Another drawback is that solar panels can require a large amount of area for solar collection. A typical 1 kW system, which would only satisfy 2% of HCA's average hourly demand, could occupy as much as 360 square feet of roof area.[106] Lastly, PVs are made with silicon and rare metals that are environmentally damaging to mine for, and demand for these materials is often higher than supply.[107]

Similar to the simulations conducted for the wind analysis, the Team used local solar flux data compiled by NREL to run solar simulations that estimated the potential power generation of three common PV arrays (a 170 watt Sharp Solar module, a 187.5 watt Green Brilliance module, and a 260 watt Green Brilliance module).[108] Assuming a real discount rate of 14.7% and an installation cost of $8 per watt of installed of capacity, Table 37 summarizes the financial results of these simulations and Table 38 summarizes the environmental benefits from those options. The estimated hourly electricity generation for each of these options, assuming an installation of 40 panels, is presented in Data Tables 8 through 10 in Appendix 2-D. It should be noted that all options would result in a negative net present value because of the high costs associated with PV installation. It is also important to note that environmental benefit-per-dollar-spent would be significantly lower than the benefit-per-dollar-spent on the installation of a wind turbine.

Table 38: Environmental Benefits of Solar Power Simulations per Solar Array

Model	Array Capacity (kW)	CO_2eq Reduced (tons)	NO_x Reduced (lbs)	SO_2 Reduced (lbs)	PV of Low Estimate for Soft Costs	PV of High Estimate for Soft Costs	NPV of System with Low Soft Costs	NPV of System with High Soft Costs
Sharp Solar, Model# 39614	0.170	0.14	0.0002	0.001	$9	$60	($1,289)	($1,238)
Green Brilliance GB54P6-190	0.188	0.18	0.0003	0.001	$11	$74	($1,413)	($1,350)
Green Brilliance GB72P6-260	0.260	0.23	0.0004	0.001	$14	$96	($1,967)	($1,885)

Potentially Available Tax Credits

Many of the options listed in this section could provide HCA with certain tax credits. These state and federal tax incentives exist to encourage the installation and use of renewable energy technologies and more energy-efficient products. Since it is unclear if these credits would apply given HCA's unique tax status, the Team did not include these rather sizable benefits into the financial calculations for each option. Instead, the relevant tax credits are listed below.

Federal Tax Credits

The products listed in Table 39 are eligible for federal tax credits of 30% of the cost, up to a total tax credit of $1,500 for the years 2009 to 2010. However, the purchase and installation of these products must occur before December 31, 2010.

Table 39: Summary of products eligible for federal tax credits

Unit Upgraded	Requirements	Restrictions
Central AC	• Split systems: o EER >= 13; SEER >= 16 • Package systems: o EER >= 12; SEER >= 14 • Credit includes installation costs	• 2009, 2010 only • Primary residence only • Existing homes only
Air-Source Heat Pumps	• Split Systems: o HSPF >=8.5; EER >= 12.5; SEER >= 15 • Package systems: o HSPF>= 8; EER>=12; SEER >= 14 • Credit includes installation costs	• 2009, 2010 only • Primary residence only • Existing homes only
Furnaces and Boilers	• Natural gas or propane furnace: AFU >= 95 • Oil Furnace: AFUE >= 90 • Gas, Propane, or Oil Hot Water Boiler: AFUE >= 90 • Credit includes installation costs	• 2009, 2010 only • Primary residence only • Existing homes only
Insulation and air sealing products	• Primary purpose must be to insulate (example: insulated siding does not qualify). • Must meet 2009 International Energy Conservation Code (IECC) & Amendments • Credit does not include installation and labor costs.	• 2009, 2010 only • Primary residence only • Existing homes only
Water heaters (non-solar) – gas, oil, propane water heater	• Energy Factor >= 0.82 or a thermal efficiency of at least 90%. • Credit includes installation costs.	• All ENERGY STAR gas tankless water heaters qualify • Most storage tank water heaters do not qualify • Electric storage tank and electric tankless water heaters are not eligible for tax credits.
Exterior windows, doors, skylights	• U factor <= 0.30; SHGC <= 0.30	• Not all ENERGY STAR products qualify.
Storm windows and doors	• U factor <= 0.30; SHGC <= 0.30	• When combined with the exterior window or door over which it is installed.

Source: DOE

Additionally, some products can receive the same tax credit of 30% of the cost but do not have an upper limit. As Table 40 summarizes, these products must be purchased and installed before the end of 2016.

Table 40: Summary of incentives available through 2016

Appliance	**Requirements**	**Credit**	**Restrictions**
Geothermal Heat Pump	Closed Loop: EER >= 14.1; COP >= 3.3 Open Loop: EER >= 16.2; COP >= 3.6 Direct Expansion: EER >= 15; COP >= 3.5		Primary residences. Vacation homes eligible for partial credit; no rentals. New and existing homes
Solar water heater	At least half of the energy generated by the "qualifying property" must come from the sun.		Primary residences. Vacation homes eligible for partial credit; no rentals. New and existing homes
Photovoltaic Systems (Solar Electricity)	Photovoltaic systems must provide electricity for the residence and must meet applicable fire and electrical code requirement.		
Residential Small Wind Turbines	Nameplate capacity of not more than 100 kilowatts.		
Residential Fuel Cell and Microturbine Systems	Efficiency of at least 30% and must have a capacity of at least 0.5 kW.	30% of cost, up to $500 per 0.5 kW of power capacity	

Source: DOE

State Incentives

In 2009, the U.S. Department of Energy allocated Virginia $7.45 million for appliance rebate programs under the American Recovery and Reinvestment Act. Through this program, Virginia will develop an appliance rebate program with some utilities. However, the details of this program will not be released until late April 2010.[109]

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[31] For purposes of our evaluation, we defined *activity* to include any action that consumes energy according to the smallest unit of measurement (within reason) for grouped processes. Examples of such activities include burning fuel oil in a boiler, using electricity for powering a water heater, and driving vehicles owned by the community.

[32] Certain devices, such as The Energy Detective (TED) 1001, can measure and record the real-time power consumption for all major appliances and electronics on a specific electric panel. Such devices can provide homeowners with the exact energy consumption, cost of usage, and resulting emissions from the use of each appliance or electronic. Unfortunately, measurement devices such as the TED were not compatible with HCA’s power configuration, so we used the more traditional method to determine inventory data with consumption.

[33] This type of analysis also could be completed for the bakery, gift shop, and Retreat House, but the Team focused on the monastic enclosure because space heating and cooling has the largest financial and environmental impact.

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[46] The electricity from one generator feeding the grid is like a river that flows into body of water that has multiple outflow rivers. If there were only one river feeding that body of water, then it would be proper to assume that all of the water molecules that are collected from one of the many out-flowing rivers came from the one inflow river. However, if there were two or more rivers that fed the body of water, it would be improper to assume that all of the molecules that are collected from an outflow came from one particular inflow river. The PJM Interconnection works the same way.

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WATER

3

Understanding how fresh water is used, how wastewater is managed, and how water resources may be threatened at HCA is critical to the process of developing strategies to conserve water resources and protect water quality. This section seeks to guide HCA in developing sustainable water management strategies by providing an overview of the fundamental issues surrounding water both globally and locally, detailing the components of HCA's water system, assessing the community's water use, evaluating the most significant threats to water quality, and discussing options to effectively conserve and protect HCA's water resources.

CONTEXT: Understanding Water Use and Quality Global Water Distribution and Limitations

With 70% of the earth's surface covered by water, it is oftentimes easy to take for granted the finite nature of fresh water supplies. However, only 2.5% of the earth's water supplies are fresh water. And of that 2.5%, nearly 70% is frozen in the polar icecaps, with much of the remaining 30% otherwise inaccessible to humans. The striking reality is that only 0.007% of the earth's total water supply is accessible, fresh water.[1]

Arguably more important than total amount of accessible, fresh water, however, is the distribution and variability of the supply. While areas like Virginia have access to plentiful fresh water in most years, they are still susceptible to drought. Even so, globally, 1.2 billion people live in areas where water scarcity is a constant concern. Similarly, 1.6 billion people lack the infrastructure to adequately harness surface and groundwater supplies.[2] And as populations in water-scarce areas grow, water stores are being depleted rapidly. For example, America's heartland depends heavily on the Ogallala Aquifer, a giant underground reservoir, for water. However, it is estimated that the Aquifer will be functionally depleted within 15 to 50 years.[3] Unfortunately, if the Ogallala does become depleted, it will take 6,000 years to recharge.[4]

Water supplies are further limited by pollution. According to a recent assessment by the EPA, in the US alone, "44% of assessed stream miles, 64% of assessed lake acres, and 30% of assessed bay and estuarine square miles were not clean enough to support uses such as fishing and swimming."[5] Water pollution can come from a variety of sources including wastewater treatment systems, agricultural runoff, storm water runoff, and others. Some water pollution—particularly issues arising from wastewater treatment systems—is directly related to water use. Other threats to water quality may stem from land use practices, solid waste disposal practices, and the use of toxic chemicals. For the purposes of this section, discussion of water quality issues will be limited to those problems driven by water use.

Water Use and On-site Wastewater Treatment in the United States

In 2005, total daily water use in the United States was estimated to be 410 billion gallons per day. Residential water use accounts for just over 7% of total US water use, which is equivalent to 29.4 billion gallons per day. Of this total amount, wells and other private sources provide residential users with over 3.8 billion gallons of water per day.[6] On a more personal level, this translates to per capita residential water use of approximately 101 gallons per day in the US.[7]

But despite the amount of water we use at home, we often give little thought to what happens next. Where does all that water go? For the purposes of this discussion, we will ignore centralized wastewater treatment (i.e., sewer systems) and focus on on-site treatment. At HCA, all wastewater from toilets, sinks, showers, and other plumbing fixtures and appliances flows into one of 11 septic systems on site. So, let us consider how septic systems work.

Conventional septic systems consist of two primary components: the septic tank and the leach field. First, wastewater from plumbing fixtures and appliances is piped into the underground septic tank, where dense solids separate from liquids and settle to the bottom of the tank. In the septic tank, naturally occurring anaerobic bacteria partially break down solid waste. Remaining solids are periodically pumped out of the tank by a septic service provider. Liquid effluent is piped from the tank to a leach field, where the wastewater is dispersed into the soil.[8] Septic wastewater may contain a variety of pathogens and other substances that can be harmful to human health and the environment. Failing or leaking septic systems often release substantial amounts of these contaminants into the surrounding watershed. According to at least one study, 75% of septic leach field failures result from hydraulic overloading (adding too much water to the system at a given time).[9] This problem can be mitigated through water conservation.[10]

Contamination from Wastewater

Specific types of contaminants found in septic wastewater include nitrates, bacteria, and viruses, which can pollute ground and surface waters. Generally, these contaminants are treated by naturally occurring organisms in the soil, which act as a buffer to prevent ground and surface water contamination. However, septic systems must be properly sited and maintained to ensure adequate treatment.[11]

E. coli is commonly found in human and animal waste and, along with total coliform, provides a useful indicator of whether a given water source is contaminated with animal and/or human excrement. While many strains of E. coli are harmless, E. coli 0157:H7 is of particular concern as it can cause significant adverse health effects in humans when ingested. Specific human health effects include diarrhea, stomach cramps, and, in 2%–7% of cases, an acute form of kidney failure called hemolytic uremic syndrome.[12] Evidence of negative impacts of E. coli 0157:H7 on the aquatic environment, unrelated to human health, is limited.[13] E. coli contamination in drinking water can be effectively treated by boiling or by treating the water with chlorine, ozone, or ultraviolet light.[14] HCA currently uses ultraviolet light to treat water for the monastic enclosure, bakery, Retreat House, and Westwood House. However, water testing provides a way to validate the performance of treatment systems.[15]

In addition to pathogens, septic systems have the potential to contribute other types of pollution to ground and surface waters. For example, septic wastewater contains nitrogen and phosphorus, which have the potential to enter groundwater and surface water, especially (but not exclusively) when septic systems are leaking or failing. Once nitrogen and phosphorus enter water sources, they may negatively impact the environment and, in the case of nitrogen, human health.

Ingestion of phosphorus is not generally considered to be harmful to human health.[16] In contrast, the impact of nitrate (a form of nitrogen) on human health is widely debated. Some studies have linked the excessive consumption of nitrates from drinking water with Blue-baby syndrome (methemoglobinemia) in infants, which can be life-threatening if left untreated. Other studies have examined potential links between nitrate ingestion and certain forms of cancer and negative reproductive effects. However, other recent studies have questioned the validity of past research. A 2005 report published in the *Journal of Environmental Health Perspectives* concluded that more research must be done to fully understand the complex interactions between nitrate ingestion and human health. In the meantime, the report suggests maintaining current regulatory limits on nitrate concentrations in drinking water.[17]

Environmentally, the introduction of excessive amounts of phosphorus and nitrogen can cause severe damage to aquatic environments through a process called eutrophication. Eutrophication is a process in which excessive levels of introduced nutrients stimulate abundant algae growth in aquatic ecosystems. As algae dies and decays, it is broken down by naturally occurring bacteria. This process requires oxygen and can cause hypoxic (low oxygen) or anoxic (no oxygen) conditions, which are inhospitable to fish and shellfish. In severe cases, eutrophication can lead to massive numbers of fish deaths or “fish kills” and dead zones. Dead zones are areas that cannot support any animal life due to their lack of oxygen. While septic systems can, in some cases, be a significant contributor to nutrient pollution of water bodies, nutrient pollution can also come from municipal sewage treatment facilities, agricultural operations, lawns, gardens, power plants, and vehicle emissions.[18]

Wastewater and the Chesapeake Bay

Regionally, nutrient pollution is of particular concern in the Chesapeake Bay and the Bay's watershed, which includes the Shenandoah River. Samples taken by Friends of the Shenandoah River–a local environmental advocacy group–show that rivers in Clarke County are impaired by nitrate pollution. Similarly, samples showed tributaries in Clarke Country to be severely impaired by nitrate pollution. On a positive note, further sampling showed both rivers and tributaries in Clarke County to be unimpaired by orthophosphate (phosphorus) pollution.[19] On a larger scale, according to 2004 data, 3.74 million pounds of nitrogen and 526,514 pounds of phosphorus are entering the Shenandoah annually. In 2005, 80% of the adult smallmouth bass population was killed in a 100-mile stretch of the river. Experts believe this fish kill is at least in part attributable to nutrient pollution. Effluent from sewage treatment plants is a major source of this pollution.[20]

According to the Chesapeake Bay Foundation (CBF), "Largely because of pollution from excess nitrogen and phosphorus, the Chesapeake Bay and its tidal rivers are on the Clean Water Act's list of impaired waters."[21] In CBF's 2008 State of the Bay report, it gave the Bay a grade of F for nitrogen pollution and a grade of D- for phosphorus pollution.[22] While the Bay remains in "critical condition," according to CBF found Will Baker, a number of steps are being taken to clean the waters. For example, Maryland law now requires new septic systems that are installed within 1,000 feet of the Bay to use nitrogen removal technology.[23] In addition, in January 2009, CBF filed a lawsuit against the U.S. Environmental Protection Agency to require the agency to enforce the Clean Water Act as it applies to the Chesapeake Bay.[24] One of the primary objectives of the lawsuit is to force sewage treatment plants to meet stricter nutrient pollution targets.[25] As a result of the lawsuit, President Obama issued an Executive Order obliging EPA to enforce compliance. CBF has subsequently suspended its lawsuit.[26]

The HCA Water System

The hydrologic cycle is constantly looping through its natural course. Precipitation falls to the earth's surface where water that is not used by plants infiltrates into groundwater. Groundwater discharges into surface waters where it evaporates and condenses back into the atmosphere.[27] HCA's human-designed water system intertwines closely with this natural system.

HCA's system is composed of six primary, human-designed components: wells, cistern, pump house, treatment systems (ultraviolet and softening), fixtures and appliances, and septic systems. All six components are connected by piping infrastructure. HCA's wells (along with Cool Spring) are recharged in conjunction with natural groundwater recharge. Well water is pumped from the wells for use by the HCA community. In some cases, water passes through ultraviolet (UV) treatment and/or water softening systems before reaching plumbing fixtures and appliances. Finally, all of HCA's wastewater ends up in septic systems where, as discussed previously, solids and liquids are separated in the tanks. Liquids then drain into the accompanying leach fields and ultimately into ground and surface waters. A map that includes the locations of all wells and septic systems can be found in **Error! Reference source not found.**.

The Argument for Water Efficiency and Conservation at HCA

With knowledge of the context in which water is used globally and locally and with an understanding of HCA's water system, we will now revisit the rationale for conserving water at HCA. Because HCA draws its water from private wells, it does not pay a utility to access its water. However, there are other economic, environmental, and social costs and benefits associated with water use and conservation at HCA.

Costs associated with water use include the following:

- Septic system replacement
- Septic system pollution
- Energy expenditures
- Drilling new wells

Benefits of water conservation include the following:

- Extended life of wells and septic systems
- Improved surface and groundwater quality
- Improved drinking water quality
- Resilience in case of drought
- Leadership in sustainability

Below, we discuss the costs of water use and the benefits of water conservation in detail. Later, we discuss the economic costs of implementing various technological and behavioral strategies for water conservation. While the costs and benefits associated with water conservation are not always easily monetized, the Team has nevertheless attempted to present a complete picture of the rationale for conservation. Ultimately, decisions about which water conservation strategies to adopt should be made after considering all economic, environmental, and social costs and benefits of each proposed strategy.

Avoiding Septic System Costs

How long a septic system last and how effectively it functions are in large part functions of how much wastewater is put into that system. As previously discussed, 75% of septic leach field failures result from hydraulic overloading.[28] In essence, this means that putting less wastewater into a system will allow that system to function more effectively and for a longer period of time. Because septic systems are expensive to replace, there is a potentially significant cost savings associated with water conservation as it relates to extending the useful life of a septic system. Specifically, septic systems can cost anywhere from $1500 to over $8000 to replace (with an average cost of approximately $4000) and can last for over 20 years with proper maintenance, according to an EPA report published in 1999.[29]

Avoiding Septic System Pollution

Even septic systems that function as intended release some amount of pollution into groundwater supplies. The higher the amount of wastewater inflow to a septic system, the higher the potential for significant levels of groundwater (and possibly surface water) pollution. In addition, Karst topography, which is found at HCA, may compound the problem by providing conduits that can allow contaminants to reach ground and surface water more quickly and in greater volumes than would normally be the case. Common sources of water pollution in septic wastewater include nitrogen, phosphorus, and/or bacteria. As previously discussed, bacteria can pose a human health risk if it enters drinking water supplies. Nitrogen may pose a human health risk, and both nitrogen and phosphorus can contribute to algae blooms and hypoxic events in surface waters. The threat of water contamination can be mitigated by limiting the throughput of wastewater within a septic system, which can be achieved through a long-term water conservation strategy.[30]

Avoiding Energy Costs of Hot Water Use

Water heating accounts for 14 to 25% of all residential energy use in the United States.[31] For this reason, hot water use can be economically costly. Hot water use also negatively impacts the environment (e.g., heating water requires energy, and fossil energy use produces CO_2 emissions). However, limiting the use of hot water as part of an overall water conservation strategy provides the opportunity to reduce both energy bills and associated environmental costs.

Many strategies exist to reduce the amount of hot water used for showering, dishwashing, hand washing, clothes washing, and more. These strategies will be discussed subsequently.

Increasing Resilience

While water is more plentiful in Virginia than in other parts of the country, Virginia is not immune to drought. The worst Virginia drought in recent history occurred from 1930–1932. Virginia also experienced periods of drought from 1938–1942, 1962–1971, and 1980–1982.[32] Additional droughts struck the state in 2002 and 2007.[33] In response to the most recent Virginia drought, the Virginia Department of Environmental Quality (VA DEQ) discussed the challenge of shifting "consumer behavior from consumption to conservation and re-use to ensure the sustainability of all beneficial water demands."[34] At HCA, the 2007 drought made it necessary to drill a new well to meet the needs of the community. While it is not possible to predict when or how severe the next Virginia drought will be, establishing a water conservation strategy would increase the HCA community's resilience in the face of uncertain future water availability.

Leadership in Conservation

In addition to the previously mentioned reasons, implementing a water conservation strategy would position HCA as a leader in sustainability among religious communities (five other OCSO American Monasteries have already implemented water conservation measures). In addition to the positive public relations that this leadership position could offer, efforts by HCA to conserve water would also set a positive example for other religious and secular communities and encourage them to implement their own water conservation strategies.

Measuring Sustainability in Water Use

To help the HCA community consider appropriate water conservation goals, the Team has identified three certification programs that provide guidance in this area. These programs are discussed in detail below.

EPA WaterSense

The EPA WaterSense program identifies and labels water-conserving fixtures including toilets, urinals, and sink faucets. The EPA is also developing WaterSense standards for showerheads, pre-rinse spray valves, and irrigation systems. According to the EPA, WaterSense labeled products are typically approximately 20% more efficient than average products in the same category.[35]

ENERGY STAR

For clothes washers and dishwashers, ENERGY STAR-labeled products provide a useful benchmark for gauging water efficiency. ENERGY STAR clothes washers use approximately 50% less water than standard clothes washers.[36] ENERGY STAR dishwashers use about 8 gallons of water less per wash cycle than dishwashers purchased prior to 1994.[37]

LEED for Homes

The LEED green building rating systems, developed by the U.S. Green Building Council (USGBC), provide guidelines for designing and maintaining buildings in an environmentally responsible way. For HCA's purposes, the LEED for Homes rating system is most appropriate. Within its water efficiency category, LEED for Homes offers credits for water reuse, irrigation system efficiency, and indoor water use efficiency. Water reuse credits are given for installing graywater or rainwater capture systems. Irrigation systems are credited for efficiency gains of 45% or greater. Indoor water use credits are offered for installing bathroom faucets and showers that all use ≤ 2.0 gpm, as well as toilets that all use≤

1.3 gpf or have dual-flush capability. LEED for Homes also provides additional credits for achieving greater indoor and outdoor water efficiency.[38]

METHODOLOGY

Because the HCA community draws its water exclusively from unmetered, private sources, no data was initially available regarding the quantity of water used on-site. In order to make recommendations with respect to how HCA can reduce its water consumption, it was first necessary to gain an understanding of the HCA community's water use. Specifically, the goals of the HCA water use analysis were as follows:

1. To approximate how much water is being used, in total, by the HCA community
2. To develop an understanding of how that water use is distributed across various locations within the HCA property
3. To develop an understanding of how HCA water use is distributed across activities (such as showering, toilet flushing, dishwashing, etc.)

The information gained from the water use analysis allowed the University of Michigan Team to consider potential water conservation strategies both in terms of expected water savings and expected implementation costs and to develop options and recommendations accordingly. This analysis does not consider water use by guests, gift shop customers, or farm workers. In addition, it does not consider water used in the course of bakery or farm operations. Rather, this analysis focuses solely on water used by the immediate HCA community during the course of their daily lives. The following section describes how the analysis was developed and conducted.

HCA Water Use Analysis

This section describes the structure and methodology behind the HCA community water use assessment. In order to complete a full assessment of water use at HCA, the Team compiled the following information pertaining to the community's water system and water use:

- An inventory of HCA water sources, drinking water treatment systems, septic systems, and additional components used to facilitate water transport and storage (e.g., the pump house and cistern)
- An inventory of all fixtures and plumbing appliances within all buildings on the HCA property, including flow rates and manufacturer information when possible
- An inventory of all outdoor fixtures, including corresponding flow rates
- An estimate of one week's water use (based on data from a sample of 16 HCA community members)

Well and Septic System Inventory

To compile information on wells, springs, and septic systems, the Team relied on information gathered through conversations with members of the HCA community in May of 2009. Subsequently, the Team developed preliminary maps of well and septic system locations using Google Maps and ArcView GIS software. Members of the HCA community examined the maps for accuracy and returned them to the Team with comments. The Team then updated the GIS maps to include the location of a cistern (used to store water for use at the Westwood House) and a pump house (which houses the pump that transports water to the bakery and the monastic enclosure).

Fixture and Appliance Inventory

In order to compile a database of all HCA plumbing fixtures, appliances, and corresponding flow (or flush) rates, the Team first developed worksheets based largely on those described in Amy Vickers's *Handbook of Water Use and Conservation*. Worksheets were separated into two categories: indoor and outdoor water use. During the Team's visit in May of 2009, we recorded all applicable data regarding water-using fixtures and appliances on the worksheets. We also recorded the locations of all water-softening systems at this time.

For sink faucets, showerheads, bath faucets, outdoor faucets, hoses, sprayer attachments, and water fountains, the Team recorded the flow rates listed on the fixtures when the data was available. When flow rate data was not listed, the Team calculated flow rates by collecting and measuring the water flowing out of the fixtures during 10-second intervals. Flows were recorded at the maximum flow rate (in ounces) for all fixtures, aside from dishwashing sink faucets. For dishwashing sink faucets, flows were recorded at a "reasonable" flow (approximately 50% of the maximum flow). For fixtures in rooms that were inaccessible, the Team assumed flow rates based on fixtures in comparable rooms in the same building. Later, flow rates were converted to gallons per minute (gpm). In addition, flow rates for faucets and showerheads were adjusted down to reflect typical use of 67% of the maximum measured flow.[39]

For toilets, flush rates were estimated in one of three ways. In cases where low-flow toilets were installed, flush rates were typically printed on the fixture. Whenever available, the Team used these printed flush rates. Typically, flush rates were listed on low-flow models only. In cases where flush rate information was not listed, we assumed toilets to be 3.5 gallons per flush (gpf). The assumed 3.5 gpf is a common flush rate associated with toilets manufactured between 1980 and 1994. All non-low-flow toilets at HCA are assumed to have been manufactured within this timeframe. Other common flush rates associated with toilets manufactured during this period are 4.0 gpf and 4.5 gpf.[40] For all urinals, flush rates were assumed to be 1.5 gpf based on the perceived age of the fixtures.

For all clothes washers, the Team recorded all available manufacturer and model information during the May 2009 trip to HCA. Subsequently, the Team contacted the applicable manufacturers to gather information on each model's average water use per load of laundry. When necessary, we made assumptions about water use based on the perceived age of the clothes washer, using information from Vickers's *Handbook of Water Use and Conservation*.

Later in 2009, the Team collected additional information regarding the locations of ultraviolet water treatment systems via email correspondence with the HCA community.

Survey Instrument Design

In addition to collecting data and compiling a database of all water-using fixtures and appliances, it was necessary to gather information about how water is being used on-site by the HCA community. Combining inventory data, flow rate data, and data on community water use was necessary in order to calculate water-use statistics, which were used to guide water conservation strategy recommendations. To gather data on water use, the Team asked HCA community members to keep a log of their water-use activities over the course of seven days. To provide a systematic way for community members to record their water use, we developed and distributed a log worksheet to each HCA resident and employee. These worksheets collected the following information about the community's water use:

- Activity (hand washing, cooking, flushing toilet, etc.)
- Date of water use
- Location of water use
- Fixture or appliance used
- Duration of water use (or number of uses when applicable)

- Water temperature

In addition to the water-use log, the Team administered a brief exit survey in an attempt to capture typical water use activities that did not occur while the log was kept.

Database Design

The next step in the water use assessment was to build a Microsoft Excel database template to facilitate the transfer of data from the paper-based log worksheets. All data was coded to facilitate standardization of database entries. Each row entry in the Excel database represents an individual water-use event (for example, one flush of a toilet or a single period of time spent washing dishes). Clothes washing entries may include multiple loads of laundry in one row. Initially, the database included the following specific categories (column headers):

- Participant (participating community members were each assigned a unique number)
- Date of the specific water-use event
- Location of the specific water-use event
- Fixture or appliance used
- Activity associated with the specific water-use event (hand washing, cooking, flushing toilet, etc.)
- Duration of use (in seconds) of the specific water use event (not applicable to toilet/urinal flushing or clothes washing)
- Number of loads (applies to clothes washing only)
- Model used (applies to clothes washing only)
- Water temperature (associated with activities where temperature can be controlled)
- Notes (any additional pertinent information)

After the data transfer was complete, the Team programmed the database to calculate the quantity of water used during each water-use event. These calculations incorporate flow (and flush) rate data from the database of fixtures and appliances and water-use data from the community water use assessment. Because it was not possible to allocate water use down to the fixture level, calculations incorporated average flow rate data from similar fixture types within the rooms where water use occurred. For example, for a hand-washing event occurring in the northwest dormitory washroom, the database calculated quantity of water used based on the average flow rate of all sinks within that room and the duration of the event.

Next, the Team disaggregated the data into two user categories—residents and full-time employees—and calculated average daily and annual per capita water use for both user types. The Team also estimated daily and annual per capita water use for part-time employees. Because no log data was available for this user type, we assumed their water use to be approximately 65% that of full-time employees. The Team then used per capita water-use estimates for each user type to approximate the daily and annual water use of the entire HCA community (20 residents, 4 full-time employees, and 4 part-time employees). Using the same methodology, water-use data was then sorted by activity and location. By doing so, we were able to estimate how much water is being used for each activity in each location within and outside of the Abbey.

In order to also estimate hot water use and its associate energy costs, the Team also broke data down into the following four temperature streams:

- Cold: 0% hot water
- Cool: 33.33% hot water
- Warm: 66.67% hot water

- Hot: 100% hot water

In cases where water temperature associated with water-use events was not logged by HCA community members, temperatures were assumed based on the mode of logged responses within each type of water-use activity. When less than 30 water-use events included temperature data for a given activity, the Team made reasonable assumptions based on common experience. Using this methodology, the following water temperatures were assumed for events of the given activity types when data was not provided:

- Agricultural: cold
- Bathing: warm
- Brushing teeth: cold
- Cleaning indoor surfaces and fixtures: warm
- Cooking: cold
- Drinking and making beverages: cold
- Flushing toilet: cold
- Flushing urinal: cold
- Outdoor washing and cleaning: cold
- Shaving: hot
- Showering: warm
- Washing clothes: warm
- Washing dishes: hot
- Washing hands or face: warm
- Watering plants: cold

Next, the Team used this data to estimate the total community water and hot water use associated with each location and activity type. Energy costs associated with hot water use were determined by linking water use data with energy costs, which the Team calculated for each boiler in the monastic enclosure.

Finally, the Team used location and activity level data, as well as associated energy cost data, in conjunction with replacement cost data for fixtures and appliances to evaluate options for replacing particular fixtures and appliances in specific locations. Recommendations are based both on the potential for water savings and financial cost associated with the investments. The data was also used to provide the community with recommendations for behavioral changes that could result in significant water savings.

Water Quality Study Design

Based on data received from the HCA community in the fall of 2009, the Team found no evidence that comprehensive water testing had been performed on the property in recent years. In addition, the Team identified a number of potential threats to the current drinking, ground, and surface water quality at HCA. For these reasons, we contracted a local environmental services firm called Greenway Engineering (located in Winchester, VA) to perform a battery of water-quality tests.

Through independent research, examination of past data, and conversations with various members of the HCA community, the Team identified the following hazards and potential sources of water contamination at HCA:

- *Nitrogen* from septic systems, manure, and sludge application
- *Phosphorus* from septic systems, manure, and sludge application
- *Coliform bacteria* (including E. coli) from septic systems, manure, and sludge application
- *Atrazine* from cornfield application
- *Gasoline* from underground storage tanks
- *Heating oil* from underground storage tanks

It is important to note that of the above potential contaminants, only nitrogen, phosphorus, and coliform bacteria (including E. coli) can be reasonably (though not exclusively) associated with water use. These and other potential sources of contamination are also discussed in Chapter 1 and Chapter 5.

Existing UV treatment and water conditioning systems only treat drinking water for bacterial contamination and hardness, respectively, but not for the other previously listed contaminants. For this reason, and because bacterial contamination is of greater concern from a human health perspective than from an environmental perspective, the Team determined that it would be most efficient and useful to conduct all water testing at indoor taps.

In order to determine which water sources were at risk from which potential sources of contamination, the Team mapped the location of all wells, septic systems, underground fuel tanks, cattle grazing areas, cornfields, and surface water flows. A detailed map of these locations is included in the **Error! Reference source not found.**. By combining this data with information about which wells supply which buildings, the Team was able to develop a water-testing plan to examine drinking water, and by extension groundwater, throughout the HCA property. After numerous consultations with Andrea Martin, an environmental scientist with Greenway Engineering, the team chose the proper analytes to test for contamination from nitrogen, phosphorus, bacteria, atrazine, gasoline, and heating oil. The testing plan is detailed in

Table 1 below. Water testing was conducted on January 26, 2010 by Jeremy Ferguson of Greenway Engineering.

Table 1: Water testing plan (January 26, 2010)

Testing Location and Corresponding Well Number	Potential Contaminants	Tests Performed
Hermitage indoor tap (well 1)	septic, atrazine, biosolids, manure, gasoline tank, heating oil tank	total kjeldahl nitrogen, nitrate + nitrite, total phosphorus, total coliform, E. coli, atrazine, OA-2, and total petroleum hydrocarbons–gasoline range organics
Monastery kitchen tap (well 2)	septic, atrazine, biosolids, manure, gasoline tank, heating oil tank	total kjeldahl nitrogen, nitrate + nitrite, total phosphorus, total coliform, E. coli, atrazine, OA-2, and total petroleum hydrocarbons–gasoline range organics
Gift shop indoor tap (well 3)	septic, biosolids, manure, gasoline tank, heating oil tank	total kjeldahl nitrogen, nitrate + nitrite, total phosphorus, total coliform, E. coli, OA-2, and total petroleum hydrocarbons–gasoline range organics
(Well 4)	N/A	N/A
Bishop's house indoor tap (well 5)	septic, biosolids, manure	total kjeldahl nitrogen, nitrate + nitrite, total phosphorus, total coliform, E. coli
Retreat House kitchen tap (well 6)	septic, biosolids, manure, gasoline tank, heating oil tank	total kjeldahl nitrogen, nitrate + nitrite, total phosphorus, total coliform, E. coli, OA-2, and total petroleum hydrocarbons–gasoline range organics
(Well 7)	N/A	N/A
Westwood house indoor tap (well 8)	septic, manure	total kjeldahl nitrogen, nitrate + nitrite, total phosphorus, total coliform, E. coli
Wynkoop house indoor tap (well 9)	septic, atrazine, biosolids, manure, heating oil tank (water tested for oil in 2008)	total kjeldahl nitrogen, nitrate + nitrite, total phosphorus, total coliform, E. coli, atrazine

RESULTS

By analyzing data from the plumbing inventory and the community water use evaluation, the Team was able to estimate how much water is being used by the HCA community, where the water is being used, and what the water is being used for. Results from the water testing performed on January 26, 2010 were also analyzed. Using this data to determine where the greatest potential water savings and water quality problems are located, the Team was able to make informed recommendations for future HCA water management strategies.

Inventory of Wells, Drinking Water Treatment Systems, and Septic Systems

HCA has a total of nine wells on-site. These wells currently supply water to all HCA facilities (

Table 1: Water testing plan (January 26, 2010. HCA also has the option of drawing water from the Cool Spring to supply the monastic enclosure. In most cases, water is pumped directly from the wells into HCA's buildings. However, in the case of the Westwood House, well water is first pumped into a cistern on the hill above the house and then drawn directly from the cistern. In the case of the monastic enclosure and the bakery, water is pumped through a pump house en route to the buildings.

Ultraviolet (UV) treatment systems are currently being used to treat water for the bakery, monastic enclosure, Retreat House, and Westwood House. UV treatment systems are designed to disinfect water by destroying harmful microorganisms.[41] Water softening systems are in use at the Retreat House, bakery, monastic enclosure, Wynkoop House, and Westwood House. Water softening systems are designed to reduce the hardness of water by removing calcium and magnesium.[42] According to a technical service representative at RainSoft, a major supplier of home water treatment systems, neither UV treatment nor water softening systems are designed to treat water for contamination from nutrients, volatile organic compounds (VOC's), or other chemicals.

Following use, all of HCA's wastewater ends up in one of 11 septic systems, and some of it ultimately makes its way into surrounding ground and surface waters. As mentioned previously, a map that includes the locations of all wells and septic systems can be found in the section **Error! Reference source not found.**.

Inventory of Plumbing Fixtures and Appliances

The Team's comprehensive inventory of HCA plumbing fixtures and appliances revealed a total of 256 indoor appliances and fixtures as well as 14 outdoor appliances and fixtures. The greatest number of indoor plumbing fixtures and appliances can be found in the Retreat House bathrooms, the infirmary wing bathrooms, the northwest dormitory bathroom and shower room, the senior wing bathrooms, and the bathroom under the church. The majority of the outdoor fixtures are located in the gardens on the north side of the monastic enclosure (including the butterfly garden).

Flow Rates of Plumbing Fixtures and Appliances

As part of the inventory performed in May of 2009, the Team recorded flow rates, flush rates, and water use per load (in the case of clothes washers) for all applicable plumbing fixtures and appliances. High flow rate fixtures and appliances are typically outdated and, depending on usage, may be the best candidates for replacement.

The highest average flow rates for showerheads are found in the shower room under the chapel, the downstairs bathroom of the Westwood house, and the northwest dormitory washroom. The highest flow rate sink faucets are found in the bakery mixing room, the monastery laundry room, and the Retreat House boiler room. However, it should be noted that the sinks in these rooms are industrial sinks, which typically have higher flow rates than standard hand washing sinks. Other rooms with particularly high-flow hand washing sink faucets include the old dormitory bathrooms and the northwest dormitory bathroom (Table 2).

The majority of HCA toilets are high volume fixtures. Of all the toilets at HCA, low-flow (1.6 gpf) toilets were found only in the mansion bathroom, the senior wing bathrooms, the Westwood house downstairs bathroom, and the William's hermitage bathroom. All other toilet fixtures are assumed to be 3.5 gpf. All HCA urinals are high flow and assumed to be 1.5 gpf (Table 3).

According to the results of the inventory, HCA has five clothes washers on-site. Of the five washers, four are residential size and one is industrial size. Flow rates were determined for the industrial washer and three of the four residential washers based on make and model information as well as purchase date information from the HCA community (Table 4). The Team was unable to determine water use for the final residential washer located in the Bishop's house. The Team also determined outdoor fixture flow rates, which are presented in Table 5. Based on the inventory and discussion with HCA community members, it is apparent that all garden irrigation is accomplished using hoses and sprinklers, which are less efficient than drip irrigation methods.

Community Water Use Evaluation

Total Water Use

As previously discussed, inventory and flow rate data were combined with HCA community water use evaluation data to construct water use estimates. Of the 33 water use evaluation worksheets sent to HCA community members, 16 were completed and returned by individual community members. The Team also received two supplemental completed worksheets that detailed community laundry and the administration of medical treatment. Of the 16 completed log worksheets, 14 were completed by HCA residents and 2 were completed by full-time employees.

Based on flow rate data and data from the HCA community water use evaluation, the Team estimated total HCA community water use to be 558,139 gallons of water per year. This level of use translates to 46,512 gallons of water per month, 10,733 gallons per week, and 1,529 gallons per day and includes water use by residents as well as full-time and part-time employees. These totals do not include water used by guests, gift shop patrons, or farm personnel and do not include water used during the course of farm or Bakery operations. In addition, these totals exclude any water use that may occur as a result of leaking plumbing fixtures.

Of the 558,139 total gallons of water used by the community annually, we estimate that HCA residents use 534,134 gallons. For residents only, this number translates into a per capita water use of 73.2 gallons daily. This level of water use, which includes both indoor and outdoor use, compares favorably with the 91.5 gallons that is used daily (per capita) in an average North American single-family home, excluding leaks.[43]

However, for a more useful comparison, we also need to look at indoor and outdoor water use separately. In terms of outdoor water use, HCA residents use only 4.5 gallons of water per capita per day. By contrast, the average North American resident (living in a single-family home) uses 31.7 gallons of water per day.[44] However, In terms of indoor water use, HCA residents actually use more water per capita than the average North American. Average indoor water use, excluding leaks, in a typical non-conserving North American single-family home is 59.8 gallons per capita per day.[45] Indoor water use for an average HCA resident is about 68.7 gallons per day. This finding suggests that there is ample room for HCA to reduce its water use, especially indoors. Figure 1 and Figure 2 present detailed breakdowns of HCA residents' daily indoor water use and North Americans' daily indoor water use, respectively.

Table 2: Average faucet and showerhead 67% flow rates by location (gallons per minute)

Location	Showerheads	Sink Faucets
Bakery mixing room		4.92
Bakery bathroom		1.47
Bathroom under church		1.87
Bishop's house kitchen		1.34
Bishop's house master bathroom	1.01	1.47
Bishop's house second bathroom	1.68	1.19
Gift shop		1.35
Infirmary wing bathroom (by chapel, small)		1.01
Infirmary wing bathroom (in room)	1.07	2.26
Infirmary wing outside access bathroom		1.01
Monastery kitchen		3.12
Mansion bathroom	1.68	0.94
Mansion closet (first floor)		1.01
Monastery laundry room		4.71
NW dormitory toilets		3.06
NW dormitory washroom (showers)	3.02	1.34
Old bakery bathroom		1.63
Old dormitory bathroom (lower level)		4.02
Old dormitory bathroom (upper level)		3.55
Refectory dishwashing room		2.47
Retreat House bathroom (in room)	1.68	1.34
Retreat House boiler room		4.71
Retreat House dining area		3.14
Retreat House guest master's suite	1.68	1.34
Retreat House kitchen		1.45
Retreat House public bathroom		1.26
Sacristy sink		0.94
Senior wing bathroom (in room)	1.68	1.13
Shower room under church	4.35	
Westwood downstairs bathroom	3.45	1.07
Westwood kitchen		0.75
Westwood upstairs bathroom (shower only)	0.69	1.47
Westwood upstairs bathroom (toilet only)		1.47
Westwood upstairs bathroom (tub and toilet)		1.34
William's hermitage bathroom		1.47
Wynkoop bathroom	1.68	1.01
Wynkoop kitchen		1.47

Table 3: Average toilet and urinal flow rates by location (gallons per flush)

Location	Toilets	Urinals
Bakery bathroom	3.50	
Bathroom under church	3.50	1.50
Bishop's house master bathroom	3.50	
Bishop's house second bathroom	3.50	
Gift shop	3.50	
Infirmary wing bathroom (by chapel, small)	3.50	
Infirmary wing bathroom (in room)	3.50	
Infirmary wing outside access bathroom	3.50	
Mansion bathroom	1.60	
NW dormitory toilets	3.50	1.50
Old bakery bathroom	3.50	
Old dormitory bathroom (lower level)	3.50	
Old dormitory bathroom (unspecified)	3.50	
Old dormitory bathroom (upper level)	3.50	
Retreat House bathroom (in room)	3.50	
Retreat House guest master's suite	3.50	
Retreat House public bathroom	3.50	
Senior wing bathroom (in room)	1.60	
Westwood downstairs bathroom	1.60	
Westwood upstairs bathroom (toilet only)	3.50	
Westwood upstairs bathroom (tub and toilet)	3.50	
William's hermitage bathroom	1.60	
Wynkoop bathroom	3.50	

Table 4: Clothes washer water use per load by location (gallons)

Location	Clothes Washer	Industrial Clothes Washer
Basement boiler room (bakery storage)	27.00	
Monastery laundry room	27.00	100.00
Retreat House boiler room	27.00	

Table 5: Average outdoor plumbing fixture flow rates by location (gallons per minute)

Location	Hose	Hose Sprayer	Hose Sprinkler	Sprinkler
Butterfly garden				4.41
Garden (north side of monastery)	7.73	4.69	8.44	
Gift shop garden		0.84		

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However, for a more useful comparison, we also need to look at indoor and outdoor water use separately. In terms of outdoor water use, HCA residents use only 4.5 gallons of water per capita per day. By contrast, the average North American resident (living in a single-family home) uses 31.7 gallons of water per day.[47] However, In terms of indoor water use, HCA residents actually use more water per capita than the average North American. Average indoor water use, excluding leaks, in a typical non-conserving North American single-family home is 59.8 gallons per capita per day.[48] Indoor water use for an average HCA resident is about 68.7 gallons per day. This finding suggests that there is ample room for HCA to reduce its water use, especially indoors. Figure 1 and Figure 2 present detailed breakdowns of HCA residents' daily indoor water use and North Americans' daily indoor water use, respectively.

While examining water use per resident is useful as a way to compare HCA water use against a baseline, it is necessary to look more closely at total community water use in order to accurately assess water conservation options. For this reason, the Team broke annual HCA community water use down by location and activity. Locations where the highest level of water use occurs include the northwest dormitory shower room, the monastery laundry room, the northwest dormitory bathroom, the bathroom under the church, and the refectory dishwashing room. Water use by location is represented graphically in Figure 3. The Team also considered community water use in terms of activities. The top water-using activities include flushing toilets, washing clothes, showering, washing dishes, and watering plants. Water use by location is shown in Figure 4.

Figure 1: HCA resident daily per capita indoor water use in gallons (excluding leaks, 68.7 gallons total)

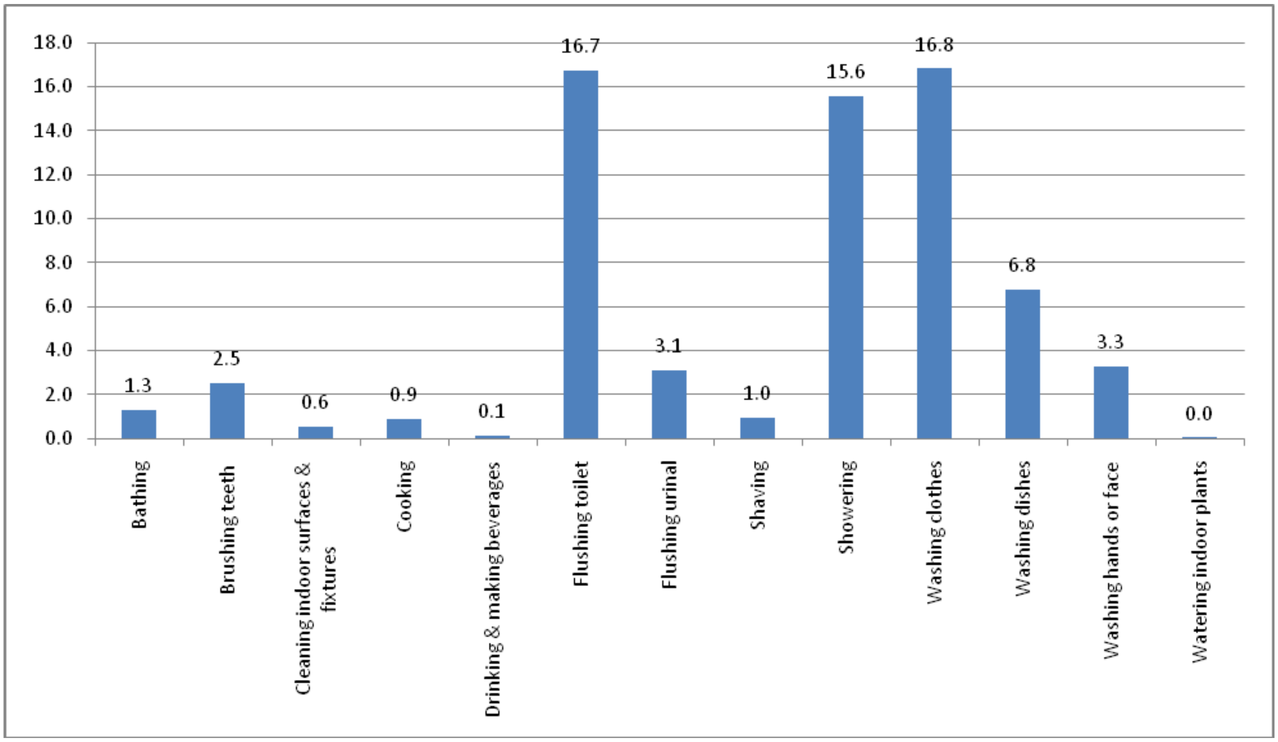
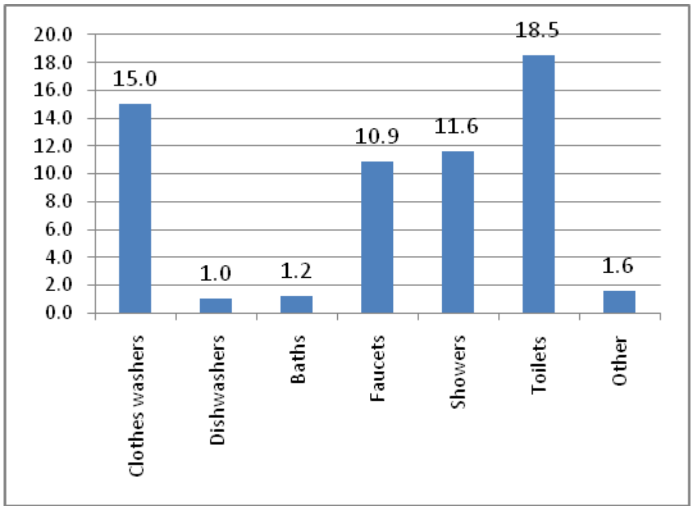


Figure 2: North American single-family home daily per capita indoor water use in gallons (excluding leaks, 59.8 gallons total)



Source: Vickers, 2001

Figure 3: HCA community annual water use by location (gallons)

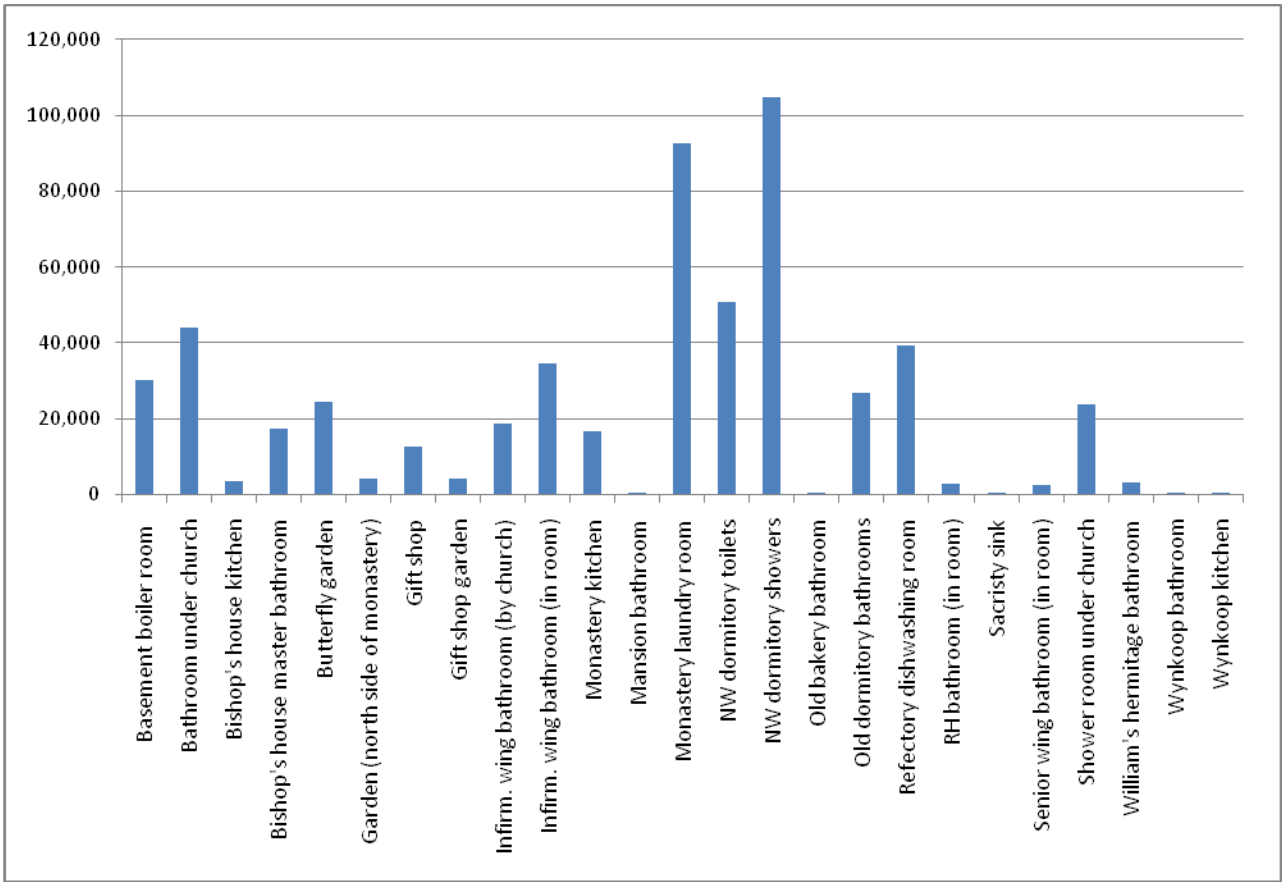
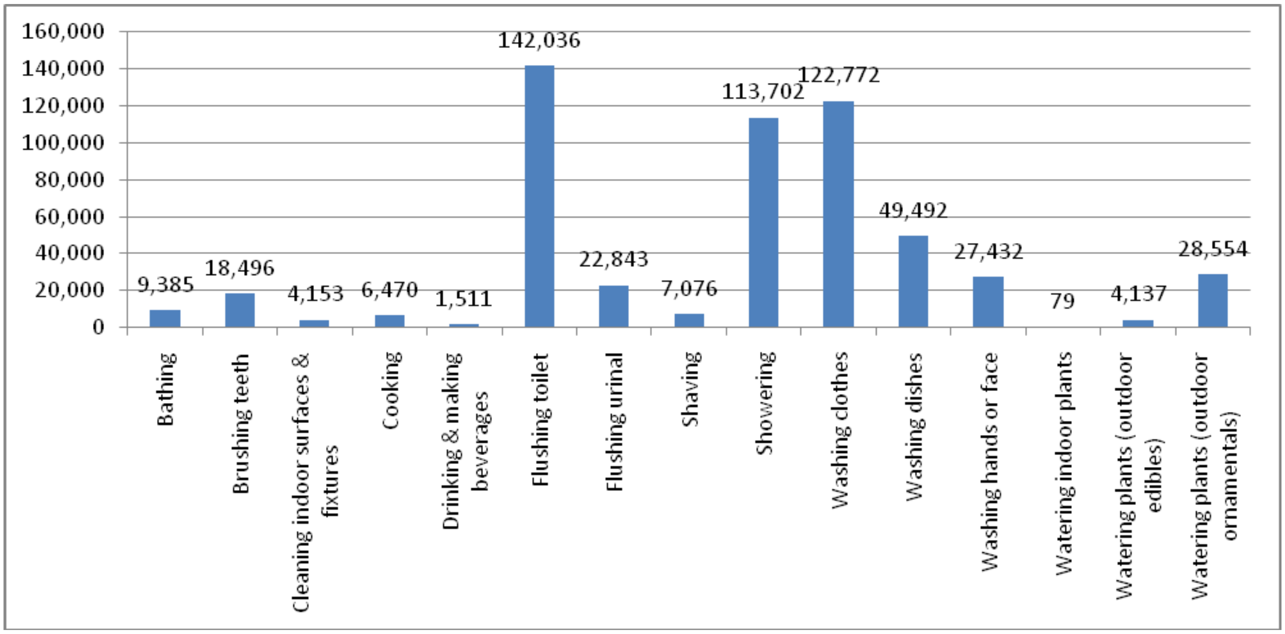


Figure 4: HCA community annual water use by activity (gallons)



Next, the Team broke annual water use down by activity within each location. The following list presents the top ten specific sources of water use at HCA:

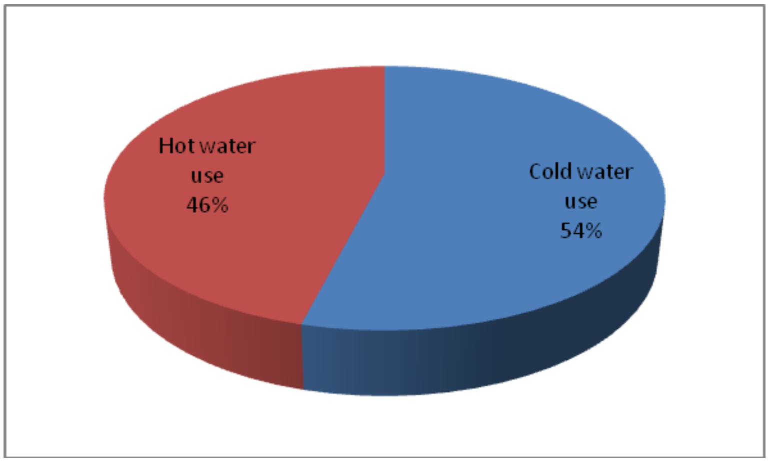
1. Monastery laundry room, washing clothes: 92686 gallons per year
2. Northwest dormitory shower room, showering: 85,669 gallons per year
3. Refectory dishwashing room, washing dishes: 36,021 gallons per year
4. Northwest dormitory bathroom, flushing toilets: 31,051 gallons per year
5. Monastery basement boiler room, washing clothes: 30,086 gallons per year
6. Infirmary wing bathrooms (all in-room bathrooms), flushing toilets: 27,525 gallons per year
7. Butterfly garden, watering plants: 24,402 gallons per year
8. Shower room under chapel, showering: 23,894 gallons per year
9. Bathroom under chapel, flushing toilets: 22,880 gallons per year
10. Northwest dormitory bathroom, flushing urinals: 18,386 gallons per year

Hot Water Use

In order to accurately assess the costs and benefits of potential water management strategies, it is imperative to consider the community's hot water use. Hot water use is particularly important because it is directly associated with energy use. In other words, the more hot water the community uses, the more energy it uses. Strategies to reduce hot water use, therefore, have the potential to reduce associated energy costs in addition to reducing overall water use.

Based on water temperature data provided in the HCA community water use evaluation and on the assumptions made about water temperature where temperature was not specified in the evaluation, the Team calculated hot water use to amount to 46% of the community's total water use or an estimated 256,849 gallons of water per year (*see* Figure 5). Given these results, we can conclude that the potential for reducing hot water use at HCA is high.

Figure 5: Annual hot and cold water use (gallons)



In addition to evaluating overall hot water use, the Team also examined hot water use from the perspective of location of use and associated activity. This level of analysis allowed the Team to locate the greatest potential for hot water savings.

At HCA, the locations where the most hot water is used include the northwest dormitory shower room, the monastery laundry room, the refectory dishwashing room, the monastery basement boiler room (bakery storage), and the shower room under the church (*see* Figure 6). The activities that consume the most hot water are showering, washing clothes, washing dishes, washing hands or face, and brushing teeth (Figure 7).

Figure 6: HCA community annual hot water use by location (gallons)

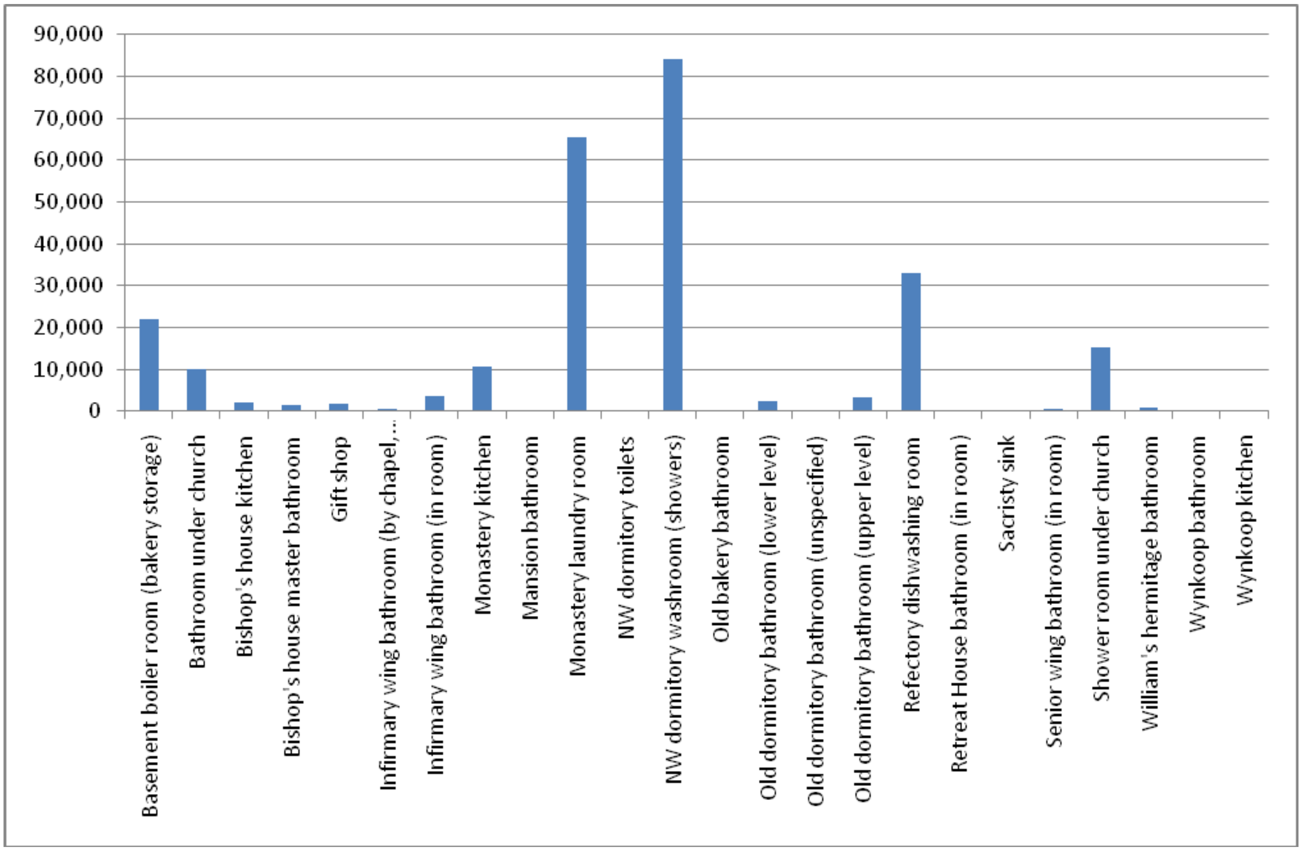
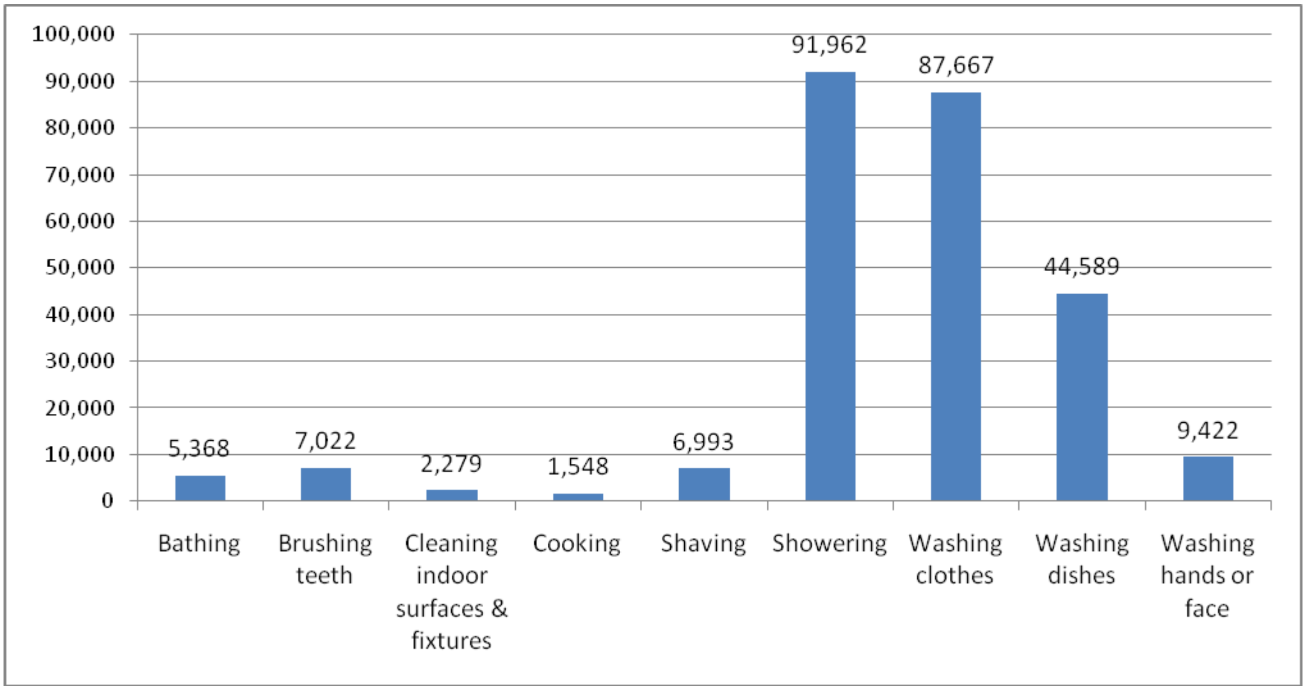


Figure 7: HCA community annual hot water use by activity (gallons)



Finally, the Team examined hot water use by activity within each possible location to provide another layer of data to guide recommendations for improving HCA's hot water efficiency. The subsequent list presents the top ten sources of hot water use at HCA:

1. Northwest dormitory shower room, showering: 74,135 gallons per year
2. Monastery laundry room, washing clothes: 65,604 gallons per year
3. Refectory dishwashing room, washing dishes: 32,838 gallons per year
4. Monastery basement boiler room (bakery storage), washing clothes: 22,063 gallons per year
5. Shower room under church, showering: 15,068 gallons per year
6. Monastery kitchen, washing dishes: 8,473 gallons per year
7. Northwest dormitory shower room, brushing teeth: 5,774 gallons per year
8. Bathroom under chapel, shaving: 4,853 gallons per year
9. Bathroom under chapel, washing hands or face: 3,946 gallons per year
10. Old dormitory upper level bathroom, bathing: 3,178 gallons per year

Water Quality Testing

In order to inform the creation of a water testing plan, the Team gathered information about historical water testing performed at HCA. The results from these water tests are presented below.

- November 26, 1984: levels of hardness, total dissolved solids (TDS), and non-coliform bacteria at the hermitage exceed maximum contaminant levels (MCLs) set by the Safe Drinking Water Act (SDWA)
- November 26, 1984: levels of hardness at the Guest House exceed MCLs set by the SDWA
- November 26, 1984: levels of non-coliform bacteria at the monastery kitchen exceed MCLs set by the SDWA
- August 20, 1985: coliform bacteria were not found to be present in the New Ground well water supply
- August 1, 1986: coliform bacteria were found to be present in the monastery family guest house water supply
- August 28. 1991: levels of nitrates/nitrites and total coliform bacteria at the hermitage exceed MCLs set by the SDWA
- December 22, 1997: coliform bacteria were not found to be present in the new Wynkoop house's well
- May 15, 2002: levels of nitrate at an undisclosed HCA well did not exceed MCLs set by the SDWA
- May 14, 2002: coliform bacteria were not found to be present in the parking lot well by the hermitage
- June 7, 2007: World Wide Water installed a RainSoft EC4 water conditioning system to treat the bakery water supply for manganese, hardness, and dissolved iron

Because past testing did not address the potential contamination issues that the Team identified, the Team contracted with Greenway Engineering to perform a full battery of water tests. These tests were meant to identify contamination, if present, in the HCA drinking water supplies and to identify any contamination in the groundwater with potential to negatively affect the surrounding water quality. The results of the testing confirmed bacterial contamination in the wells supplying water to William's hermitage, the monastic enclosure, and the gift shop. No bacterial contamination was found in other wells. Nutrient levels fell below EPA maximum contaminant levels in all cases. However, a substantial level of nitrate and nitrite was found in the well supplying William's hermitage. No contamination from heating oil or gasoline was found in any of the water samples tested. Table 6 presents a summary of all water test results from January 26, 2010.

Table 6: Water testing results (January 26, 2010)

Testing Location and Corresponding Well Number	Total Kjeldahl Nitrogen	Nitrate + Nitrite	Total Phosphorus	Total Coliform	E. coli	Atrazine	OA-2	TPH-GRO
Hermitage indoor tap (well 1)	0.26 mg/l	8.48 mg/l	0.04 mg/l	**present**	**present**	non-detect	non-detect	non-detect
Monastery kitchen tap (well 2)	0.26 mg/l	1.88 mg/l	0.03 mg/l	**present**	**present**	non-detect	non-detect	non-detect
Gift shop indoor tap (well 3)	0.27 mg/l	0.44 mg/l	0.03 mg/l	**present**	absent	N/A	non-detect	non-detect
Bishop's house indoor tap (well 5)	0.34 mg/l	1.1 mg/l	0.04 mg/l	absent	absent	N/A	N/A	N/A
Retreat house kitchen tap (well 6)	0.25 mg/l	0.11 mg/l	0.03 mg/l	absent	absent	N/A	non-detect	non-detect
Westwood house indoor tap (well 8)	0.35 mg/l	2.96 mg/l	0.07 mg/l	absent	absent	N/A	N/A	N/A
Wynkoop house indoor tap (well 9)	0.14 mg/l	1.68 mg/l	0.06 mg/l	absent	absent	non-detect	N/A	N/A

OPTIONS

Based on the results of the water use and water quality analyses, the Team offers the following options for conserving water as well as monitoring and enhancing water quality.

- Install new showerheads. 2.0 gpm rated showerheads provide a relatively low cost way to conserve a substantial amount of water. In two locations, replacing showerheads provides a positive net present value.

- Install sink faucet aerators. 1.5 gpm rated sink faucet aerators provide a low cost way to conserve a substantial amount of water. In three locations, retrofitting faucet aerators provides a positive net present value.

- Install low-flow toilets. 1.28 gpf toilets have the potential to provide substantial water savings in a number of HCA locations.

- Install composting toilets. Composting toilets are an option to consider if new buildings are being designed. These systems can provide substantial water savings and nutrient recycling. However, they are not generally a good retrofit option due to design constraints.

- Install new urinals. 0.5 gpf urinals have the potential to provide substantial water savings in two HCA locations. Waterless urinals have the potential to provide even greater water savings than low flow urinals. However, before retrofitting waterless urinals, the HCA community should verify that the existing plumbing infrastructure is appropriate to accommodate the urinals.

- Install a high efficiency clothes washer. A modern, high efficiency clothes washer has the potential to provide moderate to substantial water and energy savings. However, new commercial clothes washers are quite expensive and residential washers may not have the load capacity that HCA requires.

- Install a high efficiency dishwasher. A high efficiency dishwasher has the potential to save a substantial amount of water in the refectory dishwashing room. The installation of a high efficiency dishwasher should also save the community a substantial amount of time.

- Install a graywater system. Graywater systems keep water out of septic systems. One type of graywater system uses graywater (wash water) for plant irrigation. Another type of system reuses graywater to flush toilets.

- Install drip irrigation systems. Drip irrigation systems are substantially more water efficient than sprinklers because they distribute water directly to the plant roots. Drip irrigation could effectively replace the sprinkler system now in use at the butterfly garden.

- Install flow meters. Flow metering would allow HCA to monitor the progress of its water conservation efforts.

- Adopt the following behavioral strategies for water conservation. (1) Watch out for leaking fixtures and fix leaks immediately when they are found. (2) Take short showers rather than baths. To encourage community members to adopt shorter showers, it may be useful to place a timer or sign in or near each shower as a reminder. (3) Turn the sink faucet off while brushing teeth, shaving, and scrubbing dishes. (4) Wash full loads of laundry or choose appropriate load-size setting. (5) Wash laundry with cold water.

- Develop a drinking water monitoring problem. A regular drinking water monitoring program would give the HCA community better information about the quality of its drinking water over time.

- Investigate septic system siting. Poor septic system siting can be a cause of water quality problems. The team's analysis indicates that one or more of HCA's septic systems could be located in a floodplain. HCA should consult a plumbing professional to determine whether current siting poses any risk to water quality.

- Develop a septic system maintenance program. A regular septic system maintenance program can help to increase the useful life of HCA's septic systems and help protect water quality.

Supporting details for all previously mentioned options are provided throughout the Options section.

Framework for Assessing Options

The purpose of this section is first to describe and analyze technological and behavioral options for reducing both overall water use and hot water use at HCA. The second purpose of this section is to provide additional options for monitoring and improving water quality and maintaining septic systems. This section does not specifically address options for mitigating threats to ground and surface water quality that arise from farming practices, UST's, or other sources, nor does it seek to dictate one specific course of action for HCA with respect to managing water resources.

Broadly speaking, with respect to water use and water quality, HCA should seek to (1) ensure continued access to an adequate water supply, (2) protect human health, and (3) minimize negative environmental impacts on the surrounding watershed. These objectives should be achieved in an economically responsible manner. With respect to water conservation goals, HCA should use the LEED for Homes water efficiency point system as a barometer to gauge the relative impact of various technological options for saving water. In keeping with these goals, HCA should select EPA WaterSense and EPA ENERGY STAR certified products or their equivalents when choosing new plumbing fixtures and appliances. Regarding options for monitoring and improving water quality, HCA should exercise the precautionary principle when addressing potential threats to human and ecosystem health. In doing so, HCA should acknowledge, monitor, and mitigate the potential for water pollution from a variety of sources including septic systems, USTs, and farming practices.

The following analysis does not consider water use by guests, gift shop customers, or farm workers. In addition, it does not consider water used in the course of bakery or farm operations. Rather, the options discussed below focus solely on water used by the immediate HCA community during the course of their daily lives. It is important to note, however, that while this analysis does not specifically include a discussion of strategies for water conservation at the Retreat House, many of the options discussed below would also be appropriate for that location. Water management strategies for the Retreat House should be considered not only as a way to further reduce water consumption but also as a way to communicate the importance of water conservation to guests.

Technological Strategies for Water Conservation

The following section discusses technological options for conserving water at HCA. Options will be discussed in terms of potential water savings, cost, and, when appropriate, potential cost savings related to reductions in hot water use.

High Efficiency Showerheads

Currently, the HCA community uses approximately 113,702 gallons of water–including 91,962 gallons of hot water–for showering, according to the Team's estimates. The data shows that showering accounts for the third-most total water use and the most hot water use of all activities at HCA. For this reason, showering is an obvious place to begin looking for opportunities to conserve water.

The following analysis will focus on the use of high efficiency showerheads as a technological strategy for reducing the amount of water used for showering. Related behavioral recommendations will be discussed later in the section. By analyzing showerhead inventory, flow rates, and water use data, along with related energy and capital cost data, the Team was able to construct a clear picture of the water savings, hot water savings, energy savings, and financial value associated with replacing showerheads in all HCA locations where shower use was recorded during the community water use assessment.

Table 7: Energy Cost and Discount Rate Assumptions

Price of electricity	$0.039
Price of oil	$1.850
Dampening effect	10%
Nominal discount rate	6%
Real discount rate (oil)	4.43%
Real discount rate (electricity)	5.68%
Annual oil inflation	1.50%
Annual electricity inflation	0.30%

The Team's analysis assumes that existing showerheads will be replaced with 2.0 gpm rated showerheads, which meet the criteria for both EPA WaterSense certification and LEED for Homes credits. The Team also assumed that these showerheads will be used at 66.67% of their rated capacity, or 1.33 gallons per minute, and that they will operate for 15 years.[49] We estimated replacement cost of showerheads to be $65.50 per unit including installation.[50] Energy costs and discount rates were assumed to be identical to those used in Chapter 2 and are shown in Table 7.

The Team evaluated showerhead replacement in terms of potential water savings, hot water savings, water savings per dollar invested, and net present value of investment on a location by location basis. In doing so, we found that the northwest dormitory shower room and the shower room under the church provide the most potential for water savings related to showerhead replacement (*see* Table 8). Our analysis also shows that showerhead replacement in both of these locations provides a positive net present value (NPV) investment opportunity due to energy cost savings related to a decrease in hot water use (*see* Table 9).

For the previously mentioned reasons, the Team strongly recommends replacing all showerheads in both the northwest dormitory shower room and the shower room under the church. The Team does not recommend replacing showerheads in the infirmary wing or the Bishop's house master bathroom at this time, as the measured flow rates in those locations are less than the estimated flow rates of high efficiency showerheads, possibly due to low water pressure in these locations. With respect to other locations, the data is limited. However, replacing the showerheads in the Retreat House, mansion bathroom, senior wing bathrooms, and Wynkoop bathroom could reduce water used for showering in each location by approximately 20%, given the current flow rates of the showerheads located there.

Table 8: High efficiency showerheads, cost of replacement and water savings potential

Location	Number of Shower-heads	Cost to Replace Showerheads With High Efficiency Showerheads	Annual Water Use by Current Showers (gallons)	Annual Water Savings With High Efficiency Showerheads (gallons)	Annual Water Savings Per Dollar Invested (gallons)
Bishop's house master bathroom	1	$65.50	1,680	-548	-8.37
Infirmary wing bathroom (in room)	11	$720.50	2,459	-611	-0.85
Mansion bathroom	1	$65.50	0	0	0.00
NW dormitory washroom (showers)	8	$524.00	85,669	47,793	91.21
Retreat House bathroom (in room)	16	$1,048.00	0	0	0.00
Senior wing bathroom (in room)	6	$393.00	0	0	0.00
Shower room under church	5	$327.50	23,894	16,566	50.58
Wynkoop bathroom	1	$65.50	0	0	0.00
Total	**49**	**$3,209.50**	**113,702**	**63,200**	**19.69**

Table 9: High efficiency showerheads, hot water savings and NPV analysis

Location	Number of Shower-heads	Total Cost to Replace Showerheads With High Efficiency Showerheads	Annual Hot Water Savings With High Efficiency Showerheads (gallons)	Annual Cost Savings From Reducing Hot Water Use With High Efficiency Showerheads	NPV of Replacing Showerheads With High Efficiency Showerheads
Bishop's house master bathroom	1	$65.50	-365	unknown	unknown
Infirmary wing bathroom (in room)	11	$720.50	-407	-$3.68	-$760.20
Mansion bathroom	1	$65.50	0	$0.00	-$65.50
NW dormitory washroom (showers)	8	$524.00	41,358	$179.32	$1,254.28
Retreat House bathroom (in room)	16	$1,048.00	unknown	unknown	unknown
Senior wing bathroom (in room)	6	$393.00	0	$0.00	-$393.00
Shower room under church	5	$327.50	10,447	$94.43	$691.26
Wynkoop bathroom	1	$65.50	0	unknown	unknown
Total	**49**	**$3,209.50**	**51,033**	**$270.07**	**$726.84**

Faucet Aerators

Currently, the HCA community uses roughly 114,711 gallons of water–including 71,852 gallons of hot water–from sink faucets, according to the Team's estimates. The following analysis focuses on sink faucet aerators, an excellent cost-effective means of reducing indoor water use. Related behavioral recommendations will be discussed subsequently. By analyzing sink faucet inventory, flow rates, and water use data, along with related data on the energy costs of hot water use and faucet aerator costs, the Team was able to construct a clear picture of the water savings, hot water savings, energy savings, and financial value associated with installing faucet aerators in all HCA locations where sink use was recorded.

The Team's analysis assumes that 1.5 gpm rated aerators, which meet the criteria for both EPA WaterSense certification and LEED for Homes credits, will be retrofitted to existing sink faucets. We also assumed that faucets will continue to be used at 66.67% of their rated capacity, or 1.0 gallons per minute, and that they will operate for 15 years.[51] The Team estimated the unit cost of faucet aerators cost to be $18.15 including installation.[52] Energy costs and discount rates were assumed to be the same as those used in Chapter 2 and are illustrated in Table 7.

The Team assessed faucet aerator retrofits in terms of potential water savings, hot water savings, water savings per dollar invested, and net present value of investment, on a location by location basis. In doing so, the Team found that the refectory dishwashing room, the monastery kitchen, and the bathroom under the church provide the highest potential for water savings and the highest potential for water savings per dollar invested (*see* Table 10). The Team's analysis also shows that faucet aerator retrofits in these three locations provide a positive NPV investment opportunity due to energy cost savings related to a decrease in hot water use (*see* Table 11).

For the previously mentioned reasons, the Team strongly recommends retrofitting faucet aerators in the refectory dishwashing room, the Monastery kitchen, and the bathroom under the church. It should, however, be noted that the addition of a dishwasher would reduce water savings potential in the refectory dishwashing room and possibly in the Monastery kitchen. In addition to the three previously mentioned locations, all other locations shown in Table 10, with the exception of the mansion bathroom and the Sacristy, also provide opportunities for water savings with respect to faucet aerator installation. These opportunities should be prioritized according to water savings potential and potential water savings per dollar invested.

Table 10: Sink faucet aerators, cost of replacement and water savings potential

Location	Number of Faucets	Total Cost of Adding Faucet Aerators to Sinks	Annual Water Use by Current Sinks (gallons)	Annual Water Savings With Faucet Aerators (gallons)	Annual Water Savings Per Dollar Invested (gallons)
Bathroom under church	7	$127.05	16,695	7,751	61.00
Bishop's house kitchen	1	$18.15	3,437	872	48.06
Bishop's house master bathroom	1	$18.15	1,369	440	24.24
Gift shop	2	$36.30	3,298	856	23.58
Infirmary wing bathroom (by chapel, small)	1	$18.15	778	4	0.21
Infirmary wing bathroom (in room)	11	$199.65	4,727	2,637	13.21

Table 10: (cont.)

Location	Number of Faucets	Total Cost of Adding Faucet Aerators to Sinks	Annual Water Use by Current Sinks (gallons)	Annual Water Savings With Faucet Aerators (gallons)	Annual Water Savings Per Dollar Invested (gallons)
Monastery kitchen	4	$72.60	16,666	11,333	156.10
Mansion bathroom	1	$18.15	35	-2	-0.12
Monastery laundry room	1	$18.15	0	0	0.00
NW dormitory toilets	2	$36.30	1,202	809	22.30
NW dormitory washroom (showers)	8	$145.20	19,153	4,861	33.48
Old bakery bathroom	1	$18.15	121	47	2.59
Old dormitory bathrooms	5	$90.75	5,101	3,739	41.21
Refectory dishwashing room	3	$54.45	39,224	23,348	428.79
Retreat House bathroom (in room)	16	$290.40	465	118	0.41
Sacristy sink	1	$18.15	356	-22	-1.20
Senior wing bathroom (in room)	6	$108.90	686	79	0.73
William's hermitage bathroom	1	$18.15	1,367	439	24.21
Wynkoop bathroom	1	$18.15	13	0	0.00
Wynkoop kitchen	1	$18.15	19	6	0.34
Total	**74**	**$1,343.10**	**114,711**	**57,315**	**42.67**

Table 11: Sink faucet aerators, hot water savings and NPV analysis

Location	Number of Faucets	Total Cost of Adding Faucet Aerators to Sinks	Annual Hot Water Savings With Faucet Aerators (gallons)	Annual Cost Savings From Reducing Hot Water Use With Faucet Aerators	NPV of Adding Faucet Aerators to Sinks
Bathroom under church	7	$127.05	4,664	$42.16	$327.75
Bishop's house kitchen	1	$18.15	517	unknown	unknown
Bishop's house master bathroom	1	$18.15	59	unknown	unknown
Gift shop	2	$36.30	466	unknown	unknown
Infirmary wing bathroom (by chapel, small)	1	$18.15	2	$0.02	-$17.94
Infirmary wing bathroom (in room)	11	$199.65	1,092	$9.87	-$93.18
Monastery kitchen	4	$72.60	7,121	$64.36	$621.79
Mansion bathroom	1	$18.15	-1	-$0.01	-$18.24

Table 11: (cont.)

Location	Number of Faucets	Total Cost of Adding Faucet Aerators to Sinks	Annual Hot Water Savings With Faucet Aerators (gallons)	Annual Cost Savings From Reducing Hot Water Use With Faucet Aerators	NPV of Adding Faucet Aerators to Sinks
Monastery laundry room	1	$18.15	0	$0.00	-$18.15
NW dormitory toilets	2	$36.30	20	$0.09	-$35.42
NW dormitory washroom (showers)	8	$145.20	2,514	$10.90	-$37.11
Old bakery bathroom	1	$18.15	5	unknown	unknown
Old dormitory bathrooms	5	$90.75	96	unknown	unknown
Refectory dishwashing room	3	$54.45	19,644	$177.55	$1,861.10
Retreat House bathroom (in room)	16	$290.40	34	unknown	unknown
Sacristy sink	1	$18.15	-21	-$0.19	-$20.24
Senior wing bathroom (in room)	6	$108.90	49	$0.21	-$106.81
Shower room under church	0	$0.00	0	$0.00	$0.00
William's hermitage bathroom	1	$18.15	291	unknown	unknown
Wynkoop bathroom	1	$18.15	0	unknown	unknown
Wynkoop kitchen	1	$18.15	4	unknown	unknown
Total	**74**	**$1,343.10**	**36,554**	**$304.95**	**$2,463.54**

High-Efficiency Toilets

According to the Team's estimates, toilet flushing accounts for more water use at HCA than any other activity. The HCA community uses an estimated 142,036 gallons of water annually for flushing toilets. Of this total, approximately 57% occurs in the northwest dormitory, the infirmary wing, and the bathroom under the church. None of these locations use low flow toilets.

Toilets manufactured between 1980 and 1994 typically use at least 3.5 gallons per flush.[53] The LEED for Homes rating system specifies that high-efficiency toilets must use less than 1.3 gallons per flush to qualify for LEED credits. Because the majority of HCA's toilet fixtures use 3.5 gallons per flush or more and because toilet flushing accounts for more water use than any other activity at HCA, there is a significant opportunity for HCA to improve its water efficiency by replacing old toilet fixtures. Unfortunately, replacing toilet fixtures is fairly expensive. The estimated cost of a single toilet replacement, including installation, is $715. Table 12 provides information regarding the cost and water savings achievable by replacing existing toilet fixtures with high-efficiency 1.28 gpf fixtures in each relevant location at HCA.

In terms of total water savings achievable through the replacement of toilets, the northwest dormitory bathroom, the infirmary wing bathrooms, and the bathroom under the church have the most potential. It should also be noted that there is likely significant potential for water savings from toilet replacement in the Retreat House as well, as the in-room toilet fixtures in that location are not of the high-efficiency variety. However, minimal usage data is available from that location. As mentioned earlier, another important metric for measuring the efficiency of toilet replacement is annual water savings per dollar invested. In these terms, the most efficient locations to invest in toilet replacement, according to data from the community water use assessment, are the small infirmary wing bathroom by the church, the Bishop's house master bathroom, and the bathroom under the church. When deciding which toilets to replace, the HCA community should take both measures of effectiveness and efficiency into account.

Table 12: Toilet replacement, cost of replacement and water savings potential

Location	Number of Toilets	Total Cost to Replace Toilets	Annual Water Used to Flush Toilets (gallons)	Annual Water Savings With 1.28 gpf Toilets (gallons)	Annual Water Savings Per Dollar Invested (gallons)
Bathroom under church	4	$2,860	22,880	14,512	5.07
Bishop's house master bathroom	1	$715	14,300	9,070	12.69
Gift shop	2	$1,430	9,360	5,937	4.15
Infirmary wing bathroom (by chapel, small)	1	$715	17,940	11,379	15.91
Infirmary wing bathroom (in room)	11	$7,865	27,525	17,459	2.22
Mansion bathroom	1	$715	475	95	0.13
NW dormitory toilets	7	$5,005	31,051	19,695	3.94
Old bakery bathroom	1	$715	260	165	0.23
Old dormitory bathrooms	5	$3,575	12,220	7,751	2.17
Retreat House bathroom (in room)	16	$11,440	2,340	1,484	0.13
Senior wing bathroom (in room)	6	$4,290	1,783	357	0.08
William's hermitage bathroom	1	$715	1,902	380	0.53
Total	**56**	**$40,040**	**142,036**	**88,285**	**2.20**

Composting Toilets

Composting toilets are an environmentally responsible alternative to conventional flush toilets, and they typically use no water for flushing. Micro-flush options, which reduce water used for flushing by over 95% when compared to conventional 1.6 gpf toilets, are also available. In addition to eliminating or substantially reducing water use, composting toilet systems provide a means of converting the nutrients in human waste, through natural biological decomposition, into solid and liquid compost end products, which are appropriate for use as a soil amendment and fertilizer, respectively.

There are two basic types of composting toilet systems: the self-contained system and the remote composting system. Self-contained systems combine the toilet fixture and composter into one single unit. These systems are typically used in vacation cottages and other applications where usage requirements are minimal. Due to the usage limitations of these self-contained systems, they would not likely be feasible options for HCA.

Remote composting systems, in contrast, include a toilet fixture and a separate composter that is located in a basement or utility room below the toilet fixture. Such systems can be designed to accommodate a large amount of usage and are used in a variety of buildings, including nature centers, offices, and universities. However, because these systems require an accessible basement or utility space below the restroom (or restrooms) where composting toilet fixtures are installed, these systems are typically only appropriate for new construction. The maximum expected per-fixture cost for a single composting toilet system is $1525 not including installation.[54]

For more information about remote composting toilet systems, contact Brian Barry at Clivus Multrum, Inc. by calling 800-425-4887 or by email at forinfo@clivusmultrum.com. *Full disclosure: Team member Alex Linkow previously worked for Clivus Multrum, Inc. prior to attending the University of Michigan.*

High Efficiency Urinals

HCA currently has three urinals installed in the monastic enclosure: one in the bathroom under the church and two in the northwest dormitory bathroom. It is estimated that HCA's currently installed urinals use 1.5 gallons per flush. Overall, the water use evaluation indicates that the HCA community uses 22,843 gallons of water to flush urinals annually. High efficiency urinals provide the potential to significantly reduce or eliminate water use associated with flushing urinals. In discussing high efficiency urinals, we focus on two alternatives: low-flow urinals (which use less than or equal to 0.5 gallons of water per flush) and waterless urinals.

Low-Flow Urinals

EPA WaterSense guidelines for flushing urinals require certified urinals to achieve a flush rate of 0.5 gpf or less and meet third-party testing requirements. WaterSense-certified urinals require similar maintenance, achieve comparable performance, and operate in the same manner as older, less efficient urinals.[55]

Replacing all three of HCA's urinals with 0.5 gpf urinals would yield an annual water savings of 15,229 gallons, assuming usage patterns remained the same. The estimated per-fixture cost of a low-flow urinal is $945 including installation.[56] Table 13 shows the estimated cost and reduced water use associated with replacing existing urinals with low-flow urinals in both HCA locations. The cost figures do not include labor associated with removing old fixtures.

Waterless Urinals

Waterless urinals, as the name suggests, use no water for flushing. In lieu of a flush mechanism, waterless urinals employ a cartridge that prevents odor from escaping up through the piping and into the bathroom. Waterless urinals are not eligible to receive EPA WaterSense certification because they are functionally different from flushing urinals. However, waterless urinals are still an important component in many LEED rating systems and are encouraged by many professionals within the green building community as a way to significantly reduce indoor water use.[57]

Despite the significant support for waterless urinals and their increasingly widespread adoption, there are issues surrounding the technology that deserve mention. First, some older waterless urinal models had problems with splashing and staining. However, these issues have largely been resolved.[58] Nevertheless, there is still concern about the release of odor that could occur when cartridges are checked or replaced. In addition, before retrofitting waterless urinals, it is important to ensure that drain lines are sloped significantly and routed properly to avoid build-up of sediment in the pipes. It is also imperative that existing drain heights are compatible with the waterless urinal being purchased. Finally, drain lines cannot be made of copper due to copper's tendency to corrode.[59]

Replacing all three of HCA's urinals with waterless urinals would yield an annual water savings of 22,843 gallons, assuming usage patterns remained the same. Like high efficiency urinals, the estimated per fixture cost of a waterless urinal is also $945 including installation.[60]

Table 14 shows the estimated cost and reduced water use associated with replacing existing urinals with waterless urinals in both HCA locations. The cost figures do not include labor associated with removing old fixtures.

An increasing number of companies manufacture waterless urinals. These companies include Waterless, Falcon Waterfree Technologies, Kohler, Zurn, ZeroFlush, Caroma, and others. Recently, Caroma released a new waterless urinal with an innovative odor seal that lasts for 10,000 uses or longer. According to *Environmental Building News* executive editor Alex Wilson, Caroma's new H2Zero waterless urinal "is likely to prove to be the best waterless urinal out there."[61]

For more information about Caroma's H2Zero waterless urinal, contact Alterna Corporation at 800-605-4218 x815 or visit Caroma's Web site at www.caromausa.com.

Table 13: Urinal replacement, low-flow

Location	Number of Urinals	Total Cost to Replace Urinals	Annual Water Used to Flush Urinals (gallons)	Annual Water Savings With 0.5 gpf Urinals (gallons)	Annual Water Savings Per Dollar Invested (gallons)
Bathroom under church	1	$945.00	4,457	2,971	3.14
NW dormitory toilets	2	$1,890.00	18,386	12,257	6.49
Total	**3**	**$2,835.00**	**22,843**	**15,229**	**5.37**

Table 14: Urinal replacement, waterless

Location	Number of Urinals	Total Cost to Replace Urinals	Annual Water Used to Flush Urinals (gallons)	Annual Water Savings With Waterless Urinals (gallons)	Annual Water Savings Per Dollar Invested (gallons)
Bathroom under church	1	$945.00	4,457	4,457	4.72
NW dormitory toilets	2	$1,890.00	18,386	18,386	9.73
Total	**3**	**$2,835.00**	**22,843**	**22,843**	**8.06**

High-Efficiency Clothes Washers

According to the Team's estimates, the HCA community uses approximately 122,772 gallons of water annually for washing clothes. This number incorporates water use attributed to three clothes washers: one in the monastery basement boiler room (bakery storage) and two in the monastery laundry room. The small washers in the boiler room and the laundry room are assumed to be relatively new and therefore relatively efficient machines (27 gallons per load). The large Wascomat clothes washer in the monastery laundry room, however, is known to be over 25 years old. Clothes washing technology has improved a great deal in terms of efficiency in the past 25 years. Conversations with manufacturer representatives indicate that the Wascomat machine uses between 100 and 110 gallons of water per load.

Because the Wascomat clothes washer is over 25 years old and uses approximately twice as much hot water as either of the smaller clothes washers (according to the water use assessment), we focus on the Wascomat in the following options analysis. However, Table 15 shows the current hot water use and costs associated with each clothes washer.

Table 15: Clothes washers – hot water, energy use, and associated cost

Washers	Number of Loads	Hot Water Per Load (gallons)	Annual Hot Water Use (gallons)	Electricity per load (kWh)	Annual Electricity Use (kWh)	Annual Oil Use (gallons)	Current Electricity Annual Cost ($)	Current Oil Annual Cost ($)
Wascomat	624	69	43,333	0.84	524	235	$20	$435
Kenmore	941	23	22,063	0.79	743	120	$29	$222
Whirlpool	1,122	19	20,926	0.79	886	114	$35	$210
Total	**2,687**		**86,322**		**2,154**	**469**	**$84**	**$867**

Below, we consider three options for managing bulk of the HCA community's clothes washing in the future: (1) continue to use the current Wascomat as long as possible, (2) replace the Wascomat with a new similar model washer, and (3) replace the Wascomat with one or two smaller clothes washers.

- **Option 1: continue to use the current Wascomat as long as possible.** We believe this option to be the least expensive of the three options because it requires no current capital investment. Even though energy costs would be reduced by replacing the current Wascomat with a new Wascomat, the associated monetary savings are minimal in comparison to the expense of purchasing a new machine, which would cost over $10,000. Further, realistically, we could expect the Wascomat to continue to function for a number of years given its limited use. To elaborate, a Wascomat representative mentioned that typical commercial clothes washers like the one HCA possesses last for approximately 30,000 loads. According to the results of the water use assessment, the Wascomat washes approximately 624 loads over the course of a year. At this rate, the Wascomat should last for approximately 48 years, so there is no immediate need to replace it. However, from a water and energy use standpoint, replacing the Wascomat is preferable. These replacement options are discussed below.

- **Option 2: Replace the Wascomat with a new commercial-sized clothes washer.** This option is the most environmentally responsible choice in terms of water and energy use for the foreseeable future. A Wascomat representative stated that the new ENERGY STAR rated Wascomat model W655co, which is roughly the same size as the current machine, uses approximately 93 gallons of water per load, for an efficiency improvement of 7–15% over HCA's current Wascomat washer. In terms of electricity use, the new Wascomat is approximately 14% more efficient than the current model. With respect to energy use associated with water heating, there is no difference between the two washers, assuming that the HCA adopts cold water washing as suggested below (*see* the Behavioral Strategies for Water Conservation section). However, as previously mentioned, the cost of purchasing and installing a new Wascomat is in excess of $10,000. The HCA community should weigh all of these factors when making a decision about how to manage clothes washing in the future.

- Table 16 shows the environmental impacts associated with the current Wascomat washer compared to a new Wascomat washer, in terms of total water and electricity use.

- **Option 3: Replace the Wascomat with a new residential sized clothes washer.** This option replaces the existing Wascomat with an ENERGY STAR rated, residential-sized, front-loading clothes washer. The Bosch machine (listed in

- Table 16) is simply an example of such a machine. This option is a far less costly proposition than option 2. In addition, this option seems to provide a higher degree of water efficiency than either of the other options. In terms of energy efficiency, the differences are relatively slight, although the Bosch (residential-sized clothes washer) does not perform quite as well as the Wascomat Model W655co. Nevertheless, the primary drawback of this option is the fact that it replaces a large capacity machine with a machine half its size. This means that twice as many loads (approximately 24 loads per week) would be necessary following the replacement. One potential way around this problem would be to purchase two residential-sized front loading washers, which, in sum, have approximately the same capacity as a commercial clothes washer.

Table 16: Clothes washers, comparison of replacement options

Clothes Washer	Replace-ment Cost	Number of Loads	Water Use Per Load (gallons)	Annual Water Use (gallons)	Electricity Use Per Load (kWh)	Annual Electricity Use (kWh)	Annual Electricity Cost	Annual Water Savings Per Dollar Invested (gallons)
Wascomat (in use)	$0.00	624	100	62,400	0.84	524	$20.44	0
Wascomat (model W655co)	$10,175.00	624	93	58,032	0.72	449	$18.00	0.43
Bosch (model WFVC3300UC)	$832.99	1,248	15.4	19,219	0.45	556	$21.67	51.84

High-Efficiency Dishwashers

Currently, the HCA community uses approximately 49,492 gallons of water annually for handwashing dishes, according to the Team's analysis. This total includes an estimated 44,589 gallons of hot water. Of the total estimated water use, approximately 46,119 gallons of water per year are used in either the monastery kitchen or refectory dishwashing room. Of this amount, 36,021 gallons of water are used annually for dishwashing in the refectory dishwashing area alone. The Team assumes that this is where the vast majority of place settings are washed following community meals. Because the refectory accounts for such a large proportion of the community's overall water use and because place settings (rather than pots and pans) are most likely to be washed in a dishwasher due to size constraints, we focus on the refectory dishwashing area when discussing dishwasher options.

In order to understand the potential environmental impact of a high-efficiency dishwasher, we need to be able to compare hand washing to dishwashing on an even scale. A study from the University of Bonn in Germany helps us to make this comparison. Using data from the study, we calculate that the average person would use approximately 45.35 gallons of water to hand wash 20 place settings. If we assume that all place settings are washed in the refectory dishwashing room, we can calculate that the community washes approximately 15,886 place settings per year. Using this information, we can compare the current water used for hand washing dishes to the amount of the water required to wash dishes using two different types of high-efficiency dishwashers: a commercial countertop washer and a residential washer. Time savings and financial cost will also be considered.

- **Option 1: purchase a high-efficiency commercial countertop dishwasher.** Countertop dishwashers are commonly used in food service and other applications. They are the least expensive type of commercial dishwashing system. These dishwashers are fast and highly efficient in terms of water and energy use. As an example, we focus on the Jet-Tech F-14 countertop dishwasher. This model is ENERGY STAR certified and retails for approximately $2,100.00. It can wash approximately six place settings per load, and its run time is three minutes per load.

Given its capacity, the Jet Tech F-14 would require four cycles, or 12 minutes of cycle time, to wash the entire community's place settings. Over the course of a year, it would save an estimated 34,697 gallons of water when compared to handwashing dishes in the refectory dishwashing room. Compared to the residential dishwasher option, the F-14 is superior in terms of cycle time and overall water savings. However, due to its high price, the F-14 falls short of the residential dishwasher in terms of water savings efficiency, as represented by water savings per dollar invested. A comparison of the two options is shown in Table 17.

- **Option 2: purchase a high-efficiency residential dishwasher.** Residential dishwashers have improved significantly in terms of water and energy efficiency in recent years, but they are generally not as efficient or as fast as commercial machines. Residential dishwashers are, however, considerably more affordable than commercial models. As an example, we look at the Kenmore Model 13482. This model is ENERGY STAR certified and retails for approximately $495.99. It can wash approximately 14 place settings per load, and its run time ranges from 35 to 106 minutes depending on the options selected.

  Given its capacity, the Kenmore would require two cycles, or 70–212 minutes of cycle time, to wash the entire community's place settings. Over the course of a year, it would save an estimated 31,447 gallons of water when compared to handwashing dishes in the refectory dishwashing room. Compared to the commercial dishwasher option, the Kenmore is superior in terms of water savings efficiency, as represented by water savings per dollar invested. However, the Kenmore falls short of the commercial dishwasher in terms of overall water savings and cycle time. A comparison of the two options is shown in Table 17.

Table 17: Dishwashers, comparison of options

Model	Unit Cost	Water Use Per Load (gallons)	Loads Per Year	Annual Water Use (gallons)	Annual Water Savings (gallons)	Annual Water Savings Per Dollar Invested (gallons)
Jet-Tech F-14	$2,100.00	0.5	2,648	1,324	34,697	16.52
Kenmore model 13482	$495.99	4.03	1,135	4,574	31,447	63.40

Graywater Systems

Graywater (or greywater) is generally defined as non-toilet wastewater coming from sinks, showers, clothes washers, dishwashers, and other non-toilet sources. Currently, HCA's graywater is piped directly into septic systems along with toilet wastewater (or black water). However, there are alternative options for handling graywater that allow for its beneficial reuse. Options include graywater irrigation systems, which reuse graywater for plant irrigation, and graywater recycling systems, which reuse graywater for flushing toilets. Both types of graywater systems are aligned with principles for sustainable water use, as evidenced by their specific mention in the LEED for Homes water efficiency category.

Graywater Irrigation Systems

Graywater irrigation systems collect graywater from non-toilet sources and reuse it for plant irrigation. NutriCycle Systems, of Jefferson, MD, specializes in this type of system. NutriCycle's graywater systems consist of two primary components: a dosing basin and an irrigation chamber. Graywater from various sources is collected in the dosing basin for not more than one day and then released through a discharge pipe into the irrigation chambers. The irrigation chambers are typically half-round pipes that evenly disperse graywater into the plant root zone where plants can use the small amounts of nutrients found in the graywater.[62] A graywater irrigation system could potentially be used to irrigate one of the monastic enclosure's lower garden areas or possibly the butterfly garden, which could eliminate the need to use potable water for irrigation in one of those locations. John Hanson, owner of NutriCycle Systems, provided the following preliminary cost estimate to design and install a graywater irrigation system at the HCA monastic enclosure:

"A budgetary estimate for a flooding dose to irrigation chambers system would be $40,000, including design ($3,000), dosing equipment, chambers, and installation in a rectangular area about 50' by 80' (4,000 square feet). A slow perc rate or a more spread out plan could easily double the cost."

For more information about graywater irrigation systems, contact John Hanson of NutriCycle Systems at 301-371-9172 or by email at jhanson@nutricyclesystems.com.

Full disclosure: Team member Alex Linkow previously worked for Clivus Multrum, Inc., a company that is directly affiliated with NutriCycle Systems.

Graywater Recycling Systems

Graywater recycling systems use graywater from non-toilet plumbing fixtures to flush toilets. By reusing graywater in this way, less potable water is required for flushing toilets, which accounts for an estimated 142,036 gallons of water use annually at HCA (not including urinal flushing)–more than any other water use activity. One well-known graywater reuse technology is the AQUS System by WaterSaver Technologies. The AQUS system captures, filters, and treats graywater from sinks and reroutes it to be used for flushing toilets. According to the manufacturer's Web site, a single AQUS system is expected to reduce daily potable water use by between 9 and 14 gallons per day in a typical two-person bathroom, which amounts to 3,285 to 5,110 gallons of water saved over the course of a year in this scenario.[63]

AQUS systems can be purchased for approximately $300 each.[64] The manufacturer recommends hiring a professional plumber to install the system, although anyone comfortable installing a new toilet could likely install an AQUS System.[65]

For more information about AQUS Systems, contact the manufacturer at 502-741-1859 or visit their Web site, www.watersavertech.com.

Drip Irrigation Systems

HCA uses an estimated 32,691 gallons of water per year for watering outdoor plants. Of this annual total, 24,402 gallons are estimated to be used at the butterfly garden. The remainder of the water used for watering outdoor plants is allocated to the gift shop garden and the lower gardens on the north side of the monastic enclosure. Currently, plants in the lower garden are watered using a hose with a sprayer or sprinkler attachment. Gift shop garden plants are watered using a hose with a sprayer attachment. Because both gardens require relatively little water, current methods are probably most appropriate. In contrast, the butterfly garden is watered via a permanent sprinkler system. Because this garden receives a substantial amount of watering each year, it is a better candidate for a more efficient drip irrigation system.

According to the *Handbook of Water Use and Conservation*, drip irrigation systems are "generally considered the most water-efficient type of automatic irrigation system for nonturf areas." These systems generally use buried plastic tubing to distribute water in small doses directly to the plant root zone. Because they allow water to be distributed directly to plant roots and are less susceptible to evaporative water loss, drip irrigation systems can be anywhere from 25% to 75% more efficient than sprinklers.[66] These systems are well-aligned with the LEED for Homes water efficiency guidelines, which specifically mention drip irrigation systems as a high-efficiency irrigation system.

Given a 25% to 75% efficiency improvement, HCA would save between 6,101 and 18,302 gallons of water annually by switching to drip irrigation in the butterfly garden only (based on the Team's water use estimates). Because the butterfly garden is relatively small, it may be possible for HCA to install a simple do-it-yourself drip irrigation system there. Such systems are generally available at hardware and home and garden stores. The typical equipment cost for such a system is $50–$100.[67]

For more information about drip irrigation systems, call the Irrigation Association at 703-536-7080 or visit a local hardware or home and garden store.

Flow metering

Currently, HCA has no straightforward way to measure and monitor its water use. For this reason, even if an aggressive water conservation program is implemented, HCA will have no way to easily and accurately measure the success of its efforts or to quantify the savings. Flow metering provides a simple solution to this issue.

There are two basic types of flow meters: positive displacement meters and velocity meters. Positive displacement meters are capable of accurately calculating water use over a variety of flow rates and are appropriate for residential settings. Velocity meters are designed for use where higher flow rates are common. Positive displacement meters are likely to be more appropriate for HCA. The appropriate size of the meter depends on flow rate, pipe size, pressure loss, and safety issues. For HCA, the appropriate meter size is probably between 5/8" and 2 inches. Meters may be installed outside, but they are often installed inside the building where water use is being measured (typically in the basement). The approximate total equipment cost for each meter connection is $280. Regular maintenance and calibration should occur every 7 to 10 years.[68]

For more information on water metering, contact the American Water Works Association (AWWA) at 800-926-7337 or contact the National Environmental Services Center (NESC) at 800-624-8301.

Behavioral Strategies for Water Conservation

Technological strategies can provide significant improvements in water efficiency for the HCA community. However, behavioral strategies for conserving water can also lead to considerable improvements in water conservation where they are not already being implemented regularly by the community. In particular, the HCA community should be vigilant about abiding by the following simple behavioral strategies for conserving water:

- **Watch out for leaking fixtures and fix leaks immediately when they are found.** Leaking fixtures can waste significant amounts of water—over 3,000 gallons per year for a slow-leaking faucet or showerhead. Leaking toilets can waste 200 gallons of water daily. A simple way to test for toilet leaks is to add a drop of food coloring to the toilet tank. If the food coloring appears in the toilet bowl within 15 minutes, there is a leak. The toilet should be flushed right away, after the test, to prevent staining of the toilet bowl.[69]

- **Take short showers rather than baths.** While data from the water use assessment indicates that the HCA community uses only approximately 9,385 gallons for bathing and 113,702 gallons of water for showering annually, it is still worth mentioning that short showers are generally far more water efficient than baths. In fact, filling a bathtub requires approximately 70 gallons of water. A five-minute shower, by comparison, typically requires between 10 and 25 gallons of water and possibly less than 6 gallons with very high-efficiency showerheads. [70, 71]

Currently, however, HCA residents shower for 7 minutes and 51 seconds on average. Northwest dormitory showers, where the majority of showers are taken, have an average flow rate (adjusted to 67% of maximum) of 3.02 gallons per minute. It is estimated that HCA residents shower 0.66 times per day on average. This usage pattern translates to 15.64 gallons of water used per HCA resident per day for showering. Under these circumstances, if HCA residents shortened their showers to an average of 5 minutes, each resident would save 5.67 gallons of water per day. For the entire HCA residential community, over the course of a year, this hypothetical change would lead to a savings of 41,420 gallons of water—enough water to fill 591 bathtubs. To encourage community members to take shorter showers, it might be helpful to place a timer or sign in or near each shower as a reminder.

- **Turn the sink faucet off while brushing teeth, shaving, and scrubbing dishes.** If the HCA members adopt this behavior consistently just while brushing their teeth, it will lead to significant water savings. For example, at their estimated actual flow rates (67% of rated flow), the northwest dormitory washroom sink faucets (where the majority of teeth brushing takes place) have an average flow rate of 1.34 gallons per minute. According to the water use evaluation data, each resident brushes his teeth, on average, 1.22 times per day for an average of 1 minute and 23 seconds per brushing. This usage pattern translates to 2.26 gallons of water use per HCA resident per day (slightly below the overall estimated average of 2.5 gallons per day for brushing teeth). In this scenario, if community members turned off the sink faucet while brushing and instead simply rinsed their toothbrushes for 10 seconds before and after brushing, each resident would save 1.72 gallons of water per day, on average. If the entire HCA residential community participated, this hypothetical change would lead to a savings of 12,556 gallons of water over the course of one year—enough to fill 179 bathtubs.

- **Wash full loads of laundry or choose appropriate load-size setting.** If load-size settings are not available, clothes washers should be filled to capacity when washing laundry in order to minimize the number of loads washed and so minimize the associated water use. If load-size settings are available, settings should be adjusted to reflect the actual size of the load of laundry being washed. [72]

- **Wash laundry with cold water.** According to the HCA water assessment data, clothes washing accounts for the second highest total of hot water use at 87,667 gallons per year. By switching from warm to cold water when washing clothes, the HCA community could achieve significant energy savings and related monetary savings of up to $780 per year, given current oil prices. The savings are shown below in
- Table 18. In order to allow for the transfer to cold water washing, HCA should switch to a cold water detergent. One product option is Tide Coldwater, which was recently award the *Green Good Housekeeping Seal* by the Good Housekeeping Research Institute and retails for approximately $14.49 for a 100 ounce bottle. [73]

Table 18: Potential annual savings from cold water clothes washing

Reduction of Hot Water	Number of Loads	Total Hot Water (gallons)	Oil Saved (gallons)	Annual Savings ($)
25%	2,687	64,742	105	$195
50%	2,687	43,161	211	$390
75%	2,687	21,581	316	$585
100%	2,687	0	422	$780

Drinking Water Treatment and Monitoring

Prior to water testing on January 26, 2010, HCA maintained UV treatment systems to disinfect drinking water for the bakery, monastic enclosure, Retreat House, and Westwood house. However, the monastic enclosure's UV system was determined to have been out of order at the time of testing. The system breakdown was caused by a snake that electrocuted itself and destroyed the UV light bulb in the process.

As discussed previously, the tap water testing performed at HCA on January 26, 2010 revealed the presence of total coliform bacteria in the drinking water supplies of William's hermitage, the monastic enclosure, and the gift shop. Testing also revealed the presence of E. coli bacteria in the water supplies of William's hermitage and the monastic enclosure.

Following the results of the January water testing, an Atlantic Ultraviolet Corporation Model # MP49C UV system was installed to treat the monastic enclosure's water at a cost of $2163.76. Also, on March 26th, 2010 an Atlantic Ultraviolet Corporation Mighty Power Ultraviolet Water Purifier Model # MP36C was installed to treat the bakery's water. Given the presence of coliform bacteria in the gift shop water supply, HCA should also add a UV treatment system at this location. HCA should consider installing a UV treatment system at William's hermitage as well. In addition, despite the fact that bacterial contamination was only identified at the three previously mentioned sites, HCA should consider installing UV treatment systems at additional locations as a precautionary measure.

The fact that pathogens and other contaminants were not found in all water sources does not exclude the possibility that these sources could become contaminated in the future. For this reason, regardless of whether HCA decides to install additional UV treatment systems, the community should continue to monitor and test its drinking water supplies regularly in the future. Table 19, Table 20, and Table 21 are taken from the Virginia Cooperative Extension Web site.

Table 19: Laboratory tests for nuisance problems

Symptom	Description	Recommended Tests
Stained plumbing fixtures cooking utensils and/or laundry	red or brown	iron
	reddish-brown slime	iron bacteria
	black	manganese
	green or blue	copper
	chalky white	hardness
Off-color water	cloudy	turbidity, suspended solids
	black	hydrogen sulfide, manganese
	brown or yellow	iron, tannic acid
Unusual taste and odor	rotten egg	hydrogen sulfide
	metallic	pH, corrosion index, iron, zinc, copper, lead
	salty	total dissolved solids (TDS), chloride, sodium
	septic, musty, earthy	total coliform bacteria, methane
	alkali, bitter	pH, total dissolved solids (TDS)
	gasoline or oil	hydrocarbon scan
	soapy	surfactants (surface-active agents)
Corrosive water	deposits, pitting of plumbing fixtures	corrosion index, pH, copper, lead

Source: Virginia Cooperative Extension, 2009

Table 20: Tests for specific health concerns

Situation	Recommended Tests
Family members or guests have recurring incidents of gastrointestinal illness.	coliform bacteria, nitrate, sulfate
Household plumbing contains lead pipes, fitting or solder joints.	pH, corrosion index, lead, copper, cadmium, zinc
Household with pregnant resident or infant less than six months old.	nitrate, coliform bacteria
Family member on recommended low salt/sodium diet (particularly if a water softener is currently installed).	sodium

Source: Virginia Cooperative Extension, 2009

Table 21: Testing for suspected contamination

If you suspect/observe	Recommended Tests
Leaking fuel tank	hydrocarbon scan
Coal mining	total dissolved solids (TDS), iron sulfate, pH, corrosion index, manganese, aluminum
Gas and oil drilling	total dissolved solids (TDS), chlorine, sodium, barium, lead, pH, corrosion index, strontium
Road salt storage/ application or near sea coast	total dissolved solids (TDS), chlorine, sodium
Landfill	total dissolved solids (TDS), pH, chemical oxygen demand (COD), volatile organic scan, heavy metals
Land application of sludge	total coliform bacteria, nitrate, heavy metals
Septic system	fecal coliform bacteria, fecal streptococcus, nitrate, surfactants (surface-active agents)
Intensive agricultural use	total coliform bacteria, nitrate, pesticide scan, pH, total dissolved solids (TDS)

Source: Virginia Cooperative Extension, 2009

Septic System Siting

Septic systems are designed to treat sanitary waste from plumbing fixtures and appliances on-site. While even properly functioning septic systems may release small amounts of nutrients and pathogens into the groundwater, according to the EPA, "When properly sited, designed, constructed, and operated, [septic systems] pose a relatively minor threat to drinking water sources." However, the EPA bulletin goes on to say that septic systems can pose significant threats to groundwater (and by extension, drinking water) quality when they are not functioning correctly.[74]

When correctly designed, installed, and maintained, septic systems have a useful life of at least 20–30 years.[75] Although it is not clear whether any of HCA's septic systems are currently candidates for replacement, the Team has identified issues that warrant further investigation, including the possible location of leach fields in floodplains, which may be contributing to water contamination. These issues, as well as general best practices for maintaining septic systems, are discussed below.

According to the Clarke County Standards and Procedures for Siting and Installation of Subsurface Septic Systems, subsurface septic systems "shall be prohibited or restricted" in soils with an unsatisfactory percolation rate.[76] *Percolation rate* refers to the speed at which water is able to move through soils, with clay soils typically exhibiting a slower percolation rate than sandy soils. Also according to the Clarke County Standards and Procedures for Siting and Installation of Subsurface Septic Systems, soils "subject to flooding" tend to have unsatisfactorily slow percolation rates and are therefore not typically suitable locations for subsurface septic systems. Because flood-prone locations do not typically have soils that are suitable for adequate septic system draining, septic systems located in these areas may pose threats to groundwater and surface water quality.

Figure 8 shows the approximate locations of septic systems that are located in or near 100-year floodplains. A local septic system service provider, such as Powell's Plumbing of Clarke County, can provide a full consultation on the significance of this issue. Powell's Plumbing of Clarke County can be reached by phone at 540-955-3988 and found on the Web at www.powells-plumbing.com.

In addition, the Clarke County Standards and Procedures for Siting and Installation of Subsurface Septic Systems specify that septic system leach fields should be at least 500 feet away from springs when the leach field is at a higher elevation than the spring to adequately protect water quality. In addition, leach fields should be located at least 100 feet from free-flowing streams, 50 feet from intermittent streams, and 100 feet from sinkholes.[77] The locations of HCA's septic leachfields do not appear to violate any of these rules. Even so, it is possible that some of HCA's septic systems are failing and therefore contributing to the bacterial contamination found in the water supplies of the monastic enclosure, hermitage, and gift shop during water testing on January 26, 2010. It is also conceivable that a failing septic system could be contributing to the relatively high nitrate/nitrite levels found in the hermitage's water supply during that same round of water testing. It should be noted, however, that the Team has found no direct evidence of any septic system failure at HCA.

Moving forward, HCA should take steps to ensure that its septic systems are functioning as intended. Recommendations are outlined below, but again, a local septic system service provider, such as Powell's Plumbing of Clarke County is best qualified to provide a full consultation on these issues.

Septic System Maintenance

Ongoing maintenance of septic systems is extremely important in preserving their ability to adequately treat wastewater and prevent contamination of ground and surface waters.[78] With respect to ongoing maintenance of HCA's septic systems, the Team suggests the following measures, in accordance with EPA recommendations from their July 2001 report "Managing Septic Systems to Prevent Contamination of Drinking Water," in the *Source Water Protection Practices Bulletin*:

- Monitor septic leach field locations for any odor, bubbling up of sanitary wastewater, and unusually lush vegetation on an ongoing basis.

- In general, septic tanks should be inspected annually to ensure that they are in proper working order. Those systems that are used less often may not require the same frequency of inspections as systems that are subjected to consistently heavy use. A local septic system provider such as Powell's Plumbing of Clarke County can provide more detailed information.

- In order to prevent hydraulic overloading, a major cause of septic system failure, technological and behavioral water conservation measures should be implemented. In addition, storm water runoff should be directed away from leach fields.

- Septic tanks should be pumped out every two to five years depending on use, tank size, and usage. Conversations with a Powell's Plumbing representative in 2009 indicate that pumping out a single 1,000-gallon septic tank would cost $175. The cost of a thorough inspection to test the integrity of a septic tank after pumping is $500.

- Hazardous waste (defined in Chapter 4) should not be disposed of in septic systems. Items that do not easily decompose and may inhibit proper system functioning should also not be disposed of via septic systems. Such items include grease, cooking fats, coffee grounds, sanitary napkins, and cigarettes.

- The use of septic system additives and bacterial "starters" are unnecessary

- All heavy equipment should be kept off of leach fields. In addition, construction and planting trees on leach fields should be avoided.[79]

Figure 8: Septic systems and flood plains

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SOLID WASTE

4

Understanding the source and disposition of HCA's waste materials and implementing responsible waste management practices is absolutely essential to HCA's sustainability efforts. To facilitate this understanding, this chapter focuses on the most pertinent and largest subcategory of solid waste:[1] municipal solid waste (MSW) (commonly referred to as "trash" or "garbage").[2] We also discuss a number of subclasses of MSW (e.g., electronic and pharmaceutical waste) when specifically relevant to HCA and its sustainability efforts.

CONTEXT: Understanding Solid Waste Management

Municipal Solid Waste

Although it is difficult to establish an accurate estimate for the amount of MSW produced at the global level, most experts believe that humans are generating roughly two billion tons of global trash every year. To put this value into perspective, this volume of waste is nearly equivalent to covering the entire state of Virginia with a half foot of uncompacted garbage on an annual basis. Another unsettling statistic related to trash indicates that annual worldwide production of MSW is predicted to grow to more than three billion tons within the next twenty years due to rises in global population and consumption; regrettably, this prediction even takes into consideration enhanced recycling rates for most countries.[3,4] In light of the aforementioned, it is clear that successfully managing the increasing flow of waste is a significant issue when viewed in the global aggregate. It is also an issue that individual nations must continue to address despite often having limited infrastructure and resources to support their regional- or local-based waste management systems.

Even though there are clear differences among countries with regard to how they logistically manage MSW and the various resources available to them, almost all nations and their respective communities still demonstrate a similar "disposal-focused" approach. Specifically, the overwhelming majority of MSW in any given country is typically disposed of in a landfill and/or incinerated.[5] The United States is prime example of this. In 2008, Americans produced over 250 million tons of MSW, of which approximately 67% was either placed in a landfill or incinerated at a certified facility.[6]

MSW Landfill Disposal Issues

Unfortunately, landfill disposal can cause an array of environmental, social, and economic problems. Specifically, some of the key issues associated with the disposal of MSW in landfills include the items listed below.

Loss of Natural Resources

By burying discarded items in landfills, billions of tons of useful materials (nonrenewable resources) are permanently lost or made economically inaccessible.[7] In fact, many of the manufactured products humans throw away will take hundreds of years to completely decompose in a traditional landfill setting, ultimately inhibiting the natural cycling and reuse of the resources contained within the product.[8] For example, it is estimated that approximately 200 million metric tons of discarded plastic are present in Great Britain's landfills, which is worth approximately $100 billion dollars if the material could be easily recovered and recycled. Surprisingly, formalized landfill mining in some countries is being seriously debated and even piloted despite the high cost and challenging recovery process. Ultimately, this fact is a testament to the quantity and value of resources that are being continuously locked away in the world's landfills.[9,10] In addition, it is important to note that a significant amount of land resources and native habitat are also lost as a result of converting natural areas into landfill space.[11]

Inflated Fees

Although many countries (including the US) report that they have "sufficient" nationwide landfill capacity, there are still numerous regions within their respective borders that often have limited landfill capacity. For example, many highly urbanized and densely populated areas on the east coast of the US have inadequate local landfill space.[12,13] In these areas, low capacity spurs inflated collection and dumping fees. In many instances, MSW is also transported over long distances within the country and even exported to other nations with more capacity. Consequently, this extensive hauling of MSW drives up the cost of waste management in general.[14,15]

Pollution of Ground Water and Soil

As rain water passes through a landfill and comes into contact with various waste products, it becomes contaminated. This liquid, often referred to as “leachate,” can then seep into the soil and groundwater supplies, which has serious public health ramifications. Most modern landfills have liners and/or leachate collection systems, but leakage is still possible and does occur.[16,17]

Greenhouse Gas (GHG) Emissions

Methane, a highly potent GHG, is produced in landfills as a result of organic waste decomposing under anaerobic conditions (i.e., without oxygen). In fact, landfills are the second leading source of anthropogenic methane emissions in the US. Consequently, this method of waste disposal can be linked to climate change. Furthermore, when MSW is disposed of in a landfill, additional resources are needed to manufacture and distribute new products that replace the discarded items. These additional manufacturing and distribution processes generate significant GHG emissions.[18] Finally, the hauling and exporting of sizeable quantities of MSW over long distances in order to dispose of refuse in a landfill that is far away from its source results in GHG emissions due to the fact that large amounts of fuel are consumed to transport the waste.[19,20]

MSW Incineration Issues

There are also various issues associated with incinerating MSW. On a positive note, formally burning MSW at a certified facility reduces the volume and weight of waste, and in some cases the refuse can be combusted at special waste-to-energy (WTE) plants to produce electricity that can be sold. However, there are significant air pollution and public health issues associated with basic incineration and WTE processes. Both approaches entail burning MSW, which produces carbon dioxide and nitrous oxide (both GHGs) and causes dioxins, heavy metals, and particulates to be emitted into the air. The release of these pollutants into the atmosphere can lead to a wide range of problems including heart damage, nervous system complications, and respiratory-related illnesses. Moreover, smog, acidification, and climate change can be linked to large-scale incineration of waste.[21]

When comparing the two combustion options, WTE is deemed far superior over basic incineration. Research has shown that modern WTE plants have a lower negative impact on the environment and public health than basic incineration facilities due to lower pollutant and GHG emissions. In addition, WTE is able to partially recover the embodied energy of MSW and produce electricity, which is a significant advantage.[22] It is also important to note that there are other WTE options that do not involve direct combustion of waste (e.g., gasification and pyrolysis). However, these technologies are relatively new, expensive, and/or not currently used on a large-scale commercial level.[23]

As with landfilling, the process of incinerating waste (even when used to produce electricity) also results in a significant loss of natural resources as recyclable products are converted into gases, particulates, and ash. Plus, additional resources are typically needed to manufacture and distribute new products to replace the items that were discarded and then incinerated. As previously mentioned, these additional manufacturing and distribution processes also generate significant GHG emissions.[24]

Electronic Waste

Electronic waste, also referred to as e-waste, encompasses items such as computers, televisions, cell phones, digital audio players, and video gaming systems that are near or at the end of their useful life. Typically, e-waste falls under the official classification of MSW for most countries, but it is treated in a special manner due to the fact that electronic materials frequently contain both valuable and some potentially hazardous materials. As a result, these discarded electronic items necessitate specific handling and recycling procedures to prevent potential negative impacts to human health and the environment.[25]

On a global scale, it is estimated that humans currently produce 25–40 million tons of e-waste per year.[26,27] However, this annual amount is expected to increase dramatically over the next several years—most experts predict that by the year 2015 annual e-waste generation will reach roughly 75 million tons.[28] There a number of factors that are driving this swell in e-waste production, including greater global demand for electronic devices, rapid technological advances that render electronic devices obsolete in a shorter amount of time, and the decreasing costs of replacing electronic equipment (which stimulates frequent purchasing).[29,30]

The fact that e-waste only comprises a small amount of the total MSW generated worldwide makes it seem like a rather insignificant solid waste issue. However, it is a topic that warrants concern since this type of waste is the fastest-growing type of MSW and only a small percent of global e-waste is actually being recycled. This means that a significant amount of potentially hazardous materials have been, and most likely will continue to be, disposed of in landfills and/or incinerated as a result of humans discarding electronic items.[31] For example, only 414,000 of the three million tons of e-waste produced in the US in 2007 were recycled, constituting a low recycling rate of approximately 14%. The remaining 2.6 million tons of discarded electronic devices were primarily dumped in landfills, and a small percentage was incinerated.[32] Most countries follow a similar approach to managing e-waste; the majority is disposed of in landfills, followed by some incineration.[33]

Unfortunately, placing e-waste in a landfill or incinerating it poses serious threats to the environment and human health due to various hazardous materials that are contained within most electronic devices. When e-waste is disposed of in landfills, there is potential for leaching of hazardous substances into the soil and groundwater. Moreover, incinerating e-waste can release GHGs (carbon dioxide and nitrous oxide), as well as emit dioxins, heavy metals, and particulates into the air.[34,35]

The list of harmful substances contained in e-waste changes radically as new electronic items enter the market with different compositions; however, the five primary constituents of concern are: lead, cadmium, mercury, hexavalent chromium, and brominated flame retardants. Regarding human health impacts, these substances have been linked to numerous medical problems, such as nervous and endocrine system damage, kidney malfunctioning, respiratory complications, compromised brain development/functioning, and cancer in the digestive and lymph systems.[36,37] As for environmental impacts, the aforementioned constituents have also been shown to have chronic and acute toxic effects on plants, animals, and microorganisms in aquatic and terrestrial ecosystems.[38]

In addition, disposing of e-waste in a landfill or incinerating it at a certified facility leads to robust losses in natural resources. Many e-waste items contain a slew of valuable materials and metals (such as silver, lead, copper, and gold), which could be obtained via recycling. For example, 95% of the materials contained within desktop and laptop computers can be salvaged.[39] Consequently, when items are not recycled and instead are permanently disposed of via landfills or incineration facilities, additional resources are needed to manufacture and distribute new products that replace the items that were discarded. This leads to the increased consumption of nonrenewable resources and generates additional GHG emissions.[40]

Pharmaceutical Waste

Pharmaceutical waste (i.e., unused or expired medication) is another subcategory of MSW. It does not constitute as “medical waste” (e.g., discarded syringes used in a clinical setting), which is regulated differently than standard MSW due to the fact that it poses a direct biohazard risk to the health and waste management workers who handle it.[41,42] In essence, as a “special” type of MSW, pharmaceutical waste can still be legally discarded in a landfill or incinerated without any restrictions in most countries and states. However, due to its potentially hazardous nature, it is recommended that pharmaceutical waste be managed in a particular way in order to minimize its impact on the environment and human health.[43]

Recent studies have found that trace levels of nonprescription drugs, prescribed medications, and reproductive hormones are commonly found in wastewater effluent, surface waters, and groundwater. This is believed to be the result of a number of activities, one of which is flushing unused and expired medications down the toilet or drain. Despite the dearth of evidence regarding the environmental and public health impacts of pharmaceutical waste due to the paucity of studies that have been conducted, these pharmaceutical residues are generally deemed “potentially” harmful to human health and aquatic wildlife.[44,45]

Sustainable Management of MSW

In order to sustainably manage MSW (i.e., to eliminate or mitigate many of the environmental, social, and economic problems associated with disposing of waste), the EPA has suggested an approach labeled, integrated solid waste management (ISWM). ISWM has been defined by MSW management researchers as a “holistic approach that integrates waste streams, collection and treatment methods, environmental benefit, economic optimization, and social acceptability into a practical and sustainable system for any specific region.”[46] Ultimately, the goal is to manage MSW in a way that most effectively and feasibly safeguards the environment and human health. Specifically, the approach entails using a combination of various waste management practices, which includes waste prevention, recycling, composting, combustion (WTE), and landfill disposal (with methane recovery). In essence, ISWM espouses a hierarchy of alternatives for responsibly managing MSW ranging from the most preferred to the least desirable.[47]

ISWM Activities

Below, the ISWM prioritized activities are defined and the benefits are briefly explained.

Waste Prevention

Waste prevention, often referred to as “source reduction,” is the most preferred waste management option. It involves any action that reduces waste by not actually generating it in the first place. Purchasing durable or reusable items instead of disposable items and purposefully selecting products with less packaging are examples of waste prevention. The benefit of this practice is clear; generating less waste to begin with means that more resources are conserved, less pollution is produced, community health is better protected, and there is overall less MSW to manage so costs are minimized.

Recycling

As part of the ISWM framework, recycling includes the act of reusing all or part of a specific product as well as collecting and reprocessing discarded materials to create new products. By engaging in recycling, natural resources are conserved since the demand for raw materials is reduced. Recycling also prevents usable items and materials from being sent to a landfill or combusted, thus eliminating the negative impacts and the typical high costs associated with these two disposal methods. Furthermore, using recycled materials as feedstock generally cuts down on the energy needed to manufacture products.

Composting

Composting is a form of recycling that involves the controlled, aerobic decomposition of organic material like food scraps and yard trimmings. This process reduces the overall volume of waste and converts it into a soil additive that can be used as a natural fertilizer. Thus, in addition to diverting organic MSW from landfills and combustion facilities, composting can also reduce the amount of chemical fertilizers used in agricultural and landscaping activities.

Incineration via Waste-to-Energy Facilities

Within the context of ISWM, this disposal option refers to the controlled burning of nonrecyclable and noncompostable waste items at a certified WTE facility that has proper control equipment such as acid gas scrubbers and fabric filters. As previously noted, this process reduces the volume and weight of MSW and converts waste into electricity. Unfortunately, it also produces GHGs as well as air pollution, which are connected to various health problems.

Landfill Disposal

This disposal option involves placing MSW that cannot be recycled or composted into a well-designed, constructed, and managed landfill that contains an effective leachate collection system and ideally a mechanism for burning or capturing methane gas to generate electricity (or a landfill gas-to-energy (LFGTE)). As mentioned earlier, this practice unfortunately can also pollute groundwater, emit the GHG methane (depending on the system in place), and lead to the loss of valuable natural resources and native habitat.[48]

Although WTE is generally deemed more advantageous than LFGTE, the fourth and fifth disposal options listed above are interchangeable depending on the location and specific situation of a given community.[49] Moreover, when WTE, LFGTE, or a landfill equipped with a methane flaring (burning) system are not available to a community, the least preferred disposal options of landfilling without methane recovery or basic combustion at a certified incineration facility are considered satisfactory alternatives for disposing of nonrecyclable and noncompostable MSW.

It is also important to note that the sustainable management of both e-waste and pharmaceutical waste follows the aforementioned ISWM principles except for a few minor adaptations to the management guidelines given the specialized nature of these two subcategories of MSW. To read more about the slightly modified approaches, please see Appendix 4-A.

Zero Waste: A New Perspective on MSW Management

Although the EPA's ISWM hierarchy is the generally accepted approach for sustainably managing MSW, there has been a recent paradigm shift over the past decade regarding how "garbage" is viewed. Specifically, there has been a movement toward embracing the concept of Zero Waste, which redefines waste as "a resource that is not safely recycled back into the environment or the marketplace."[50] In other words, waste is seen as a resource in disguise and, as a result, sustainable management is expected to focus solely on developing systems that reuse this resource rather than responsibly handling and disposing of it.[51]

Ultimately, the ISWM and Zero Waste approaches are compatible and strive to achieve the same goal—to reduce waste and minimize its impact on human health and the environment. However, Zero Waste takes the concept of sustainable waste management a step further by suggesting that garbage is a human-made creation and that it is possible to completely eliminate waste from the production, distribution, and consumption of materials.[52] A Zero Waste system emulates the processes demonstrated by nature in which every output from an organism or system is an input for a different organism or system; there is no waste, and resources and energy continuously cycle. In light of this, Zero Waste resource management takes into account the entire lifecycle of a product and emphasizes modifying product design and distribution to ensure that materials can be reused for natural or industrial purposes.[53]

It is also import to note that in reality, true Zero Waste (i.e., 100% diversion) is seen as more of a journey or goal than something to be achieved due to the fact that most human-created systems for producing, distributing, consuming, and disposing of products do not represent a circular system model in which all materials are recycled. Considering this, most advocates of this approach define Zero Waste as achieving a 90% or higher diversion rate, but encourage communities to continue to progress toward the ultimate goal of generating no waste at all.[54]

Evaluating MSW Management Programs

A specific MSW management program at the national, regional, and even the local community level can be evaluated with regard to sustainability based on whether its practices reflect the prioritized activities of ISWM and move a community toward Zero Waste status. The ultimate goal is to eliminate waste by first maximizing waste prevention efforts and then reusing and recycling/composting to the extent possible. Disposal is viewed as a last resort that should only incorporate nonrecyclable and noncompostable items. If a management program follows this framework, a relatively small amount of MSW will actually be placed in a landfill or incinerated and the impacts to the environment and public health will be minimal.[55]

METHODOLOGY

In order to assess HCA's current waste management program and compare its practices to the ISWM hierarchy and the Zero Waste philosophy, the following objectives were established:

- Identify all recovery and disposal procedures
- Determine the quantity of MSW produced and diverted
- Ascertain the composition of MSW that is discarded
- Determine storage and disposal procedures for electronic and pharmaceutical waste
- Locate informal dump sites on the property
- Identify any collective or individual waste prevention behaviors

To satisfy these objectives, the Team conducted two MSW characterization studies, multiple qualitative interviews, and personal observations. An open-ended sustainability questionnaire, which included inquiries about conservation behaviors, was also administered to HCA community members and full-time employees. All data were triangulated to verify the validity of the results.

Background Information

Before explaining the various methodological steps involved with the analysis, it is important to further describe MSW as it pertains to this section and HCA, as well as to provide a brief introduction of HCA's current waste management program.

Expanded Description of MSW

As noted previously, MSW is typically referred to as trash or garbage and consists of discarded items from homes, businesses, and institutions. This type of waste includes the following:

- *Durable goods* (products that have a lifetime of three years or more) like printers, carpet, and luggage
- *Nondurable goods* (products that have a lifetime of less than three years) like paper plates, disposable diapers, and clothing
- *Containers & packaging* (glass pickle jars, plastic milk jugs, aluminum soda cans, etc.)
- *Food waste* (meal preparation waste and uneaten food)

- *Yard trimmings* (grass clippings, tree branches, etc.)
- *Miscellaneous inorganic refuse* (stones, small pieces of concrete, excavated soil, etc.)

MSW is typically broken down into nonhazardous waste and household hazardous waste (HHW); the latter constituting leftover portions of products that are harmful to the environment and public health, but state and federal law does not officially regulate them as “hazardous.” HHW can be described as household products that are typically flammable, toxic, corrosive, and/or have reactive ingredients.[56]

For the purpose of this report, empty containers that previously stored HHW will be included in the MSW category and discussed within this chapter. The actual HHW (leftover solvents, cleaners, corrosive materials, etc.) and the appropriate disposal of HHW chemicals will be addressed in Chapter 5. The special “hazardous” subcategories of MSW—e-waste and pharmaceutical waste—will also be included in this chapter.

HCA’s Current MSW Management Program

HCA has four primary waste streams: the Retreat House, bakery, farm, and monastic enclosure; the latter includes waste that is also routed from the gift shop and all exterior guest houses (e.g., Westwood House).

MSW is collected by HCA maintenance staff from the monastic enclosure and Retreat House, and then deposited in the dumpsters provided by HCA’s trash and cardboard recycling hauler, Allied Waste Services (AWS). Waste produced by the bakery and the farm is placed directly into the AWS dumpsters by the respective personnel.

AWS hauls away HCA’s discarded MSW bi-weekly (26 times per year) and its recovered cardboard once every four weeks. The discarded MSW is then routed to the Frederick County Landfill, which is located approximately 12 miles from HCA. The landfill includes a flaring-based gas control system designed to minimize the amount of methane emitted into the atmosphere. As for the cardboard, this recovered item is transported 19 miles to a recycling company called Southern Scrap.

MSW Characterization Studies

Two site-specific MSW characterization studies were conducted at HCA (the first in May of 2009 and the second in November of 2009). As part of these studies, discarded MSW and recovered items (e.g., cardboard) were sorted and weighed according to the following potential recovery categories:

- aluminum/steel
- mixed glass
- mixed paper
- mixed plastic
- compostable food scraps
- wood scraps (pallets)
- cardboard

Any item that could not be recycled or composted was categorized as trash. An average was then calculated for each category based on the combined findings from the two studies.

The waste characterization studies included MSW taken from three of the four primary waste streams: the monastic enclosure, the bakery, and the Retreat House. The bakery manager also provided detailed waste composition and material recovery data for waste produced by the bakery to supplement the findings of the studies. Unfortunately, the Team was not able to include the farm waste stream in either of the MSW characterization studies due to the fact that the farm tenant was unable to set aside trash for the desired time frame. However, a brief interview was conducted with the farm tenant. He was able to provide limited information about MSW that is typically produced by HCA's farming operations and personnel. Despite the dearth of information about waste produced by the farm, the Team was able to generate an estimated overall weight for MSW related to farming operations and personnel using data provided by AWS. By deducting the weight of the other three waste streams (monastic enclosure, Retreat House, & bakery) from the total estimated weight of MSW collected by AWS, we were able to determine an approximate value for farm MSW.

Our MSW characterization studies were based on waste that accumulated over an average week. Based on triangulation of the study data and the interview data, it appears that the samples appropriately represented the amount and type of waste that is typically generated during an average week; thus, calculations for monthly and yearly totals are deemed to be valid estimates. Nonetheless, in ideal situations and when feasible, waste characterization studies should be conducted several times throughout the year to rule out potential seasonal variations and other time-sensitive confounding variables that can affect the accuracy of monthly and yearly estimates.

Qualitative Interviews

Interviews that focused on MSW disposal and recovery were conducted with the following individuals:

- HCA cellarer
- HCA maintenance supervisor & assistant
- HCA bakery manager
- HCA farm tenant
- HCA Retreat House manager
- HCA gift shop manager
- Multiple HCA community members who are responsible for waste collection
- AWS account representative
- Frederick County Landfill environmental manager
- Frederick/Clarke Counties solid waste manager
- President of Southern Scrap
- Waste Management account representative
- Winchester Scrap Company representative
- President of Zuckerman's

Personal Observations

In addition to acquiring information from these interviews, Team members walked the HCA grounds to identify informal dump sites located on the property. Waste items were identified and logged. A map noting the various waste sites was also created based on our observations.

Questionnaire

In the fall of 2009, a general, open-ended questionnaire focused on sustainability was administered to all willing HCA members and full-time employees. The survey included a question that inquired about the types of behaviors that individuals personally engage in to conserve natural resources (e.g., source reduction behaviors related to waste) while living and/or working at HCA.

Tools Used for GHG Emissions Calculations

We used the EPA's Waste Reduction Model (WARM) to calculate the GHG emissions related to HCA's current MSW disposal and recovery practices. The WARM calculator, which was updated in November of 2009, is one of the primary tools used by solid waste managers in the United States to determine GHG impacts of waste management practices and various alternative MSW disposal activities. In addition, the EPA's Greenhouse Gas Equivalencies Calculator was used to instantiate the concept of carbon dioxide equivalent (CO_2eq) and provide tangible examples of activities that produce comparable amounts of GHG emissions.

RESULTS

Our analysis revealed the following key findings:

- HCA generated 21,320 total pounds of MSW in 2009, which is significantly lower than the amount of MSW produced by the equivalent number of "average" Americans in one year.
- From the total amount of MSW produced, HCA was able to recover 37% of it (7,878 pounds) through various recycling and diversion activities.
- HCA's recovery rate exceeded the national average (33%), but it fell short of meeting the recycling rates for the state of Virginia (38.5%) and Frederick/Clarke Counties (45%).
- Of the 13,442 pounds of MSW that HCA discarded (into the landfill), 68% of it was recyclable or compostable.
- There are over seven different informal dump sites located on HCA's property.
- There is no official procedure in place for responsibly storing and disposing of electronic waste.
- The farm tenant burns some MSW (e.g., tire inner tubes and plastic buckets), which has serious negative environmental implications.
- As a result of its recovery activities, HCA avoided producing a net total of 8,670 pounds of CO_2eq in 2009.
- If HCA recovered all of the potentially recyclable and compostable MSW that it generates, it could avoid producing 26,675 pounds of CO_2eq per year, which is equivalent to the carbon dioxide produced by consuming 1,235 gallons of gasoline.

HCA Total MSW Generation

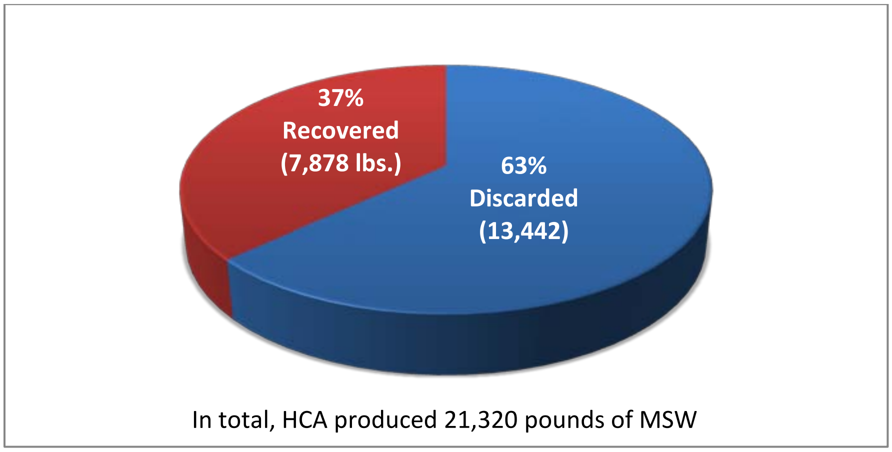
In 2009, HCA generated a total of 21,320 pounds of MSW (before recycling and diverting food waste). Considering the fact that the average American produces approximately 1,700 pounds of MSW per year, the HCA community (which consists of 20 resident monks/observers, seven employees, and multiple weekly retreatants) generates significantly less waste compared to the equivalent number of average Americans.[57] Undoubtedly, this disparity can be primarily attributed to Cistercian monastic values and culture, which focus on living a life of simplicity and frugality.[58]

From the 21,320 total pounds of MSW produced by HCA, 37% was recovered. This recovery rate was primarily a result of diverting some food waste, recycling cardboard, and reusing specific bakery plastics. The remaining 63% of MSW was ultimately disposed of in the Frederick County Landfill (see Figure 1).

Compared to the United States' nation-wide recovery rate of 33%,[59] HCA demonstrated a slightly larger diversion percentage. However, HCA fell short of meeting the current recovery rates of the state of Virginia (38.5%) and

Frederick/Clarke Counties (45%).[60] In addition, HCA's 37% recovery rate pales in comparison to the EPA's estimate that up to 75% of MSW produced in the United States is potentially recyclable.[61]

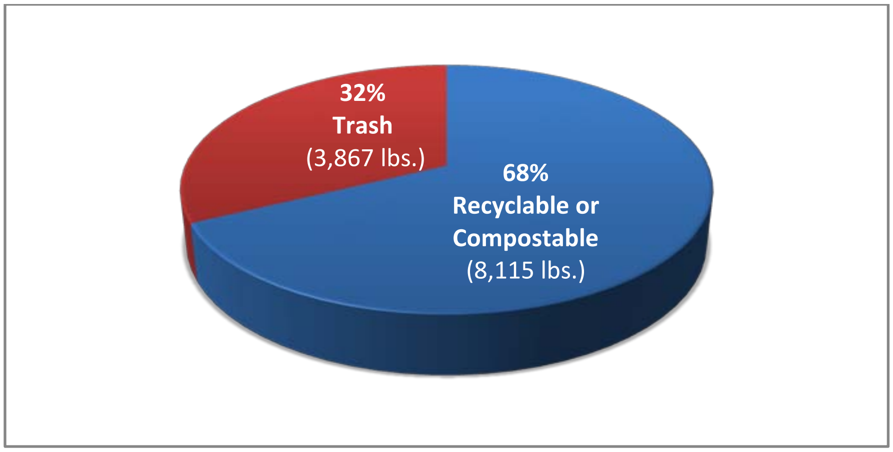
Figure 1: Total amount of MSW discarded & recovered by HCA (2009)



Recovery Potential of Discarded Items

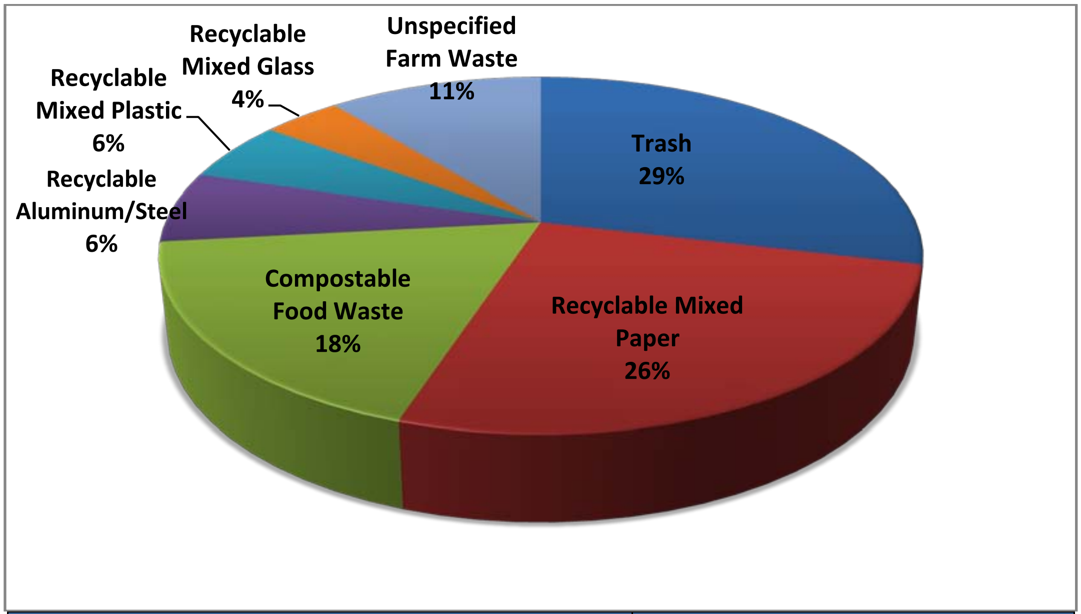
The recovery potential for the MSW that HCA discarded was quite high. In fact, from the 11,982 pounds of waste that HCA discarded (this value excludes the unspecified farm waste), 68% of it was either recyclable or compostable. In essence, approximately two-thirds of the items that HCA threw away (equivalent to 8,115 pounds) could have been diverted from the landfill (see Figure 2).

Figure 2: Recovery potential for the total items that HCA discarded (2009)



***This figure does not include "unspecified farm waste."**

Figure 3: HCA's total discarded waste by category (2009)



Category	Weight (lbs.)
Trash (includes unspecified farm waste)	3,867
Recyclable Mixed Paper	3,533
Compostable Food Waste	2,446
Unspecified Farm Waste	1,460
Recyclable Aluminum/Steel	861
Recyclable Mixed Plastic	737
Recyclable Mixed Glass	538

Breakdown of HCA's Discarded Items

For the entire HCA property in 2009, the primary three categories of discarded MSW by weight consisted of trash (29%), recyclable mixed paper (26%), and compostable food waste (18%). Please see Figure 3 for breakdowns of the discarded items by category.

The trash category was the only waste grouping that HCA could not have recycled or composted. The unspecified farm waste most likely contained discarded items that were recyclable and/or compostable; however, due to the fact that a study could not be conducted on this waste stream, all MSW produced by the farm was considered nonrecyclable and noncompostable. As for recyclables, these potentially recoverable items were grouped into four main categories to make the data easier to decipher. These categories included:

1) *Recyclable aluminum/steel* (aluminum and steel cans, as well as other metal containers and items (ferrous and non-ferrous))

2) *Recyclable mixed glass* (clear, amber-, and green-colored glass)

3) *Recyclable mixed paper* (high- and low-grade paper, such as white computer paper, newspaper, magazines, etc.)

4) *Recyclable mixed plastic* (plastic containers and bottles constituting grades 1 (PETE), 2 (HDPE), 4 (LDPE), or 5 (PP))

All of the aforementioned recyclable items are accepted by the local recycling company, Southern Scrap.

As for compostable food waste, this category consisted of food scraps and other organic materials (e.g. coffee grinds/filters) that were discarded by the Retreat House and the monastic enclosure.

Breakdown of HCA's Total Recovered Items

As mentioned previously, HCA successfully recovered 37% of the total waste that it generated, which is equivalent to 7,878 pounds. This recovery rate was a result of the following actions:

- The majority of the food scraps produced by the monastic enclosure was diverted.
- Almost all of the cardboard waste that was generated by the Retreat House, bakery, and monastic enclosure was recovered.
- A number of the waste items produced by the bakery were either reused or recycled. For example, wood pallets and used honey buckets were given to different companies and nonprofit organizations in the local area for reuse.

Table 1 below illustrates the amount of MSW that was diverted according to each recovery category.

Table 1: HCA's total recovered items (2009)

Recovered Items	Weight (lbs)	Percent of Total Recovery
Diverted Monastery Food Waste	4,175	53%
Recycled Cardboard	2,725	34%
Recycled/Reused Bakery Plastics	678	9%
Recycled/Reused Bakery Pallets	300	4%

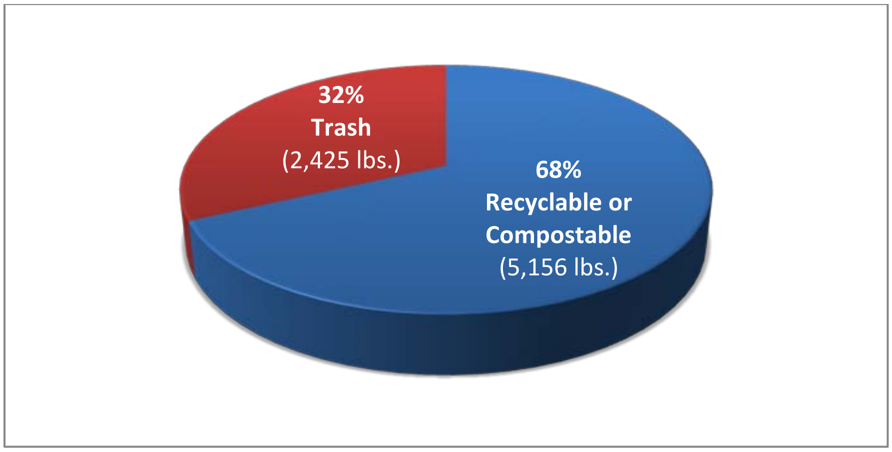
MSW Generation by Specific Waste Stream

In addition to presenting the aforementioned aggregate amounts of MSW that were discarded and recovered by HCA as a unified entity, this report also provides generation, recovery, and disposal data for each of the four individual waste streams: the monastic enclosure, Retreat House, bakery, and farm.

Monastic Enclosure Waste Stream

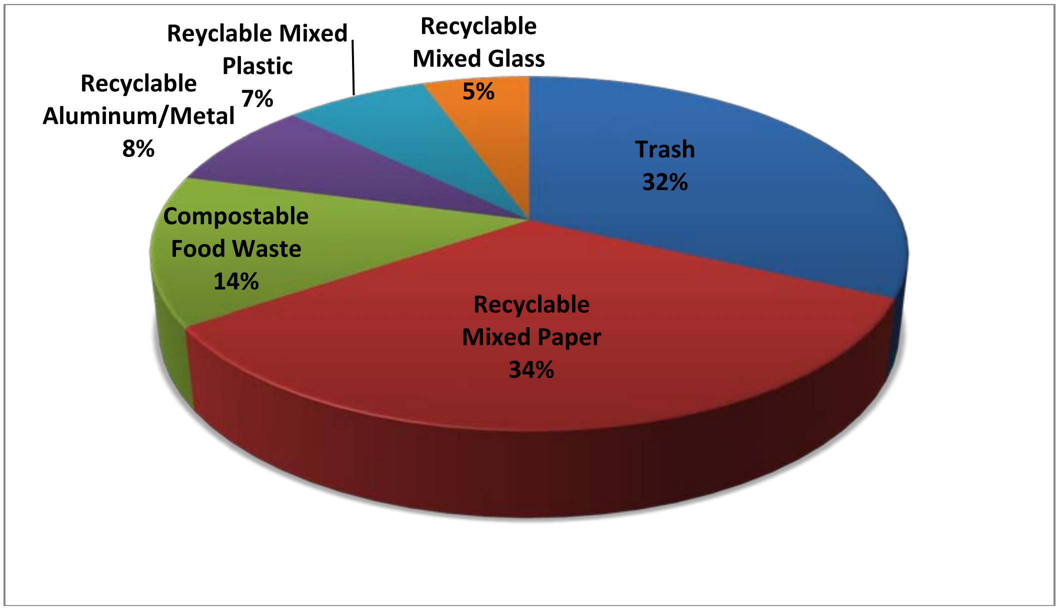
In 2009, 13,490 pounds of MSW was generated by the monastic enclosure. From this amount, the community was able to divert 5,909 pounds (44%) as a result of cardboard recycling and recovering most of its food scraps. However, despite this high recovery rate, there were still 7,581 pounds of MSW discarded in the landfill from this waste stream. Moreover, the MSW that was landfilled had very high recovery potential; in fact, 68% of the items were either recyclable or compostable (see Figure 4). Thus, over two-thirds of the MSW that was discarded by the monastic enclosure could have been diverted from the Frederick County Landfill. For a more detailed breakdown of the MSW discarded by the monastic enclosure, please see Figure 5.

Figure 4: Recovery potential for monastic enclosure's discarded MSW (2009)



As alluded to previously, the HCA residents were able to recover almost all of the cardboard waste generated in the monastic enclosure (1,734 pounds) and a majority of the food scraps (4,175 pounds). Nonetheless, a sizeable amount of food waste from the kitchen as well as other compostable items (e.g., coffee grounds/filters) were still discarded, totaling 1,037 pounds.

Figure 5: Breakdown of monastic enclosure's discarded/landfilled MSW (2009)



Category	Weight (lbs.)
Trash	2,425
Recyclable Mixed Paper	2,542
Compostable Food Waste	1,037
Recyclable Aluminum/Metal	608
Recyclable Mixed Plastic	553
Recyclable Mixed Glass	416

It is also important to note that HCA's food waste recovery process is rather unique. Food scraps are deposited into a small caged area near Cool Spring and allowed to naturally biodegrade or be consumed by animals. Although this diversion act is beneficial in terms of removing food scraps from the waste stream, it is not technically considered composting. According to the EPA, composting involves the biological decomposition and transformation of organic MSW into a stable humus-like product under controlled, aerobic conditions.[62] The natural decay of organic MSW in uncontrolled situations, which HCA engages in, does not constitute composting. Ultimately, with the uncontrolled approach, it takes longer for food waste to break down and it also typically produces pungent odors at the depository site.

Retreat House Waste Stream

In 2009, 3,893 pounds of MSW produced at the Retreat House were discarded and only 111 pounds of cardboard were recovered, which is equivalent to a recovery rate of 3%. Given this low diversion rate, the recovery potential for the Retreat House is very high—of the 3,893 pounds of MSW that were discarded, 70% was either recyclable or compostable. Thus, almost three-fourths of the MSW discarded by the Retreat House could have been diverted from the Frederick County Landfill (see Figure 6 and Figure 7).

Figure 6: Recovery potential for Retreat House's discarded/landfilled MSW (2009)

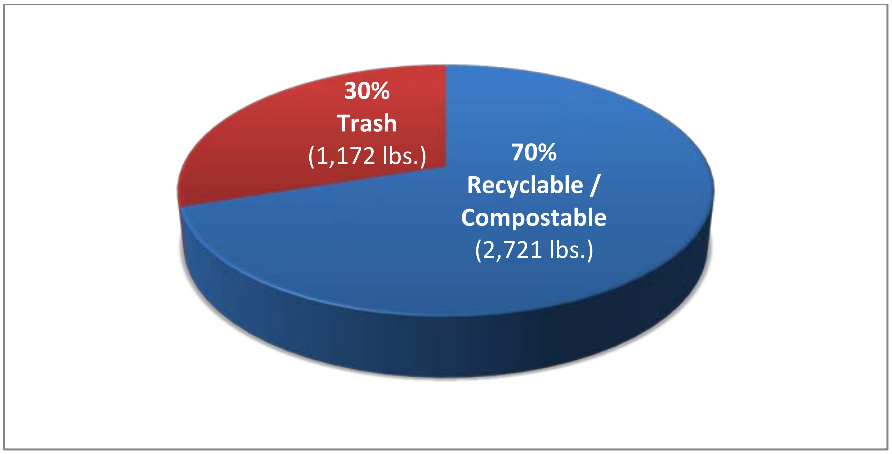
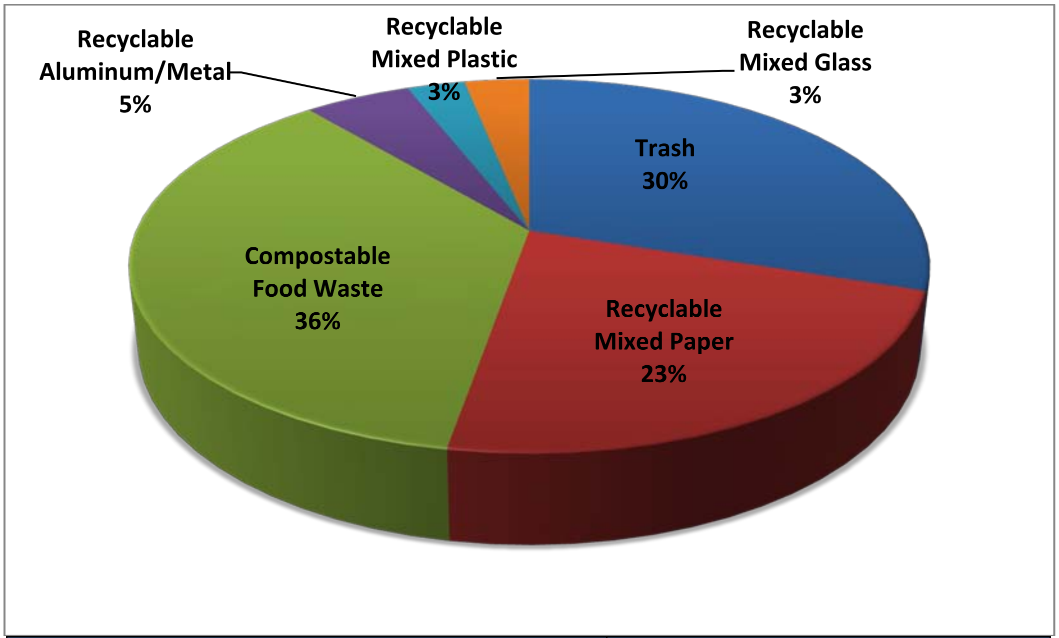


Figure 7: Breakdown of Retreat House's discarded/landfilled MSW (2009)



Category	Weight (lbs.)
Trash	1,172
Compostable Food Waste	1,409
Recyclable Mixed Paper	881
Recyclable Aluminum/Metal	200
Recyclable Mixed Glass	122
Recyclable Mixed Plastic	109

Bakery Waste Stream

In 2009, the bakery demonstrated an incredibly high recovery rate of 79%. Of the 2,360 pounds of MSW that were produced at the bakery, 1,857 pounds were diverted from the landfill. This elevated recovery rate was the result of the following actions:

- Giving away wood pallets and honey seed buckets to local businesses and nonprofit organizations for reuse
- Minimizing organic waste from fruitcake and creamed honey production (e.g., creating HCA fraters from excess fruitcake products)
- Internally reusing containers (e.g., raisin boxes)
- Recycling cardboard

Table 2 depicts the three significant recovery categories and the weight of the material diverted. Despite recovering a large percentage of the MSW that was generated at the bakery, the community still had the potential to divert more items from this waste stream. Of the 503 pounds of MSW that were discarded, 47% was recyclable (see Figure 8 and Figure 9).

Table 2: Bakery's recovery categories

Recovered Items	Weight (lbs)	Percent of Total Recovery
Recycled Cardboard	879	47%
Reused/Recycled Mixed Plastics	678	37%
Reused/Recycled Wood Pallets	300	16%

Figure 8: Bakery's recovery potential for discarded/landfilled MSW (2009)

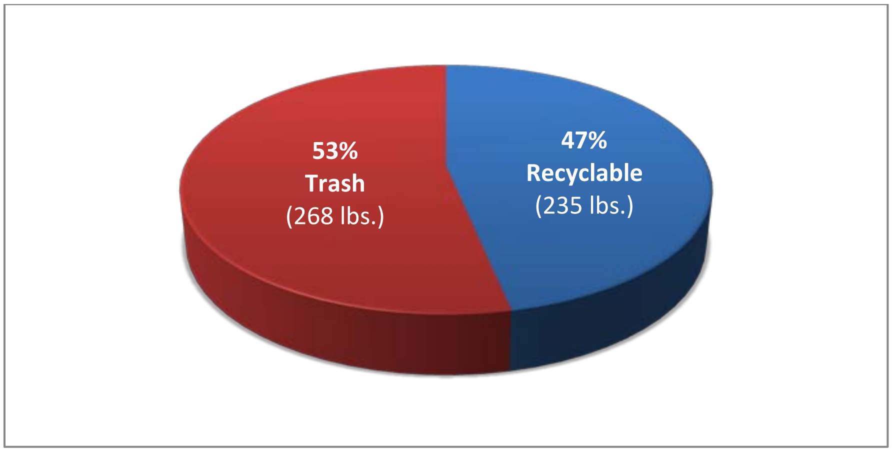
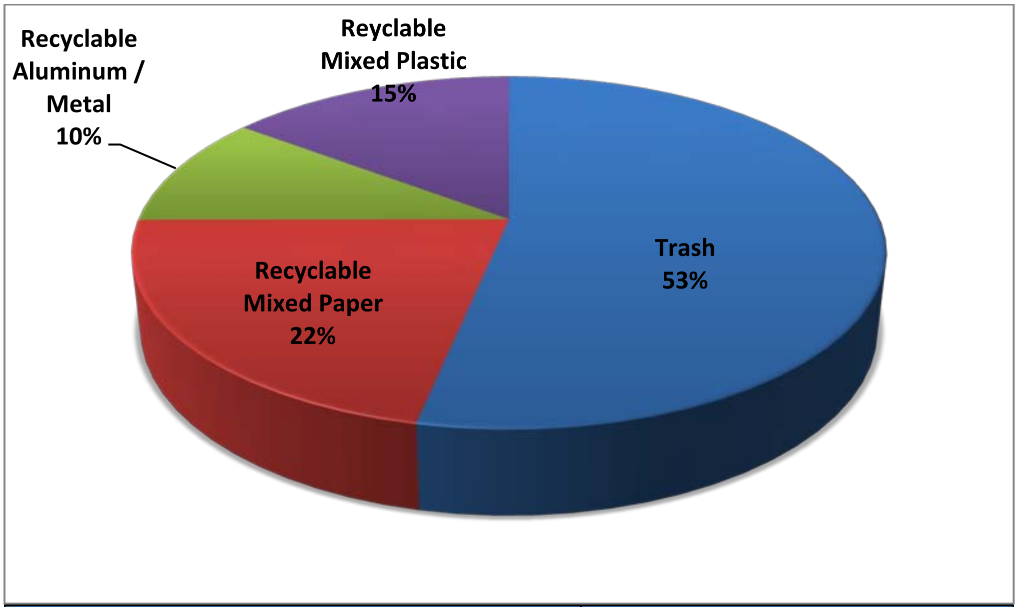


Figure 9: Breakdown of bakery's discarded/landfilled MSW (2009)



Category	Weight (lbs.)
Trash	268
Recyclable Mixed Paper	109
Recyclable Mixed Plastic	74
Recyclable Aluminum/Metal	52

Farm Waste Stream

As noted earlier, the HCA waste characterization studies did not include the farm waste stream. Nonetheless, the Team was able to generate an estimated overall weight for MSW related to HCA's farming operations and personnel using data provided by AWS. By deducting the weight of the other three waste streams (the monastic enclosure, Retreat House, and bakery) from the total estimated weight of MSW collected, we were able to determine an approximate value of 1,490 pounds for farm MSW in 2009. In other words, it is assumed that nearly three-quarters of a ton of MSW is routed to the HCA trash dumpster by the farm tenant. However, this value may be misleading. The farm tenant and his assistant reported that they burn a sizeable amount of the MSW that they produce, such as tire inner tubes, plastic buckets, food containers, hay bale wrapping, and aluminum beverage cans (see Figure 10 below). Thus, the farm most likely produces more MSW than the estimated 1,490 pounds. Moreover, the composition of this waste is unknown. In light of this and for the purpose of the report, it is assumed that the 1,490 pounds of MSW is entirely trash; however, it is likely that a significant percentage of this estimate is recyclable and/or compostable.

Uncontrolled, informal burning of MSW (commonly referred to as "open burning") is a very harmful practice that can have detrimental impacts on human health and the environment. The act of open burning emits GHG's, dioxins, heavy metals, and other particulates, which pollute the air, soil, and water bodies. These emissions have been linked to various long-term health effects ranging from emphysema to nervous system damage.[63] To put the negative consequences of this practice into perspective, the EPA conducted a study that found that open burning ten pounds of trash can potentially produce the same amount of air pollution as incinerating 400,000 pounds of MSW at a modern, well-controlled incineration facility.[64]

Figure 10: Open burning at farm headquarters

Figure 11: E-waste stored in an open-air bay

Electronic Waste

HCA does not have a formal system for storing and disposing of electronic waste (e.g., computers). At the present time, end-of-life computer equipment and TV sets are precariously housed in open-air bays in the maintenance building (see Figure 11 below). We also suspect that there are other e-waste items randomly located throughout the monastic enclosure; however, the whereabouts of these individual items is unknown. Moreover, there are roughly 30 functional computers currently being used by the community and employees.

Yard Waste

HCA engages in the environmentally friendly practice of grasscycling, which diverts lawn clippings from entering the waste stream. In addition, when trees and shrubbery are pruned, all trimmings are deposited in a specific area for the items to naturally decompose.

Pharmaceutical Waste

HCA does not have a formal system for disposing of pharmaceutical waste. However, one of the HCA members who is a licensed physician currently collects and stores all unused or expired prescription medication in an effort to prevent improper disposal.

Informal Dump Sites

HCA has seven known informal dump sites located throughout the property. Most of the exposed waste items at these sites do not pose a direct or significant threat to the environment or human health. However, from an aesthetic perspective, these informal dumping grounds do appear to blight the natural and built settings in which they are located.

The following dump sites were indentified:

- Cool Spring creek channel (various locations throughout the creek)
- Cool Spring pond
- Farm headquarters
- Northern stream drainage ditch
- Outside of the old shed located at the edge of the monastic enclosure’s north parking lot
- Shenandoah River shoreline (southern part of the property, near the Waterloo House)
- Wynkoop House (grounds)

Figures 12–18 contain photographs taken at each dump site. Please see Appendix 4-B for maps indicating the location of the respective sites, an inventory of the waste items, and additional photographs.

A large old metal tank is stored behind the new bakery to the north. According to the bakery manager and maintenance manager, this tank has never been used for operating the bakery. In addition, significant amounts of MSW and unused/nonfunctioning equipment have amassed over time in the old bakery. Figures 19 and 20 depict the unused tank behind the new bakery and the waste items that are present on the inside of the old bakery building.

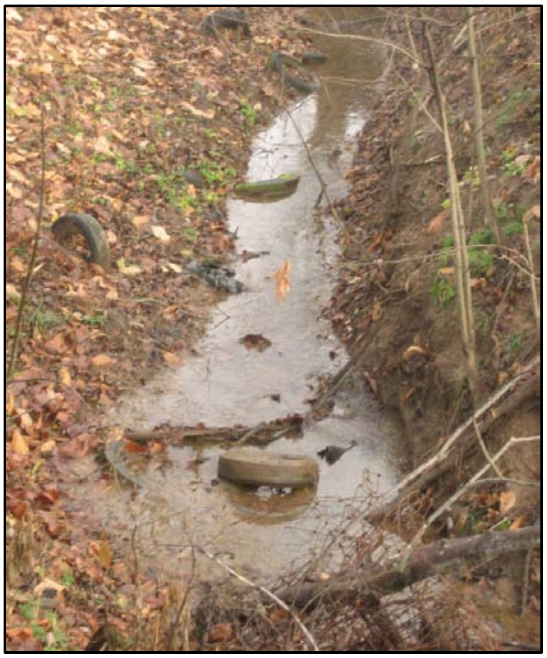


Figure 12: Cool Spring creek channel

Figure 13: Cool Spring pond

Figure 14: Farm headquarters

Figure 15: Old shed, north parking lot

Figure 16: Northern stream drainage ditch

Figure 17: Shenandoah River shoreline

Figure 18: Wynkoop House grounds

Figure 19: Behind the new bakery

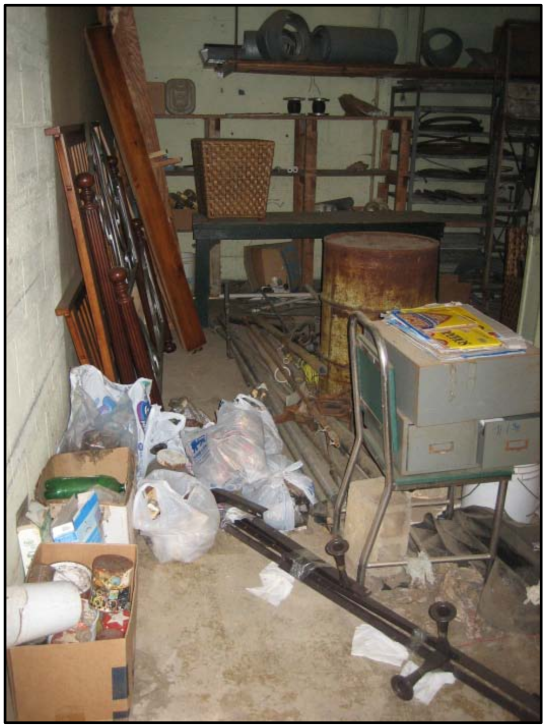


Figure 20: Inside the old bakery facility

HCA Waste Management Activities and Carbon Dioxide Equivalent Production

With regard to waste management, HCA actually saved (avoided) more CO_2eq than it produced in 2009. In fact, HCA generated 3,529 pounds of CO_2eq as a result of its disposal activities, but it was able to avoid the production of 12,199 pounds of CO_2eq due to its various recovery activities (see Table 3 and Table 4). Thus, in 2009, HCA avoided emitting a net total of 8,670 pounds of CO_2eq.

Despite HCA's success in limiting GHG emissions related to waste management, it is possible for the community to reduce even more CO_2eq given the incredibly high recovery potential of the MSW that it sends to the landfill. Specifically, if the community members recycled all of their paper, glass, aluminum/steel, and recoverable plastic and composted all of their food scraps, they could avoid emitting a net total of 26,675 pounds of CO_2eq per year (see Table 5). This "savings" is equivalent to the amount of CO_2 produced by consuming 1,235 gallons of gasoline or 25.5 barrels of oil—a significant savings in GHG emissions considering the size of the HCA community.[65]

Table 3: Carbon dioxide equivalent (CO_2eq) produced by HCA's MSW disposal practices (2009)

Material	Amount Land filled (lbs.)	C02 Equivalent Produced (lbs.)
Compostable Food Scraps	2,446	873
Recyclable Aluminum/Steel	861	35
Recyclable Mixed Glass	538	22
Recyclable Mixed Paper	3,533	*-1,181
Recyclable Mixed Plastic	737	31
Trash	3,867	2,722
Unspecified Farm Waste	1,460	1,027
TOTAL	**13,442**	**3,529**

*Recyclable mixed paper shows a reduction in CO2 equivalent because it is an organic substance that decomposes in the landfill. This decomposition process in an anaerobic environment produces the GHG methane, but the Frederick County Landfill has a flaring system, which burns off methane emissions given off by the site. Thus, the net CO2 equivalent is negative with regard to mixed paper.

Table 4: Carbon dioxide (CO2) equivalent avoided due to HCA's recovery efforts (2009)

Material	Amount Recovered (lbs.)	C02 Equivalent Avoided (lbs.)
Diverted Food Scraps	4,175	-923
Recycled Cardboard	2,725	-9,323
Reused/Recycled Plastics	678	-1,142
Reused/Recycled Wood Pallets	300	-811
TOTAL	**7,878**	**-12,199**

Table 5: CO2 equivalent avoided/produced if HCA achieves full recovery potential

Material	If Recovered (lbs.)	If Discarded (lbs.)	CO2 Equivalent Avoided/Produced (lbs.)
Compostable Food Scraps	6,621	0	-1,466
Recyclable Aluminum/Steel	861	0	-2,620
Recyclable Cardboard	2,725	0	-9,323
Recyclable Mixed Glass	538	0	-165
Recyclable Mixed Paper	3,533	0	-13,654
Reusable/Recyclable Mixed Plastic	1,415	0	-2,385
Reusable/Recyclable Wood Pallets	300	0	-811
Trash	NA	3,867	2,722
Unspecified Farm Waste	0	1,460	1,027
TOTAL	**15,993**	**5,327**	**-26,675**

Questionnaire Responses: Waste Prevention & Recycling Behaviors

Over 90% of the monks who responded to the open-ended sustainability questionnaire that we administered in the fall of 2009 indicated that they typically engage in at least one conservation behavior on a daily or weekly basis and that they are mindful of conserving natural resources. None of the respondents indicated that they engage in "specific" waste prevention behaviors related to waste; however, a few members did indicate that they generally try to reuse items in different capacities until they are no longer functional. Despite these findings, the Team observed the community engaging in a number of source-reduction behaviors such as buying in bulk, double-side printing, using durable tableware, and wearing second-hand clothes to name a few. Moreover, HCA members live an incredibly simplistic lifestyle and generally consume very little, which is the hallmark of waste prevention.

Unfortunately, the questionnaire did not provide a list of waste prevention behaviors for respondents to check, which may have helped generate more valid results. Instead, community members and employees were asked to write down behaviors from memory. Due to the flawed format, some HCA members and employees might actually engage in source reduction behaviors without realizing it. Respondents may also have failed to recall certain conservation behaviors that they perform when they completed the questionnaire.

Based on the responses to the questionnaire, it appears that community members and employees would be willing to adopt additional pro-environmental behaviors (potentially waste prevention behaviors) if they are educated about the various actions they can engage in. It is also important to note that multiple respondents indicated that they would be willing to recycle more items (other than just cardboard) if there was a formalized system for recycling.

Results Summary: Comparison to EPA's ISWM Hierarchy & Zero Waste

HCA's waste management program does appear to follow some elements of the ISWM hierarchy and the Zero Waste philosophy; however, there is definitely significant room for improvement in the areas of waste prevention and recycling/composting. With regard to waste prevention, HCA members do, undoubtedly, live very frugal lifestyles and demonstrate some source reduction behaviors. Nonetheless, based on the results of the questionnaire and general observation, it does appear that there are several additional waste prevention actions that HCA members could adopt.

As mentioned earlier, HCA recycles nearly 37% of the MSW that it generates, which exceeds the national average but falls short of the recycling rates demonstrated by the state of Virginia and Clarke/Frederick Counties. Moreover, HCA diverts a large percentage of its food scraps from entering the waste stream (even though this diversion action is technically not composting). Despite these efforts, the recovery potential for the MSW that HCA disposes in the Frederick County Landfill is extremely high (68%). If formalized systems were in place to encourage waste prevention and permit recycling and composting for all potentially recoverable materials, HCA could achieve this recovery potential, better exemplify the principles of ISWM, and potentially attain Zero Waste status. Furthermore, if HCA recovered all of the recyclables and compostable items that it generates, the community could avoid a significant amount of GHG emissions related to waste management.

OPTIONS

Based on the results of the analysis and the research conducted on possible alternatives, the Michigan Team proposes the following options related to the sustainable management of solid waste at HCA:

1) Contract with Waste Management for comprehensive recycling collection services to recover all recyclable material

2) Implement a composting system to capture all food scraps and yard waste

3) Discontinue burning trash at the farm headquarters
4) Adopt/continue various waste prevention practices to limit total MSW produced
5) Develop a formal management system for e-waste
6) Develop a formal management system for pharmaceutical waste
7) Remove and recycle waste from the informal dump sites located on the property

If all of these options are implemented, HCA could potentially divert up to 90% of its MSW from entering the Frederick County Landfill, thus achieving Zero Waste status and fully embodying the concept of sustainable waste management as espoused by the EPA's ISWM principles. In addition, HCA would avoid producing a total of 26,675 pounds of CO_2eq per year (possibly more, depending on the waste prevention activities that are adopted), which is equivalent to avoiding the amount of carbon dioxide produced by consuming 1,235 gallons of gasoline—a significant savings in GHG emissions given the size of the HCA community.

Option 1: Contract for Comprehensive Recycling

On a positive note, HCA community members recycle nearly all of their cardboard waste and reuse much of the plastic generated by the bakery; however, they still fail to recover a significant amount of the recyclable MSW they discard. In fact, HCA throws away an estimated 5,670 pounds of recyclable materials each year, which ultimately ends up in the Frederick County Landfill. In other words, half of the inorganic refuse (non-food waste) that HCA places in the AWS dumpster could be recycled. Considering this recovery potential, the Michigan Team proposes that HCA expand its recycling activities to capture more than just cardboard and some bakery plastics. Details for implementing this option are explained below.

Recycling Option

The Michigan Team suggests that HCA contract with Waste Management to provide comprehensive single-stream recycling services on a weekly basis using an eight-yard dumpster (the same size as the current AWS dumpsters).

- This option is less expensive than HCA's current service, does not require presorting of items prior to collection, and allows the community members to recover all of their recyclable materials.
- This option would also entail discontinuing the existing cardboard recycling service while retaining AWS as the provider for trash collection services; however, the service schedule would change to monthly pickup.
- Cost: $2,230 per year (plus upfront costs estimated at $775)

Details Regarding Recycling Option

When considering cost and environmental benefit, the Team's recommended alternative is far superior to the current services provided by AWS. First of all, the annual cost for the recommended course of action ($2,230/year) is lower than what HCA currently pays ($3,800/year). This option also falls below the reduced fee that AWS plans to introduce during the 2010 calendar year. According to a verbal report from the AWS account representative, the revised annual fee for HCA's current services (bi-weekly trash and monthly cardboard pickup) will be $2,495 per year. Even with the reduced charges, the recommended alternative is still the preferred option from a financial standpoint. Granted, there are some limited upfront costs associated with the implementation of our recommendation (totaling an estimated $775). These one-time costs will cover educational signage and additional bins that most likely will need to be purchased for areas that guests/retreatants frequent, such as the gift shop and Retreat House. In the monastic enclosure, bakery, and various guest houses (e.g., Westwood House), the community can reuse existing bins and materials for the new recommended system.

From an environmental perspective, the recommended option also diverts more recyclables from the Frederick County Landfill. Currently, HCA recovers 3,705 pounds of recyclable inorganic material (this excludes organic/compostable materials). By implementing the recommendations presented in Option 1, HCA would meet its full recovery potential for inorganic recyclables, diverting a total of 9,375 pounds of recyclable material. As a result, the resources contained in these materials will serve as feedstock for new products instead of being permanently locked away in a landfill. Furthermore, by diverting its recyclable material, HCA would not be contributing to the pollution of groundwater and soil from landfill leaching. The community would also avoid generating 25,209 total pounds of CO_2eq by implementing these recommendations, which would be an additional 16,589 pounds of CO_2eq beyond what the HCA's current services help avoid. For a visual comparison of the recommended alternative and HCA's current services (which incorporates AWS's proposed reduced fee), please see Table 6.

One of the major advantages of implementing the recommended alternative and contracting with Waste Management (WM) for recycling services is that WM offers comingled (mixed) recyclables collection, which means that HCA would not have to separate various types of recovered items. The community and staff would simply have to place all recyclable materials in one dumpster and trash in the other. This is due to the fact that WM works with a local comprehensive recycling center in Manassas, Virginia that processes comingled recyclables (this process is often referred to as "single-stream recycling"). Moreover, the Manassas recycling facility accepts the full spectrum of recyclable MSW, which is why HCA can recover all of the recyclable items that it is currently throwing away as part of this recommended option.

Table 6: Recommended recycling/trash options vs. HCA's current services

Service Info	Recommended Alternative (WM recycling/AWS trash)	HCA's Current Services (reduced AWS fees included)
Schedule	• WM weekly "all" recyclables pickup • AWS monthly trash pickup	• AWS monthly cardboard pickup • AWS bi-weekly trash pickup
Annual Fee Breakdown	• Monthly trash pickup = $780 • Weekly recyclables pickup = $1,140 • Total fuel charges = $310	• Bi-weekly trash pickup = $1,560 • Monthly cardboard pickup = $570 • Total Fuel charges = $365
Additional Upfront Expenses	• One-time delivery charge = $75 (WM recycling dumpster) • Additional recycling bins & signage = $700 (primarily for Retreat House & gift shop)	Not applicable
Total Annual Cost	**$2,230** *(plus $775 for estimated upfront costs)*	**$2,495** *($3,800 under current contract)*
Recyclables Recovered Per Year	**9,375 lbs.** *(all recyclables recovered)*	**3,705 lbs.** *(5,670 lbs. of recyclables still disposed of in landfill)*
Total Lbs. of CO_2eq Avoided/Year	**25,209 lbs. of CO_2eq avoided**	**8,620 lbs. of CO_2eq avoided**

In reality, it would be slightly more cost effective for Waste Management to provide trash services as well. However, the Team is not recommending that HCA drop its contract with AWS for trash collection services due to the fact that the community values its long-term business relationship with the company. According to input from select HCA members and staff, the community would generally prefer to maintain at least a part of its contract with AWS despite the fact that its services are more expensive and less comprehensive.

AWS does offer expanded recycling services, which were evaluated by the Team according to cost, environmental benefit, and logistics. Unfortunately, this AWS option is significantly more expensive—roughly $4,695 per year—and would only allow selective recycling. In essence, HCA would only be able to recover three additional types of recyclable materials (mixed paper, aluminum, and PETE grade 1 plastic), which would have to be manually sorted prior to pickup. For a more detailed explanation of why an expanded AWS recycling service is not a preferred option and for a comparison with the recommended alternative, please see Appendix 4-C.

On a final note, the recommended course of action assumes that HCA will attempt to compost all of the organic MSW (e.g., food waste) that it produces. If not all of HCA's organic MSW is composted (e.g., HCA continues to place food waste from the Retreat House into the trash dumpster), the AWS trash pickup schedule may need to be modified to bi-weekly instead of monthly. The Team did consider and evaluate the idea of using volunteers to assist with transporting recyclables rather than having HCA sign a contract for a formalized service. Unfortunately, this would be difficult to manage and is a less-preferred alternative when compared to the convenience and relatively low cost of WM's recycling service.

Regarding contact information for representatives associated with Waste Management and Allied Waste Service who are familiar with the aforementioned recycling option, please see Appendix 4-D.

Option 2: Implement a Composting System

According to the Team's analysis, HCA recovers nearly 4,175 pounds of organic MSW each year by diverting food scraps generated by the monastic enclosure. However, it still annually discards 2,446 pounds of food waste, which is the result of throwing away food scraps from the Retreat House and failing to capture all of the food waste and compostable materials (e.g., coffee grounds) produced in the monastic enclosure. Consequently, when this discarded organic MSW is disposed of in the anaerobic conditions of the Frederick County Landfill, it produces the highly potent GHG methane. Moreover, HCA's unique recovery process for organic MSW (which is beneficial in terms of removing food scraps from the waste stream) is technically not as effective as formally composting the materials. In light of this, the Michigan Team proposes that HCA compost all of the organic/food waste produced on the property. Details for implementing this option are explained below.

Composting Option

The Michigan Team suggests that HCA build a three-bin composting system and compost all food waste and compostable materials (e.g., coffee filters) produced on the property.

- The composting bin system could be built by HCA maintenance staff or local volunteers (e.g., the Boy Scout troop from the Shenandoah Area Council) primarily using second-hand materials.
- The Virginia Cooperative Extension (Clarke County office) will provide education regarding composting and any needed support.
- Cost: $500 or less (depending on the used materials available on the property)

Details Regarding the Composting Option

Currently, HCA collects food waste from the monastic enclosure's kitchen and then deposits the material in a small caged area near Cool Spring, allowing the items to naturally biodegrade or be consumed by animals. As mentioned above, despite the fact that this diversion act is beneficial in terms of removing food scraps from the waste stream, it technically is not composting. According to the EPA, composting involves the biological decomposition and transformation of organic MSW into a stable humus-like product under controlled, aerobic conditions.[66] The natural decay of organic MSW in uncontrolled situations, which HCA engages in, does not constitute composting.

If HCA decided to implement this option and participate in formal composting, it would see a number of benefits over the current system, such as:

- There would be no pungent odors at the composting site.
- Other compostable materials (e.g., coffee filters) could be diverted from the waste stream.
- Compost (i.e., soil amendment) would be produced via the process, which could be used to fertilize plants and/or garden areas.
- Due to the fact that no malodorous smells will be generated, the compost area could be sited closer to the monastic enclosure, necessitating less time and travel distance to dispose of the food waste.
- Food waste would break down faster and more material could be processed.[67]
- There would be no adverse effects on wildlife (inadvertently feeding certain wild animals post-consumer food can negatively disrupt their feeding cycles and habits).[68]

Consistent with the concept of reusing and recycling materials, a three-bin composting system could be built using second-hand supplies, such as leftover wood pallets from deliveries to the bakery. For a complete listing of supplies needed and instructions on how to construct a multi-bin composter, please see Appendix 4-E. We estimate the cost of building a system like this to be roughly $500 or less, depending on the used materials that are available on the property. Building a compost system is relatively easily and could be completed by HCA maintenance staff or a local Boy Scout troop. The Michigan Team has already contacted the Shenandoah Area Boy Scouts Council, and there is interest in possibly helping build a composting bin system for HCA.

A member of the HCA maintenance staff or the community would have to periodically manage (rotate) the compost piles. Although it is not difficult or time consuming to manage a composting system, there are certain best practices that should be followed. To assist with education, the local Virginia Cooperative Extension Service (Clarke County office) has agreed to provide free one-on-one instruction and continuous support. Moreover, HCA could consider building another smaller compost bin system near the Retreat House to handle its food waste; however, it seems it would be easier for HCA to have one composting site near the monastic enclosure and to transport food waste from the Retreat House via small sealed plastic containers.

HCA could also forgo building a bin system and simply use a compost pile (no structure/enclosure). This is a viable option; however, per the State Cooperative Extension Office a multi-bin system is generally easier for one person to manage compared to a large-scale compost pile due to the periodic churning that must be performed.

Contact information for representatives associated with the local Virginia Cooperative Extension Office and the Shenandoah Area Boy Scouts Council who are familiar with the aforementioned composting option are listed in Appendix 4-D.

Option 3: Discontinue Burning Farm Trash

The farm tenant and his assistant reported that they periodically burn MSW at the farm headquarters in order to limit the amount of trash they have to put in the AWS trash dumpster. They have said that they often burn items such as tire inner tubes, plastic buckets, food containers, hay bale wrapping, and aluminum beverage cans. As previously mentioned in this section, open burning results in the release of an array of pollutants that are extremely harmful to the environment and human health, and it is considered one of the absolute worst ways to dispose of MSW. In fact, the EPA has found that open burning ten pounds of trash can produce as much air pollution as incinerating 400,000 pounds of MSW at a modern, well-controlled incineration facility.[69] Plus, according to the Clarke County Sheriff's Department it is illegal for residents to burn inorganic trash in Clarke County. Considering how damaging this practice can be and that it is an illegal act, the Michigan Team proposes the following:

Farm Trash Option

The Michigan Team suggests that HCA request that the farm tenant refrain from burning MSW at the farm headquarters and instead place recyclables and MSW in the appropriate dumpsters.

- As part of this option, HCA is encouraged to adopt an official policy prohibiting the burning of trash anywhere on its property (this could also be written into a new lease with the current or future farm tenant).
- Cost: not applicable

Option 4: Adopt/Continue Waste Prevention Activities

As illustrated by the ISWM hierarchy and the Zero Waste philosophy, waste prevention is the most preferred MSW management option. By generating less waste in the first place, more resources are conserved, less pollution is produced, costs are reduced, and public health is better protected. In general, the HCA community already lives a very frugal lifestyle in accordance with Cistercian values, which is the key to waste prevention—live simply and consume very little. Members also engage in specific waste prevention activities, such as buying in bulk, wearing second-hand clothes, and primarily using nondisposable products. Plus, the Retreat House employs a number of waste prevention techniques to limit the amount of MSW generated. Despite all of this, there are still many actions that the residents of HCA can adopt in order to avoid or limit the production of waste. Our suggestions regarding this option are detailed below (we did not estimate a cost due to the difficulty of determining one for this option).

Waste Prevention Option

The Michigan Team suggests that HCA continue/adopt as many of the following waste prevention behaviors as possible:

- Reduce consumption of disposable goods by using and buying durable (or compostable) products
    - Use rags and sponges for cleaning instead of traditional paper towels; if this is not an agreeable option, use chlorine-free 100% post-consumer recycled paper towels with environmentally friendly cleaning supplies so that paper towel waste can be composted
    - Continue using and providing reusable tableware
    - Replace traditional paper napkins with cloth alternatives or switch to chlorine-free, 100% post-consumer recycled paper napkins that can be composted
    - Use cloth/reusable bags when grocery shopping
    - Use compostable trash sacks; when maintenance staff dump the trash into the dumpster, they can retain the sack for composting
    - Continue using and providing cloth towels instead of paper towels in restroom areas

  - Switch to compostable coffee stir sticks
  - Continue using and providing reusable storage containers for food and supplies instead of disposable plastic sealable sacks
  - Substitute wrapped plastic cups with durable or compostable alternatives in the Retreat House

- Continue to generally buy supplies and food in bulk
- Buy rechargeable batteries
- Refrain from purchasing individually packaged creamers and sugar packets; instead, buy in communal/family size quantities that can be shared and stored for repeated access
- Cancel newspaper/magazine subscriptions and sign up for on-line versions
- Opt out of junk mail (refer to the Web site www.dmachoice.org)
- Refill toner cartridges instead of buying new ones
- Continue to use the double-sided printing option
- Continue to cut up printed, one-sided paper to be used for scratch paper before recycling it
- Save and reuse paper bags, rubber bands, twisty ties, and packaging material that are accumulated via deliveries of materials to the monastic enclosure, Retreat House, bakery, and gift shop
- Continue to generally look for ways to reuse items in different capacities to extend the life of the products
- When the community needs to purchase new computers, buy models that can be easily upgraded
- Whenever possible, buy products that are packaged efficiently and/or that are made with 100% post-consumer recycled content (or at least some recycled material)
- Look to purchase second-hand items from local reuse centers before buying new (e.g., Blue Ridge Hospice Thrift in Berryville, Goodwill, Salvation Army, and Habitat for Humanity Restore in Winchester)
- Consider renting or borrowing items from neighbors or local area residents before buying them
- Continue to repair products and equipment before replacing them
- Encourage the bakery’s suppliers to reduce packaging, provide returnable/reusable packaging, and/or change to recyclable materials
- Periodically ask the HCA community, staff, and retreatants to generate ideas about how to further prevent or limit the production of waste at HCA

Option 5: Develop an E-Waste Management System

At the present time, end-of-life computer equipment and television sets are precariously stored in open-air bays in the maintenance building, and it is suspected that there are other e-waste items randomly located throughout the monastic enclosure. There are also roughly 30 functional computers currently being used by the community and staff that will need to be upgraded, repaired, donated, or recycled at different times over the next several years. Considering the aforementioned, the Michigan Team proposes that HCA develop an official system for managing e-waste. Details for implementing this option are provided below.

E-Waste Option

The Michigan Team suggests that HCA recycle its existing nonfunctioning e-waste housed in the maintenance building and develop a formal system for storing, donating, and recycling future e-waste items.

- This option would entail selecting a spacious indoor storage room that could temporarily house e-waste in a safe manner and that would limit the chance of damaging items and exposing harmful materials contained within the units.
- This option also includes adopting an official policy that e-waste items be removed from the property after a certain span of time (e.g., every 3 months) by volunteers or the maintenance staff. Functional electronic items that are no longer needed should be donated to Goodwill Industries in Winchester, and nonfunctioning e-waste items should be taken to the Citizen’s Convenience Center at the Frederick County Landfill on designated e-recycling collection dates.
- Cost: $8–$12 recycling fee for computer monitors and televisions; all other electronic equipment is accepted and recycled for free.

Details Regarding E-Waste Option

As mentioned in the Sustainable E-Waste Management subsection, electronic items should not be improperly stored, disposed of in a landfill, or incinerated. Thus, by adopting a policy that focuses on appropriate storage procedures and by donating and/or recycling e-waste items, HCA will be diverting valuable resources from the waste stream and preventing potentially harmful substances from being released into the environment.

Regarding details as to where HCA can take their e-waste items, the Goodwill retail and donation center in Winchester accepts a wide spectrum of functioning electronic items for resale (a list of accepted items is provided on their Web site). The Citizen’s Convenience Center accepts e-waste items for recycling on the second Saturday and the fourth Wednesday of each month. A comprehensive list of items that are accepted for e-recycling is provided on Frederick County’s Recycling Programs Web site. For the contact information of Goodwill and the Citizen’s Convenience Center, please see Appendix 4-D.

Option 6: Develop a Pharmaceutical Waste Management System

Currently, one of HCA’s members who is a licensed physician collects unused and expired medication in an effort to prevent improper disposal (such as flushing pharmaceuticals down the toilet or drain). However, past the point of collection, there is no official system for properly recycling or disposing of the medication. In light of this, the Michigan Team proposes the following pharmaceutical waste option:

Pharmaceutical Waste Option

The Michigan Team suggests that HCA continue to collect unused and expired medication per its existing procedure and adopt a formal system that routes unused and expired medication to appropriate recycling and disposal sites located in Winchester and Leesburg.

- This option entails periodically taking unused pharmaceuticals that have not yet expired to the Free Medical Clinic of Northern Shenandoah Valley, which can legally redistribute the medication to needy patients who cannot afford prescription drugs.

- Expired medication should be taken to the Leesburg Pharmacy, where it is picked up by a certified recycler who incinerates pharmaceutical waste—the most preferred disposal method for this type of waste according to the FDA and EPA.
- Please Note: Although uncommon, if the label on a certain medication specifically instructs the user to flush leftover portions down the toilet/drain, HCA is advised to follow these instructions.
- Cost: nominal (travel/time)

Details Regarding the Pharmaceutical Waste Option

Using a community drug take-back program is an appropriate method for recycling pharmaceutical waste. Ultimately, by using a take-back program and refraining from flushing medication or haphazardly discarding it in the regular trash, HCA will limit the pharmaceutical residue that it releases into local water bodies (e.g., the Shenandoah River) via its septic systems or possible landfill leaching.

It is also important to note that the Free Medical Clinic of Northern Shenandoah Valley may not be able to take all unused/nonexpired pharmaceuticals depending on the type and the condition of the medication. HCA is encouraged to call beforehand to confirm that the respective medications can be accepted. For the contact information of the Free Medical Clinic of Northern Shenandoah Valley and the Leesburg Pharmacy, please see Appendix 4-D.

Option 7: Remove and Recycle Waste from Informal Dump Sites

HCA has several known informal dump sites located throughout the property. Most of the exposed waste items at these sites do not pose a direct or significant threat to the environment or human health. However, from an aesthetic perspective, these informal dumping grounds blight the natural and built settings in which they are located. Therefore, the Michigan Team proposes that HCA remove and recycle all of the waste items located at these sites. Details for implementing this option are listed below.

Dump Site Option

The Michigan Team suggests that HCA work with local scrap collection companies and/or volunteers to assist with the removal, recycling, and appropriate disposal of all waste items contained at the known dump sites.

- This option involves removing items from the following sites:
    - Cool Spring creek channel (various locations throughout the creek)
    - Cool Spring pond (in and around the pond)
    - Farm headquarters
    - Grounds of the Wynkoop House
    - Northern stream drainage ditch
    - Outside/inside the old shed (monastic enclosure’s north parking lot)
    - A section of the Shenandoah River shoreline (southern part of the property)
- The unused above-ground tank behind the new bakery and an abundant amount of MSW and unused equipment located in the old bakery should be removed/recycled as well.

- HCA should adopt an official policy prohibiting dumping on its grounds (this could also be written into a new lease with the current or future farm tenant).
- We would expect the cost to be minimal for implementing this option. If HCA works with a scrap collector, the community will make money from the metal waste, which should offset any costs for collecting and recycling nonmetal waste items.

Details Regarding the Dump Site Option

HCA could have volunteers assist with cleaning up various dump sites instead of contracting with a scrap company to remove the waste items. If the community chooses to work with volunteers, they need to consider the potential physical risk to participants, liability, and logistical challenges associated with removing the items.

Regarding contact information for two local scrap companies who are familiar with the aforementioned dump site recommendation and are interested in working with HCA on this issue, please see Appendix 4-D. In addition, Appendix 4-B depicts a map and an inventory of the waste items at each dump site.

ENDNOTES

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[1] The term *solid waste* refers to discarded materials that are produced by residential, commercial, and industrial activities. Specific definitions of *solid waste* differ between countries and tend to be very elaborate because typically there are regulatory implications associated with the specific wording.[1] In light of the diverse and convoluted nature of the classification, it is easier to understand solid waste when it is broken down into seven primary subcategories (municipal solid waste (MSW), medical waste, construction & demolition waste, commercial/industrial-process waste, hazardous waste, radioactive waste, and sewage sludge). We focus on MSW because most of these subcategories are not germane to the HCA community and its operations.

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TOXICS

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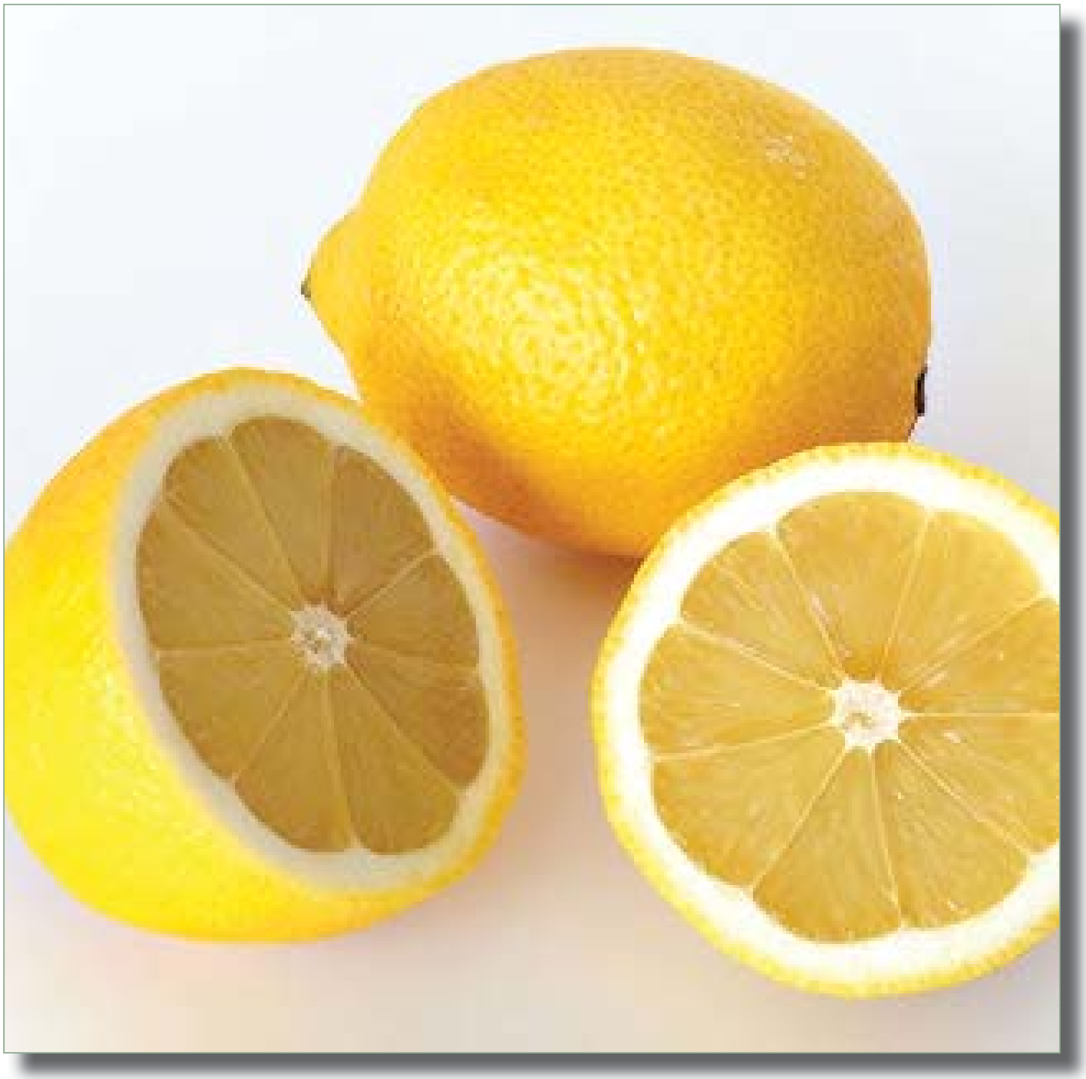


Not every effect of every chemical used by humans is known for certain, but many of them are potentially harmful to humans and the environment. A number of these chemicals are commonly found in homes and in surrounding landscapes. The production, use, and disposal of chemicals and other toxic substances in the home and the environment can affect human and environmental health. In addition, biotic factors can negatively impact human health (for example, the growth of mold indoors can result in a variety of illnesses). Possible results of exposure to these toxins include respiratory problems, cancers, ecosystem disruption, and animal and plant mortality.

This chapter explores the human health issues associated with toxic substances commonly found in the indoor and outdoor environments. We describe the methodology that we used to investigate HCA's toxics management practices and summarize the types and amounts of chemicals in HCA's environment. Finally, this chapter presents options and recommendations that HCA might implement to reduce its chemical use and the resulting impact.

CONTEXT: CHEMICALS IN THE ENVIRONMENT

According to the World Wildlife Fund, the global production of man-made chemicals increased from 1 million to 400 million metric tons each year between 1943 and 2000.[1] Chemical production (and resulting exposure) is continuing to rise, making chemical exposure a growing problem in America and around the world. Humans are increasingly exposed to these chemicals both indoors and through outdoor environmental exposure.

Indoor Environment

The average American spends 90% of the day indoors, so the quality of the indoor environment is critical.[2] Simply living in their home can expose people to a variety of environmental pollutants. The use of household chemicals has continued to grow. The market grew almost 10% (in value) from 2003 to 2008,[3] indicating that the use of potentially hazardous materials is continuing to grow, and thus exposure and the harmful impacts are likely increasing. Items of concern include:[4]

- Biological pollutants (i.e., mold/mildew)
- Asbestos-containing insulation
- Carbon monoxide
- Formaldehyde/pressed wood products
- Lead
- Insecticides/pesticides
- Radon
- Respirable particles
- Typical household cleaners and chemicals

Human health impacts of indoor pollutants can develop immediately or over an extended period after repeated exposure depending on the level of exposure. Effects can include eye, nose, and throat irritation; skin irritation; asthma; headaches; dizziness; and fatigue. Longer-term effects can include some respiratory diseases and cancer.[5] Table 1 describes the sources of indoor pollution and summarizes the potential short-term and long-term health impacts of exposure to each specific form of pollution.

Table 1: Summary of indoor pollutants and health impacts[67]

Pollutant	Source/Use	Short-term impact	Long-term impact
Mold/mildew	Found in indoor and outdoor air; grow in damp places	Allergic reactions; asthma; immunological effects; hypersensitivity pneumonitis; eyes, skin, nose, throat, and lungs irritation	Increased allergenic sensitivity, hypersensitivity, pneumonitis
Asbestos	Insulation, fireproofing, floor tiles (fibers are inhaled and remain permanently in lungs)	None	Chest and abdominal cancers, lung diseases
Carbon monoxide	Gas space heaters, leaking furnaces, gas water heaters	Low concentrations: fatigue, chest pain in people with heart disease Moderate concentrations: angina, impaired vision, reduced brain function High concentrations: impaired vision and coordination, headaches, dizziness, confusion, nausea, potentially fatal	
Formaldehyde/ pressed wood products	Used in many pressed wood products as an adhesive (e.g., particleboard, hardwood plywood cabinetry, furniture) Emissions from products occur at the highest levels right after installation	Watery eyes; burning sensations in eyes and throat; nausea; difficulty breathing (wheezing, coughing); eye, nose, throat irritation; skin rash	Potential carcinogen
Lead	Lead paint; water pipes	Convulsions, coma, death	Delays in physical and mental development, lower IQ levels, shortened attention spans, increased behavioral problems for young children
Insecticides/pesticides	Products used to kill household pests, products used outdoors that may drift or get tracked inside	Eye, nose, throat irritation; central nervous system and kidney damage; headaches; dizziness; muscle twitching; weakness; tingling sensations; nausea	Increased cancer risk; liver, kidneys, endocrine and nervous system damage
Radon	Air, drinking water; caused by breakdown of uranium in soil, air, and water		Lung cancers
Respirable particles	Heaters, fireplaces, wood stoves, furnaces	Eye, nose, and throat irritation; respiratory infections and bronchitis	Lung cancer
Household cleaners and chemicals	Cleansers, disinfectants, air fresheners, paints, paint strippers, aerosol sprays	Variable: Eye, nose, and throat irritation; headaches; loss of coordination; nausea	Variable: Kidney, liver, and central nervous system damage; cancer

In addition to impacting the health of people indoors, the use of chemicals in the indoor environment can have environmental health impacts once they enter the outdoor environment. Chemicals that are improperly disposed of down the drain or dumped in storm drains or sewers can contaminate water supplies and be toxic to humans and animals. Other chemicals can disrupt endocrines (important hormones) in fish and amphibians.

Outdoor Environment

Common types of outdoor pollutants/toxics include: lawn care chemicals, pesticides, insecticides, and fertilizers. Once used, these substances can vaporize into the air or leach into the soil contaminating ground and surface waters and impacting humans and the environment.

Human Health Issues

The human and environmental health impacts of exposure to agricultural inputs, such as atrazine, biosolids, artificial fertilizers, and manure, depend on the inputs. Impacts of these chemicals can vary from affecting the nervous system, irritating the skin or eyes, affecting the endocrine (hormone) system, and being carcinogens.[8]

Environmental Health Issues

While pesticides and herbicides are beneficial in that they can help improve crop yields, keep insect populations low, and kill weeds, they can also have harmful environmental impacts. Pesticides can contaminate the environment in several ways. First, they can drift away from the target area by the wind or air. Second, through volatilization, pesticides can evaporate from soil, foliage, or surface waters and can move and be redeposited in nontarget areas. Third, pesticides can be carried by water through soil and leach into groundwater where it causes contamination. Fourth, rainfall and/or watering can cause pesticides to wash off of soil and plants. The runoff can then contaminate storm drains and nearby waterways.[9]

Approximately 70 to 75 pounds of the active ingredients in pesticides (meaning the pesticide components that kill living organisms) are used in the US annually. However, only an estimated 0.1 percent of applied pesticides actually reach the target pest, meaning that 99.9 percent is released into the environment (the soil, air, water, or nearby vegetation).[10]

The effects of agricultural inputs vary. First, ground and surface water quality can be affected. Impacts on animal species can include mortality, diminished reproductive success, and sterility. Habitat destruction can also occur. [11] The environmental impacts that result from agricultural inputs are discussed in Chapter 1: Land Use.

Underground Storage Tanks

Underground storage tanks that hold heating oil or gasoline are an outdoor environmental hazard due to the potential for leakage which could result in soil and water contamination. According to the U.S. EPA, there are 611,000 regulated underground storage tanks (USTs) in the United States. These tanks can pose a serious threat to groundwater and drinking water quality as well as overall environmental health.[12] The challenge with USTs is that they can leak slowly and thus go undetected for several years. The oil leaking out can contaminate soil and groundwater, posing a human and environmental health hazard.

When petroleum products leak from underground storage tanks, they may be contained in the soil or leach into groundwater. When leaks reach groundwater, they continue to spread out, moving from the leak site in the direction of groundwater flows.[13]

The most common means of human exposure to petroleum products that have leaked from a UST is via drinking water. Depending on the specific petroleum product that escaped the UST and the level of exposure, human health effects can include irritation of the throat and stomach, central nervous system depression, difficulty breathing, and pneumonia. Ingestion of petroleum products, again depending on the type of petroleum product and the level of exposure, may also affect blood, immune system, liver, spleen, kidney, and lung function. In addition, exposure to certain types of petroleum products is associated with higher incidences of cancer. [14]

Environmentally, petroleum leaks from underground storage tanks can threaten all levels of an ecosystem. Depending on the severity of the leak, petroleum products may degrade or destroy microorganism and plant populations living in contaminated soils. Local animal populations may also be negatively affected. Wetlands and other particularly sensitive ecosystems are most vulnerable to the negative effects of petroleum contamination.[15]

Principles for Sustainability

A number of standards exist pertinent to maintaining a toxin-/pollutant-free home. Many of them relate to safer cleaning chemicals.

- Green Seal is an organization that offers environmental certification standards for products based on science. Green Seal has issued environmental standards since 1991 after conducting life-cycle assessments as well as rigorous testing and evaluation with collaboration from industry, government, academia, and the public.[16]

- The US Green Business Council developed a LEED standard for existing buildings: LEED for Existing Buildings: Operations & Maintenance. This standard contains guidelines for green cleaning.[17]

Households, organizations, and communities could examine their practices according to Green Seal or LEED's standards to determine how to improve toxics management.

METHODOLOGY

We established the following objectives to assess HCA's current toxics management and compare its practices to standards such as Green Seal and LEED. Specifically, we (1) identified and assessed the use of toxic chemicals and other substances in the monastery buildings and around the farm and (2) identified alternative chemicals and processes for minimizing the release of toxics into the environment.

Visual Inventory

To assess the use of chemicals used in the monastic enclosure, bakery, Retreat House, and other buildings, we took a visual inventory of the household cleaners and chemicals, pesticides/herbicides, maintenance products, and automotive products utilized at HCA. In addition to collecting a chemical inventory, we visually inspected the facility to identify the location of mold and various disposal areas.

Indoor Testing

To explore what possible indoor pollutants are present, we hired a regional company (Hinson & Jung, LLC) to inspect for asbestos, lead paint, mold, and any other potential issues.

Underground Storage Tanks

HCA has nine underground storage tanks. All known underground storage tanks at HCA contain either #2 heating oil or gasoline—both petroleum products. Of these, seven are in use; 1 of the USTs not in use contained diesel and is located by the bakery. To evaluate the potential for leakage from the tanks, we selected areas downstream of the USTs to obtain water quality samplings from. The methodology we used for the water quality testing is discussed in detail in Chapter 3: Water.

RESULTS

Overview: Key Findings

- At the time of the inventory, HCA has over 100 products that contain potentially harmful ingredients.
- Potentially harmful ingredients can be found all over the property.

- The monastic enclosure has tiles and insulation that contain asbestos, a potentially carcinogenic substance.
- Lead paint is peeling in several locations.
- A mold-like substance can be found in many locations throughout the monastic enclosure.

Visual Inventory

We identified over 100 products at HCA that contain potentially harmful ingredients during our visual assessment in May of 2009. A majority of these were cleaning products (e.g., 409, Tilex Mold & Mildew Remover, and Lysol). The remaining products were used for household maintenance (e.g., paints and varnishes), automotive uses, and detergents. (A full list of the products we identified during the inventory is included in Appendix 5-A.)

Figure 2 shows an estimate of the number of chemicals that were in use at HCA during the time of the inventory. As shown, for all locations, the greatest amount of chemicals is contained in cleaning products. The monastic enclosure contains by far the highest number of different chemical products (see Figure 3). When assessing the use of potentially toxic chemical substances, the quantity is less important than the type. The presence of any amount of toxic substances poses a threat to be addressed.

Figure 1: Total number of chemical types (by category) in each location

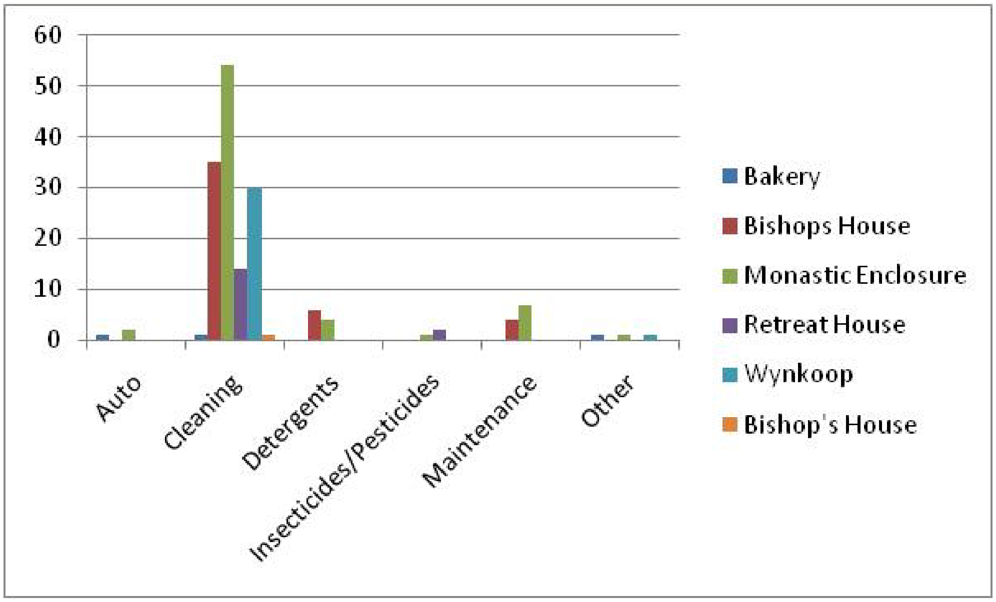
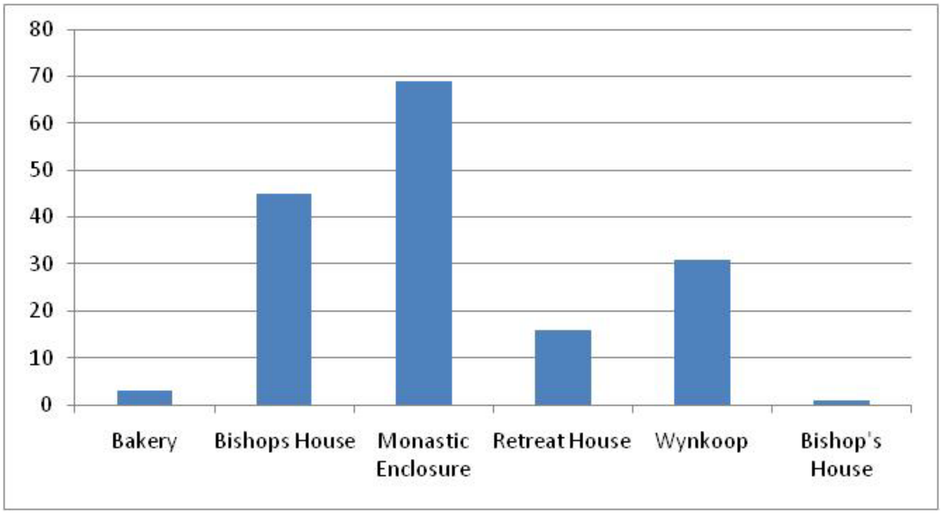


Figure 2: Total number of chemical substances in each area



Indoor Testing Summary

In the mansion basement, Hinson & Jung reported the presence of asbestos in the floor tiles, many of which are loose or broken as well as a mold-like substance.[18] The front wall of the mansion is deteriorating and the grading outside is allowing water to drain into the building. There is also peeling paint that is likely lead-based. On the second floor of the mansion, there is significant moisture intrusion and a mold-like substance. There are a number of other rooms where a mold-like substance is visibly present, including crypt chapel, scriptorium, dining room, residence rooms, laundry/boiler room, chapel, and laundry room. The report also noted concerns with the business manager's office—the walls are separating from the main building. Testing of radon revealed a level of 2.6 pCi per liter, which is well below EPA's recommended action level of 4.0 pCi per liter. The complete report and photographs are included in Appendix 5-B.

Household Hazardous Waste Disposal

A number of household products, including paints, oils, batteries, and pesticides, are considered "household hazardous waste" (HHW). Currently, there is a need for standard management of this HHW at disposal to make sure that these materials do not leak into the ground or water.[19]

OPTIONS

HCA has several options for handling toxics responsibly. Depending on the substance/chemical of concern, there are different ways to address the impacts of these substances/chemicals. Overall, a general strategy is needed to protect the human and environmental health of the HCA community. Some of these options, described below in more detail, include:

- Proper handling/removal of asbestos materials
- Installation of a carbon monoxide detector
- Reduction of volatile organic carbon emissions
- Proper handling/removal of lead paint
- Reduction in use of insecticides/pesticides

- Tests for radon
- Reduction of airborne particles
- Use of more environmentally friendly household chemicals and cleaners
- Removing mold-impacted areas
- Replacing underground storage tanks with aboveground storage tanks
- Properly disposing of any chemicals/cleaners

Handling Asbestos

Asbestos, which is found in products such as ceiling tiles and insulation, can be carcinogenic if asbestos particles get into the environment. As long as asbestos-containing products are undamaged, it is best to leave them alone. An initial site assessment should be done to identify all asbestos-containing products. If these products must be removed, a trained contractor should be used and should clean up the site appropriately.[20] As noted in the indoor inspection, there is some damage to the floor tiles, which are likely to contain asbestos. These should be removed or covered up.

- Cost to remove asbestos: Estimates can range widely. An initial inspection and recommendations report is approximately $0.25 to $0.55 per square foot. To remove an infected area, pipe insulation, for example, could cost $15 to $65 per foot. Removing spray insulation typically costs $15 to $25 per square foot, while encapsulation only costs approximately $2 to $6 per foot.[21,22] Other contractors charge a minimum fee of $1,500 to $3,000 regardless of how small the project is.[23] To determine what the exact cost for HCA would be, one or more contractors should be consulted for an estimate.

Carbon Monoxide

Hire a trained professional to inspect, clean, and tune-up the central heating system annually in order to discover and repair any leaks. To monitor carbon monoxide levels, HCA should install carbon monoxide monitors in various locations around the building, particularly near sleeping areas.[24,25]

- Cost: A carbon monoxide monitor costs $20 to $40 dollars, and installation is very quick and can be done by anyone.[26,27]

Volatile Organic Chemicals

To reduce the amount of volatile organic chemicals (VOCs) emitted, there are several steps that can be taken. First, to reduce formaldehyde levels, avoid purchasing pressed wood products containing phenol resins. Use air conditioning and dehumidifiers to moderate temperature and reduce humidity levels, which will reduce formaldehyde emissions. After using products containing formaldehyde, increase ventilation.[28] The use of environmentally friendly materials will reduce the amount of VOCs released from cleaners. When areas are repainted, low VOC paint should be used.

- Costs: The cost of safer wood products varies depending on the type of furniture purchased. The cost of paint with low levels of VOCs or no VOCs is about the same as premium lines of paint.[29]

Lead Paint

Any paint used before 1978 likely has lead in it. If the paint is damaged and pieces or particles are peeling off, there is the risk that lead is being released into the environment. We do not recommend that HCA try to remove paint themselves or at all if it is in good condition.[30] However, the building inspection revealed some peeling paint around window frames that is cause for concern. We recommend HCA hires a trained professional to fix the areas that contain peeling paint.

- Cost: Lead paint removal can be extremely costly. Estimates range from $8 to $15 per square foot. However, lead paint encapsulation (which involves applying a liquid coating over the paint that creates a watertight layer over lead paint) costs less than $0.50 per square foot.[31]

Insecticides/Pesticides

The development of an integrated pest management (IPM) strategy that uses nonchemical based solutions can reduce the number of pests in HCA's buildings safely. Such a strategy involves implementing sanitation and structural improvements to prevent initial infestation. The next stage is to use mechanical (e.g., traps) or biological controls (e.g., plants) to eradicate the pest. The final stage is to use the least toxic pesticide possible following the application instructions carefully.[32,33]

- Cost: uncertain--varies widely depending on the strategy chosen.

Radon

No radon was detected during the indoor inspection. Radon testing should be done approximately once every 5 years. This can be done by a professional or by purchasing a self-home testing kit.

- Cost: A self-home test can range from $10 to $35.[34,35]

Respirable Particles

We encourage HCA to make sure that all furnaces vent to outdoors. They could hire a trained professional to inspect, clean, and tune-up their central heating system each year and repair all leaks properly. Filters should be changed on central heating and cooling systems and air cleaners per manufacturer's directions. LEED recommends using a filtration system that has a particle removal effectiveness of MERV13 or greater to protect inhabitants from particulate contaminants.[36]

- Cost: Unknown. The cost could vary widely depending on the approach chosen.

Household Chemicals/Cleaners

HCA should use all products according to manufacturer's directions and properly ventilate the areas of use. The community should only purchase quantities of chemicals that will be used soon and dispose of old/unneeded chemicals quickly and safely. A variety of alternatives exist for the chemicals that HCA uses. The LEED standard for existing buildings provides guidance on the use of green cleaners including purchasing guidelines and strategies for safe handling and storage of cleaning chemicals.[37] Green Seal has certified a wide range of products that can be used to substitute for traditional cleaners through the Environmental Standard for Industrial and Institutional Cleaners (GS-37). Green Seal has also certified a number of products for hand soaps and cleaners through Standard GS-41A Hand Cleaners and Hand Soaps.

The visual inventory of chemicals around the HCA community showed that chemicals and cleaners are stored in multiple locations throughout the property. The Team recommends that these chemicals and cleaners be consolidated and stored in only a few sites to minimize the risks of accidental spills. While EPA law permits the disposal of HHW (including cleaners), it is best to dispose of them in an environmentally safer manner. Clarke County does not have an HHW program; however, Frederick County holds two collection events per year. Accepted items include: fuels (gasoline/kerosene), thinners, solvents, pesticides/insecticides/fungicides, household cleaners, stains, sealants, household batteries, mothballs, compact fluorescent lamps (CFLs) and fluorescent lamps.[38]

- Cost: The price of alternative cleaners is very close to the cost of traditional cleaners, and purchasing in bulk makes the cost of environmentally friendly cleaners negligible. A nonmonetary benefit to using environmentally friendly, less-hazardous cleaners is improved indoor environment quality, which can have positive health benefits.[39]

Mold

A number of areas in the monastic enclosure were identified as having mold. These areas should be dealt with by cleaning with soap and water. Then, measures should be taken to ensure adequate ventilation which will mitigate mold growth. In some instances, more serious remediation efforts may be needed, including removal and replacement of contaminated areas.

- Cost: The cost of cleaning with soap and water is minimal. Removing mold from a somewhat larger area could cost from $500 to $4,000. However, if lots of structural damage has occurred, removal costs could range from $2,000 up to as much as $30,000.[40] HCA should hire a trained professional to determine the extent of the mold contamination. If mold is only present on the surface, these areas can be dealt with by simple cleaning. If more severe structural damage has occurred, removal and replacement may need to occur.

Underground Storage Tanks

One of the best options for mitigating the potential for leakage from USTs would be to install aboveground storage tanks where you can see if any leaks are occurring.

- Cost to remove UST: $500 to over $2,500 depending on the size of the tank, its accessibility, and its condition[41,42]

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ECONOMIES

6

One of HCA's key objectives in commissioning this project was to find ecologically responsible (i.e., sustainable) methods of managing its several economic activities. The community members make fruitcakes and creamed honey in the monastery bakery and sell the finished product to wholesalers and retail customers; oversee the production of two confections—fraters and truffles—and sell them to wholesalers and retail customers; sell books, recorded CDs and DVDs, religious iconography, and monastery food products at their gift shop; receive gifts and donations from guests who stay at the Retreat House; receive rental income from the farm tenant; and earn interest on their investments.

This chapter focuses on the sustainability of HCA's economic activities. In the first subsection, we define *sustainability* and its metrics in the business context. In later subsections, we describe HCA's economic activities in detail, explain the methodology that we used to establish a sustainability "baseline" for HCA's economies, summarize the results of our analyses, suggest general strategies for improving the sustainability performance of HCA's products and services, and recommend conservation burials as a means of both preserving and restoring HCA's property and generating revenue to fund future activities.

CONTEXT: THE BUSINESS CASE FOR SUSTAINABILITY

As noted in the Introduction, the concept of "sustainability" embraces the idea that our actions today should not limit the economic, environmental, and social options open to future generations.[1] From its earliest inception, the concept of sustainability has been extended to business and economic activities and the strain that industrialism and economic growth has placed on the earth's natural systems. As a general principle, sustainable business harmonizes the quest for economic prosperity with environmental quality and social equity.[2] Sustainable businesses ensure (at a minimum) that their activities cause minimal harm to nature and do not deplete but rather restore—and even enrich—the natural environment.[3] In addition, they acknowledge and reinforce positive relationships with the people and groups that are impacted by their activities.[4] Sustainability makes companies viable for the long term by managing according to principles that strengthen rather than undermine the company's roots in the environment, the social fabric, and the economy.[5]

What motivates businesses to adopt the sustainability agenda? Economists such as Milton Friedman and others argue that "the business of business is business" and that environmental and social issues are peripheral to the challenges of corporate management.[6] Even the World Business Council on Sustainable Development, a global organization committed to sustainable development, pointedly observes that in reality, "there is only one bottom line: profit and loss."[7] So why do more and more businesses "increasingly see obligation and opportunity in today's environmental and social challenges"?[8] The factors motivating the adoption of the sustainability agenda tend to fall into two categories: economics and ethics.

Economic Motivators

Perhaps the most obvious economic reason for business to embrace sustainability is that direct and measurable cost savings are possible. Sustainability generally involves efficiency, and running a cleaner, more efficient business can save money. Inventorying energy and material inputs and reducing them as much as possible can create dramatic savings. Reviewing waste generation practices and identifying ways not only to reduce disposal but also to boost the amount of material reuse likewise saves money. For some companies, creating greener office spaces and manufacturing facilities can even save money by reducing insurance premiums.[9]

A less-obvious economic justification for embracing sustainability is that developing and implementing a sustainability strategy can increase revenues. The market for green goods and services is large and growing.[10] Lifestyles of Health and Sustainability (LOHAS), an organization that attempts to track this market, estimated that in 2006 the US marketplace for goods and services focused on health, the environment, social justice, personal development, and sustainable living had reached $209 billion. LOHAS estimated in 2006 that approximately 19% of the adults in the United States (41 million people) were attracted to this market.[11] Gallup Poll also has tracked green consumer behavior. In a poll produced for Earth Day 2008, Gallup determined that over a five-year period environmental concerns drove 28% of the US population to make major changes and 55% to make minor changes to their shopping and living habits.[12] Businesses with green products and services can strengthen relationships with existing customers in this market and also attract new customers who are looking for a green alternative.

Finally, sustainable businesses often enjoy intangible benefits that can affect financial performance. Creating more sustainable products and services often gives a company a competitive advantage over companies that are less environmentally sensitive. In fact, in a recent survey by PriceWaterhouseCoopers LLP of 140 large US-based companies, 75% of the respondents that had adopted sustainable business practices did so to obtain a competitive advantage.[13] This is especially true for companies that are first-movers in offering sustainable products.[14] Moreover, companies that green their work environments have happier, more loyal, and more productive workers. A study of green government buildings undertaken by the U.S. General Services Administration showed that people who work in a green facility have as much as 27% greater job satisfaction over the national average. The study also showed that 80% of the workers surveyed indicated that they felt greater motivation and loyalty toward their company due to its sustainability initiatives.[15]

Ethical Motivators

Even though sustainable business can have significant economic benefits, some businesses adopt the sustainability agenda simply because “it’s the right thing to do.” Businesses—even small ones—have a profound impact on the planet. Collectively, businesses consume a large amount of the world’s resources. The earth’s population is growing exponentially and is expected to increase from 6 billion persons in 2000 to 9 or 10 billion persons in 2050. Moreover, according to the World Bank and the United Nations, approximately 20% of the population lives in abject poverty, without access to food and clean drinking water.[16] Put simply, if businesses figure out how to use resources more effectively, there will be more to go around.[17]

Businesses also have a profound impact on people. Some business entities produce toxic products (e.g., chemicals, pesticides, cleaners, paints, and dyes) and/or pollution and other emissions that can degrade human health. Nearly all businesses affect the health and well-being of the employees that work in their factories, offices, and other workplaces. Sustainable businesses reverse these impacts by creating healthy workplaces and reducing resource use and environmental damage. These improvements can have a ripple effect on employees, community, suppliers, competitors, and customers and can influence them to take positive steps toward sustainability.[18] In addition, creating green business products and processes can be a source of pride and motivation for managers, employees, and staff.

It is important to note that while large businesses may be responsible for the majority of environmental impact and likely will achieve the greatest improvement in sustainability over the next several decades, even very small businesses cannot escape accountability for the overall impacts of their products and services. According to the U.S. Small Business Administration, small businesses make up 99% of all businesses nationwide, employ nearly 59% of the private sector workforce, and are responsible for half the country’s economic output.[19] “In what seems a much smaller and highly imperiled world, it is difficult for any business […] to say that social, economic, or environmental problems across the state, nation, or globe are irrelevant or ‘not our concern.’”[20] Small business collectively has enormous power to effect change.

Measuring Sustainability in the Business Context

One metric for evaluating the sustainability of business activities is to measure their "triple bottom line": financial performance, environmental impact, and social performance.[21] The triple bottom line (TBL), sometimes referred to as the three "Es" (economic prosperity, environmental quality, and social equity) or the three "Ps" (profit, planet, and people), suggests that businesses should measure their success not only by the traditional metric of financial performance but also by their impact on the environment and on the society in which they operate.[22] Thus, while WBCSD maintains that "there is only one bottom line: profit and loss," its members concede that "the wider metrics show how well we are likely to perform in maintaining and improving the single bottom line of profit into the long term."[23]

Economy

Traditionally, a company's economic performance is measured by its profitability as reflected on its earnings statement. The TBL analysis, by contrast, measures a company's economic performance not only by evaluating its profitability but also by examining its economic viability.[24] A company's economic capital includes both financial capital (financial resources, machines, equipment, etc.) and certain aspects of its human capital (a measure of experience, skills, and other knowledge-based assets of the individuals who make up an organization).[25] The TBL economic review examines long-term trends. The evaluation goes beyond annual or quarterly financial reports to assess whether a business exhibits good economic performance over the long term.[26]

Relevant questions for evaluating the economic sustainability of a company include the following: Are our profit margins sustainable over the long term? Are our costs competitive now and are they likely to remain competitive for the foreseeable future? Is the demand for our products sustainable or is it likely to decline? Is our rate of innovation likely to be competitive in the longer term? How can we ensure the long-term viability of our human capital?

Environment

Evaluating a company's environmental performance can be trickier than evaluating its economic performance. All businesses have the potential to face a huge array of environmental issues and a wide variety of environmental risks. Impacts resulting from a business's products and services can include direct environmental impacts such as pollution, chemical releases, and the release of other harmful emissions; the use and consumption of energy, water, and other resources; and solid and hazardous waste generation.[27] Estimating whether and to what extent a business adversely impacts natural capital (i.e., the air, water, soils, minerals, flora and fauna, and ecosystem services that comprise its natural environment) is the essence of measuring that company's environmental sustainability.

There are as many methods for evaluating a company's environmental performance as there are companies. Heavy manufacturers and other highly regulated businesses might focus particularly on the impact of pollution, odors, and toxic emissions on human systems, urban environments, and labor and employment relationships. Agricultural companies might focus particularly on water consumption, soil depletion, pesticide and insecticide use, and other impacts to land. Each company or industry has a unique environmental profile because it offers a unique combination of products and services and uses a particular set of materials, production processes, and other business practices.

One of the more precise ways of measuring a company's environmental impact is to measure it directly. Some companies must obtain permits from federal, state, and local environmental agencies in order to operate their factories or other production facilities. Even if permits are not required, many of the environmental regulations that restrict or prohibit the discharge of pollution and waste into the environment require companies to track the use and discharge of chemicals and pollutants. Information generated during compliance with these programs can provide direct measurements of environmental impact and can assist in evaluating a company's environmental sustainability.

For other companies, assessing a business's environmental impact often involves a particular focus on the products and services that a company offers. One tool that is available for evaluating the environmental performance of a company's products, processes, and services is the *life-cycle assessment* (LCA). LCA measures the lifetime environmental impact of a product, process, or service so that opportunities can be identified for producing, moving, using, and/or disposing of the product more responsibly.[28] Assessing the actual and potential impacts associated with a product through LCA generally has three components: (1) an inventory of relevant energy and material inputs and environmental releases related to the product, (2) an evaluation of the potential environmental impacts associated with those inputs and releases, and (3) an interpretation of the results to help designers make informed decisions about how to reduce the environmental impacts of that product.[29]

LCAs can be highly technical, complicated, and time consuming because the full life cycle of a product generally includes impacts beyond the direct control of the manufacturer. A process LCA includes impacts that occur upstream of the production process (e.g., impacts caused by ingredient or raw material suppliers or even during the production of electricity and other energy used in production) and/or downstream of production (e.g., impacts caused during shipment to customers or by customers during use or after disposal). The upstream and downstream impacts are included so that all of the environmental burdens associated with a product are truly minimized or eliminated, rather than shifted from one step in production to another.[30] LCAs therefore generally require product designers or manufacturers to gather information and obtain data about materials, energy, and activities within a product's life cycle that are available only by contacting suppliers, customers, and energy suppliers.

Another LCA method is the Economic Input-Output Life Cycle Assessment (EIO-LCA) model, which was developed by researchers at Carnegie Mellon University (www.eio-lca.net). EIO-LCA calculates the material and energy resources that are required for various activities in our economy to estimate the resulting environmental impacts. Based on NAICS industry codes, the model uses information about industry transactions (i.e., purchases of materials by one industry from other industries) and the information about direct environmental emissions of industries to estimate the total emissions that result from economic activity considering the entire supply chain. We use the EIO-LCA to provide a comparison for HCA's baseline environmental performance in the Results section of this chapter.

Calculating a *carbon footprint* is another technique that has gained acceptance for measuring the environmental impact of a given operation or activity. The essential purpose of a carbon footprint is to account for the carbon emissions that result from energy and material inputs to a product, process, or service.[31] The carbon footprint concept originated from the idea that a certain amount of the earth's productive land is required to provide energy, materials, and other resources for production. The footprint, therefore, involves inventorying the various types of energy, materials, and other resources involved in production and using conversion factors to estimate how much land was required to produce those inputs. In more recent versions of the technique, the footprint focuses on the carbon emission impact of economic activities, using carbon emissions as a proxy for estimating the overall environmental impact of the system.[32]

Carbon footprints that focus on business activity generally take into account carbon emissions from three sources.[33] *Direct emissions* refer to the carbon emitted directly by the business at its facility, which could be caused by activities like the burning of fossil fuels in boilers, engines, and other equipment. *Indirect emissions* are emissions caused by the production of purchased energy, such as electricity or heat. Indirect emissions include, for example, emissions by utilities that generate electricity or natural gas that fuels the company's production process. *Other indirect emissions* include emissions caused upstream and downstream of the production process.

Examples of upstream processes include the mining or production of raw material inputs and emissions attributable to the transportation of materials to and from the target company's facility. Thus, a LCA of a washing machine generally includes emissions generated in the production of the plastic parts that make up the controls and the aluminum sheet that houses the machine.

Downstream processes include emissions that occur during the use of a product and emissions that occur during its disposal or recycling.[34] In the case of the washing machine, downstream processes might include the electricity that a consumer uses to operate the machine after they purchase it and the cost of recycling the machine after its useful life has ended.

Aggregating carbon emissions from each stage of a product's production, distribution, use, and disposal produces a relatively standard method for comparing the environmental impacts of various business operations and products.

As stated previously, each company must choose environmental performance indicators that best reflect the important environmental performance characteristics of its business. Whether it undertakes a life cycle analysis, calculates a carbon footprint, or uses another technique, general questions for evaluating environmental sustainability include the following: How much waste or pollution does our production process produce, and to what extent does it negatively impact the natural environment? Does our operation or do our products and services contribute to climate change? Have we been the subject of an environmental enforcement action brought on by a governmental entity, and did we pay fines and/or penalties to the government as a result? Do our products use water, energy, or other natural resources as an input, and if so, is the consumption wasteful or inefficient? Do we generate waste that can be reused? Are we planning any future activities that might affect the natural environment? Is our affect on local, regional, and/or global ecosystems understood and likely to be sustainable?

Equity

Evaluating a company's social performance is perhaps the most difficult component of the TBL metric. How does a sustainable corporation measure its social capital (i.e., human capital in the form of public health, skills, and education; and, more generally, society's health and wealth-creation potential)?[35] In Cannibals with Forks, author John Elkington suggests that social capital arises when there is a "prevalence of trust in a society" and that it can be measured by the degree to which people work together in groups and organizations for a common purpose.[36] He suggests that social accounting should assess the impact of a business on people—both inside and outside the organization—including impacts to community relations, product safety, training and education initiatives, sponsorship, charitable donations of money and time, human rights, responsible marketing, political contributions, and employment of disadvantaged groups.

Relevant questions for evaluating the social sustainability of a business include the following: What forms of social capital do we need to become a sustainable corporation? What are the underlying trends in terms of the creation, maintenance, or erosion of these forms of social capital in our organization? To what extent is inter- and intragenerational equity likely to change the ways in which we define and measure social capital?[37]

BACKGROUND: HCA's Economic Activities

In the previous section, we defined *sustainability* and its metrics in the business context. Although debate continues as to business's proper role in solving the world's problems, businesses are increasingly adopting the sustainability agenda. In this section, we describe HCA's primary economic activities. For accounting purposes, HCA groups its economic activities into four departments: the monastery bakery, gift shop, Retreat House, and farm. Each department is described in the sections that follow.

The Monastery Bakery

HCA first established a bakery in the early 1950s in a small building located close to the farm and away from the main monastic enclosure. The original purpose of the bakery was to bake bread that the monks could consume along with the vegetables they grew on the farm. In the late 1960s, the community constructed a new bakery building, installed industrial ovens and commercial refrigerators, and began to produce bread and a small number of fruitcakes for commercial distribution. Several times per week, the monks baked white, whole wheat, and raisin bread, loaded the finished product into the back of a pickup truck or van, and delivered the bread to various grocery stores and small markets in the greater Washington D.C. area. Over time, the monks gradually increased their production of fruitcakes, which had grown in popularity throughout the 1970s and 1980s.

By 1977, the bakery was so successful that the community began to rely on the bakery as its primary means of financial support. But as the population aged, the bread-making schedule became too demanding for the monks—particularly since the bread contained no preservatives and therefore had to be baked and delivered to customers several times per week. In response to these pressures, the monks discontinued making bread in 1990 and began to focus its bakery activities on fruitcake. Fruitcake is a specialty baked good that is comprised of dried and glace fruits (such as papaya, pineapple, cherries, citron, citrus peels, and raisins) and nuts held together by rich cake batter. The dense fruitcakes are particularly festive and are traditionally served in thin slices at holiday dinners and other special occasions. A summary of the fruitcake baking process is included as Appendix 6-A.

In 2003, HCA expanded its product line to include creamed honey. HCA makes creamed honey by mixing natural crystallized honey purchased from local beekeepers with a “starter” and (sometimes) with various flavors to create a smooth, spreadable honey product. HCA packages the creamed honey in 10 oz. plastic tubs and sells the honey to customers in two flavor varieties, CH1 (lemon, raspberry, cinnamon, and natural) and CH2 (almond, brandy, cinnamon, and natural).

HCA added fraters to its product line in 2003 as a way to use the fruitcakes that are over- or underweight or for some other reason not suitable for sale to customers. Fraters are thick slices of fruitcake that are covered in a rich dark chocolate glaze and white chocolate swirls (produced by DeFluri’s Fine Chocolates in Martinsburg, West Virginia). Several times each month, monks transport “rejected” fruitcakes to DeFluri’s by car or van, assist in the production process by coating the fruitcake slices in chocolate and packaging the completed fraters in cellophane wrappers, then transport the fraters back to the monastery. HCA sells the 2.6 ounce fraters in boxes of 6.

HCA’s fourth bakery product consists of truffles, which HCA added to its product line in 2005. HCA’s truffles are chocolate candies made and packaged by DeFluri’s. The monks pick up truffles from DeFluri’s when they go to make fraters, then sell the candy in boxes of 18.

HCA takes most orders for its bakery products by telephone, fax, mail, or e-mail, and uses a computerized direct mail system to handle orders placed through the monastery’s Web site. HCA sells bakery products wholesale (mostly to small grocery stores, specialty food shops, and to other monasteries) and directly to customers. Products ordered for retail delivery are packaged in modular cardboard boxes and shipped by UPS to locations around the world. The direct-mail system and other administrative activities occur in business offices located in the basement of the monastic enclosure. HCA also inventories finished products in the basement.

Several employees and community members are involved in the production of fruitcakes and creamed honey. HCA has a full-time bakery manager who is responsible for ordering ingredients and materials, overseeing the production process and packaging, and processing customer orders. From time to time, the bakery manager also has employed part-time assistants to do prep work and facilitate the production process. Several community members participate in the production and package the end products for sale. Retreatants and lay volunteers assist and provide additional labor when available. Labor inputs for each type of bakery product are discussed more thoroughly below.

The Retreat House

Visitors have come to Cistercian monasteries from the earliest days of the Order to share in the contemplative quiet and prayer and to take advantage of the monks' famous hospitality. Today, visitors come to HCA's Retreat House to escape from the tension and pressures of modern life. Visitors spend their time observing the rule of silence while they read, contemplate, and attend Mass and other liturgical services with the monks at the main chapel. Many retreatants enjoy walks on the monastery's extensive grounds and views of the Shenandoah River and the mountains. Occasionally a monk or other member of the community will read to the retreatants from an inspirational text during dinner. If desired, they may schedule an appointment with one of the monks for personal counseling and spiritual direction, or may volunteer to assist in the bakery.

In the early days of the monastery, HCA's visitors would stay in one of the farm houses on the property. HCA constructed the current Retreat House in 1986 to expand and create a more comfortable space for visitors. The Retreat House has 16 single rooms, each with a private bath, and common areas that include a library, chapel, dining room, kitchen, and welcome area. Following the Cistercian tradition, HCA generally keeps one of the 16 rooms open each day to accommodate a "solitary traveler-of-the-road" or someone else who may suddenly need accommodation.

HCA accepts reservations for weekday retreats (Monday afternoon through Friday morning) and for weekend retreats (Friday afternoon through Sunday afternoon). Retreats are offered throughout the year, except for the week between Christmas and New Year's and the week of the community's retreat. All meals are provided. Until fairly recently, one of the HCA monks served as the community's "guest master" and was responsible for ensuring the comfort of retreatants and guests. Today, several dedicated employees, volunteers, and community members welcome guests, care for the Retreat House, and manage hospitality. The role of these individuals and the services they provide are shown below in Table 1.

Table 1: Retreat house personnel

Role	Status	FT/PT	Responsibilities
Business Manager	Employee	Full time	Accepts reservations, oversees personnel, arranges maintenance, general administration
Spiritual Director	Community Member	Part time	Provides counseling and spiritual direction to retreatants; occasionally reads at dinner
Caretaker	Volunteer	Full time	Welcomes guests, cares for property and grounds, sees to overall operations in exchange for room and board
Staff	Employees	1 full time 2 part time	Ensure the day-to-day comfort of retreatants; shop for, plan, and cook meals; clean the rooms

Source: HCA

HCA does not charge a fee for its retreats; hospitality is an essential component of the Cistercian tradition and is considered by the community to be one of the Order's most important ministries. As noted in the Cistercian Patrimony 3, "In simplicity and labour [the monks] seek the blessedness promised to the poor. By generous hospitality they share with their fellow-pilgrims the peace and hope which Christ has freely given." Thus, retreatants are not required to pay the cost of a retreat—they are simply encouraged to make an offering at the end of their stay. Suggested offerings are $300 to $500 per person for a full weekday retreat and $150 to $300 per person for a weekend retreat. HCA requests an advance deposit of $50 to $75 to hold a reservation. Some guests leave very little money at the end of their stay and others leave much more than the recommended offering. According to HCA personnel, retreatants have been known to leave donations of as little as $5 or as much as $5,000.

The Gift Shop

HCA built the current gift shop in 1985. The shop is located on the monastery grounds in an area that is readily accessible to retreatants walking from the Retreat House to the chapel for services. The shop features books on Cistercian and monastic spirituality as well as other Christian themes; recorded music, including monastic chants; religious statuettes, prints, greeting cards, and rosaries; and food products from HCA and other monasteries. The shop is open throughout the year, but closes on occasion to accommodate the monks' schedule. From January through mid-October 2009, the shop operated Sunday through Friday from 1:15 p.m. to 5:00 p.m. and on Saturdays from 10:00–12:00 a.m. and 1:15–5:00 p.m. From mid-October through December 2009, the shop operated on Sundays from 9:00 a.m. to 5:00 p.m. and Monday through Saturday from 12:00–5:00 p.m.

HCA purchases merchandise for the gift shop from commercial suppliers that give the community a discount on the retail price of each item. HCA establishes the price of each item by adding a markup that generally returns the item to the retail price. For example, a supplier might sell HCA a book that retails for $25.95 for $19.46 (or a 25% discount) plus the cost of shipping. HCA would then price the book at $25.95. Discounts from suppliers range from 15% (for chocolates from Gethsemane Abbey) to 50% (for hand-painted prints from Conception Abbey, a Benedictine monastery in Missouri). Gift shop merchandise is hand selected by one of the monks, who also is responsible for placing the orders, unpacking the merchandise, stocking the shelves, and serving customers.

The Farm

In HCA's early days, the monks operated the second-largest farm in Clarke County on the 1,200 acres that surround the monastic enclosure. The monks managed a herd of cattle, cultivated orchard grass for hay, and planted fields with alfalfa and oats. The two silos and the hayshed that the monks built during this period are still standing, adjacent to a newer hay barn and workshop. One of the monks planted and tended a large vegetable garden to supply fresh vegetables for the community's table.

In 1977, however, the community decided to discontinue farm operations and lease the farm property to a neighbor. The aging monks could no longer provide the manual labor necessary for the farming activities, and the bakery operations had reached a level of success that enabled the monks to rely on the bakery for its primary means of support. As a consequence, since 1977 the revenue generated by the farm has consisted solely of rental income received from the tenant. The dates of each lease, lease amendments, and the amount of the rental under each lease are summarized in Table 2.

Table 2: Farm leases

Lease Date	Term (yrs)	Start	End	Acreage		Rent (per acre)		Total Rent (per yr)
				Crops	Pasture	Crops	Pasture	
12/18/79	5	1/1/80	3/31/85	417	554	$40.00	$12.50	$23,500
3/31/85	5	4/1/85	3/31/90	417	544.5	$40.00	$16.50	$25,500
9/3/88*	8	4/1/85	3/31/93	n/a	n/a	n/a	n/a	$18,000
4/1/96	4	4/1/96	3/31/00	417	584.5	n/a	n/a	$14,000
4/1/06	3	4/1/06	3/31/09	417	584.5	n/a	n/a	$16,000
4/1/09	3	4/1/09	3/31/12	417	584.5	n/a	n/a	$18,000

*This lease amendment superseded the previous lease. ** n/a = not available from lease documents

METHODOLOGY

In the previous sections, we outlined the concepts and ideas related to business sustainability and described HCA's primary economic activities. This section describes the techniques related to business sustainability that we applied to establish HCA's sustainability baseline. We used a modified triple bottom line analysis that, as noted above, has three dimensions: financial performance, environmental performance, and social performance.

Assessing HCA's Financial Performance

We applied relatively straight-forward analyses for evaluating the financial performance of HCA's products. The Team evaluated financial performance by examining HCA's profitability by department (monastery bakery, Retreat House, gift shop, and farm) using HCA's Profit & Loss statements and Comparative Statements of Activities for the years 2004 through 2009. In addition, we evaluated the profitability of each of the products produced in the bakery by determining the contribution of each product using HCA's "Summary of Costs and Profit Margins for Bakery Products" for the year 2009. We evaluated the future profitability of HCA's products by evaluating trends in sales, fixed and/or variable costs, and other key financial indicators. Finally, the Team considered qualitative factors, where relevant, in order to depict HCA's economic sustainability.

Assessing HCA's Environmental Performance

We focused on the products that HCA provides to customers in order to establish the baseline environmental performance of HCA's economic activities. A vast combination of inputs and processes are required for HCA to make money by producing fruitcake, creamed honey, and other products in the bakery. HCA obtains ingredients, packaging materials, and other supplies; operates appliances and the oven; drives back and forth to DeFluri's to participate in frater and truffle production; and obtains standard overhead resources of heating and cooling, power, and water for the bakery, business office, and storage area. We therefore chose to measure the environmental performance of the bakery products by trying to answer this question: What is the environmental impact of the inputs and processes required for HCA to generate revenue from the activity? The specific methodology that we applied to calculate the impact of HCA's products is described below. Additional details are provided in Appendix 6-B.

Because we chose to focus on HCA's products, we did not undertake a separate environmental impact analysis of the gift shop, Retreat House, or farm as part of the TBL analysis. However, notes providing general statements about all three are provided below.

- Like the bakery, the gift shop generates revenue by acquiring physical resources from outside suppliers, but invoices from the outside suppliers did not contain the information necessary to measure the environmental impact of the shipments.
- The Retreat House does not generate revenue by acquiring physical resources from outside suppliers or cause environmental impact beyond the HCA boundary.
- The farm certainly has a significant environmental impact, but the economic benefit that HCA derives from the farm is not dependent on its management. The HCA community does not make decisions regarding the management of livestock, the crops that are planted, or the farming methods and techniques that are applied. Nor does the community decide whether, how, or to whom the farm products are sold.

The environmental performance of the gift shop, Retreat House, and farm is a function of land use, water use, energy demand, and toxics, all of which are covered elsewhere in this report. Thus, we chose to address the environmental impact of these operations elsewhere in the report rather than measure the environmental performance as part of the TBL analysis.

Environmental Performance of the Bakery

To develop a reasonable baseline of the environmental performance of HCA's bakery products, we calculated a limited carbon profile of each product. In very general terms, the profile reflects carbon emissions that result from energy resources consumed during four stages of the production process. These stages, and the general methodology we applied to calculate carbon output from the relevant processes, are summarized in Table 3. The boundaries of the product life-cycle stages that we chose for our analysis are depicted in Figure 1.

As shown in Figure 1, this analysis does not consider all stages in the life cycle of HCA's products. The primary reason for this limitation is that a full life-cycle analysis of each of HCA's bakery products would be outside the scope of this project. For example, a complete life-cycle analysis of the fruitcake might require an accounting of how much and what kind of energy, water, and other resources are used to grow, harvest, and process the fruits and nuts; mill the flour; make the butter; distill the brandy and sherry; fabricate the tins, cardboard boxes, plastic wrap, and other items used for packaging; and recycle or dispose of the packaging after the cake has been consumed. Quantifying complete life cycle impacts would require an accounting of energy and resources used by farmers, sugar factories, distilleries, paperboard manufacturers, customers, and waste disposal facilities upstream and downstream of HCA's operation. Calculating these impacts would be so complicated and time consuming that the analyses could easily qualify as one or more stand-alone project(s).

Table 3: Product life-cycle stages and general methodology

Life-Cycle Stage	Figure 1 Reference*	Description and General Methodology
Upstream transportation	A	Includes transportation of product ingredients, packaging, and other inputs from suppliers to the HCA facility. Carbon output based on energy consumed for transportation.
Manufacturing processes	B	Includes activities required to convert ingredients and inputs into marketable products. Carbon output based on energy used to run appliances and equipment (electricity, heating oil, etc.).
In-process transportation	C	Considers transportation during the production process. Carbon output based on carbon resulting from use of gasoline/diesel in HCA's vehicles.
Downstream transportation	D	Includes transportation of finished product to customers. Carbon output based on energy required to ship finished product (primarily bakery products) to wholesale and retail customers.

Thus, to estimate carbon emissions attributable to each of HCA's products, we determined the amount of energy used at each stage of production and distribution, and then applied published emission factors to the amount of energy resources used in each activity (*see* Table 4). We aggregated carbon emissions from each activity and expressed the output in various units, focusing particularly on pounds of CO_2eq per pound of product. Using a "pound for pound" comparison provided a mechanism for comparing HCA's various products and merchandise on the basis of their relative environmental impact.

Figure 1: System boundaries for assessing carbon emissions from HCA's products

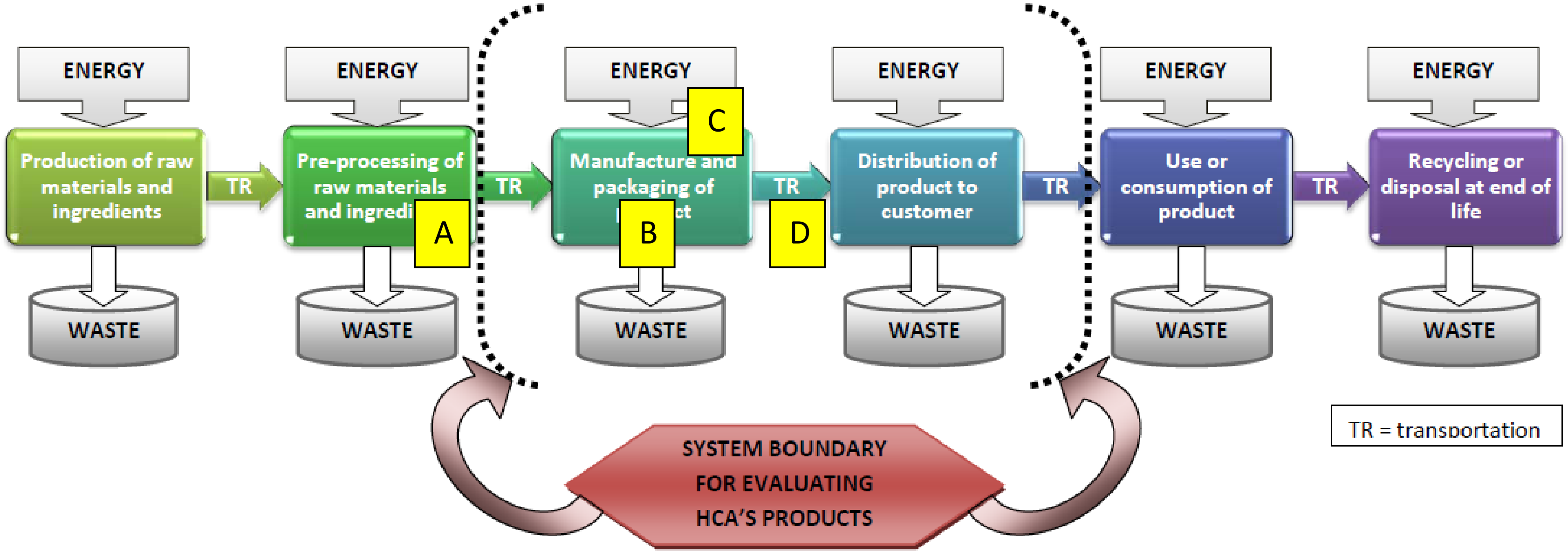


Table 4: Carbon emissions from transportation and fuel

Conversion Factor	Amount	Unit	Source
CO_2eq from UPS Air Freight	1.42	lb/ton-mile	United Postal Service
CO_2eq from truck freight	0.3275	lb/ton-mile	www.carbonfund.org
CO_2eq from gasoline	19.40	lb/gallon	EPA
CO_2eq from diesel	22.20	lb/gallon	EPA
CO_2eq from purchased electricity	1.22	lb/kWh	EPA
CO_2eq from heating oil	161.29	lb/MMBtu	EPA
CO_2eq from propane	137.34	lb/MMBtu	US Energy Information Administration

By concentrating the analysis on the product stages shown in Figure 1, we focused on carbon emissions that result from HCA's *direct actions* in furtherance of economic profit. As such, the analysis, though incomplete, reflects the environmental impact from those aspects of HCA's economies that HCA reasonably can reduce or eliminate in order to develop more ecologically responsible business practices. The methodology we used to establish a carbon profile for each stage of production and distribution is discussed below.

Upstream Transportation

For each ingredient or packaging component that HCA receives through UPS freight, the Team calculated the carbon output of the energy used to bring the ingredient or item to HCA by using two key calculations. First, we calculated freight units (ton-miles) for transporting enough of each ingredient or packaging component for production event. Freight units are a function of the weight of the shipment (in tons), the shipping distance (in miles), and the quantity of the ingredient used in the bake. Second, we estimated carbon output resulting from each transportation event. We calculated carbon output by multiplying the freight units by the emission factor that UPS publishes for air freight (1.42 lbs CO_2eq per ton-mile).

The Team used a slightly different formula for calculating upstream carbon emissions from ingredients that HCA picks up from local retailers. First, we used the estimated fuel efficiency of HCA's vehicle to estimate the amount of fuel that HCA uses to drive to and from the retailer location. Then, we estimated the carbon output resulting from HCA's transportation event by multiplying the gallons of fuel used by the appropriate carbon emission factor from Table 4. We added these two results to determine the aggregate carbon emissions from all upstream processes.

Manufacturing Energy

Energy used during the bakery's manufacturing processes consists of electricity and heating oil used for lighting; controlling the climate within the bakery building; operating the cool room, commercial freezer, and other storage areas; and running HCA's appliances and oven. Because the bakery is used exclusively for producing fruitcake and honey (and has no other purpose), we allocated all of the bakery's energy use to these products. The Team quantified the manufacturing energy use for the bakery using HCA's energy bills and heating oil inventories. We allocated part of the bakery energy to fruitcake and part to honey on the basis of the relative weight of each product that HCA produced in 2008.

In-Process Transportation

In-process transportation was not a significant part of fruitcake or honey production because the entire manufacturing process for fruitcake and honey occurs at HCA. However, in-process transportation is a significant part of frater and truffle production. HCA drives fruitcakes to DeFluri's and then returns completed fraters and truffles to the monastery for shipment to customers.

To calculate carbon emissions associated with the transportation to and from the bakery and DeFluri's, we calculated the fuel consumed during one trip to DeFluri's and multiplied it by the number of trips that HCA makes to DeFluri's per year (11–13 times per year, according to DeFluri's). Then, we multiplied the total amount of fuel by the appropriate carbon emissions factor in Table 4.

Downstream Processes

We used a multi-step process to calculate energy consumed downstream of production. First, we used information provided by HCA to determine the total number of each type of product that HCA shipped to each state, territory, and foreign country in a reference year (2008). Second, because it would have been prohibitive to determine the shipment distance for each shipment that HCA made during the year, we identified a reference city within each state and foreign country and estimated the distance between the reference city and Berryville, Virginia. We generally selected relatively large cities located in the center of each state, territory, or country. We used the number of units shipped, the product shipment weight (as reported by HCA), and the distance to the reference city to calculate the freight units for shipments to each state and country.

Using the freight units, we estimated carbon output resulting from the shipments by multiplying the total freight units for all HCA product shipments to each state or country by the emission factor that UPS publishes for air freight (1.42 lbs CO_2eq per ton-mile, as shown in Table 4). The Team aggregated emissions for shipments to each state and country to calculate the total carbon emissions that resulted from shipping HCA's product to customers in 2008.

A Note about Allocation

We allocated a part of the carbon output from the fruitcake manufacturing process to fruitcakes and a part of the emissions to fraters in order to reflect the fact that some of the fruitcakes become inputs to the frater process. We determined from HCA's 2008 and 2009 operational records that on average, 46 fruitcakes from each bake are not suitable for sale to customers due to cracking, being under- or overweight, or other factors. Most of these fruitcakes were converted to fraters, and those that were not were either consumed by the community or tossed out as waste. This estimate was confirmed by DeFluri's, who informed us that HCA converts around 720 fruitcakes per year (approximately 48 per bake) to fraters. Thus, while a full bake generally produces an average of 675 fruitcakes, on average only around 627 fruitcakes per bake are available for sale to customers. Thus, 93% (= 627/675 x 100) of the emissions from the upstream and manufacturing stages of the fruitcake process were allocated to fruitcake in the final results. The rest of the emissions were allocated to fraters.

We allocated emissions from in-process transportation between fraters and truffles. In-process transportation for fraters is two-way because HCA drives fruitcakes to DeFluri's in one trip and then sometimes drives completed fraters back to the monastery in a second trip. In-process transportation for truffles is one-way because HCA only drives completed truffles to HCA. Finally, according to HCA, community members often combine frater and truffle deliveries with other business activities in the Martinsburg, West Virginia area. To account for these differences, the Team calculated in-process transportation emissions for fraters and truffles separately. For combined trips, we allocated one-third of the emissions to fraters and truffles, and then divided the allocated portion between fraters and truffles on the basis of weight.

Assumptions

To make the emissions calculations and establish a carbon profile for HCA's products, we were required to make certain assumptions. The assumptions made by the Team are discussed below.

- The shipment weight for packaging components was not available on invoices or other documents from packaging vendors. Accordingly, we estimated the shipment weight by multiplying the weight of each packaging component by the total number of pieces shipped, and then adding 5% to account for packaging (e.g., plastic wrap, pallets, boxes, etc.) that the vendor used to package the shipments.

- We calculated the distance of each freight shipment on the basis of a door-to-door delivery. We did not attempt to determine whether UPS shipments first went to one of the UPS hubs before being shipped to HCA.
- We used the published UPS emission factor for air freight instead of attempting to determine the type of UPS delivery vehicle that was used for UPS deliveries to HCA and applying separate emission factors for each transportation method.

These assumptions reduced the precision of the emissions estimates.

Assessing HCA's Social Performance

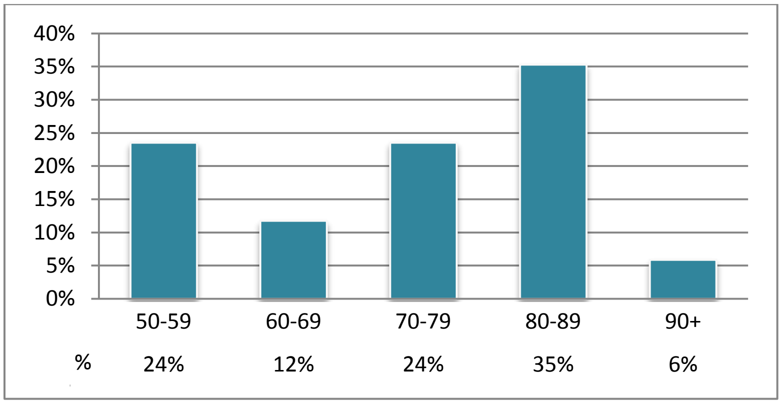
Selecting an appropriate metric for measuring the social performance of HCA's physical products proved to be even more challenging than measuring the environmental impact. As noted above, a company's social performance generally reflects the degree to which business activity impacts people both inside and outside of an organization. HCA's Retreat House and farm, and even its fruitcakes, certainly impact—often profoundly—the people within the HCA community and those who support or visit the community. Community members work in the bakery, manage and staff the gift shop, and provide counseling services in the Retreat House. HCA also has several full- and part-time employees who work in or manage the bakery and Retreat House. Retreatants, visitor, and guests volunteer their time in the bakery, often working alongside the monks as they produce the bakery products. All of these individuals are impacted by the work environment, employment policies, operational decisions, and organizational features of HCA's economies. But no simple metric is available for evaluating the impact across all of these individuals.

For purposes of this analysis, therefore, we chose to focus on one aspect of HCA's social performance: the impact of HCA's revenue-generating work on individual members of the community and on the community as a whole. Work is an essential component of the Cistercian vocation. According to the Cistercian Constitution:

> Work, especially manual work, has always enjoyed a special esteem in the Cistercian tradition since it gives monks the opportunity of sharing in the divine work of creation and restoration, following in the footsteps of Jesus Christ. This hard and redeeming work is a means of providing a livelihood for the brothers and for other people, especially for the poor. It expresses solidarity with workers. Moreover, work is an occasion for a fruitful asceticism that fosters personal development and maturity. It promotes health of mind and body and contributes greatly to the unity of the whole community.

However, HCA is an aging community. The youngest monks living at the monastery in Berryville are 57 years old, the oldest is 91, and the average age is 74 years. The age composition of the current members of the HCA community is shown in Figure 2. Moreover, monastic vocations are and have been declining for many years because fewer and fewer people are seeking to join this simplistic and religious lifestyle. In fact, only half a dozen or so new monks have joined HCA since 1970, and the overall size of the community has decreased dramatically.

Figure 2: Age composition of the HCA community



Source: HCA

We therefore chose to evaluate HCA's TBL social performance on the basis of the degree to which the work required to generate revenues are a drain on its aging population. To evaluate the impact of the work on the community given its declining population, we estimated the amount of work that each economy demands. The Team measured this component simply by collecting data on the number of hours various members of the community spend on each economic activity in a given period of time. (Importantly, when counting the work hours, we included only the time spent by members of the HCA community, visitors, or volunteers. We did not consider the time spent by paid employees because their time was included in the financial cost of labor.)

To evaluate the impact of the work on the community given the members' age, we evaluated the degree to which the work performed by the monks is physically demanding. We measured the physical demands of the work by characterizing the monks' various work tasks as either "normal" or "active." In our analysis, we labeled work as "active" if it has one or more of the following characteristics:

- The monk must remain standing while performing the work.
- The work requires lifting (e.g., shifting trays of fruitcakes from table to rack or racks of fruitcakes into the bed of the HCA pickup).
- The work involves the movement or use of machinery (e.g., the hydraulic lift or commercial mixers in the bakery).
- The work is very fast-paced (e.g., wrapping finished fruitcakes in plastic).

To incorporate these work characteristics into the social performance evaluation, we considered the number of hours the monks spend doing "active" work to be twice as demanding as the hours the monks spend doing "normal" work. We used the number of work hours, weighted by the work characteristics, to calculate a metric for evaluating the quality of HCA's work activities.

RESULTS

This section summarizes the results of our analyses. Our key findings are described below.

- Profits from HCA's economic activities are declining rapidly, from a high of $174,000 in 2005 to just $32,000 in 2009.

- The Retreat House and the farm consistently generate a net loss.
- The bakery generates a profit, but bakery profits have declined dramatically over the past five years due primarily to a decline in fruitcake sales and increased payroll costs at the bakery and Retreat House.
- The overall environmental performance baseline for HCA's current bakery products is 94 tons of CO_2eq per year.
    - HCA's fruitcakes are responsible for more carbon emissions in a year than any of HCA's other bakery products.
    - Creamed honey also is responsible for a significant portion of HCA's bakery emissions (30 tons per year).
    - Truffles are responsible for the least amount of emissions (less than 5 tons per year).
- At 9.5 to 10 lbs CO_2eq per sales unit, HCA's fruitcake, honey, and fraters are more carbon-intensive than many common foods.
- Most of the emissions from HCA's bakery products result from manufacturing activities (primarily electricity and heating oil used for lighting, climate control, operating the cool room and freezer, and to run appliances and the oven).
- With respect to HCA's social sustainability baseline, we determined that the bakery and gift shop demand the vast majority of the community's time (approximately 1,900 hours per year for each of these activities). The Retreat House and farm demand only a small fraction of the monks' time compared to what is spent at the bakery and gift shop.

Economic Performance

The results show that HCA's economic activities generate a positive net income, but HCA's profitability has declined significantly in recent years and may not be sustainable. Figure 3 reflects the net income from each of HCA's economies from 2004 to 2009, taking into account all costs that HCA assigns to each economy (including the cost of goods sold, payroll expenses, operating expenses, and depreciation, as applicable). As shown by the black line in Figure 3, HCA's overall economic profits have declined over the past five years from around $174,000 in 2005 to just $32,000 in 2009.

Two key drivers adversely impact HCA's overall profitability:

1. HCA's net profits are modest to begin with due to consistent annual losses at the Retreat House and farm.
2. HCA's profits have declined dramatically in the past five years due primarily to a decline in fruitcake sales and increased costs at the Retreat House and bakery.

The following sections discuss these factors in the context of HCA's specific economies.

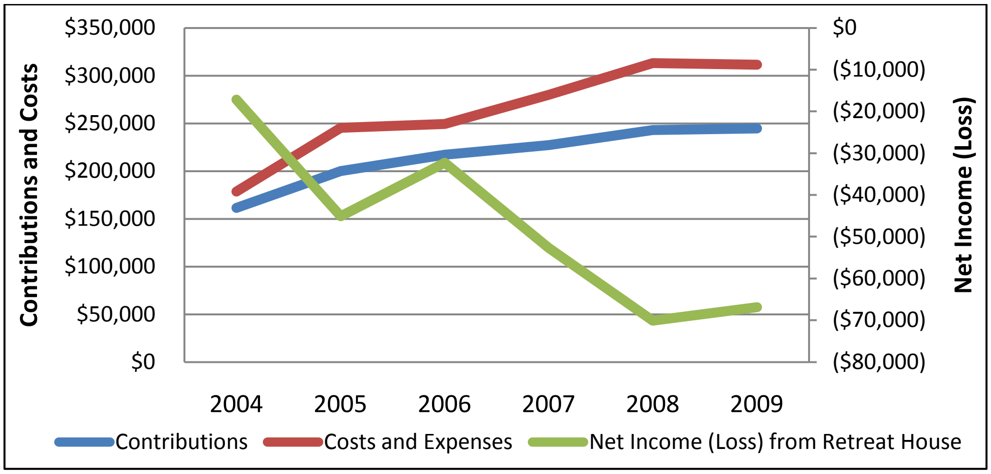
Figure 3: All economies—net income (loss) from 2004–2009

Source: HCA, Comparative Statements of Activities (2004-2009).

The Retreat House

Between 2004 and 2009, the Retreat House consistently operated at a net loss due primarily to increasing payroll expenses. *See* Figure 4. In fact, the annual net loss from the Retreat House nearly tripled during this time period (from roughly 10% of contributions in 2004 to nearly 27% of contributions in 2009).

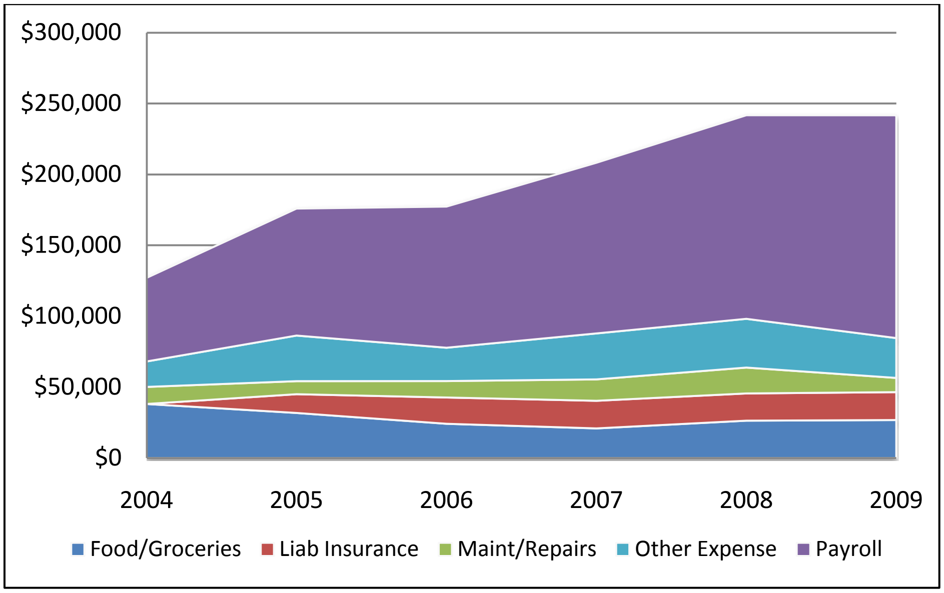
Figure 4: Retreat House contributions, costs, and net income (loss), 2004–2009



Source: HCA, Comparative Statements of Activities (2004-2009).

The loss from the Retreat House did not increase due to declining contributions. In fact, overall contributions from retreatants have increased year after year from 2004 to 2009. Rather, the loss deepened because the total cost of operating the Retreat House increased more rapidly than contributions. Of all of the major expenses associated with the Retreat House, payroll expense increased the most—166% from 2004 to 2009 (*see* Figure 5). Other costs remained relatively constant, or even declined.

Figure 5: Retreat House—total costs and expenses, 2004–2009

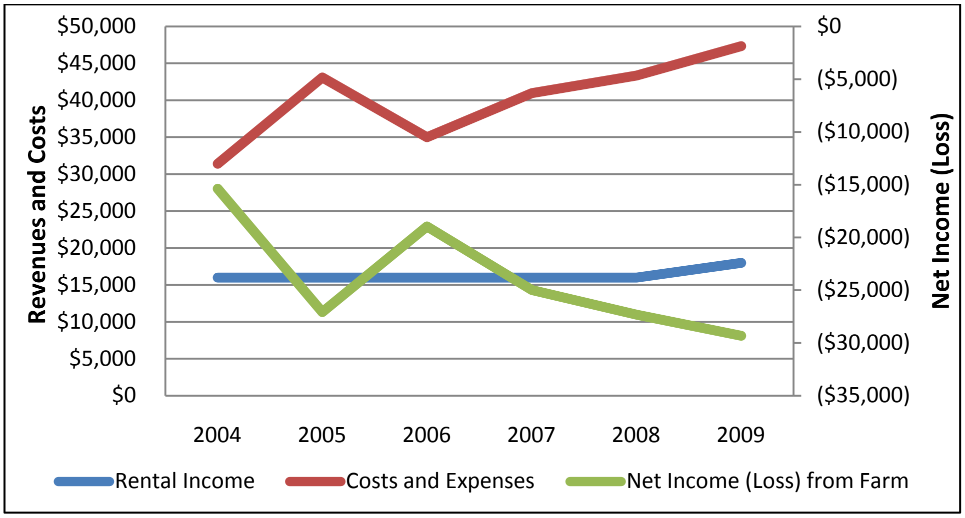


Source: HCA, Comparative Statements of Activities (2004-2009).

The Farm

Like the Retreat House, the farm also operated at a net loss between 2004 and 2009. In fact, in 2004 the rental income that HCA received covered only one-half of HCA's total costs, and in 2009 the rental income covered only one-third of HCA's total costs. *See* Figure 6.

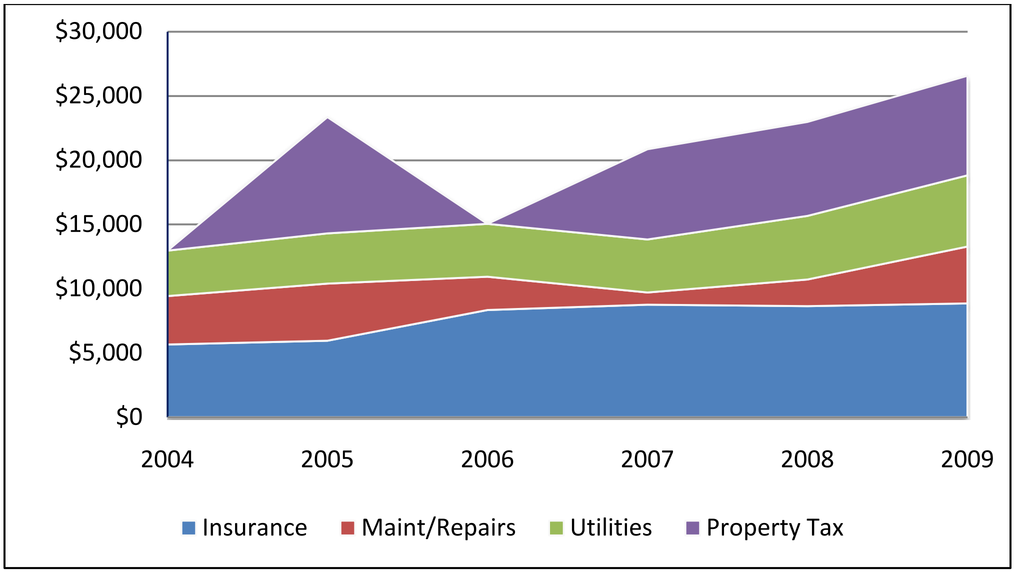
Figure 6: Farm's rental income, total costs, and net income (loss), 2004–2009



Source: HCA, Comparative Statements of Activities (2004-2009).

As in the case of the Retreat House, the annual loss from farm operations resulted from increased costs rather than declining revenues. HCA currently receives $18,000 per year in rental income, up from $16,000 per year between 2006 and 2009 (a 13% increase). However, the total cost to HCA associated with the farm exceeded rental income received in each of the relevant years. Moreover, the community's costs associated with the farm have increased 51% since 2004. Most of the change resulted from a 53% increase in the cost of liability insurance over this five-year period, although maintenance and repair costs as well as utility costs have increased significantly since 2007 (*see* Figure 7).

Figure 7: Major operating costs and expenses for the farm, 2004–2009



Source: HCA, Comparative Statements of Activities (2004-2009).

It is important to note that until recently the annual rental income that HCA received from the farm was actually lower than it was when HCA first entered into the lease in 1979. The original lease required the tenant to pay to HCA $23,500 per year for 971 acres (an average of $24.20 per acre). The current lease requires the tenant to pay $18,000 per year for 1,002 acres (an average of $17.97 per acre).

The Bakery

In addition to losses sustained by the Retreat House and farm, HCA's profit from economic activity is declining due to depleting revenues and increasing costs at the bakery. As shown in Figure 8, the bakery generated a positive net income from 2004 to 2009, but profits have declined significantly in recent years—from a high of around $180,000 in 2005 to just over $60,000 in 2009. Because bakery revenue consistently comprises 50%–60% of HCA's overall revenue, these negative revenue trends have a significant impact on the overall financial performance of HCA's economies.

For the most part, the bakery's declining profitability is not the result of increased costs. Between 2004 and 2009, payroll costs increased from just over $100,000 in 2004 to a peak of $150,000 in 2008, but cost of goods sold (ingredients and packaging) declined during this same period. Overall, the total cost of running the bakery increased approximately 4% between 2004 and 2009 (*see* Figure 9).

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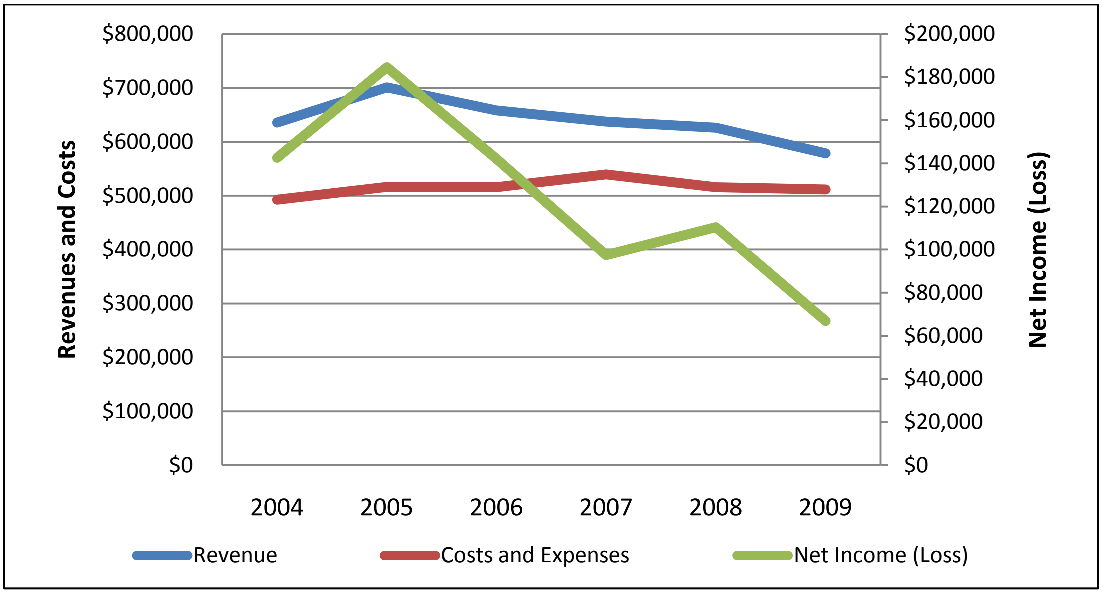
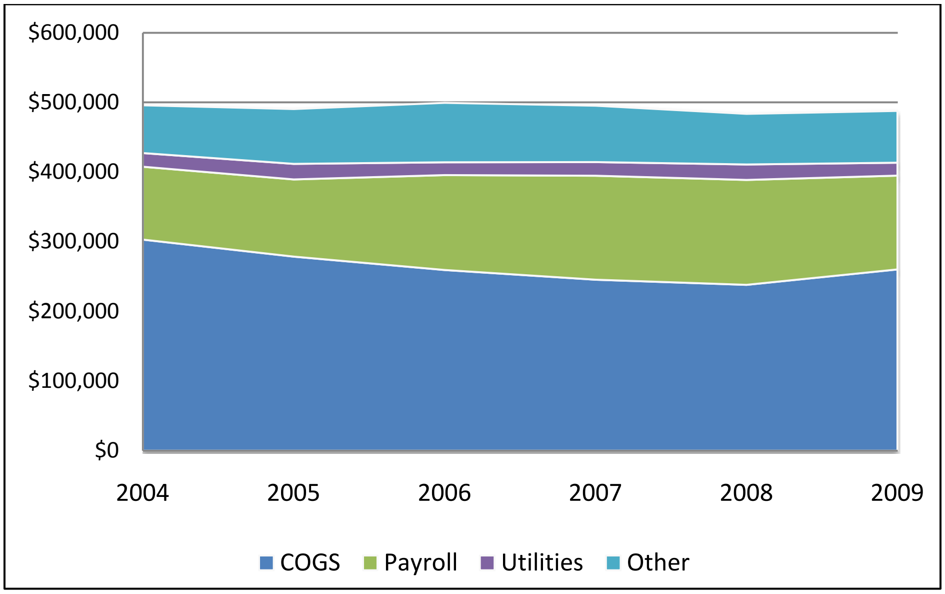
Figure 8: Bakery revenues, total costs, and net income (loss), 2004–2009



Source: HCA, Comparative Statement of Activities 2004-09

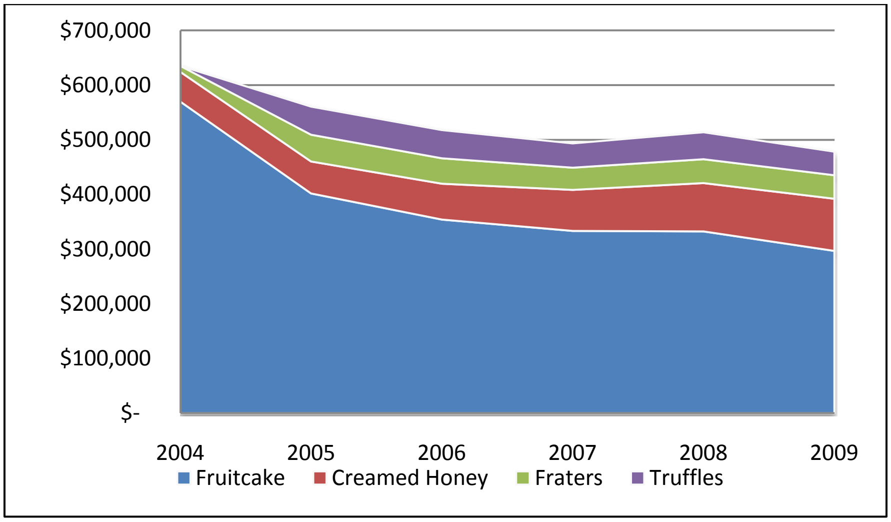
Figure 9: Major costs and expenses for the bakery, 2004–2009



Source: HCA, Comparative Statement of Activities 2004-09

The primary cause of declining bakery profits is declining revenues due to decreasing unit sales of fruitcakes and, to a lesser extent, truffles. The decline in fruitcake revenues has been the most dramatic (*see* Figure 10).

Figure 10: Bakery revenue trends per product, 2004–2009



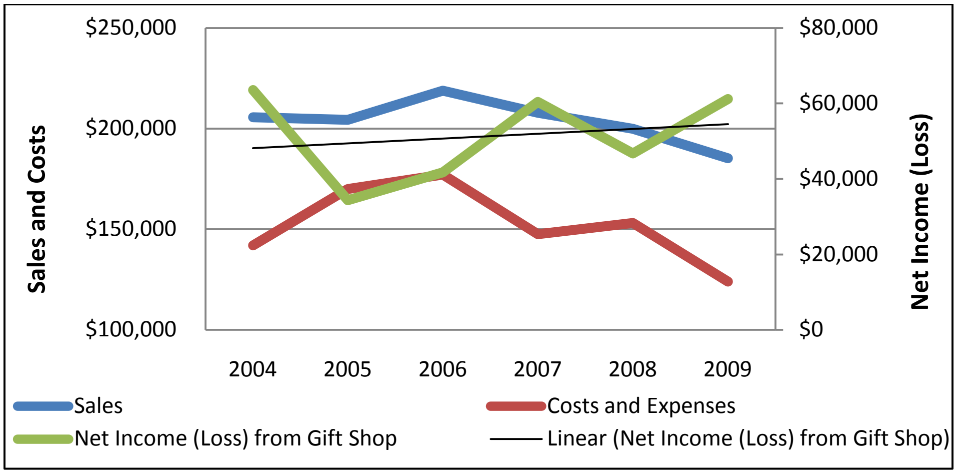
Source: HCA, Comparative Statements of Activities (2004-2009).

By contrast to fruitcake and truffles, sales of creamed honey and fraters have increased since 2004. Honey sales have shown the most dramatic increase (from over $54,000 in 2004 to over $95,000 in 2009). Revenues from fraters have shown a less dramatic increase in sales. However, notwithstanding these increases, in 2009, fruitcake sales still accounted for the majority of bakery revenues (approximately 62%).

The Gift Shop

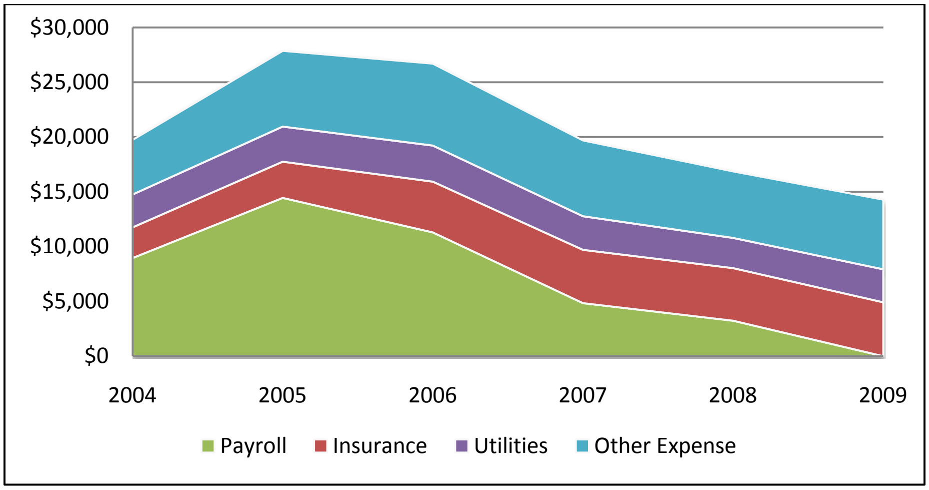
Gift shop profits help to balance the losses generated by the Retreat House and farm as well as the bakery's declining profitability. Gift shop revenues declined between 2004 and 2009, but the total cost of operating the gift shop also decreased (*see* Figure 11). Most of the decrease was due to declining payroll expense (*see* Figure 12); HCA previously employed a clerk to assist in the gift shop, but over time the clerk worked fewer and fewer hours and the shop is now operated entirely by one of the monks. Because costs and expenses decreased more than revenues declined, overall profitability at the gift shop improved slightly between 2004 and 2009.

Figure 11: Gift shop revenues, total costs, and net income (loss), 2004–2009



Source: HCA, Comparative Statements of Activities (2004-2009).

Figure 12: Major costs and expenses for the gift shop, 2004–2009



Source: HCA, Comparative Statements of Activities (2004-2009).

Environmental Performance of the Bakery

We calculated an overall environmental performance “baseline” of *94 tons CO_2eq per year* for HCA’s current bakery products. The breakdown of the baseline by each of HCA’s bakery products is shown in Table 5.

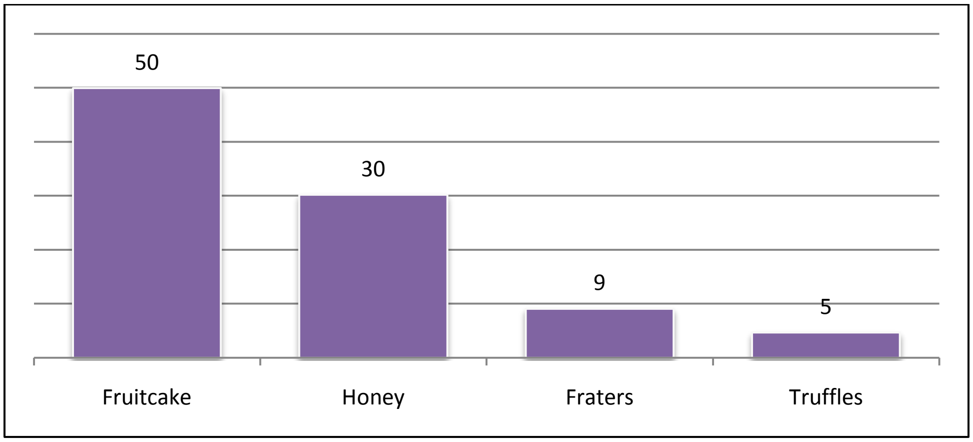
Table 5: Summary of carbon output of bakery products

	CO2					
	% of total	tons/yr	lbs/yr	lbs/lb product	lbs/sale unit	lbs/prod'n unit
FRUITCAKE	**53%**	**49.82**	**99,645**	**4.30**	**10.03**	**10.03**
Upstream		7.28	14,566	0.64	1.44	1.44
Ingredients		*7.14*	*14,280*	*0.63*	*1.41*	*1.41*
Packaging		*0.14*	*286*	*0.01*	*0.03*	*0.03*
Manufacturing		35.69	71,381	3.13	7.05	7.05
Electricity		*22.82*	*45,631*	*2.00*	*4.51*	*4.51*
Heating Oil		*12.87*	*25,750*	*1.13*	*2.54*	*2.54*
In-Process Transportation		0.02	36	-	-	-
Downstream		6.83	13,661	0.52	1.55	1.55
HONEY	**32%**	**30.37**	**60,733**	**1.60**	**9.56**	**2.39**
Upstream		0.25	506	0.03	0.07	0.02
Ingredients		*0.08*	*162*	*0.01*	*0.02*	*0.01*
Packaging		*0.17*	*344*	*0.02*	*0.05*	*0.01*
Manufacturing		29.13	58,264	1.15	8.22	2.06
Electricity		*18.99*	*37,974*		*5.36*	*1.34*
Heating OIl		*10.14*	*20,290*	*1.15*	*2.86*	*0.72*
In-Process Transportation		-	-	-	-	-
Downstream		0.98	1,962	0.42	1.27	0.32

	CO2					
	% of total	tons/yr	lbs/yr	lbs/lb product	lbs/sale unit	lbs/prod'n unit
FRATERS	**10%**	**9.10**	**23,356**	**10.35**	**10.10**	**1.68**
Upstream		0.54	1,085	0.47	0.46	0.08
Ingredients		*0.54*	*1,079*	*0.46*	*0.45*	*0.07*
Packaging		*0.00*	*6*	*0.01*	*0.01*	*0.00*
Manufacturing		7.92	21,004	8.98	8.75	1.46
Electricity		*1.65*	*3,302*	*1.41*	*1.38*	*0.23*
Heating OIl		*0.93*	*1,863*	*0.80*	*0.78*	*0.13*
DeFluri's		*5.34*	*15,838*	*6.77*	*6.60*	*1.10*
In-Process Transportation		0.18	361	0.15	0.15	0.03
Downstream		0.45	907	0.76	0.74	0.12
TRUFFLES	**5%**	**4.67**	**9,346**	**4.83**	**3.63**	**-**
Upstream		0.08	159	0.07	0.05	-
Ingredients		*0.05*	*104*	*0.05*	*0.03*	-
Packaging		*0.03*	*55*	*0.02*	*0.02*	-
Manufacturing (DeFluri's)		4.35	8,696	3.86	2.90	-
In-Process Transportation		0.01	25	0.20	0.15	-
Downstream		0.23	466	0.70	0.52	-
Total All Products		**93.96**	**193,080**	**21.08**	**33.32**	**14.11**

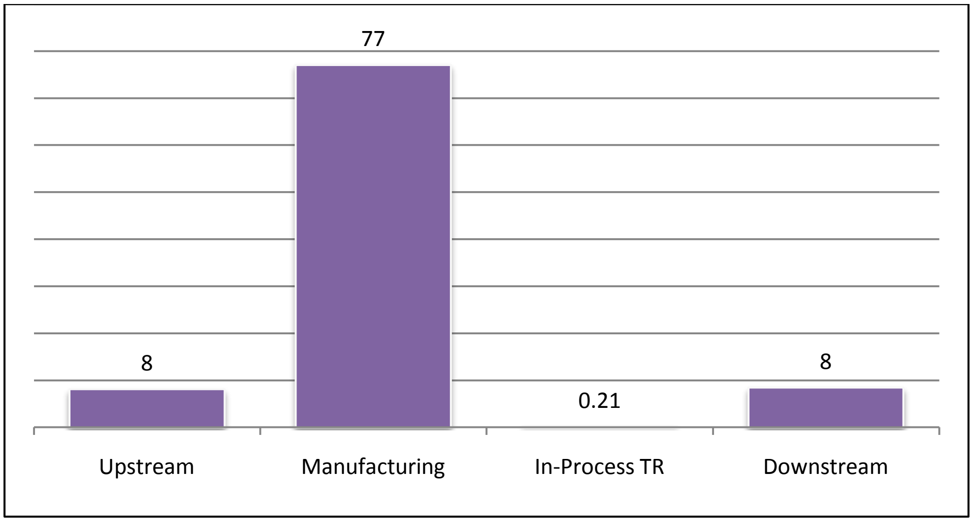
The baseline is summarized by bakery product in Figure 13. As shown in Figure 13, at approximately 50 tons per year, HCA's fruitcakes are responsible for more carbon emissions in a year than any of HCA's other bakery products. Creamed honey also is responsible for a significant portion of HCA's bakery emissions (30 tons per year). Truffles are responsible for the least amount of emissions (less than 5 tons per year).

Figure 13: HCA's annual carbon output by bakery product, lbs CO_2eq/yr, 2008



HCA's overall emissions baseline is summarized by production activity in Figure 14. As shown in Figure 14, the vast majority of the emissions from HCA's bakery products result from manufacturing activities. As mentioned previously, in this analysis, manufacturing activities consist of electricity and heating oil used for lighting, climate control in the bakery building, operating the cool room and freezer, and running appliances and the oven.

Figure 14: HCA's annual carbon output by production activity (2008)



It is important to emphasize that the annual carbon baseline that we calculated for HCA does not reflect the entire carbon impact of HCA's bakery products. As noted previously, a full life-cycle analysis of HCA's products would include each of the product stages depicted in Figure 1. Including all of the product stages likely would generate a larger carbon footprint for HCA's products. For example, according to the Economic Input-Output Life-Cycle Analysis model for calculating carbon emissions that we discussed in the Methodology section of this chapter,

- The activities required to generate $100,000 of business for a commercial bakery consumes roughly 300,000 kWh of energy and results in more than 180 tons of CO_2eq.
- Every $100,000 generated in business for a chocolate-based confectionary involves activities that collectively consume roughly 360,000 kWh of energy and result in more than 220 tons of CO_2eq.

HCA's bakery generates approximately $500,000 of business, which (according to the EIO-LCA model) could generate as much as 1,000 tons of CO_2eq (approximately 10 times the amount reflected in our analysis). Limiting our analysis to the product stages in Figure 1 excludes the impact that occurs before the ingredients and packaging components are ready for shipment to HCA. Therefore, our result may vastly understate the true carbon impact of HCA's products.

It is also important to note that while the carbon footprint of many food products is surprisingly high, at approximately 10 lbs CO_2eq per fruitcake, HCA's fruitcakes are more carbon intensive than many common foods (*see* Table 6). Of course, the footprints shown in Table 6 are of the entire product life cycle (not including consumer transportation or preparation). Therefore, a true apples-to-applies comparison of the HCA fruitcake with these products is not possible.

The sections that follow Table 6 provide additional insights into the source of the carbon emissions reflected in the figures.

Table 6: Carbon footprint of common food items

Item	Quantity	CO_2eq Footprint (lbs)
Soup (chicken noodle)	8-oz can	0.4
Chocolate bar (milk)	3.5 oz bar	0.75
Chicken	1 lb	1.1
Wine (imported, France)	750 ml	3
Truffles	***Box of 18***	***3.63***
Orange juice	½ gallon jug	3.75
Eggs (organic, free range)	1 dozen	5.2
Coffee (Arabica)	1 lb ground	5.7
Beer (microbrew)	6-pack	7
Honey	***4 tubs***	***9.5***
Fruitcake	***1 fruitcake***	***10***
Fraters	***Box of 6 Fraters***	***10***
Beef	1 lb	14.8

Source: StarFish.com

Fruitcake

As mentioned above, the environmental performance baseline for HCA's fruitcakes is approximately *50 tons (nearly 100,000 lbs) of CO_2eq per year*. Figure 15 depicts the annual fruitcake baseline by production process.

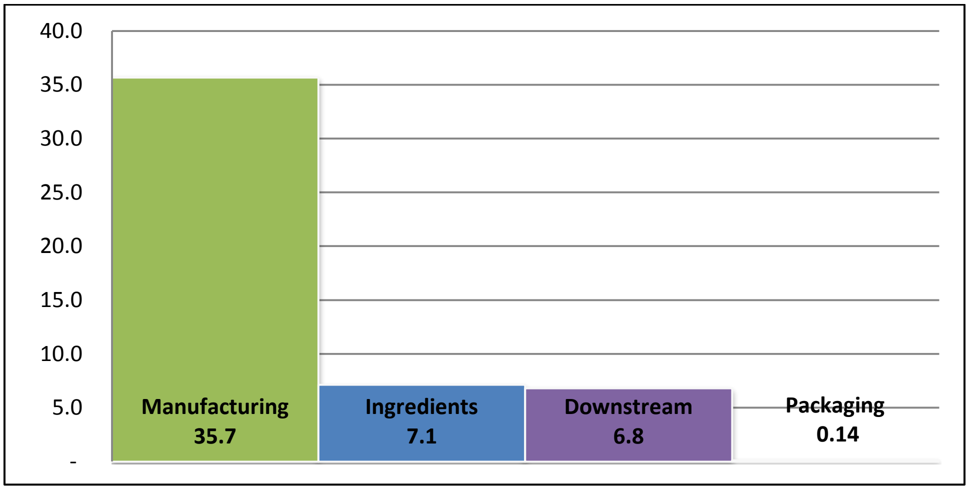
Highlights

- Most of the carbon output of the fruitcake—around 75%—is attributable to the manufacturing process. Two-thirds of these manufacturing emissions are from the use of electricity; one-third is from heating oil.

- The vast majority of the manufacturing emissions, whether from electricity or heating oil, are from "background" uses (lighting, refrigeration, heat, and air conditioning). Only a tiny proportion of the emissions (around 2% overall) is from the use of appliances and the oven.

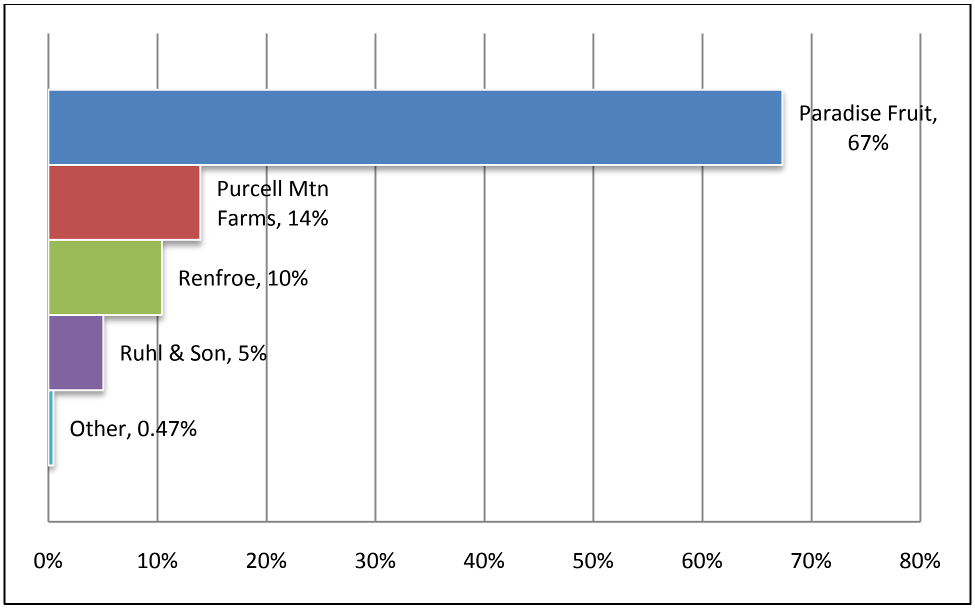
- Regarding upstream carbon emissions, nearly all (97%) of the annual output is attributable to the process of bringing ingredients to HCA. Only a small portion (3%) is attributable to shipping packaging components to HCA.

Figure 15: Carbon emissions for fruitcake by production activity, tons per year (2008)



- HCA's choice of ingredient suppliers impacts the carbon emissions that are attributable to fruitcake. HCA relies on seven key vendors for their fruitcake ingredients. Although HCA uses more than 30 ingredients for the fruitcake, nearly 92% of the annual upstream emissions is attributable to three vendors: Paradise Fruit (67%), Purcell Mountain Farms (14%), and Renfroe (10%). *See* Figure 16.

Figure 16: Sources of upstream carbon emissions, fruitcake ingredient vendors (2008)

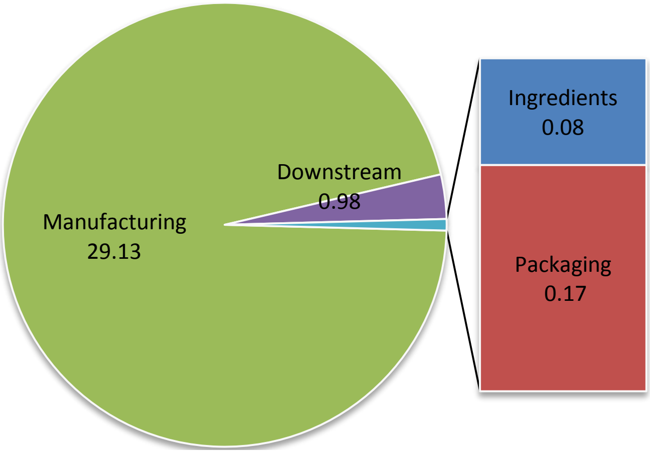


- Nearly 70% of the upstream emissions from fruitcake is attributable to Paradise Fruit, which supplies candied fruit to HCA. Emissions attributable to Paradise Fruit shipments probably are relatively high because the fruit is heavy and it is shipped to HCA from Paradise Fruit's facility in Pensacola, Florida.

Honey

The environmental performance baseline for HCA's honey is approximately 30 tons (around 60,600 lbs) of CO_2eq per year. Figure 17 depicts the annual emissions from HCA's creamed honey by production process.

Figure 17: Carbon emissions for honey by production activity, tons CO_2eq/year (2008)



Highlights

- As with fruitcake, most of the emissions attributable to honey (approximately 88% on an annual basis) result from the manufacturing process. Of those manufacturing emissions, two-thirds result from electricity use in the bakery and the remaining third results from the use of heating oil.

- The vast majority of the manufacturing emissions attributable to honey production are from background uses (lighting, refrigeration, heat, and air conditioning). Less than 2% of the emissions are from the use of appliances for mixing the honey and depositing the honey in containers.

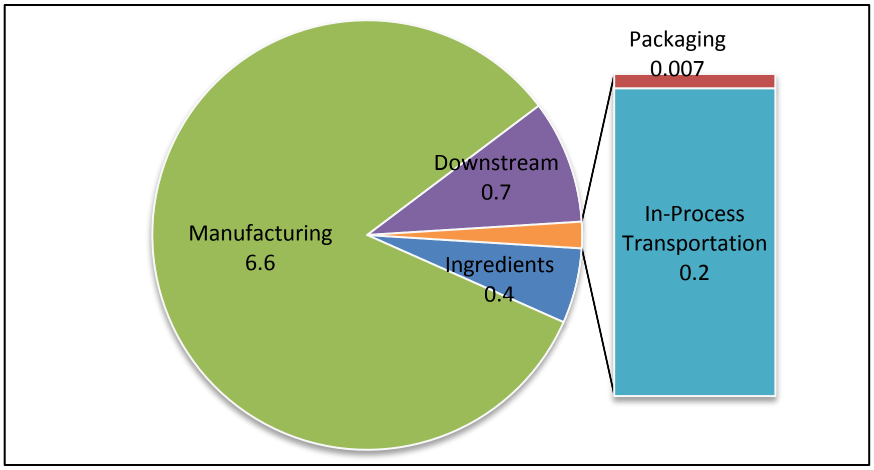
- Relative to fruitcake, upstream transportation makes up only a small portion of the emissions profile for honey (around 6% on an annual basis). This is because HCA obtains virtually all of the honey ingredients from local sources.

- By contrast to fruitcake, packaging components comprise a relatively large proportion of the upstream emissions attributable to honey. The honey packaging is not substantially different than the fruitcake packaging (in each case, packaging accounts for approximately only 0.01 lb or 0.02 lb CO_2eq per lb of product), but it makes up a relatively large share of the upstream budget because it is shipped a relatively longer distance from the supplier to HCA than the honey ingredients.

Fraters

The annual environmental performance baseline for HCA's fraters is approximately 9.1 tons (around 23,375 lbs) of CO_2eq per year. Figure 20 depicts the annual frater emissions baseline by production process.

Figure 18: Carbon emissions for fraters by production activity, tons CO_2eq/year (2008)



Highlights

- Like fruitcakes and honey, a lot of manufacturing energy goes into frater production. Emissions from the manufacturing process comprise 87% of the total emissions attributable to fraters.

- Approximately one-third the manufacturing emissions results from energy used to run HCA's bakery and the bakery appliances, although (as noted above) appliance use reflects only a few percent of the energy use at the bakery. Two-thirds of the manufacturing energy results from DeFluri's production process.

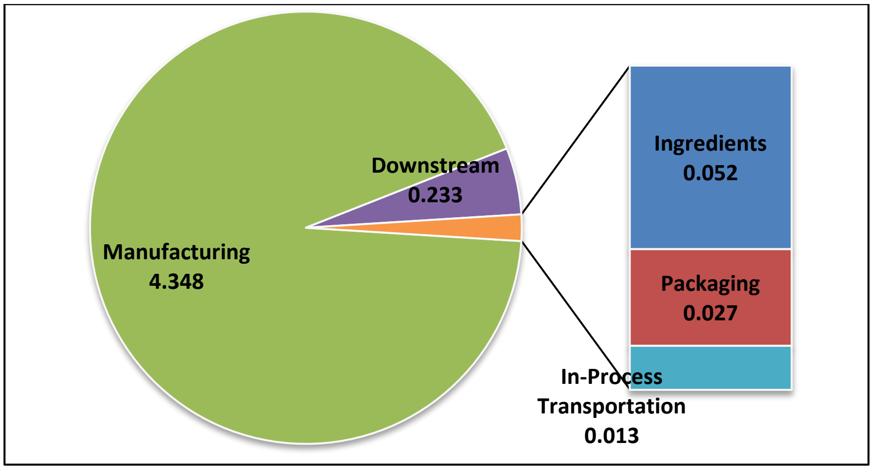
- Around 9% of the frater emissions is attributable to upstream processes. Nearly all of the upstream emissions (93%) are attributable to fruitcake ingredients. The remainder is attributable to sourcing the chocolate (5%) and the packaging (2%).

- In-process transportation comprises a greater proportion (4%) of the carbon profile for fraters than it does for fruitcakes and honey. This is because HCA delivers the fruitcake to DeFluri's in one trip and picks up fraters from DeFluri's in another trip. HCA drives only between the bakery and monastery for fruitcake and honey production.

Truffles

HCA's truffles are responsible for the least amount of annual carbon output of all of HCA's products. The baseline for the truffles is approximately 4.7 tons (around 9,350 lbs) of CO_2eq per year. Figure 19 depicts the truffles baseline by production process.

Figure 19: Carbon emissions for truffles by production activity, tons CO_2eq/year (2008)



Highlights

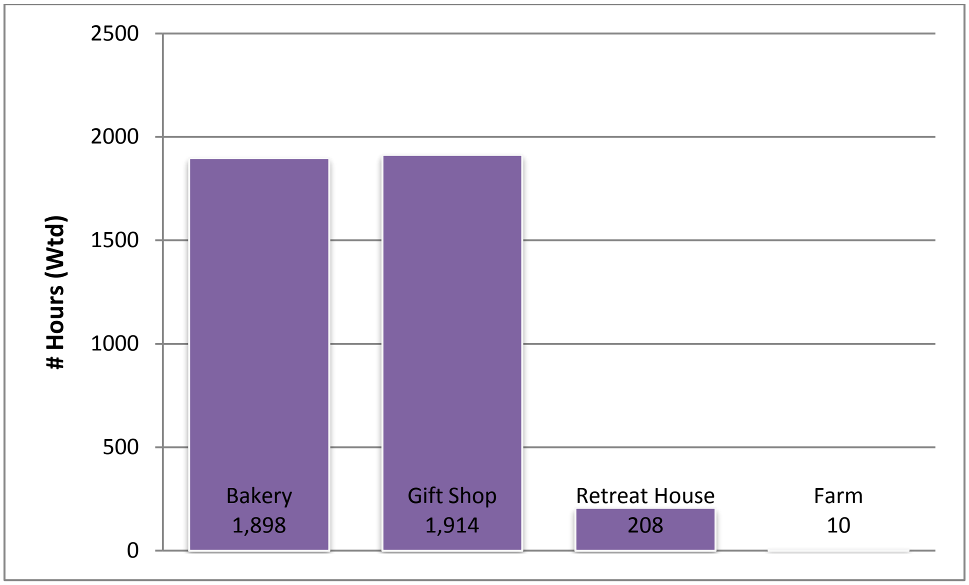
- Most of the emissions in the truffles' carbon profile (93%) are from manufacturing emissions. All of these manufacturing emissions result from DeFluri's production process as HCA does not manufacture truffles in the bakery.

Social Performance

In the Methodology section, we explained that the baseline metric for evaluating the social performance of HCA's economies has two components: a *quantity* component that estimates the amount of time that each economy demands of HCA's members and a *quality* component that evaluates the physical demands of the work on the aging population. Specifically, we measured the social performance of HCA's economies by calculating the total number of hours the monks spend on each activity, weighting hours the monks spend in "active" work by a factor of two.

The social performance index for each of HCA's existing economies is depicted in Figure 20.

Figure 20: Social performance, all economies



Not surprisingly, the bakery and gift shop demand the vast majority of the community's time—approximately 1,900 hours per year for each of these activities. The Retreat House and farm demand only a fraction of the time spent at the bakery and gift shop. In reaching these conclusions, the Team relied on the assumptions listed below.

- For purposes of calculating the demand for the monks' time at the bakery, we considered three bakery-related tasks to be "active": (1) the use of the hydraulic lift to combine fruit and nuts with batter to make fruitcakes, (2) the process of loading fruitcakes into and out of the oven, and (3) the process of loading finished fruitcakes and fraters into the storage area at the monastic enclosure. All other tasks were considered "normal."

- For purposes of calculating the demand for the monks' time at the gift shop, we considered stocking shelves with merchandise to be active and assumed that these tasks comprise approximately 25% of the monks' time at the gift shop.

- For purposes of calculating the demand for the monks' time at the Retreat House, we assumed that the monks spend an average of four hours per week providing counseling and spiritual direction to retreatants.

- Finally, we assumed that the monks spend only ten hours per year administering the farm lease.

OPTIONS AND SUGGESTIONS

Based on the results of the analysis and research conducted on possible alternatives, we propose the following options related to HCA's economies:

- Improve overall energy efficiency. At the Retreat House and gift shop, focus on conservation behaviors that address conventional energy uses such as light, heat, and space cooling. Actively invite retreatants to join HCA in these conservation practices by turning room lights off when not in use, keeping thermostats low in the winter and high in the summer, and taking shorter showers.

- Reduce energy consumption in the bakery. Investigate options such as sealing leaks, installing additional roof and wall insulation, eliminating summer bakes (if possible), and insulating the walls and ceiling of the ingredient storage room to reduce the huge amount of energy currently being consumed to heat and cool the bakery building (as discussed in Chapter 2).

- Reduce reliance on fruitcake sales. Prepare for a declining demand for fruitcake by focusing on creamed honey, which has more favorable margins and upward trending sales. Introduce new honey flavors and upgrade packaging to increase competitiveness.

- Introduce new bakery products. Focus on market segments with high growth potential, such as gourmet/specialty, organic, and gluten-free products. Balance the seasonality of fruitcake sales by developing products for events that occur early in the year, such as Easter and Mother's Day. Develop products that use locally grown and available ingredients (e.g., apples, peaches, tomatoes, and peanuts) to reduce the carbon footprint of the products sold.

- Partner with others to expand and modify economies. Find a partner or hire an employee to develop new products and find ways to more fully utilize the bakery's assets. Partner with a commercial baker who can use the oven in exchange for cash or personnel. Consider an arrangement with a private label manufacturer who can manufacture fruitcakes (as appropriate) and other bakery products for sale under the HCA label.

- Design and introduce more sustainable packaging. Consider the sustainability aspect of various packaging materials when reordering existing packaging and making future packaging decisions.

- Raise prices. Eliminate the range in the contribution amount that HCA suggests for retreats and suggest a single contribution that more than covers HCA's costs. Raise the price of fruitcake $2 per unit to better reflect market prices. Raise the rental rate per acre on the farm property to better reflect the rental market for agricultural land in northern Virginia and the Shenandoah Valley. Incorporate an annual percentage increase or rate schedule in future farm leases that reflects anticipated increases in the market rate.

- Control costs. Reduce payroll expense to the fullest possible extent through flexible staffing and by reducing the weekday retreat by one day. Determine whether HCA currently is paying variable costs related to the tenant's farm operation and shift the burden of those costs to the tenant.

- Solicit additional funding for the Retreat House. Seek annual gifts from retreatants, create and solicit contributions to a building fund, and organize workshops and other themed events that are consistent with HCA's overall mission when Retreat House occupancy is low.

- Develop promotional programs for the gift shop. Display gift shop merchandise in public areas within the monastic enclosure (such as the lobby or library of the Retreat House and the foyer of the mansion), advertise in local and regional church bulletins, offer discounts on gift shop merchandise purchased before or at the conclusion of a retreat, create a book club for individuals that regularly attend retreats or patronize the shop, and/or establish a program for used book sales.

- Create a substantive Web site specifically for the gift shop. The Web site would provide substantive information about gift shop merchandise as well as basic information about shop hours and location, and *might* provide a platform for future online sales.

- Create areas for conservation burials. A 60-acre parcel at the southeastern end of the former Wynkoop Farm is a promising site because it can be reached from a separate entrance off Castleman Road and will not interfere with the community's daily routine. Construct walking trails and a non-denominational chapel to support the conservation burial services; restore the area to a natural forest as part of the conservation efforts

These options and suggests are organized into two subsections: Suggestions for Existing Economies and Suggestions for New Economies.

Suggestions for Existing Economies

Retreat House

Environmental Performance

As noted previously, we did not evaluate the environmental performance of the Retreat House as a specific element of the business analysis. We wish to emphasize, however, that this approach is not intended to diminish its environmental impact. As noted in Chapter 2, on average the energy use at the Retreat House (electricity, heating oil, and propane) generates approximately 132 tons of CO_2eq per year. (Compare this total to the bakery's environmental performance, which we determined to be only 94 tons of CO_2eq per year.) Approximately 54 tons of CO_2eq emissions from the Retreat House are attributable to electricity use—nearly 40,500 kWh per year. As noted in Chapter 2, one option for reducing this impact is for HCA to modify its own actions, (for example, by exchanging incandescent light bulbs for CFLs and taking other actions).

To further reduce the environmental impact of the Retreat House, the Team suggests that HCA encourage Retreat House visitors to adopt conservation practices. During the retreatant orientation, community members might mention to retreatants that they are engaged in a significant effort to reduce their carbon footprint and remind retreatants to turn room lights off when not in use, keep thermostats low in winter and high in summer when the retreatants is not in the room, and take shorter showers when possible. HCA can post signs, provide informational literature, and organize educational lectures that encourage simple conservation behaviors. Encouraging retreatants to participate in HCA's sustainability initiatives not only would help to reduce HCA's impact but also would spread the knowledge of sustainability outside the boundary of HCA.

Economic and Social Performance

We hesitate to offer conventional business recommendations for the Retreat House because the Retreat House is at the core of the Cistercian tradition of hospitality and therefore is one of HCA's most important ministries. We offer only a few recommendations that HCA might consider to reduce the need to subsidize Retreat House operations with other income sources.

First, we suggest that HCA eliminate the range in the suggested contribution and instead suggest a single contribution that more than covers HCA's costs. Currently, HCA's suggested contribution equals $75 to $125 per night for a weekday retreat and $75 to $150 per night for a weekend retreat. According to HCA, however, on average retreatants contribute less than the low-end contribution for a typical retreat. Per-night revenues, selected costs, and total costs over the past three years are shown in Table 7. As shown in Table 7, the average nightly contribution in 2009 was only $74.73, $20 less than the daily cost to HCA of owning and operating the Retreat House.

Table 7: Average contributions and selected costs for the Retreat House, per person per night, 2007–2009

Year	Contribution	Food Cost	Payroll Cost	Maintenance and Repairs	Total Cost	Excess (Shortfall)
2007	$ 64.17	$ 5.89	$ 34.00	$ 4.26	$ 78.85	$ (14.68)
2008	$ 71.59	$ 7.76	$ 42.32	$ 5.38	$ 91.78	$ (20.20)
2009	$ 74.73	$ 8.19	$ 48.07	$ 3.07	$ 94.85	$ (20.12)

Source: HCA

As mentioned above, one way that HCA might be able to minimize this shortfall could be to eliminate the range of suggested contributions and suggest a single contribution amount. We certainly do not profess expertise in the economics and psychology of charitable donations, but even a quick review of available research shows that suggesting a range of donations "anchors" likely contributions toward the low end.[38] Research also suggests that the least generous donors (i.e., those who donate the least when asked for a donation) are more influenced by anchoring mechanisms than more generous donors.[39] These principles lead us to believe that offering a range of contributions could result in most retreatants making the minimum contribution.

A second reason for eliminating the range of contributions is that the range may suggest interpretations to retreatants that HCA did not intend. We do not know precisely how retreatants interpret the range, but one possibility is that the low end of the range is appropriate for retreatants with modest means and the higher end is appropriate for wealthier patrons. Alternatively, retreatants might believe that the low end of the range covers HCA's costs and the high end covers costs but includes an extra donation to the monastery. (A given retreatant may or may not feel inclined to make an extra donation.) Requesting a single contribution tied to HCA's Retreat House costs might eliminate these unintended interpretations and value judgments.

A third reason for suggesting only one contribution amount per retreat is that a single amount at the appropriate price point might help retreatants contribute the amount they believe reflects the value received. People are accustomed to evaluating the cost of an overnight stay in a hotel, motel, inn, or resort against a single rate. Even though the Retreat House provides much more than a hotel stay, most retreatants probably compare the suggested contribution against this internal reference point. Requesting a single contribution would facilitate a comparison between the cost of a hotel and the cost of a retreat, and may encourage retreatants to recognize (and pay for) the incremental value they receive from a retreat as compared to a traditional overnight experience.

In addition to suggesting a single contribution amount for each retreat, we recommend that HCA choose a suggested contribution that covers its costs (and then some). Unless additional funding sources are identified to subsidize the Retreat House (*see* below), HCA must cover its costs if the Retreat House is to operate over the long term (i.e., be sustainable). We also suggest that HCA mark up the costs when suggesting contribution amounts by, say, 15% for a weekday retreat and 25% for a weekend retreat in order to reflect higher payroll costs on weekends. The additional "buffer" will offset variations in costs due to cost increases and the tendency of many retreatants to offer less than the recommended contribution. By adding the cost buffer, the community of retreatants (rather than HCA) would help to subsidize those who cannot afford the full contribution.

Applying this recommendation to HCA's current costs would suggest a minimum contribution of $110 per weeknight or $440 for a weekday retreat (4 nights * $95/night * 115%) and $120 per weekend night or $240 for a weekend retreat (2 nights * $95/night * 125%).

If HCA chooses not to change the suggested contributions, we suggest that payroll expense be reduced to the fullest possible extent. More than half of the cost associated with the Retreat House is charged to payroll expense. In fact, in 2009 each night of retreat cost HCA nearly $50 in payroll expense—over $157,000 in total. Although a full evaluation of this cost is outside the scope of this project, it *see* ms intuitive that HCA might be able to reduce this expense. For example, redefining the weekday retreat to be one day shorter (e.g., from Tuesday morning to Thursday afternoon) might eliminate the need to schedule staff on Mondays. As long as the current cost of the weekday retreat does not change, the affect of the reduced payroll expense on HCA's bottom line could be significant.

Solicit additional funding for the Retreat House. Another way that HCA might be able to minimize or eliminate the shortfall in contributions is to seek additional donations (besides the suggested contribution for a retreat). For example,

- HCA could seek contributions for a separate fund designated for maintenance and upkeep of the Retreat House. As shown in Table 7, maintenance, repairs, and depreciation cost HCA approximately $25 per day per retreatant (approximately $78,000 in 2009). Retreatants who have been coming to the Retreat House for many years might be willing to make an annual contribution to a building fund in order to preserve the facility.

- HCA could seek annual gifts. Thank you notes and comment cards left by previous retreatants express appreciation for the Retreat House and the experience they had during their retreat. HCA could establish an annual fund drive (at Christmas or at some other time of the year) and invite past retreatants to support the Retreat House as a token of their appreciation.

Additionally, HCA could use the Retreat House for workshops and other themed events that are consistent with HCA's overall mission. A few times per year, HCA could invite past retreatants, members of local congregations, community supporters, and others to attend the events. Topics might include a series on HCA's sustainability initiatives, the history of monastic vocations, or an insight into the Cistercian tradition. HCA also could organize themed workshops that address various aspects of spirituality, bringing in workshop facilitators when appropriate. Numerous workshop topics and schedules are available on the Internet by searching for "monastic retreats" in Google. Many structured retreats are organized by other OCSO houses.

Importantly, these events would be scheduled so as not to interfere with the unstructured silent retreats that are HCA's current specialty (and which, according to comment cards and thank you notes, are highly valued by current retreatants). In fact, the events need not even be considered part of HCA's hospitality ministry. Rather, the workshops would occur when occupancy is typically low (as in February and September) for the purpose of more fully utilizing the Retreat House facility. The Retreat House's occupancy rate currently is only around 70% on an annual basis, so there appears to be time and space for these special events.

Expanding beyond the current unstructured retreat format and using the Retreat House facility for additional purposes would benefit the community in several ways. For one thing, the events would bring in extra funds when the Retreat House otherwise is underutilized. Special events also might introduce people to HCA who otherwise would not be aware of the opportunity for retreats or other participation. Occasional workshops would also increase HCA's visibility and its opportunities to interact with the local community. Finally, organizing workshops and lectures might energize the community by introducing new thoughts, ideas, and people to HCA's daily routine.

The Gift Shop

Environmental Performance

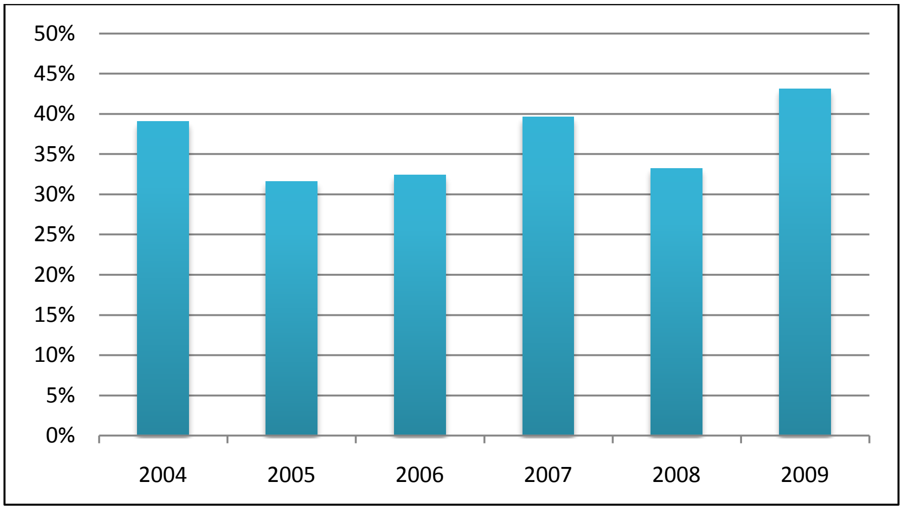
As in the case of the Retreat House, we did not evaluate the environmental impact of the gift shop as a specific element of the business analysis. However, energy use at the gift shop (electricity for heat and light) is not insignificant. The gift shop generates emissions of just under 15 tons of CO_2eq per year, and also generates emissions by purchasing merchandise from outside suppliers and shipping the merchandise to HCA by UPS or through the post office.

Finding ways to minimize energy use and emissions at the gift shop (as in all of HCA's activities) is essential to HCA's overall sustainability and will improve the gift shop's triple bottom line. HCA can reduce electricity consumption in the gift shop by exchanging incandescent light bulbs for CFLs and taking other actions suggested in Chapter 2. HCA can also improve its environmental performance by looking for opportunities to reduce shipping distance and shipping weights for merchandise orders (i.e., by sourcing merchandise locally or choosing paperbacks rather than hard covers when possible) and by consolidating incoming shipments. These efforts will help to reduce the upstream emissions associated with the gift shop's operation.

Economic and Social Performance

Because the gift shop generates positive net income on gross margins of 30%–40% (see Figure 22), our recommendations for improving the gift shop's economic performance generally target increased sales and revenue. In general, the recommendations are designed to address four broad marketing categories: (1) people (expanding the customer base), (2) products, (3) place (suggestions regarding the shop itself), and (4) promotion.

Figure 21: Gift shop gross profit margins, 2004–2009



Source: HCA

The first marketing category we would like to address is *people*. Because the gift shop is located in a relatively rural location and several miles from the nearest highway, we assumed that most customers who stop in at the gift shop are people who visit HCA for a retreat. However, gift shop sales are not as closely correlated with the number of visitors to the Retreat House as we expected. In fact, we learned through statistical regression analysis that only 50%–60% of the month-by-month variation in gift shop revenues over the last few years can be explained by changes in Retreat House occupancy.[40] During the months of October, November, and December, sales and the number of guests at the Retreat House essentially were unrelated.

It therefore appears that many gift shop customers visit HCA for reasons other than to participate in a retreat, such as to attend Mass at the chapel or meetings with the monks, or for the specific purpose of purchasing goods at the gift shop. This conclusion suggests that revenues from the sale of gift shop merchandise can be increased by developing promotional programs that target three general customer types: retreatants, people who visit HCA for business or worship purposes (e.g., worshippers, lay Cistercians, and other friends of the community), and regular retail customers from Berryville and surrounding regions. A few examples follow:

- Small displays of books and other gift shop merchandise could be set up in public areas (such as the lobby or library of the Retreat House and the foyer of the mansion) to introduce visitors and retreatants to products offered at the shop.

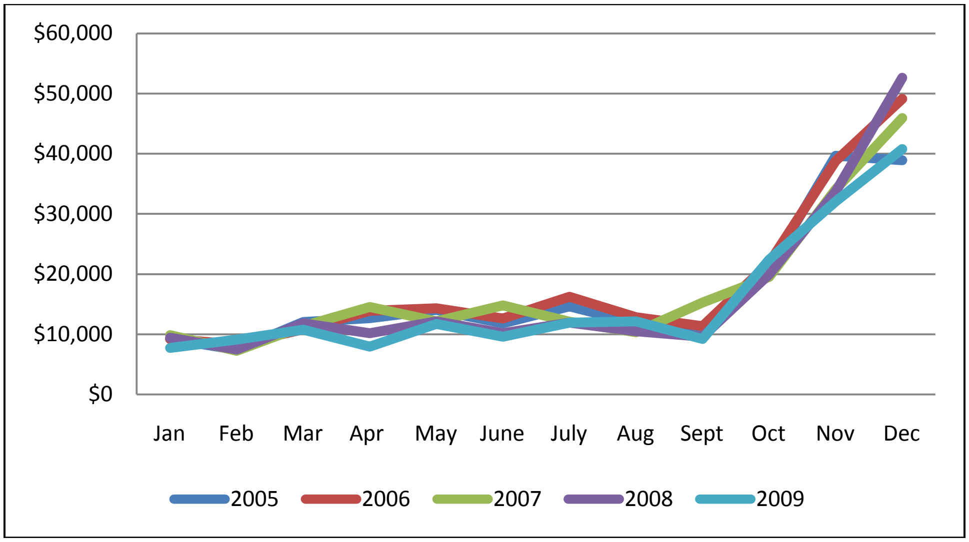
- HCA might place advertisements in local and regional church bulletins to make local churchgoers aware of items offered at the gift shop. Advertisements might be tailored to holidays and ecumenical seasons, and might be placed not only with Catholic churches but also with other denominations that might not be aware of the monastery's presence in the community.

- HCA might offer retreatants a small discount (say, 10%) on merchandise purchased at the gift shop before or at the conclusion of a retreat. A small discount might be sufficient to attract retreatants who otherwise might not make a purchase during their retreat experience.
- HCA might create a book club for individuals that regularly attend retreats or patronize the shop. Book clubs are simple and inexpensive to create (HCA need only keep a list of the members and create a membership card) and could offer several advantages to members, such as:
    - Newsletters or e-mails that describe newly arrived merchandise
    - "Buy 10, get 1 free," punch-card-type discounts that enable customers to get the tenth full-price book or CD free (these programs encourage customers to return to the store after making an initial purchase)
    - If enough people join the club, the community could offer invitations to private spirituality workshops and other special events (if HCA decides to host such events at the Retreat House).

Next, we will discuss *products* as a marketing category. We do not have the expertise to suggest modifications to the interesting and eclectic mix of merchandise that is offered for sale at the gift shop, nor (due to lack of data) can we offer a market analysis of religious books, CDs, and iconography. However, we would like to offer one product idea that might enhance the sustainability aspect of the gift shop operation. We believe overall production could increase if HCA begin selling (i.e., recycling) gently used books and CDs. HCA could encourage customers and retreatants to return books and CDs previously purchased from the gift shop and trade them in for cash or store credit. HCA then could mark up the used books and resell them from a special shelf marked "used." (Obviously, the markup at least would have to cover the cash or store credit paid to the customer.) Recycling used books would enable HCA to change up the product mix without shipping goods to the store from long-distance suppliers, and would encourage customers to return to the store and possibly make another purchase. A recycling program also might create substantial goodwill with customers interested in promoting sustainability.

Thirdly, the Team will discuss *place* as a marketability aspect of the gift shop. HCA's Gift Shop is conveniently located between the Retreat House and the chapel to encourage worshippers, retreatants, and other visitors to stop in. To make the gift shop even more convenient, we recommend that HCA consider extending the shop hours. As noted previously, while gift shop revenues are relatively constant through most of the year, revenues increase dramatically in October, November and December (*see* Figure 23). The additional revenue may be attributable in part to holiday shopping, but it also is likely due to the fact that the gift shop is open more during these months than it is during the rest of the year. In fact, the shop is open 10 additional hours per week during this period, including from 9:00 a.m. to 5:00 p.m. on Sundays. (From the beginning of January to mid-October, the shop is open only from 12:00 to 5:00 p.m. on Sundays.)

Figure 22: Gift shop monthly sales revenue, 2004–2009



Source: HCA

Sales might increase if HCA opened the shop from 9:00 a.m. to 5:00 p.m. on Sundays throughout the year. Opening on Sundays would provide an opportunity for churchgoers to shop before and after they attend the 11:00 a.m. Mass on Sunday mornings. In addition, HCA could open the shop from noon to 5:00 p.m. Monday through Saturday (instead of 1:15 p.m. to 5:00 p.m.), at least on a trial basis, to *see* whether opening over the lunch hour increases sales and revenue. If sales revenue does not increase after a few months of the extended hours, the hours can be returned to the current schedule.

The final marketing aspect we would like to address is *promotion*. The Team suggests that the community generate general ideas for promoting the shop to all customer types. None of these suggestions are novel or complicated, but having a list in one place might help the community develop a comprehensive promotional plan.

HCA could also create a substantive Web site specifically for the gift shop. More than half of online adults in the US use search engines for shopping, and half of those who do look for local retailers where they can buy products off-line.[41] Even people who do not shop online use the Internet to obtain basic information, such as store hours and location. Most retail experts agree that Yellow Pages listings (even online listings) are not enough; customers want more information about product offerings than Yellow Pages provides. Moreover, unlike traditional advertising, Web sites are available to customers and potential customers around the clock, all year long, and Web site design and site maintenance generally are considered to be extremely cost effective compared to other forms of advertising.

Unfortunately, searching for “Holy Cross gift shop” on Google fails to produce information regarding HCA’s gift shop in the first two search pages. Searching for “Holy Cross *Abbey* gift shop” turns up the hcava.org Web site within the first few results, but the link on the results page does not reveal information about the gift shop itself. At present, the gift shop Web page is buried two levels deep into HCA’s Web site, linking only through the Retreat House main page.

A new gift shop Web site should include substantive information about the gift shop’s offerings as well as basic information about shop hours and location. HCA’s current gift shop page contains only a brief description of the types of products offered and the store hours. A good promotional Web site lists product information, availability, pricing, photos, and (for bookstores) might even include book and music reviews or recommendations. The site should be updated frequently to reflect changes in inventory.

At some point, HCA might use the gift shop Web site as a platform for online sales (or "e-commerce"). E-commerce theoretically would enable HCA to serve more customers than currently visit the shop. Moreover, HCA's online store would include at least one collection—the religious iconography—that otherwise might not be available on the Internet. By offering these items through e-commerce, HCA might be able to reach a broader customer base than currently visits the shop. (We note, however, the e-commerce sales will increase the gift shop's carbon emissions because products purchased over the Internet would have to be shipped to customers through UPS or the USPS. HCA would have to balance this consequence against the need for additional revenues.)

HCA could create a more dynamic and interactive experience for customers. As simple as it may sound, in addition to carrying products that customers want to buy, the best way to get customers to return to a store is by making the shopping experience memorable. To us, two special factors characterize HCA's gift shop: its location within the grounds of the monastery and the opportunity it offers to discuss books, CDs, and other items with a monk.

Below are several strategies that we recommend for further enhancing the customer experience.

- Create and maintain a database of customer e-mail addresses. HCA can use e-mail to notify customers of seasonal sales, the arrival or new items, and more. HCA even can prepare and distribute book and music reviews. The gift shop list can be combined with lists maintained by the Retreat House and bakery for purposes of distributing newsletters and other information regarding events at the monastery. To create an e-mail list, HCA need only ask customers upon checking out whether they would like to be added to the list.

- Highlight gift shop products for customers while they are in the store. Post book and music recommendations and reviews near book and music displays, and photocopy published reviews when available. Erect themed displays containing books related to holidays and ecumenical seasons. Play monastic chants in the background on days when heavy customer traffic is expected, and display the name of the CD that is playing near the checkout to encourage impulse purchases.

- Carry more of HCA's bakery products (including the truffles and fraters) and display them prominently. Customers who come to HCA's gift shop most likely are especially interested in HCA's products. The community might even offer samples on days when they expect heavy customer traffic.

We encourage HCA to consider involving additional members of the community in the gift shop operations. As we make these recommendations, we are mindful of how important it is for one or more monks to staff the gift shop in order to recommend books and music and otherwise to interact with customers. Personal service is one of the hallmarks of HCA's small shop and one of the ways the shop can distinguish itself from competitors (including the growing number of online booksellers). We also are mindful that the shop currently is staffed by a single monk who manages the entire operation and also serves as sales clerk.

Over the long term, entrusting the entire operation to a single individual is not sustainable. Thus, as the community grows or other monks' time becomes available, we highly recommend that another monk be assigned to share in the responsibilities associated with the gift shop. At the very least, we encourage the community to solicit assistance at the gift shop from the volunteer community. We do not recommend hiring paid personnel at this time because personnel expense would erode profit margins.

The Bakery

Environmental Performance

As noted above in the Results section of this chapter, HCA's current bakery products generate approximately 94 tons of CO_2eq per year. The vast majority of these emissions result from the electricity and heating oil that HCA uses for lighting, climate control in the bakery building, operating the cool room and freezer, and running appliances and the oven. Emissions attributable to fruitcake production comprise approximately 50 tons per year (more than half of the total), but honey also is responsible for a significant portion of HCA's bakery emissions (30 tons per year). Fruitcake and honey bear such a large proportion of the bakery's environmental profile because, under our analysis, the energy that HCA consumes in the bakery is allocated entirely to these two products since they are manufactured in the bakery building.

HCA's best option *by far* for improving the environmental performance of the bakery is to reduce the amount of energy that it consumes for space heating and space cooling. Unfortunately, significant energy savings, while possible, are very expensive and possibly not cost effective.

There are a number of ways in which HCA could reduce the amount of energy used in the bakery for heating and cooling. The bakery uses a huge amount of energy for heating and cooling. As noted in Chapter 2, on average the bakery uses about 71,000 kWh of electricity per year. Using power meter readings, appliance and fixture specifications, and usage patterns, we estimated that:

- Between 1,000 and 2,000 kWh per year are used for lighting.
- Approximately 15,000 kWh per year are consumed during fruitcake bakes (1,000 kWh per bake).
- Around 9,500 kWh per year are consumed during honey production (around 350 kWh per production day).
- Space cooling consumes between 25,000 kWh and 45,000 kWh per year.
- Space heating consumes almost 4,000 kWh per year.

The bakery also uses approximately 2,100 gallons of heating oil. At an estimated oven capacity of 145,000 to 180,000 Btu per hour, we determined that approximately 80 gallons of heating oil per year are consumed to fuel the oven (approximately 5 gallons of oil per bake). The remainder of the 2,100 gallons of heating oil that HCA uses each year is consumed for space heating.

From these numbers it appears that most of the energy use at the bakery—41% to 69%—is attributable to space heating and cooling, not the production process. This intensive energy use is alarming, especially considering that the bakery is used relatively infrequently compared to other units (such as the monastic enclosure). In fact, at an average usage of 64 kBtu per square foot, the bakery uses about 30% more energy per square foot on an annual basis than the monastic enclosure. Managing energy use at the bakery is complicated by the building type and configuration. As noted in Chapter 2, extra energy probably is required for heating and cooling the bakery because large temperature differences must be maintained between the cool room and the room where the oven is located. The problem is exacerbated by the fact that the two areas are separated only by poorly insulated walls, a poorly insulated sliding door, and hanging plastic sheeting and the difference in temperature between the two rooms must be extreme during summer bakes when both the oven temperature and the outside ambient air increase the cooling load.

The best way for HCA to improve the environmental performance of the bakery products is to reduce the energy used for space heating and cooling. Possible strategies include:

- Finding and eliminating areas where heated or cooled air could leak from the building
- Reducing the number of summer bakes to reduce cooling needs
- Installing fixed, insulated doors between the adjacent areas
- Insulating the walls of the ingredient storage room
- Installing additional insulation in the walls and roof of the building

Unfortunately, the Team was unable to estimate the energy savings that might result from these strategies because we could not estimate the heat loss and gain from the bakery building using the computer model that we used for the monastic enclosure. (The building construction type for the bakery was not included in the model parameters.) Nevertheless, we must assume that the bakery has similar, if not worse, heat loss and gain ratios to the poorest insulated areas of the monastic enclosure. We expect that both the energy reduction and the financial savings from implementing these strategies would be significant. Assuming that is the case, then HCA almost certainly can significantly improve the environmental performance of the bakery products by improving the energy efficiency of the bakery building.

HCA could also minimize emissions from the other bakery processes. Reducing overall energy use will probably achieve the most significant reduction in the environmental footprint of HCA's bakery products, but other options also are available. The following suggestions should be considered:

1. *Inspect and maintain the oven annually to make sure it is operating efficiently*. When we embarked on this project, we hypothesized that HCA's bakery oven could be replaced with a newer model to achieve much greater energy efficiency. Specifically, we assumed that the oven's age and use of fuel oil (instead of natural gas) meant that it was extremely energy inefficient, and that newer technologies were available that would significantly improve the environmental performance of the bakery. To investigate this hypothesis, we contacted manufacturers of commercial bakery equipment, researched the EPA's ENERGY STAR® program to identify energy-efficient commercial ovens, reviewed academic literature for studies of bakery efficiency, and searched the popular media for articles and blogs for anecdotal information. We even spoke directly with two bakeries in the US that advertise themselves as "sustainable."

   Our hypothesis proved to be only partially true. Commercial ovens are *extremely* energy inefficient relative to many other equipment types. In fact, some commercial ovens receive the ENERGY STAR® rating for achieving only 44% energy efficiency.[42] Our hypothesis that HCA's older oven likely is very energy efficient therefore proved true. In fact, we used an energy efficiency of 45% when determining the amount of fuel oil consumed by HCA's oven.

   However, our hypothesis that effective alternatives exist for improving bakery technology proved untrue. We contacted several commercial oven manufacturers including Heritage Food Service Group (which now services Middlebury-Marshall ovens) and AMF Bakery Systems and were told that truly energy-efficient oven technology does not currently exist. AMF Bakery Systems in Quebec is working on improving the energy efficiency of commercial bakery technology, but the AMF engineer we spoke with told us that his company is only in the early stages of product development.[43] As noted by the owner of the Birdbath Neighborhood Green Bakery in New York,

   > I'm fairly certain that no environmentally friendly oven is out there, leaving [natural] gas vs. electric as the one area where a tangible difference might be applied. Beyond the ovens, professional kitchen equipment isn't an area with much progressive development towards greener choices. […] In part, this is why we focus to the Nth degree on so many other details in the operations of Birdbath. It's been easier to change behavior (example, we've reduced how much refrigeration we use) as opposed to finding green refrigeration. I think that will be the case for some time.[44]

   Replacing HCA's oven with a truly energy-efficient technology may not be an option at this time, and making incremental improvements probably would not be cost effective. Retrofitting HCA's oven to use propane would reduce carbon emissions, but because fuel oil is cheaper than propane, the estimated retrofit cost of $15,000 to $20,000 would not be cost effective.[45] Replacing HCA's oven with an electric oven might be cost effective, but the additional electricity consumption would result in even more carbon emissions and even worse environmental performance.

Nevertheless, HCA still should make sure that its oven operates as efficiently as possible. We contacted one technician who has a long history of maintaining and rebuilding commercial bakery ovens, including older Middlebury-Marshall ovens like HCA's. According to the technician, older ovens use energy efficiently when the burners are regularly inspected and maintained. As noted by one firm, "It is common knowledge in the bakery that some of the oven burner elements just don't light. These should be detected, repaired, or shut down."[46] HCA probably inspects the oven regularly and ensures that burners and other components are operating efficiently. If not, regular inspections and routine maintenance would ensure that the oven operates as efficiently as possible.

2. *Reduce the net weight of dried fruit in the fruitcake.* Energy used to transport fruitcake ingredients to the bakery is responsible for emissions of over seven tons of CO_2eq per year. Upstream energy for ingredients is particularly high for fruitcake because the fruit included in conventional fruitcake is heavy and HCA's primary fruit supplier is located approximately 1,000 miles from Berryville. (HCA's supplier of dates is located approximately 2,000 miles from Berryville.) HCA can reduce the energy used to transport fruitcake ingredients by reducing the amount of fruit it includes in each fruitcake. HCA can also reduce the energy used to transport fruitcake ingredients by sourcing the ingredients more locally.

Economic Performance

As noted in the Results section, profits from the bakery have declined significantly in recent years, primarily due to decreasing unit sales of fruitcake. Unfortunately, the market for fruitcake is likely to grow at a very slow rate over the next several years. In this subsection, we suggest that HCA reduce its reliance on fruitcake sales and introduce new products to spur revenue and profit growth. Although we do not recommend a specific new product, this subsection summarizes current trends in bakery products that HCA might consider during product development. We also propose a few suggestions for packaging that might make the Bakery operations more consistent with HCA's sustainability efforts.

The Future of Fruitcake

HCA should reduce its reliance on fruitcake and introduce new products to spur growth. The market for sweet baked goods (including fruitcakes) is expected to grow at a very slow rate, and growth is dependent on new product innovation. Moreover, HCA's fruitcake competes with numerous other fruitcakes that are available by mail order and through the Internet. Fruitcakes even are available from other OCSO houses.

Somewhat to our surprise, we located a study during our research that estimates the demand for fruitcakes during the period of 2007 through 2012. The research firm determined that the latent US demand for "holiday-type fruitcakes (excluding frozen cakes)" was $219.7 million in 2007 and was expected to grow to $312.2 million in 2012. Overall, latent demand for fruitcakes was predicted to grow approximately 42% between 2007 and 2012.[47] Three regions accounted for more than 56% of this demand: the Far West (22%), the Mid-Atlantic (18%), and the Southeast (16%).[48]

Unfortunately, this study may not be particularly useful as a way of predicting future fruitcake sales. The study extrapolates fruitcake revenues from the existence of a given level of economic activity in a particular area rather than from primary data, such as actual or historical fruitcake sales, the existence of bakeries to fulfill the fruitcake demand, or any other specifically salient factor. The study prediction (i.e., that fruitcake sales will increase 42% between 2007 and 2012) at the very least should be taken with a grain of salt.

We therefore reviewed two other market research studies to increase our knowledge of the future of fruitcake sales. The first study relied on both primary and secondary data to estimate sales of prepackaged cakes, pies, and other sweet bakery products.[49] The study concluded that sales of these products would grow, but at a very modest rate. Specifically, the study concluded that the market for prepackaged cakes (a subset of the market category) would be $927 million in 2004 and would grow at a rate of approximately 4% or 5% per year through 2009. The study did not focus specifically on fruitcakes.[50]

The second study relied on primary and secondary data to estimate sales of "gourmet and specialty" sweet baked goods. For purposes of this study, the sweet baked goods category included pound cakes, fruit breads, liqueur-flavored cakes, cheesecakes, fruitcakes, seasonal pastries (such as Italian panettone or German stolen), and small pastries such as petits fours and rugulach.[51] The study concluded that gourmet and specialty sweet baked goods produced the least growth of all confectionary and dessert categories, growing just 1% to 1.5% annually between 1996 and 2000. Slow sales growth continued between 2000 and 2005.[52]

We cannot conclude a particular growth rate from any of these market studies, but it seems likely that the growth rate for fruitcake sales will be modest at best. The market for conventional sweet baked goods in the US essentially has matured.[53] Literally thousands of products and thousands of manufacturers exist to serve up ice cream, cookies, candies, chocolate, and other confections to satisfy the American sweet tooth. As a result, there has been a constant flow of new products into the packaged sweet baked goods market, and industry experts believe that ongoing new product introduction is mandatory for any serious competitor.[54] By comparison, fruitcakes have remained essentially unchanged for decades. In addition, slow growth in fruitcake sales makes it more difficult for monastery fruitcakes to compete against one another for customers. A brief online search of mail order/e-commerce fruitcakes revealed 14 different manufacturers; five of them were monasteries.[55]

We do not recommend that HCA completely discontinue fruitcake production at this time. There probably will always be a loyal group of customers interested in buying monastery fruitcakes, in part because they like fruitcake and in part because the purchase supports the monastery. Moreover, HCA would have to produce and sell a lot of creamed honey and other products to make up the revenues that fruitcake generated in 2009. However, we do suggest that HCA reduce its reliance on fruitcake revenue and develop new products to encourage revenue growth.

We encourage HCA to consider raising fruitcake prices. We suggest a slight price increase to better reflect market prices for mail order/e-commerce fruitcakes. To evaluate HCA's prices relative to its competition, we identified competitive products by searching for "fruitcake" and/or "monastery fruitcake" on Google, and determining the products and prices offered by the competitive firms we identified in the search. The results of the search are included in Appendix 6-C.

High, low, and average prices for fruitcakes of various weights are shown in Table 8. For a fruitcake weighing an average of 36 ounces (2.25 pounds), HCA's fruitcake is priced above the average but certainly is not the highest-priced fruitcake on the market in that weight range. Raising the price to $29.95 (or, to $0.83 per ounce) would result in additional revenue of $2 per cake and would generate additional revenue of $20,000 on an annual sales volume of 10,000 fruitcakes.

Table 8: Average fruitcake prices

	Price Range (per ounce)			HCA Price
Fruitcake Weight	**Low**	**Average**	**High**	
Less than 1 lbs	$ 0.43	$ 0.93	$ 1.25	-
1-2 lbs	$ 0.34	$ 0.84	$ 1.25	-
2-3 lbs	$ 0.48	$ 0.66	$ 0.84	$ 0.78
Greater than 3 lbs	$ 0.70	$ 0.71	$ 0.73	-

Source: This table summarizes data from Appendix 6-C.

HCA could consider increasing honey production. At a retail profit margin of 65%, HCA's creamed honey is much more profitable than fruitcake, which has a retail profit margin of 17% (23% if the per unit fruitcake price is increased to $29.95). *See* Table 9. Although retail honey sales have leveled off in the past year or two, revenues from creamed honey have continued to increase (*see* Figure 23). Moreover, honey production requires much less "monk time" than baking and packing fruitcakes—around 675 hours per year compared to 2,000 hours per year for fruitcake—and has a lower environmental impact. In fact, very rough calculations suggest that the total margin on honey sales in 2009 actually may have been greater than the margin on fruitcake sales (*see* Table 10), and honey required much less of the monks' time and effort and generated less environmental impact.

Table 9: Estimated margin on bakery products, per unit (2009)

	Revenue	Cost*	Profit Margin**
Fruitcake	$27.95	$23.18	17%
Honey	$19.95	$6.92	65%
Fraters	$19.95	$11.42	43%
Truffles	$19.95	$6.00	70%

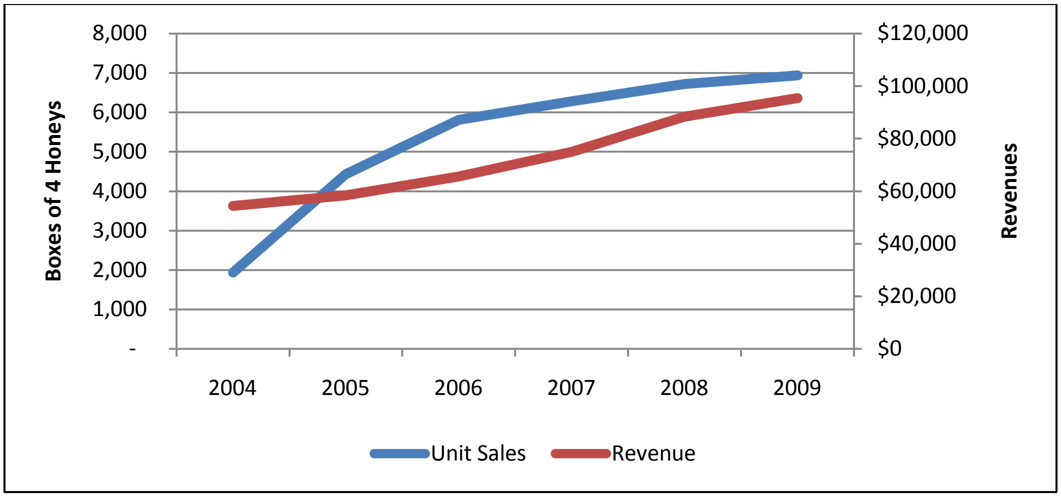
Source: HCA. *not including overhead costs **=(revenue – cost)/revenue

Table 10: Estimated annual margin on bakery products (2009)

	Revenue	Profit Margin	Est. Margin*
Fruitcake	$296,936	17%	$50,676
Honey	$95,373	65%	$62,291
Fraters	$42,991	43%	$18,382
Truffles	$43,149	70%	$30,172

Source: HCA. *=revenue x profit margin

Figure 23: Creamed honey unit sales and revenue

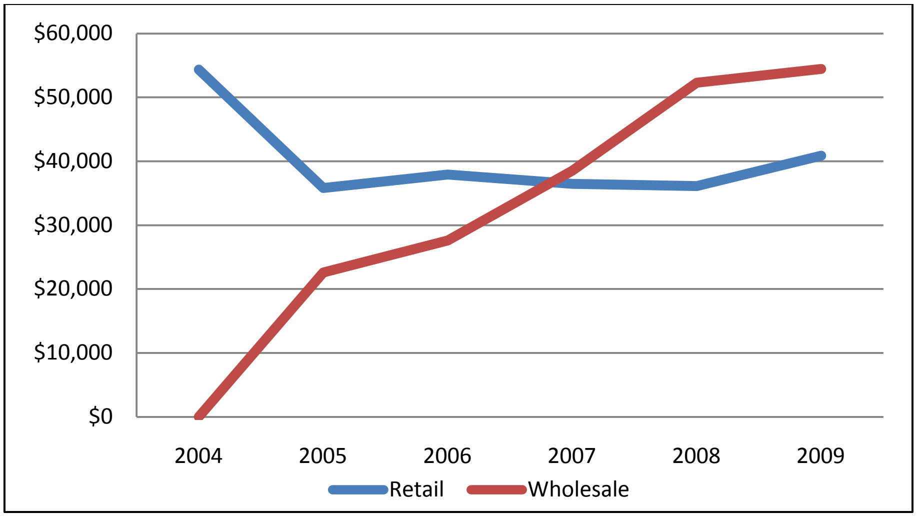


Source: HCA

While HCA's honey is a terrific product, simply making and selling more of the current honey varieties may not generate sustainable long-term sales growth. New flavors could be introduced to stimulate and sustain sales. Our research revealed that, in addition to the traditional favorites (natural, cinnamon, and lemon), creamed honey is offered in several untraditional flavors, such as peach, raspberry, strawberry, jalapeno, pecan, amaretto, ginger, and orange. Commercial honey flavors are sold in 12-oz or 14-oz glass jars for $6.95 to $7.89 per jar.

In addition, focusing on wholesale distribution for creamed honey sales makes more sense than pursuing additional mail order/e-commerce business. Wholesale distribution has generated much of the growth in honey sales over the past few years (*see* Figure 24). Wholesale distribution can be more efficient than retail sales because wholesale orders tend to be larger than typical retail orders and require less processing time. If the honey sells well at wholesale, customers are likely to place additional orders, thereby spreading the cost of the initial order over more units.

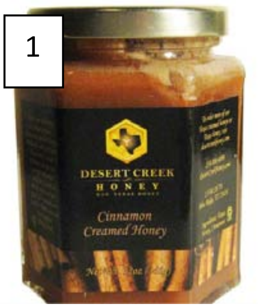
Figure 24: Wholesale vs. retail honey sales, 2004–2009



Source: HCA

If HCA continues to focus on wholesale distribution, it might decide to modify the honey packaging. HCA's honey currently is offered only in 10-oz plastic tubs, whereas competitor products are offered in higher-quality glass jars (*see* Figure 24). In addition to glass jars, one competitor (Our Lady of the Redwoods Monastery, www.holyorders.biz) packages jars of honey in small burlap bags, which allows them to include a preprinted card that describes how the honey is made (Figure 24, photograph 2). The downside of using glass jars, however, may be that the product shipping weight probably will increase. Increasing the weight of the jars will cause HCA's upstream and downstream emissions to increase, thereby increasing HCA's environmental performance. Increasing wholesale distribution rather than focusing on mail order sales might minimize this concern.

Figure 25: Creamed honey packaging



Sources: (1) www.desertcreekhoney.com, (2) & (3) www.holyorders.biz, (4) www.thevirginiamarketplace.com.

A New Focus for HCA's Bakery Products

Much more study and analysis would be required—especially detailed market research and demand analysis—before a specific product could be recommended to supplement or replace fruitcakes. Product development is beyond the scope of this project and requires expertise not represented on our Team. However, in light of HCA's sustainability initiative we offer a few general suggestions for growth areas that may be worth exploring.

First, HCA could consider a gourmet or specialty focus for new products. Sales of gourmet and specialty foods are expected to grow an average of 10% per year through 2012.[56] Specialty food products generally are foods, beverages, or confections that are "of the highest grade, style, and/or quality in their category due to their uniqueness, exotic origin, particular processing, design, limited supply, unusual application or use, extraordinary packaging, or channel of distribution."[57] The common denominator of gourmet and specialty goods is their unusually high quality.[58]

The community could address the seasonality of their current product line. Sales of fruitcakes and other specialty baked goods peak in the fourth quarter because they are associated with holiday entertaining and are often given as gifts.[59] Holiday consciousness probably stimulates fruitcake sales because fruitcakes are strongly associated with Thanksgiving and Christmas and the dense, rich fruitcake appeals to consumers during colder weather.[60]

However, seasonal sales intensify production at certain times of the year and also create uneven revenue streams. As HCA considers the future of the bakery operation, one factor it might take into account is the seasonality of existing production and whether it can be balanced by new products at other times of the year. One idea would be to develop a product that could be marketed for spring and summer entertaining and gift giving, such as for Easter or Mother's Day. Addressing seasonality would spread the production burden over more of the year and even out revenues.

HCA should consider natural and/or organic products. There is a growing synergy between the organic/natural foods industry and the gourmet foods industry. In 2000, the U.S. Department of Agriculture estimated that nearly $8 billion was spent on organic food purchases in the US, and predicted that spending on organic food over the next decade would grow approximately 20% per year.[61] According to the Organic Trade Association, sales of organic foods were $20 billion in 2007,[62] reflecting growth of approximately 21% per year. Sales were expected to continue to increase through 2010.

Sales of organic food mirror changing perceptions among consumers regarding the importance of health in food selection. In a survey conducted in 2007 by the International Food Information Council Foundation (IFIC), 65% of respondents cited "healthfulness" as a key factor in their food purchasing decisions (up from 58% in 2006) and 80% of respondents said they are consuming or would be interested in consuming foods or beverages for health and wellness benefits.[63] This is not to say that consumers will move to "ultra-healthy" food and no longer will purchase sweets and other indulgences. Whereas a decade ago Americans completely avoided sugar, fat, cholesterol, and sodium, we apparently have recovered from this trend and now allow ourselves sweets and other indulgences in moderation.[64] However, "healthfulness" as a factor in food choice is certainly a trend expected to last.

Becoming an organic food producer can be a complicated process. Federal laws and regulations require producers who intend to sell, label, or represent their products as "100 percent organic," "organic," or "made with organic ingredients" to comply with strict regulations.[65] A few examples are listed below.

- Products labeled as "100 percent organic" must contain only organically produced ingredients and processing aids.
- "Organic" products must contain at least 95 percent organically produced ingredients (except water and salt) and all remaining ingredients must meet certain additional requirements.
- Products marketed under the label "made with organic ingredients" must contain at least 70% organic ingredients; in that case, the label can list up to three specific organic ingredients (e.g., "Made with Organic Fruits and Nuts").[66]

Organic production methods generally involve natural (as opposed to synthetic) inputs, that is, the methods do not involve pesticides, herbicides, genetically engineered substances, ionizing radiation, or sewage sludge.[67]

In addition, federal law requires producers who wish to become accredited as organic food producers to submit a comprehensive application to a certifying agent that includes the applicant's organic system plan. The plan must describe (among other things) how the practices and substances used in production comply with the organic production standards, recordkeeping procedures, and practices employed to prevent commingling of organic and nonorganic products.[68] Certification can be expensive and can take six months to a year. Federal cost-sharing programs are available to defray the cost of the certification.[69]

We recommend that HCA consider organic production not only because organic food production fits well into a sustainability agenda, but also (consistent with the TBL analysis) because it may be very good business. As noted, the market for organic food is growing many times faster than the market for conventional food[70] and is expected to continue growing as consumers become more and more interested in "pure and authentic" food items.

Finally, it is worth mentioning that HCA may be able to integrate organic production into certain aspects of its existing bakery operation. There is such a thing as an "organic" fruitcake. We found a recipe for an organic dried fruitcake during our research. (We reproduced the recipe in Appendix 6-D.) We also found an organic fruitcake made and sold by Old Cavendish (www.cavendishfruitcake.com). Old Cavendish sells a 1-lb fruitcake made entirely from organic ingredients for $25.00 (including shipping). For purposes of comparison, a list of conventional fruitcake ingredients, Old Cavendish's ingredients, and the ingredients listed in the recipe we found are shown in Table 11.

Figure 26: Old Cavendish "norganic" fruitcake[1]

Source: www.mondofruitcake.com

We do not know whether Old Cavendish's fruitcake was a good seller or if organic fruitcake generally would be more profitable than another bakery product. And we are fairly certain that organic ingredients would be more expensive than conventional fruitcake ingredients.[71] But the Team is fairly certain that an organic variation of a cake containing dried fruit and nuts might appeal to the organic consumer. We encourage HCA to at least consider offering a dried fruit and nut cake.

HCA should also consider gluten-free products. One of the fastest growing segments of the specialty foods market is the segment that consists of gluten-free foods. Generally speaking, gluten is protein found in wheat, barley, rye, and other grains that has been associated with numerous medical problems (including gluten allergy/insensitivity, autism, attention-deficit/hyperactivity disorder, multiple sclerosis, repetitive strain (or stress) injury, and irritated bowel syndrome). However, the main problem with gluten is celiac disease. Celiac disease is known to afflict 40,000 to 60,000 Americans, but is often misdiagnosed. The US government estimates that celiac disease in fact may afflict as many as 1.5 million to 3 million Americans.[72]

Table 11: Conventional and organic fruitcake ingredients[73]

Conventional Fruitcake	Old Cavendish "Norganic" Fruitcake	Recipe for Organic Fruit and Nut Cake
Green cherries*	Organic cashew nuts	Organic dates
Red cherries*	Organic honey	Organic dried apricots
Papaya*	Organic raisins	Organic raisins
Pineapple*	Organic apricots	Organic dried apples
Raisins	Organic dates	Organic dried cranberries
Dates	Organic eggs	Organic dried cherries
Walnuts	Organic wheat flour	Brandy
Pecans	Organic butter	Organic walnuts
Lemon and orange peel*	Organic orange juice	Organic pecans
Butter	Organic cream	Organic butter
Eggs	Organic lemon juice	Organic sugar
Brandy concentrate	Orange liqueur	Organic eggs
Calcium propionate	Brandy	Organic flour
Spices	Organic spices	Organic spices
Flour	Baking powder	Cream of tartar
Honey		
Lemon emulsion		
Pineapple juice		
Powdered milk		
Sherry		
Shortening		
Sugar		
*contains corn syrup, high fructose corn syrup, citric acid, natural and artificial flavor, FD&C Red #40; preserved with 1/10 of 1% potassium sorbate, benzoate of soda, sulphur dioxide.		

More and more consumers have turned to gluten-free diets in recent years, either to address a specific condition or because they believe that eating gluten-free food is part of embracing a healthy diet. Correspondingly, the market for gluten-free foods grew at a rate of 25%–30% per year from 2004 to 2008, to an estimated total of $1.56 billion. The market is expected to continue to grow rapidly (15% to 20% annual growth) through 2012 and beyond.[74]

Developing a gluten-free bakery product would be challenging but certainly possible. As noted by one research firm, "[A]n astounding number of different plants have been used to create [nonglutinous] flour."[75] A list of plant types that have been used in gluten-free foods is shown in Table 10. However, recipe development for gluten-free foods can be challenging, especially in the case of breads and baked goods. Gluten generally functions to provide elasticity, structure, and substance in bread dough, so simply replacing wheat, barley, rye or other glutinous flours with gluten-free flours generally produces a poor-quality product.[76] Some combination of gluten free flours, or gluten-free flour mixed with other ingredients, generally is required to produce appealing gluten-free bakery products.

HCA might consider developing products that use locally available ingredients and can be marketed locally. Within the past few years, the movement to "go local" has begun reaching critical mass among the public.[77] Local foods generally are foods sourced within relatively close range of their ultimate point of sale, typically within a 250-mile radius, or at most no more than a day's drive away.[78] One catalyst for this trend is that the "food miles" concept (that is, how far food travels from producer to consumer) has reached the mainstream consciousness. American consumers increasingly believe that greater "food miles" causes greater environmental impact through energy consumption and pollution.[79] Another key driver behind this trend is that US consumers believe fresh and locally grown products are tastier and healthier than their packaged/processed counterparts.[80]

Table 12: Plants used to produce gluten-free flour

Acorn	Chickpea	Plantain
Almond	Corn	Potato and sweet potato
Amaranth	Flax seed	Quinoa
Arrowroot	Garbanzo beans	Rice
Brown rice	Hominy	Sesame
Buckwheat	Kasha	Milo (sorghum)
Cassava	Lentil	Sunflower
Chestnut	Millet	Soybeans

Source: Packaged Facts, "The Gluten-Free Food and Beverage Market: Trends and Developments Worldwide, 2d Edition" (April 2009).

Researchers believe that the local food movement may be one of the fastest-growing food trends in the US. Locally grown foods represent about a $5 billion market in 2007, up from approximately $4 billion in 2002. Based on the exponential growth of farmers' markets, as well as retail and foodservice initiatives to add more local products to their merchandise mix and menus, experts currently estimate that local food could be a $7 billion business by 2011.[81]

Developing products that rely on local ingredients requires HCA to identify foods and ingredients that are available locally in sufficient supply for commercial productive purposes. The Virginia Department of Agriculture and Consumer Services (VDACS) is one source of information about locally available products. VDACS prepares and updates a chart that identifies Virginia-grown produce and other products that may be available to Virginia food producers.[82] An example of the chart is included as Appendix 6-E. Similarly, the West Virginia Department of Agriculture maintains a database of producers and processers of food products made in West Virginia.[83]

Examples of locally available ingredients that may provide the basis for future bakery products include honey, apples, tomatoes, peaches, or peanuts. One of our sources of local food information suggested that the monastery might have wonderful success with sun-dried tomato focaccia.[84]

Sustainable Packaging

As noted above, very little of HCA's environmental impact arises from the upstream and downstream energy related to HCA's packaging components. As a result, focusing on the current packaging components during the early stages of HCA's sustainability initiative probably will not generate large reductions in HCA's emissions baseline. Nevertheless, in this section we provide general information about sustainable packaging practices. These best practices may help HCA integrate the sustainability agenda into future packaging decisions.

We encourage HCA to introduce sustainable packaging components when possible. Although in our analysis HCA's packaging did not contribute significantly to its emissions baseline, the full impact of HCA's packaging likely is much greater. As we explained, our analysis focused only on the energy required to ship packaging components to HCA and on including packaging in shipments to customers, not on the full life cycle of the packaging elements.

Table 13 compares common food and beverage packaging materials in terms of several aspects of sustainability and considering their full life-cycle impact. As shown in the table, all packaging components have pros and cons from a sustainability standpoint. For example, paper and cardboard packaging is lighter, made from renewable resources, and more recyclable than, say, plastic packaging, but paper packaging takes up more space than plastic if land filled (and not recycled). Glass packaging is heavy, comprised of minerals and other nonrenewable materials, and energy intensive, but glass can be recycled over and over again in most US communities.

Table 13: Sustainability comparison of common food & beverage packaging materials

Aspect of Sustainability	Paper	Plastic bottles	Plastic film	Metal cans/tins	Metal foil	Glass	Flexible*
Made from renewable raw materials	X						
Can use recycled content	X			X		X	
Can be made thin and light as appropriate	X	X	X	X		X	
High ratio of product to packaging			X		X		X
Light weight (for transport)	X	X	X				X
Energy-intensive manufacturing process	X	X	X	X	X	X	X
High GHG emissions during manufacture	X	X		X	X	X	X
Commonly recyclable	X	X		X		X	
Low landfill density		X	X	X	X		X
High landfill density	X					X	

Source: Packaged Facts, "Sustainable ("Green" Packaging Market for Food and Beverage Worldwide, 2d Edition," (May 2009). * "Flexible" packaging includes bags, pouches, and wraps.

We encourage HCA to reference this table and consider the sustainability aspects of various packaging materials when reordering existing packaging and making future packaging decisions. Here are a few suggestions:

If it has not already done so, HCA could contact the supplier of its shippers to find out whether boxes made from recycled content are available.

- HCA could determine whether shippers and frater/truffle boxes could be made thinner and lighter (without compromising functionality). Lighter packaging would reduce upstream and downstream energy consumption.
- HCA might consider eliminating the metal fruitcake tin (if alternate, more sustainable packaging (shredded paper?) can be developed that adequately secures the fruitcakes for shipping).
- HCA might reserve the fruitcake tin for use only as a promotion. For example, HCA might offer a special decorative tin only at an additional charge or for gifts. Alternatively, HCA could offer the tin only to customers who purchase Christmas fruitcakes before a specific date.

HCA could upgrade packaging to connote a gourmet or specialty focus. Packaging upgrades may be appropriate if HCA adopts a gourmet or specialty focus. Packaging is one of the key criteria that consumers consider when perceiving specialty foods as worthy of the "gourmet" label and a premium price.[85] Gourmet products often are packaged in decorative, reusable containers that are changed often to attract and maintain consumer interest. In addition, introducing special packaging for Mother's Day, Valentine's Day, Christmas, and other holidays adds to a product's continuing appeal.[86]

Additionally, HCA could design packaging for new products to communicate to consumers that a product is sustainable. According to one firm, several basic tenets apply to package communications when promoting the sustainability of a given product:

- Incorporate imagery that connects products to their natural earthly source to provide a narrative that consumers can connect to. Include sourcing cues for where ingredients are grown, emphasizing local connections where relevant and including images and descriptions of the raw ingredients themselves. Also include a narrative on how, by whom, or where the product was produced.

- Highlight key "absences" (for example, various ingredients with negative associations, such as genetically modified organisms or preservatives) rather than merely using the term *natural*. Determine which absences are most important in conveying freshness and sustainability for a given product. Reserve less-important absences for secondary messaging.

- Use eco-friendly packaging innovations as a secondary message for products that already resonate as sustainable in their essential makeup. Use a restrained color palette (neutral primary colors and complementary earth tones). Use contemporary photographic images.[87]

Social Performance

The continued viability of HCA's bakery depends not only on revenue growth and healthy profits but also on the ability of HCA's members to provide labor for bakery operations. As noted above, producing fruitcakes and creamed honey currently demands around 2,000 hours of labor per year from members of the HCA community. While HCA continues to view this and other labors as essential components of the monastic lifestyle, the diminished size of the community and the advanced age of many community members create limited opportunities for more labor-intensive activities at the bakery. In fact, unless the community gains new members, "monk time" at the bakery probably will have to decrease.

Unless HCA gains new members who can supply the necessary labor, it will have to depend on outsiders. HCA could expand the opportunities for retreatants to work in the bakery, but because retreatant labor is intermittent at best, using volunteers for complex production tasks would be impractical. HCA also could hire part-time employees to work in the bakery. However, unless revenues increase and/or profit margins improve significantly, additional personnel expense would further erode available net income from bakery operations.

Another option would be for HCA to partner with others to develop new products. As noted several times in this section, developing new products for commercial distribution can be challenging, especially when the product category is new (gourmet, organic, gluten-free, etc.). As with all economic activities, HCA may find it helpful to partner with an outside individual for expertise and assistance. In fact, HCA may find it necessary to hire a business manager to work with the bakery manager in the development of new products. The business manager ideally would have experience in new product development or at least would have contacts and ideas for connecting HCA with appropriate individuals.

During our research for this project, we spoke with one individual who expressed keen interest in helping HCA identify opportunities for creating natural and organic products. Jared Mizrahi, the owner of Blue Mountain Organics in Floyd, Virginia, told us that he would be delighted to help HCA develop an organic fruitcake (for example) without charge. Mr. Mizrahi's contact information is listed in Appendix 6-F.

HCA could also partner with others to more fully utilize the oven and other bakery assets. HCA might be able to continue or even expand bakery operations—without requiring more time from the monks—if it found a partner or tenant to share the costs of the bakery. HCA currently uses the bakery for production activities only 57 days per year. Of the 57 days, 30 are used for fruitcake production (15 bakes * 2 days/bake) and 27 are used for creamed honey production. As a result, 200 days per year theoretically remain available for another company to use the oven and other bakery appliances. HCA might be able to find a partner willing to supply personnel for fruitcake and honey production as part of an arrangement where the partner uses the bakery to produce its own products. Alternatively, a tenant might rent the bakery for cash plus an agreement to provide personnel to help make fruitcakes, honey, and other monastery products.

The community should consider additional contracts with private label manufacturers. In essence, private label manufacturers allow customers to place their own labels on boxes, jars, or bottles of products that the manufacturer produces for them. Some private label manufacturers work with clients to develop or perfect a recipe to make sure the end product satisfies the customers standards of quality. HCA's arrangement with DeFluri's is an example of private label manufacturing. DeFluri's manufactures truffles at its shop in West Virginia and sells the finished product to HCA for sale under the HCA label.

Private label manufacturing might work especially well for HCA since it has a loyal customer base and can expect some level of continued fruitcake sales. HCA also may decide to expand its product line to include new bakery products. However, HCA is becoming less and less able to produce bakery products without undue stress on the community. Contract manufacturing would enable HCA to sell fruitcakes and other bakery products without having to produce the products at the HCA facility.

Numerous private label manufacturers are available to produce baked goods. Some private label manufacturers specialize in particular types of products. For example, The Bakery Barn (www.bakery-barn.com), a bakery in the Pittsburgh area, specializes in the contract manufacture of protein-enhanced cookies and sports/nutrition bars. SunOpta (www.sunopta.com), which has several facilities in the US, specializes in high-quality, cost-efficient private label products to support the organic and natural foods industry. Whereas many private label manufacturers typically rely on large volume contracts for business, other manufacturers are trying to add retail capabilities and therefore are willing to work with entrepreneurs and smaller companies.[88] Ideally, HCA would seek out contract manufacturers who are located near the HCA facility to minimize travel and shipping distance. A few contract manufacturers and other resources are identified in the contact list that we included in Appendix 6-F.

The Farm

Environmental Performance

Conventional farming may not be consistent with HCA's sustainability initiatives. The current farm operation has a significant adverse impact on the environment. As we described in the Land Use section of this report, conventional farming releases toxic chemicals into the environment, uses a large amount of petroleum-based fuels, erodes the shoreline, and causes water pollution that contributes to hypoxia in the Chesapeake Bay. Organic and other progressive farming practices would have far less impact on the environment, while keeping HCA's property in productive use.

We encourage HCA to weigh not only the economic costs but also the environmental costs when charting a future course for the farm property. On one hand, good reasons exist for continuing to lease HCA's property for farming. Farming has long been part of the Cistercian tradition and HCA's experience in the Shenandoah Valley. Moreover, however unprofitable the current lease arrangement may be for HCA, it puts acreage outside the monastic enclosure—land that otherwise might lay fallow—to productive use. The lease also may create an economic benefit for the farmer who leases the land.[89] Finally, although we have not investigated the property tax implications of the farm as part of this project, leasing the property for farming may reduce HCA's property taxes under Virginia's Use Value Taxation system.[90] We do not know whether HCA could continue to value its land as agricultural for tax purposes if farming operations were discontinued.

Economic and Social Performance

We have identified several rather straightforward opportunities for HCA to improve the economic performance of the farm, primarily through future lease terms that are more favorable to HCA. Our recommendations include the following:

- Raise the rental rate per acre to better reflect the rental market for agricultural land in northern Virginia and (more specifically) the Shenandoah Valley.
- Incorporate an annual percentage increase or rate schedule that reflects anticipated increases in the market rate.
- Determine whether HCA is currently paying variable costs related to the tenant's farm operation and shift the burden of those costs to the tenant.

Finally, the Team recommends that HCA take a hard look at whether future farm leases make sense in the context of HCA's sustainability initiatives, considering both the environmental impact of the farm and its limited potential for generating economic profits.

HCA could increase the per-acre rental rate. HCA could significantly improve the income from the farm by negotiating new lease terms that reflect market rental rates. HCA receives an average of $18 per acre for renting approximately 1,000 acres to the current tenant. However, as explained below, market rates for agricultural property in northern Virginia and the Shenandoah Valley are significantly higher than $18 per acre. If HCA chooses to continue renting property for farming after the expiration of the current lease in 2012, we recommend that HCA negotiate a higher per-acre rental rate than is included in the current lease.

We reviewed two sources of information to identify benchmark agricultural rental rates for HCA's property. According to the U.S. Department of Agriculture, cropland in Virginia rented for an average of $45 per acre and pastureland rented for an average of $21 per acre in 2008. Average rates in the agricultural district of *northern* Virginia were not quite so high, but still were significantly higher than $18 per acre. Average per-acre rentals for each type of property in several counties in northern Virginia are listed in Table 14. As shown in Table 14, the average rental rates for cropland and pasture in the northern Virginia agricultural district in 2008 were $34.14 and $22.60, respectively.

Table 14: Average cash rents for nonirrigated cropland and pasture in northern Virginia, 2008

County	County Code	Ag. District	Cropland ($ rent/acre)	Pasture ($ rent/acre)	Average ($ rent/acre)
Culpeper	47	Northern	$29.00	n/a	n/a
Fauquier	61	Northern	$29.00	$18.00	$23.50
Frederick	69	Northern	$33.00	n/a	n/a
Page	139	Northern	$32.00	$21.00	$26.50
Rockingham	165	Northern	$59.00	$35.00	$29.50
Shenandoah	171	Northern	$28.00	$21.00	$24.50
Other counties	998	Northern	$29.00	$18.00	$23.50
Average			**$34.14**	**$22.60**	**$25.50**

Source: USDA, National Agricultural Statistics Service, www.nass.usda.gov (2010).

The second source of information we identified was the Virginia Cooperative Extension (VCE). According to the VCE, the 2009 rental rates for cropland and pasture in Clarke County were $30.49 and $23.59, respectively, which is lower than the average reported by the USDA for the northern Virginia agricultural district but still higher than the rental amount in HCA's current lease. Rental rates for all counties in the Shenandoah Valley are reported in Table 15. As explained by the VCE, within each rental category, the very high rental rates were generally for smaller parcels of land[91] and the very low rental rates often had other circumstances involved, such as the desire by landowner to maintain land use valuation on the parcel or a family relationship between landowner and tenant.

In light of the significantly higher market rates for agricultural land in northern Virginia and the Shenandoah Valley, we recommend that HCA try to obtain a higher rental rate if it chooses to continue the farm lease. Ideally, the rate would at least equal the average rental rate for Clarke County: between $30 and $34 per acre for cropland and between $23 and $24 per acre for pasture, or an overall rental rate of $26 to $29 per acre.

At current costs, receiving a higher rent per acre might enable HCA to break even on the lease. HCA incurred approximately $27,000 in costs related to the farm (i.e., liability insurance, property tax, utilities (electricity and waste removal), maintenance/repairs, and depreciation) in 2009. HCA must charge a rental rate of at least $27 per acre ($27,000/1,000 acres) to cover these costs. At a market rate of $26 to $29 per acre, HCA would have been able to cover the costs charged to the farm in 2009.

Table 15: Average cash rents for cropland and pasture in the Shenandoah Valley (per acre), 2009

County	Cropland			Pasture		
	Average	Low	High	Average	Low	High
Augusta	$45.14	$15.00	$250.00	$27.46	$3.00	$150.00
Bath	$30.44	$10.00	$40.00	$14.91	$8.00	$26.00
Highland	n/a	n/a	n/a	$17.37	$8.49	$22.40
Rockbridge	$26.73	$23.33	$34.00	$15.23	$8.57	$35.00
Rockingham	$73.59	$23.00	$140.00	$34.96	$10.00	$65.00
Clarke	**$30.49**	**$14.00**	**$40.00**	**$23.59**	**$4.00**	**$45.00**
Frederick	$20.14	$17.00	$35.00	$17.11	$9.60	$30.00
Page	$48.19	$36.00	$50.00	$27.07	$21.00	$36.00
Shenandoah	$27.20	$7.81	$50.00	$16.62	$6.15	$40.81
Warren	n/a	n/a	n/a	$10.98	$10.00	$15.00
Alleghany	n/a	n/a	n/a	$24.28	$5.33	$26.66
Botetourt	$33.63	$30.00	$50.00	$22.01	$15.00	$30.00
Craig	n/a	n/a	n/a	$12.30	$1.00	$20.00
Shenandoah Valley Average	$46.33	$7.81	$250.00	$22.85	$1.00	$150.00

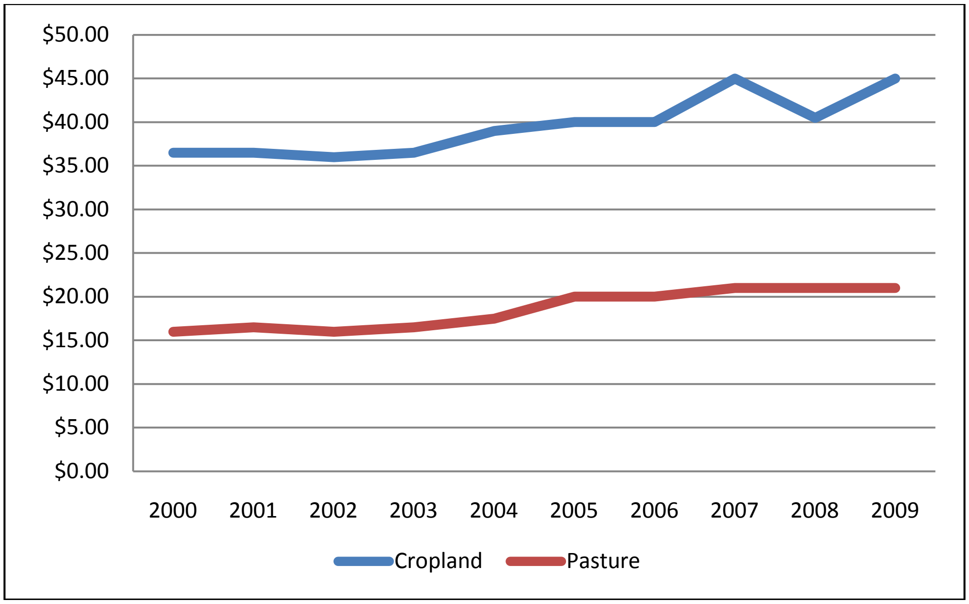
Source: Land Rental Guide, Virginia Cooperative Extension, http://pubs.ext.vt.edu (2009)

HCA also could improve the income from the Farm by anticipating increases in rental rates during the term of a revised lease. According to USDA, rental rates for cropland and pasture in Virginia increased an average of 3% and 4% per year (respectively) from 2000 to 2009. *See* Figure 27. The VCE's 2009 Land Rental Guide confirms that agricultural rental rates in the Shenandoah Valley are on the rise.[92] In leases with a term of five years or greater, annual increases of 3%–4% can make a significant difference over the term of the lease. The annual increase in the rental rate would offset increases in the costs associated with the farm property during the term of the lease and limit the extent to which HCA subsidizes the tenant's farming operation over time.

HCA could incorporate a growth rate into the rental rate in numerous ways. One method would be to incorporate a rate schedule into the lease that reflects the historic growth rate. Another method would be to incorporate a fixed rental rate into the next lease that is higher—maybe 10%–15% higher—than the market average. Under either of these methods, the average annual increase would track the historic growth rate for agricultural rentals over a five-year lease term, and the tenant would bear the risk that the increase was less than anticipated.[93]

A third suggestion for improving the income from the Farm would be for HCA to ensure that the tenant (and not HCA) is responsible for paying all costs associated with the farm operation that are within the tenant's (and not HCA's) control. According to HCA's profit and loss statements, HCA incurred $27,000 in farm-related costs in 2009. These costs fell into four cost categories: liability insurance, property tax, utilities (electricity and waste removal), and maintenance/repairs.

Figure 27: Average cash rents for agricultural property in Virginia, 2000–2009



Source: Land Rental Guide, Virginia Cooperative Extension, http://pubs.ext.vt.edu (2009)

By our calculation, nearly $10,000 of the farm-related costs incurred by HCA in 2009 may have been variable costs directly attributable to the tenant's operation. For example, whereas the current lease enables the tenant to use six of HCA's outbuildings,[94] the tenant only is required to pay for electricity in two locations (i.e., at the Harvestores and accompanying feed lots and at the cattle loafing barn in pasture field #31).[95] As a result, HCA charged over $5,000 in electricity costs to the farm in 2009. Similarly, according to the lease, the tenant must maintain and repair the Harvestores and the equipment related to the feed systems.[96] All other buildings presumably must be maintained by HCA. As a result, HCA charged the farm department over $4,420 in maintenance/repair costs in 2009.

As an initial matter, we recommend that HCA determine whether the costs that currently are being charged to the farm department are related to the tenant's farm operation. Any portion of the electricity that HCA currently pays for that is not related to farm operations (e.g., because it supplied the maintenance garage generally) should be allocated to other departments. If necessary, separate meters should be installed so that the tenant's electricity use can become its sole financial responsibility. Likewise, HCA employees responsible for maintenance and repairs should allocate to the farm only costs incurred for maintaining farm buildings, equipment, and machinery on behalf of the tenant.

Once HCA has identified costs attributable to the tenant's operations, we recommend that future leases require the tenant to pay all costs associated with their operations. Specifically, the tenant must be required to pay for all electricity that they consume. The electricity consumed by the tenant's operation does not benefit HCA in any way. Shifting this expense to the tenant would create an incentive for the tenant to use electricity efficiently because they would be for paying the bill. In addition, the tenant should be required to pay directly for all building repairs. (It may be advisable for HCA to continue paying for routine maintenance to protect the longer-term value of these assets to the community.) Shifting this expense to the tenant might cause the tenant to take better care of buildings and equipment in order to avoid a large repair bill. By requiring the tenant to pay the direct costs of the farm operation, HCA potentially would improve its income from the farm by thousands of dollars per year.

Table 16 illustrates the potential effect of the recommendations related to the farm.

- The baseline scenario reflects HCA's actual farm-related revenue and cost per the 2009 P&Ls.

- The "Revised Revenue and Cost Structure" scenario reflects improvements that might have accrued had HCA shifted the burden of all costs related to the farming operation to the tenant prior to 2009. For purposes of this illustration, this scenario assumes that all of the electricity expense and one-half of the maintenance/repair expense currently charged to the farm are related to the tenant's operation.

Neither of the scenarios includes depreciation expense.

Table 16: Farm's potential economic effect of recommendations, 2009

Category	Baseline		Revised Revenue and Cost Structure	
	Revenue	Expense	Revenue	Expense
Rental Income	$18,000		$27,000	
Insurance		$8,854		$8,854
Property Tax		$7,747		$7,747
Utilities		$5,538		$0
Maintenance/Repairs		$4,420		$2,210
Subtotal	$18,000	$26,558	$27,000	$18,811
Net Income (Loss)		($8,558)		$8,189

Potential New Economies

Sustainable Forestry

One idea that has been raised for a potential new economy at HCA is sustainable forestry. The concept of sustainable forestry embraces the idea that trees can be harvested from forests for useful products (1) while preserving or even enhancing the quality of the forest for wildlife habitat and the other ecosystem services forests provide, and (2) without destroying the value and usefulness of the forest to future generations. As noted by the Virginia Cooperative Extension (VCE), "sustainable forestry consists of those forest practices that meet present needs without compromising the ability of future generations to meet their own needs."[97] Sustainable forestry encompasses virtually all aspects of forest management (regeneration, growth, nurturing, and harvesting) while conserving soil, air, water quality wildlife, plants, aquatic habitat, and landscape aesthetic quality.

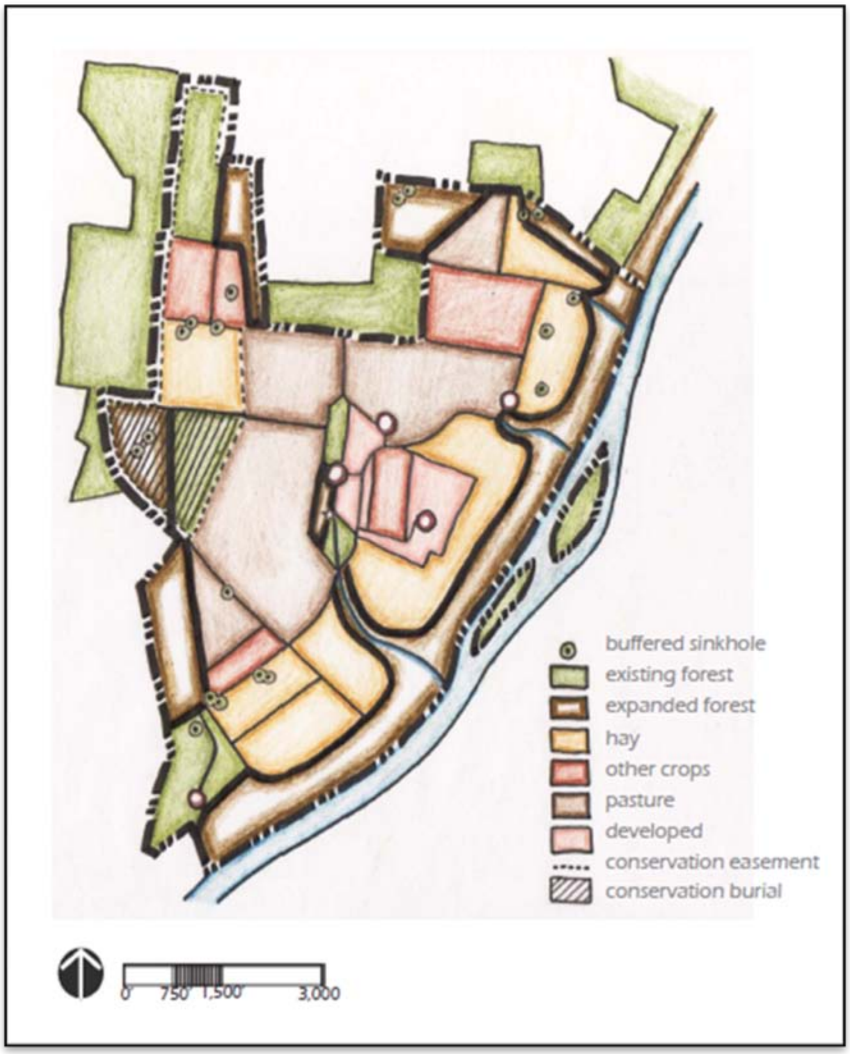
As described in Chapter 1, establishing new forests at the HCA property would have significant environmental benefits, particularly along the riverfront and the banks of the streams that lead to the Shenandoah, and for this reason alone the Team recommends that HCA work toward establishing new forested areas on the HCA property. However, sustainable forestry at best is a long-term investment and probably would not be particularly lucrative at the HCA property. Most forests are not harvested for 25 to 30 years after they are planted, and even at 25 years the revenue generated by small, private forests usually is very modest. Revenue potential is further reduced by volatility in the market for lumber. Moreover, the costs of establishing the forest and maintaining forested areas (particularly in riparian corridors) can be significant. These costs often exceed potential revenues.

The Michigan Team evaluated the feasibility of sustainable forestry as a potential new economy in two stages. First, we evaluated the costs associated with establishing forested areas, with a particular focus on federal and state incentives that may be available to help defray the costs in certain portions of the property. Second, we attempted to estimate the potential net income from sustainable forestry over a 35-year period, considering the cost of ongoing maintenance and the potential revenue that may be realized from pulpwood sales and lumber harvests.

Establishing New Forested Areas

Several areas on or adjacent to the HCA property already have some forest cover. *See* Figure 29. As shown in Figure 29isting forested areas on HCA's property include approximately 50 acres at the north end and 30 acres at the southeastern end of the former Wynkoop Farm. Both of these areas are now protected by the conservation easement. A third area of approximately 30 acres is located along Castleman Road near the Bishop's House. Other miscellaneous areas are located near the Monastic Enclosure and on the islands in the Shenandoah River.

Figure 28: Existing and Potential Forest Areas



The Team proposes three additional areas for restoration and sustainable forestry. These areas, which collectively encompass approximately 220 acres of HCA's property, include the following:

(1) various parcels (a total of 100 acres) that would create a greenbelt around the perimeter of the property and would connect the existing forests to provide expanded habitat for wildlife;

(2) areas around the streams and along the riverfront (collectively around 100 acres) that can be established to create a more effective riparian buffer for water quality improvement and wildlife habitat; and

(3) twenty acres between the Retreat House and Monastic Enclosure that can be used as a hardwood nursery and productive forest.

These areas are depicted in Figure 29, and are described in greater detail in the Design Book that accompanies this report. Once established, these parcels would bring HCA's forested areas to a total of 330 acres (approximately 30% of HCA's land area).

The initial estimated cost of establishing 220 acres of new forest at HCA is shown in Table 17. The costs in Table 17 are based on the following assumptions:

- New forests in all three areas are established at once and planted with hardwood seedlings protected by 5-ft. shelters.
- Switchgrass is planted with the seedlings in the Perimeter/Greenbelt and the Forest Nursery areas to control weeds and invasive species.
- No site preparation is required in the Forest Nursery area.
- No fencing or alternative water supplies are necessary to exclude livestock from the riverfront.
- The Riparian Buffer area is placed under a CREP conservation easement.

Table 17: Initial Cost of Establishing New Forest Areas (estimated)

Initial Project Costs	Acres	$/acre	Cost	CREP funding	Net Cost
Riparian buffer					
Site preparation	100	$100	$10,000		$10,000
Planting	100	$500	$50,000	$50,000	$0
Signing bonus	100	$10		$1,000	($1,000)
Conservation easement	100	$1,000		$100,000	($100,000)
Subtotal			$60,000	$151,000	($91,000)
Perimeter/greenbelt					
Site preparation	100	$100	$10,000	-	$10,000
Planting	100	$500	$50,000	-	$50,000
Subtotal			$60,000		$60,000
Forest nursery area					
Site preparation	20	-	-	-	-
Planting	20	$500	$10,000	-	$10,000
Subtotal			$10,000		$10,000
Total initial project cost (benefit)	220		$130,000	$151,000	***($21,000)***

Sources: G. Crowell, "Forest Stewardship Plan for Holy Cross Abbey Wynkoop Farm" (October 2009); Virginia Department of Forestry, "Conservation Reserve Enhancement Program," www.dof.virginia.gov.

As shown in Table 17, HCA may be able to establish the new forested areas without incurring out-of-pocket costs if it takes advantage of incentives available under Virginia's Conservation Reserve Enhancement Program (CREP) and places the riparian forest buffer in a conservation easement. As HCA may be aware, CREP was established to encourage farmers and other riparian owners to voluntarily restore forests along riparian corridors to improve water quality in the Chesapeake Bay watershed and other sensitive areas of the state of Virginia. The program provides cost-sharing grants, rent incentives, and other benefits for pasture, cropland, and other agricultural property that is adjacent to rivers, streams, seeps, springs, ponds, and sinkholes. To participate in CREP, HCA would have to submit an application to FSA. After FSA confirms that the property described in the application is eligible, HCA would work with the US Department of Agriculture's Natural Resource Conservation Service (NRCS) to develop a conservation plan for the property. The plan would describe the type and nature of plantings and the required maintenance activities to ensure that the buffer is established as designed. The process currently can take up to six months.[98]

According to the Farm Service Agency (FSA), which administers the program in Clarke County, several incentives are available to defray the cost of establishing and maintaining the riparian forested buffer. These incentives may be summarized as follows:

- CREP would provide an initial signing bonus of $10 per acre when a property owner signs the initial CREP contract.
- CREP would share 75 to 100% of the cost of (1) planting hardwood seedlings and native grass in buffer areas 35 to 300 feet wide along waterways, (2) constructing fencing to exclude livestock from the buffer area, and (3) installing alternative livestock watering facilities.
- Property owners willing to place property under conservation easement as part of a conservation program receive additional compensation of up to $1,000 per acre.
- CREP would pay the property owner 80% of the initial cost-share as an incentive to maintain the newly planted forests and keep up the practices described in the conservation plan.
- CREP essentially would "rent" the property subject to the conservation practices from the property owner for a period of 10 or 15 years.

Team conversations with representatives of the FSA during this project confirmed that the program currently reimburses $500 per acre for hardwood plantings and $50 per acre for site preparation. Team conversations with representatives of FSA confirmed that the program currently rents property in Clarke County under the CREP program for $72.89 per acre per year.

Table 18 illustrates the effect of CREP benefits on the estimated costs that HCA may incur during the first five years after planting 220 acres of new forest. As shown in Table 18, the key component of the estimated annual outlay is the cost of removing and replacing seedlings that do not survive after planting. Estimates vary, but according to some sources as many as 15% of newly planted hardwood seedlings do not survive the first year. The survival rate decreases each year after the initial plantings. A second component of the maintenance cost is the cost of mowing the switchgrass that would be planted between the seedlings for controlling weeds and invasive species.[99] If all CREP benefits are applied to defray these annual costs, including the funds received from CREP for placing the riparian buffer under conservation easement, the riparian buffer would result in a net benefit to HCA of over $40,000 by the end of Year 5. In essence, over the five-year time horizon, HCA's new forested areas would provide an economic benefit along with anticipated environmental improvements.

Table 18: Estimated Maintenance Costs for New Forested Areas, Years 0-5

Year	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Inflows							
Net receipt from initial site prep/plantings and conservation easement	$21,000						
CREP maintenance bonus	$40,000	-	-	-	-	-	$40,000
CREP rental payment (100 acres)	-	$7,289	$7,289	$7,289	$7,289	$7,289	$36,445
Subtotal	$61,000	$7,289	$7,289	$7,289	$7,289	$7,289	$76,445
Outflows							
Replace seedlings (220 acres)		$16,500	$13,200	$9,900	$6,600	$3,300	$49,500
Mowing (200 acres)	$800	$824	$849	$874	$900	$927	$5,175
Subtotal	$800	$17,324	$14,049	$10,774	$7,500	$4,227	$33,675
Net Income (Loss)	***$60,200***	***($10,035)***	***($6,760)***	***($3,485)***	***($211)***	***$3,062***	***$42,770***
Source: Virginia Department of Forestry, "Conservation Reserve Enhancement Program," www.dof.virginia.gov.							

Potential Revenue from Sustainable Forestry

Table 17 and Table 18 describe a scenario in which establishing and maintaining 220 acres of new forest at HCA could be economically feasible due to incentives available under CREP. Table 19 illustrates potential costs and revenues associated with the new forested areas in Years 6 through 35. Table 19 incorporates the following additional assumptions:

- The only on-going maintenance costs associated with the newly forested areas include mowing and marking trees to be removed and sold during routine thinning.
- All costs shown are calculated on the basis of 2010 costs plus average cost increases of 2% per year.
- All trees removed during thinning are sold for pulpwood at $100 per acre.
- Harvested logs are sold as medium quality hardwood ($200/acre) in Years 25 through 32, and for high-quality hardwood ($400/acre) in Years 33 through 35.

Table 19: Potential Revenues and Costs from Sustainable Forestry (Years 6 - 35)

	Estimated Costs			Potential Revenue			Estimated Net Income	
Year	Mowing	Marking	Total Costs	Thinning	Harvest	Total	Annual Net Income	Periodic Net Income
6	$2,120	$507	$2,627	$3,000	-	$3,000	$373	
7	$2,162	-	$2,162	-	-	$0	($2,162)	
8	$2,205	-	$2,205	-	-	$0	($2,205)	
9	$2,250	-	$2,250	-	-	$0	($2,250)	
10	$2,295	$549	$2,843	$3,247	-	$3,247	$404	
11	$2,340	-	$2,340	-	-	$0	($2,340)	
12	$2,387	-	$2,387	-	-	$0	($2,387)	
13	$2,435	-	$2,435	-	-	$0	($2,435)	
14	$2,484	-	$2,484	-	-	$0	($2,484)	
15	$2,533	$2,573	$5,106	$13,000	-	$13,000	$7,894	
16	$2,584	-	$2,584		-	$0	($2,584)	
17	$2,636	-	$2,636		-	$0	($2,636)	

Table 19: (cont.)

Year	Estimated Costs			Potential Revenue			Estimated Net Income	
	Mowing	Marking	Total Costs	Thinning	Harvest	Total	Annual Net Income	Periodic Net Income
18	$2,688	$2,571	$5,259	$17,139	-	$17,139	$11,880	
19	$2,742	-	$2,742	-	-	$0	($2,742)	
20	$2,797	-	$2,797	-	-	$0	($2,797)	
21	$2,853	-	$2,853	-	-	$0	($2,853)	
22	$2,910	-	$2,910	-	-	$0	($2,910)	
23	$2,968	-	$2,968	-	-	$0	($2,968)	
24	$3,028	-	$3,028	-	-	$0	($3,028)	($18,231)
25	$3,088	-	$3,088	-	$10,000	$10,000	$6,912	
26	$3,150	-	$3,150	-	$10,000	$10,000	$6,850	
27	$3,213	$3,012	$6,225	$20,081	$10,000	$30,081	$23,856	
28	$3,277	-	$3,277	-	$10,000	$10,000	$6,723	
29	$3,343	-	$3,343	-	$10,000	$10,000	$6,657	
30	$3,410	-	$3,410	-	$10,000	$10,000	$6,590	
31	$3,478	-	$3,478	-	$10,000	$10,000	$6,522	
32	$3,547	-	$3,547	-	$10,000	$10,000	$6,453	
33	$3,618	-	$3,618	-	$20,000	$20,000	$16,382	
34	$3,691	-	$3,691	-	$20,000	$20,000	$16,309	
35	$3,764	-	$3,764	-	$20,000	$20,000	$16,236	$119,489

As shown in Table 19, under this scenario the total net income from forestry operations in Years 6 through 35 would be just over $100,000 ($119,489 – $18,231) (approximately $3,500 per year). However, HCA would have to make a significant investment in the forested areas for the first several years before HCA could expect to see any significant harvest revenue. Specifically, an investment of approximately $2,500 to $3,000 per year—a total amount of just over $18,231—during Years 6 through 24. During this period, the only forestry revenues HCA would likely see would be relatively modest amounts earned by selling trees thinned from existing forests for pulpwood. Revenues from harvesting hardwood trees would begin in Year 25. At that time, HCA would begin harvesting 10% of the total forest acreage per year; harvesting only 10% of the available acreage at a time creates a 10-year harvest cycle and allows the forest healthy, sustained growth.

While the overall net income from sustainable forestry is positive, and the environmental benefit would be extremely significant and undeniable, we do not recommend that HCA establish new forest areas with an expectation of future income. Forestry is a risky business for several reasons, including the following:

- The cost estimates presented above are based on numerous gross assumptions, such as estimates of acreage; the type, density, and location of plantings; the suitability of soil for hardwood forestry; the continued viability of the CREP program, etc. These factors must be determined relative to the specific conditions at HCA.
- We have assumed relatively static conditions when in fact conditions are rarely static over long time periods. Disease, fire, insects, drought, and other mishaps create significant long-term risk for forestry operations.
- The market price for wood fluctuates wildly due to a variety of factors not within HCA's control. We did not incorporate market risk in the cost model.
- Our model assumes that HCA can rely on the Virginia Department of Forestry for expert assistance and is not required to hire a forester. This assumption alone creates substantial risk; both New Melleray Abbey and

> Spencer Abbey noted that it is essential to hire a professional forester to manage negotiations with loggers. The average salary for a professional forester in 2009 was nearly $50,000 per year.[100] Including this substantial cost would eliminate *any* economic benefit from the forestry operation.

Table 20 shows a potential investment analysis for the sustainable forestry scenario described above using three discount rates (6%, 8%, and 15%).

Table 20: Investment Analysis for Forestry Operations (Years 6-35)

Discount Rate	6%	8%	15%
Net Present Value (Years 6-35)	$17,085.84	$8,268.55	($2,414.90)

As shown in Table 20, the net present value of the income stream from the forestry operations is positive only if a 6% or 8% risk factor is applied. If a 15% risk factor is applied, the net present value of the investment is negative. Due to the risky nature of the forestry business and the long time horizons over which estimates must be made, the Team believes that the more conservative risk factor of 15% should be applied. The negative net present value suggests that sustainable forestry would not be a good economic investment.

Thus, while there may be excellent environmental reasons for planting additional hardwood forests, over the long term sustainable forestry does not appear to offer a significant source of future revenue. This conclusion was confirmed by two OCSO houses that were willing to speak with us about forestry operations. Spencer Abbey has a sustainable forestry program on 1,600 acres of hardwood forest that involves harvesting 160 acres (approximately 10%) of the forest per year. Spencer Abbey's average annual income from the forest operation during the period 1981 through 2009 was approximately $13,250 per year (around $83 per acre), not including the salary paid to a forester to manage the monastery's negotiations with logging companies. A representative of Spencer Abbey notes that sustainable forestry is "not a reliable source of income, nor a hugely profitable one."[101]

New Melleray confirmed these sentiments. New Melleray has a sustainable forestry program on 1,700 acres of hardwood forest. The Abbey cuts 40 to 50 acres at a time, twice per year, and employs a forester for $25,000 per year. (The forestor is employed both by New Melleray and by another forest owner in Iowa.) The New Melleray representative that we contacted estimated that the average annual income from the sale of the Abbey's hardwood is approximately $20,000 per year, which means that the Abbey experiences (on average) an annual loss on the forestry operation of approximately $5,000. The representative expressed the following perspective about the operation:

> [I]t is crucial to have a good forest manager who is a logger also someone you can trust. These people are very hard to find. Loggers are notorious for ripping farmers off. Logs, loggers, and sawmill business is very hard for the layman to understand, thus the need for a trustworthy manager who looks out for your interest. Don't go into it for money. Right now there is no money in logs and even in good times selling raw products is not very lucrative. Value add to the product and something might happen. *(Ed. note: New Melleray uses approximately 10% of each harvest as an input to its casket business.)* It is good to manage your forest just to be good stewards and to plan for the future. Our forester told us our woodlands will be worth $50,000 an acre if it is planted in the right way and we wait 80 or so years!!![102]

Conservation Burials

Another idea for a new economy at HCA would be for the community to convert a portion of its property to a conservation burial ground. A conservation burial provides natural death care services while serving "a higher conservation purpose" as part of an effort to restore or protect a tract of land.[103] True conservation burials have two purposes. First, conservation burials aim to reduce the impact of conventional burials on the environment. Second, conservation burial grounds are becoming an increasingly popular way to conserve and restore open space and sensitive ecosystems.

Conventional burials consume huge amounts of nonrenewable resources and typically involve large quantities of harmful chemicals. According to one estimate, conventional burials in the US annually consume

- 104,000 tons of steel
- 2,700 tons of copper/bronze
- 1.6 million tons of concrete
- 827,000 gallons of formaldehyde; and
- millions of board feet of hardwoods for caskets.[104]

The Casket & Funeral Supply Association of America estimates that of the 1.7 million caskets sold in 2007, approximately 67% were made from steel or stainless steel, 18% were made from hardwoods, and 4% were made from copper or bronze.[105]

Moreover, while cremation is often seen as a more environmentally-friendly alternative, cremation also consumes nonrenewable resources and results in toxic releases to the environment. The cremation process burns large quantities of fuel and therefore can release large quantities of GHGs and pollutants. One study estimates that a single cremation can release "the equivalent of 880 pounds of carbon dioxide into the air—equivalent to the environmental impact of a 500-mile car trip."[106] In addition, cremation recently has received negative attention from environmentalists who claim that mercury and other toxic gases are emitted when persons with dental amalgam fillings or artificial joints are cremated.[107]

Conservation burials provide a unique opportunity to protect land and enhance natural ecosystems. Devoting land to conservation burials preserves the land from development. In addition, true conservation burial practices attempt "to put death in its rightful place, as part of the cycle of life:"[108]

> Not only does the conservation burial help protect land, the burial area becomes hallowed ground, restored to its natural condition and protected forever with a conservation easement. Native plants beautify the burial sites. Citizens who support conservation are offered a more meaningful burial option with the certainty that protected land is the ultimate legacy to leave for future generations. Family and friends are brought closer to nature in the commemoration of their loved one's life.[109]

Natural burials without chemicals, caskets and vaults are nothing new; until the late 1800s most burials in the US were performed in this way. However, the popularity of "eco-friendly" burials "has exploded" in the last decade.[110] According to the Green Burial Council (GBC), an organization formed to regulate and oversee the development and certification of natural burial practices and cemeteries in the US, "every year, eco-friendly funerals account for a larger share of the $22-billion North American [death-care] industry."[111] A 2008 survey sponsored by the publisher of American Funeral Director and American Cemetery magazines, found that 43% of respondents (aged 50+) would consider green burial. A similar survey by AARP in 2007 concluded that 21% of respondents would be interested.[112]

Establishing and Operating a Conservation Burial Ground

GBC certifies four categories of green burial grounds:

- hybrid burial grounds, which are conventional cemeteries that offer the option of burial without embalming, a casket, or a vault;
- low-impact burial grounds, which *prohibit* embalming, the use of a vault, and burial containers not made from plant-derived materials;
- natural burial grounds, which meet the requirements of the previous two categories but also are "designed, operated and maintained to produce a naturalistic appearance, based on use of plants and materials native to the region and patterns of landscape derived from and compatible with regional ecosystems;"[113] and
- conservation burial grounds, which in addition to meeting the requirements of all three previous categories must further legitimate land conservation by protecting in perpetuity an area of land specifically and exclusively designated for conservation.[114]

CGC's criteria for establishing a conservation burial ground are targeted to ensure a focus on conservation. The land on which the burial ground is located must be adjacent to or otherwise augment the conservation goals of an "ecologically significant park, wildlife corridor, critical habitat area, or permanently protected open space." The burial practices at the site cannot degrade site conditions or water quality. The land must be placed under deed restriction or conservation easement, and be owned or operated in conjunction with a non-profit conservation partner.[115]

GBC requires several site evaluations before a conservation burial ground may be established. The property owner must obtain baseline information about a proposed site's geology, hydrology, soils, topography, vegetation, and wildlife. The baseline analysis evaluates the ecological value of the land and ensures that burials will not degrade existing ecosystems. The property owner also must evaluate the potential for soil erosion and establish a soil erosion prevention plan. Once site conditions have been documented, the property owner must develop a list of native plants that can be used as memorial features and also as part of the restoration/preservation of natural vegetation. Finally, the property owner must create a visitation plan that limits visitor access to sensitive areas. GBC asserts that careful site evaluation during the planning stage helps to ensure that the biological and social value of the burial ground is enhanced and preserved.

Property of almost any size can be used for conservation burials. According to Dr. Billy Campbell of Memorial Ecosystems Inc, a consultant who specializes in the establishment of conservation burial grounds, "[l]and-selection should be based on the principles of conservation biology."[116] Land devoted to conservation burials should be large enough to "feel like a space, not a postage stamp," and to contribute to the ecological sustainability of the surroundings. However, Dr. Campbell also emphasizes the practicalities of establishing and operating the burial area. To obtain GBC certification, the operator of a conservation burial ground must establish an endowment fund and agree to deposit 5% of the proceeds of each sale into the fund to ensure the long-term maintenance of the burial area. Dr. Campbell advises that the site must be large enough to permit a burial density that creates an endowment large enough to ensure that upkeep is not a burden for the property owner.[117]

It is typically necessary to construct improvements at the burial ground before plots can be utilized. Narrow roads and space for parking a few cars usually is necessary so visitors can enter the site to attend and participate in interments. Walking trails generally are necessary to reach the actual burial locations. Dr. Campbell emphasizes the importance of a small visitor center near the interment area to provide shelter during bad weather and for other reasons, and many burial grounds have a small non-denominational chapel for short services. Dr. Campbell emphasized that none of the features need to be fancy or expensive, and should be designed to minimize impact on the natural site environment.[118] Some visitor access is necessary, because families not only want to participate in interments but also to visit graves after services are over. Dr. Campbell advises, however, that effective visitor management is essential both to maintain the "wildness" of the site and to ensure that visitors do not interfere with other property uses.

Once the burial ground is established, operations are relatively straightforward. Burials occur in a linen or cotton shroud or a biodegradable container (e.g., a casket made from wood, paper, cardboard, or basketry) rather than in a traditional casket and vault. Metal, plastic, toxic finishes, and hardwoods are not permitted. No embalming fluid is permitted; preservation (if necessary) is achieved through the use of dry ice. Gravesite markers consist of flat stones that do not interfere with the natural landscape, but markers frequently are omitted in lieu of planting a native tree, shrub, or other plant to mark the burial location. Individual burial locations are mapped with a GPS system, and at some burial grounds bodies are marked with an electro-ceramic chip. Records of each burial are maintained by the steward of the burial ground.[119]

Certification by GBC is not mandatory, although the green burial industry is growing so fast that many conservationists believe certification will be necessary to separate true conservation burial grounds from "green washing" look-alikes.[120] Moreover, all states require funeral homes and other death-care service providers to obtain a license and to comply with basic operational policies. Virginia is no exception, and we briefly reviewed Virginia's cemetery regulations to determine whether a conservation burial area at HCA would be regulated by the state.[121] We even contacted the Virginia Department of Professional and Occupational Regulation to determine whether HCA would be exempt from the cemetery regulations as a church. Unfortunately, despite several attempts, we were not able to determine whether a state license would be required.

The Economics of Conservation Burial Grounds

The Team has identified a 60-acre parcel at the southeastern edge of the former Wynkoop Farm that might be suitable for a conservation burial ground. The location of the parcel is shown in Figure 29, and the layout of the property is shown in Figure 1. One-half of the parcel currently is used for crops and the other half is mostly covered with forest. As more fully described in the Design Book that accompanies this report, the topography of the site seems to offer prime locations for a visitor center/chapel and a small shelter with a view of the farm and river. The parcel is located close to Castleman Road, so that visitors to the burial ground could access the site directly without using HCA's main driveway. The parcel also is located away from the monastic enclosure, so that burial ground activities would not interfere with the monks' daily routine.

The initial estimated cost of establishing a 60-acre conservation burial area on this parcel is shown in Table 1. The costs in Table 1: Estimated Construction Costs for Conservation Burial Ground are based on the following assumptions:

- The visitor center/chapel and shelter are very simple structures. We did not factor in the cost of providing electricity or water service to the building sites.
- The access road is 20 ft wide and paved with crushed stone. The footpaths are 6 ft wide and, other than being cleared, remain in their natural state.
- Consulting fees for establishing the area are 20% of the construction costs and are incurred during the initial construction phase of the project.
- We did not include the cost of creating a vegetated buffer around the two sinkholes located on the parcel.

Figure 29: Proposed Layout of Conservation Burial Ground

As shown in Table 21 the cost of establishing a conservation burial area at HCA could be substantial. The most significant cost would involve cutting an access road into the 60-acre parcel off Castleman Road.

Table 21: Estimated Construction Costs for Conservation Burial Ground

	Length (ft)	Width (ft)	Sq ft	Price*	unit	Total	Yr 0	Yr 5
Visitor Center/Chapel	30	20	600	$85	s.f.	$51,000	$51,000	
Shelter	20	16	320	$86	s.f.	$27,520		$27,520
Foot paths								
Grading	12,000	6	72,000	$0.28	s.y.	$20,000	$10,000	$10,000
Benches, trash cans, sign posts, etc.						$5,000	$5,000	
Access road								
to chapel	600	20		$110	l.f.	$66,000	$66,000	
from chapel to shelter	1,400	20		$110	l.f.	$154,000		$154,000
Total						$323,520	$132,000	$191,520
Consulting Fee (20%)							$64,704	
Total Cost						$323,520	$196,704	$191,520

Sources: Dimensions were obtained from Figure 1. Price information was obtained from RS Means (2009)

The potential revenues associated with the conservation burial area are also very significant. Three factors determine the amount of potential revenue that may be earned through conservation burials: (1) the size of the property (in this case, 60 acres); (2) the burial density, i.e., how many gravesites can be sold per acre; and (3) the price that can be charged for each gravesite. For purposes of conducting the revenue analysis, we based the burial density on the average planned density at proposed and existing conservation burial areas on Michigan, Florida, South Carolina, and Georgia. The results of our research are summarized in Table 22. A shown in Table 22, burial densities vary widely depending on the nature of the property and the objectives of the steward. Generally, a lower burial density if preferred to ensure that plants and other features of the site are preserved, and the minimize visitor access to sensitive areas. The average density for the four areas for which we were able to obtain data was approximately 88 gravesites per acre.

Table 22: Estimates of Burial Density

	# burials	# acres	# burials/acre
MI	700	157	4.46
FLA	300	1	300.00
SC	1500	33	45.45
GA	200	70	2.86
		Average	88.19

Source: Project research

Pricing also is variable because gravesite prices are dependent on many factors, such as market conditions, the visual and emotional appeal of the conservation burial area, and the proximity of the site to urban areas. In addition, prices vary with the type of burial (cremation or non-cremation), and generally are higher for more desirable gravesite location. The Team determined that trying to average available pricing information would be unreliable because of the inherent differences between different burial grounds. For purposes of this analysis, therefore, we assumed that prices for gravesites at HCA would be the same as prices at Honey Creek Woodlands, the 70-acre conservation burial area operated by the Monastery of the Holy Spirit in Conyers, Georgia.

The result of the revenue analysis is shown in Table 23. As shown in Table 23, the potential revenue from a 60-acre conservation burial area at HCA over the lifetime of the project (i.e., until the area has reached capacity at a burial density of 88 burials per acre) is around $16 million. At higher burial densities, the potential revenue would be even more significant. At a burial density across the parcel of 300 burials per acre, the potential revenue over the lifetime of the project would be almost $56 million.

Table 23: Potential Revenue from Conservation Burials

Areas	Available acres	Burials/acre (average)	No. of Burials	Price per Gravesite	Potential Revenue
Burials					
On rise near shelter	6	88	528	$ 4,500	$ 2,376,000
Other areas on forest half	24	88	2112	$ 3,500	$ 7,392,000
Areas on grassland half of parcel	30	88	2640	$ 2,500	$ 6,600,000
Cremation burials					
On rise near shelter	6	88	528	$ 1,250	$ 660,000
Other areas on forest half	24	88	2112	$ 1,250	$ 2,640,000
Areas on grassland half of parcel	30	88	2640	$ 750	$ 1,980,000
Total			5280		$ 16,368,000

The next step in determining the economic impact of a conservation burial ground is to estimate the potential earnings from the operation. We based the earnings analysis on the following assumptions:

- In Year 1, gravesite sales are very modest—approximately one sale per month for the first year.
- In Year 15, annual gravesite sales are capped at 113 per year (approximately 2 per week) to reflect assumed limitations in the regional market demand.
- Revenue is calculated on the basis of the following product mix: (1) 12% of the gravesites sold are located on the rise, near the shelter, where the gravesites are most expensive; (2) 25% of the gravesites sold are elsewhere on the forest half of the parcel; (3) 25% of the gravesites sold are on the grassland half of the parcel; and (4) the remaining sales (38%) are for cremation burials.
- HCA invests in the capital aspects of the burial ground in two phases.
    - Phase I occurs in Year 0 and includes the cost of building the visitor center/chapel, the access road to the chapel (but not beyond), half of the footpaths, and the consultant fees. The footpaths are constructed partially on the forest half of the parcel and partially on the grassland half.
    - Phase II occurs in Year 12 and includes the cost of building the shelter and the rest of the access road and footpaths.
- The cost of operating the conservation burial area include (1) the salary for a conservation biologist to manage the project and supervise burial locations, visitor access, and the appropriateness of plantings;[122] (2) the contribution to the conservation fund (equal to 5% of the revenue received from gravesite sales); and (3) administrative expense (25% of the revenue received from gravesite sales).
- The model does not include financing costs; the Team assumes that capital investment would be raised from private funding sources.
- Gravesite sales increase each year after Year 1 at a rate of 15% per year, and operating costs and gravesite prices increase at an annual rate of 4%.

Table 24 shows the earnings potential for the conservation burials for the first 25 years of the project. As shown in Table 24, the potential net income from conservation burials over the first 25 years would be around $4.6 million. Average earnings over the lifetime of the project would be approximately $175,000 per year. In Year 0 and Year 12, HCA would make substantial investments in site improvements, but operational costs in other years would be funded by anticipated revenue. Under this scenario, the payback period for the Phase I investment would be ten years and the payback period for the Phase II investment would be approximately three years.

Table 24: Potential Earnings from Conservation Burials

Year	# burials	Revenue	Costs					Net Income
			Capital exp	Cons biologist	Admin cost	Cons Fund	Total Cost	
0	0	$ -	$ 196,704	$ 26,000	$ 9,000	$ 1,800	$ 233,504	$(233,504)
1	16	$ 41,400	$ -	$ 27,040	$ 10,350	$ 2,070	$ 39,460	$ 1,940
2	18	$ 47,610	$ -	$ 28,122	$ 11,903	$ 2,381	$ 42,405	$ 5,205
3	21	$ 54,752	$ -	$ 29,246	$ 13,688	$ 2,738	$ 45,672	$ 9,080
4	24	$ 62,964	$ -	$ 30,416	$ 15,741	$ 3,148	$ 49,306	$ 13,659
5	28	$ 72,409	$ -	$ 31,633	$ 18,102	$ 3,620	$ 53,356	$ 19,053
6	32	$ 83,270	$ -	$ 32,898	$ 20,818	$ 4,164	$ 57,879	$ 25,391
7	37	$ 95,761	$ -	$ 34,214	$ 23,940	$ 4,788	$ 62,942	$ 32,818
8	43	$ 110,125	$ -	$ 35,583	$ 27,531	$ 5,506	$ 68,620	$ 41,505
9	49	$ 126,644	$ -	$ 37,006	$ 31,661	$ 6,332	$ 74,999	$ 51,644
10	56	$ 145,640	$ -	$ 38,486	$ 36,410	$ 7,282	$ 82,178	$ 63,462
11	64	$ 167,486	$ -	$ 40,026	$ 41,872	$ 8,374	$ 90,272	$ 77,214
12	74	$ 192,609	$ 191,520	$ 41,627	$ 48,152	$ 9,630	$ 290,930	$ (98,321)
13	85	$ 221,500	$ -	$ 43,292	$ 55,375	$11,075	$ 109,742	$ 111,758
14	98	$ 254,725	$ -	$ 45,024	$ 63,681	$12,736	$ 121,441	$ 133,284
15	113	$ 292,934	$ -	$ 46,825	$ 73,234	$14,647	$ 134,705	$ 158,229
16	113	$ 336,874	$ -	$ 48,698	$ 84,219	$16,844	$ 149,760	$ 187,115
17	113	$ 387,406	$ -	$ 50,645	$ 96,851	$19,370	$ 166,867	$ 220,538
18	113	$ 445,516	$ -	$ 52,671	$ 111,379	$22,276	$ 186,326	$ 259,190
19	113	$ 512,344	$ -	$ 54,778	$ 128,086	$25,617	$ 208,481	$ 303,863
20	113	$ 589,195	$ -	$ 56,969	$ 147,299	$29,460	$ 233,728	$ 355,468
21	113	$ 677,575	$ -	$ 59,248	$ 169,394	$33,879	$ 262,520	$ 415,054
22	113	$ 779,211	$ -	$ 61,618	$ 194,803	$38,961	$ 295,381	$ 483,830
23	113	$ 896,092	$ -	$ 64,083	$ 224,023	$44,805	$ 332,910	$ 563,182
24	113	$ 1,030,506	$ -	$ 66,646	$ 257,627	$51,525	$ 375,798	$ 654,709
25	113	$ 1,185,082	$ -	$ 69,312	$ 296,271	$59,254	$ 424,836	$ 760,246
Total	1888	$ 8,809,631	$ 388,224	$1,152,105	$ 2,211,408	$ 442,282	$ 4,194,019	$ 4,615,612

Finally, and perhaps most importantly, investing in a 60-acre conservation burial ground would a positive net present value. Table 5 shows the net present value of the investment using three discount rates (6%, 8%, and 15%). At all three risk factors, the net present value of the project is positive.

Table 25: Investment Analysis for Conservation Burials

Discount rate	6%	8%	15%
Net present value (Years 0 through 25)	$1,232,882	$790,350	$117,207

ENDNOTES

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[2] Elkington, 1998.
[3] Andrew Savitz with Karl Weber, *The Triple Bottom Line: How Today's Best-Run Companies are Achieving Economic, Social, and Environmental Success* -- *and How You Can Too (*San Francisco, CA: Jossey-Bass, 2006).
[4] Ibid.
[5] Ibid.
[6] Ian Davis, "The Biggest Contract," *The Economist*, May 28, 2005: 69-71.
[7] World Business Council on Sustainable Development, *From Challenge to Opportunity: The Role of Business in Tomorrow's Society* (World Business Council on Sustainable Development, 2006).
[8] Ibid.
[9] Kim Carlson*, Green Your Work* (Avon: Adams Business, 2009).
[10] Ibid.
[11] Lifestyles of Health and Sustainability, "LOHAS Background," www.lohas.com/about.html.
[12] Carlson, 2009.
[13] PriceWaterhouseCoopers LLP, "2002 Sustainability Survey Report*,"* August 2002.
[14] Carlson, 2009.
[15] U.S. General Services Administration, "Assessing Green Building Performance" (Washington, D.C.: GSA Public Building Service, Office of Applied Science, June 2008).
[16] Carlson, 2009, 12.
[17] Ibid.
[18] Daniel Sitarz, *Greening Your Business* (Carbondale: EarthPress, 2008), 21.
[19] U.S. Small Business Administration, "The Small Business Economy: Data for the Year 2006" (Washington, D.C.: U.S. Government Printing Office, 2007).
[20] Savitz, 2006.
[21] Elkington, 1998, 2.
[22] Savitz, 2006.
[23] World Business Council on Sustainable Development, 2006.
[24] Elkington, 1998.
[25] Ibid.
[26] World Business Council on Sustainable Development, 2006.
[27] Elkington, 1998.
[28] Carlson, 2009.
[29] US Environmental Protection Agency, "Life Cycle Assessment: Principles and Practice," Research Report (Washington, DC: EPA/600/R-06/060, 2006).
[30] Ibid.
[31] Sitarz, *Greening Your Business,* 2008.
[32] Jeana Wirtenberg PhD, with William G. Russell and David Lipsky PhD, *The Sustaianble Enterprise Fieldbook: When it All Comes Together* (New York: AMACOM Books, in association with Greenleaf Publishing Limited, UK, 2009).
[33] World Business Council for Sustainable Development and World Resources Institute, "Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard," (WBCSD and WRI, revised 2006).
[34] Sitarz, 2008.
[35] Elkington, 1998.
[36] Ibid.
[37] Ibid.
[38] *See*, e.g., "Ask and Ye Shall Receive: The Effect of the Appeals Scale on Consumers' Donation Behavior," Journal of Economic Psychology, vol 24, issue 3, June 2003, pp. 349-376.

[39] Prokopec, Sonja. "When Asking for More Leads to Getting Nothing: The Impact of Anchors on Donors' Behavior," with A. DeBryun, in 38th EMAC Annual Conference Proceedings, 38th EMAC Annual Conference; European Marketing Academy, 2009, available through http://www45.essec.edu/faculty/sonja-prokopec#.

[40] Inputs to the regression analysis included two data from spreadsheets provided by HCA as part of project data collection: "Gift Shop Revenue, Yearly Comparison for 2005 through 2009" and "Retreat House Occupancy 2008-2009." Due to data limitations, we were only able to input data from 2008 and 2009.

[41] "51% of online Adults Use Search Engines for Shopping," Internet Retailer, www.internetRetailer.com (June 21, 2005), last accessed March 21, 2010. Search engines include Google, AOL, Ask Jeeves, MSN, Yahoo, and others.

[42] This rating applied to gas-powered convection ovens, which are the only ovens that have been rated to date under the ENERGY STAR® program. A complete list of qualified products is available at www.energystar.gov "Commercial Kitchen Package".

[43] Electronic correspondence, D. Roy (AMF Bakery Systems, Inc.) to K. Buckner (March 5, 2010).

[44] Electronic correspondence, M. Rubin (Birdbath Neighborhood Green Bakery) to K. Buckner (March 12, 2010).

[45] We obtained this cost estimate in a telephone conference with Fred Johnson, a commercial oven technician. Mr. Johnson's contact information is listed in Appendix 6-F.

[46] Donald Ciccolella, "Energy Management in Commercial Bakeries," CSM Worldwide, Inc (available at http://www.csmworldwide.com/literature/8%20Energy%20Management%20in%20Commercial%20Bakeries.pdf), last accessed March 2, 2010.

[47] Philip M. Parker PhD, "The 2007-2012 Outlook for Holiday-Type Fruit Cakes Excluding Frozen Cakes in the United States," ICON Group International, Inc., 2006, www.icongrouponline.com.

[48] Ibid.

[49] Packaged Facts, "The U.S. Market for Sweet Baked Goods" (May 2000), p. 6.

[50] Ibid.

[51] Packaged Facts, "Gourmet/Specialty Foods," (July 2001), p. 230.

[52] Ibid.

[53] Packaged Facts, "Sweet Baked Goods," p. 7.

[54] Packaged Facts, "Sweet Baked Goods," p. 15.

[55] The monastery fruitcake bakeries that we found in a quick search included HCA (monasterybakery.org), Assumption Abbey (trappistmonks.com), the Abbey of Gethsemani (gethsemanifarms.com), Trappist Abbey (trappistabbey.org), and Monastery of the Holy Spirit (holyspiritmonasterygifts.com).

[56] Packaged Facts, "Gourmet, Specialty, and Premium Foods and Beverages in the U.S." (November 2007), p. 4.

[57] Packaged Facts, "Gourmet/Specialty Foods," p. 39.

[58] Packaged Facts, "Gourmet, Specialty, and Premium Foods and Beverages in the U.S.," p. 8.

[59] Packaged Facts, "Gourmet/Specialty Foods," p. 237.

[60] Packaged Facts, "Sweet Baked Goods," p. 63.

[61] Carolyn Dimitri and Catherine Greene, *Recent Growth Patterns in the U.S. Organic Foods Market.* Washington, D.C.: U.S. Department of Agriculture Information Bulletin No. (AIB777), 2002. *See* also Carlson, 2009.

[62] Organic Trade Association, "Industry Statistics and Projected Growth," www.ota.com/organic/mt/business.html.

[63] Ibid, p. 9.

[64] Packaged Facts, "Sweet Baked Goods," p. 7.

[65] U.S. Department of Agriculture, "National Organic Program Factsheet: Certification" (April 2008), available at www.usda.gov/national organic program/Producers and Handlers Applying for Organic Certification. Some states also have implemented organic production standards, but Virginia does not appear to be one of them. *See* www.usda.gov/national organic program/state organic programs.

[66] U.S. Department of Agriculture, "National Organic Program Factsheet: Organic Labeling and Marketing Information" (April 2008), available at www.usda.gov/national organic program/NOP Reading Room.

[67] U.S. Department of Agriculture, "National Organic Program Factsheet: Organic Production and Handling Standards" (April 2008), available at www.usda.gov/NOP Reading Room.

[68] U.S. Department of Agriculture, "National Organic Program Factsheet: Certification."

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[69] U.S. Department of Agriculture, "National Organic Program: Organic Cost-Share Program," last accessed March 25, 2010.

[70] Greene, *Recent Growth Patterns in the U.S. Organic Foods Market, supra.*

[71] We obtained a price quote from an organic fruit supplier to approximate the cost differential for an organic fruitcake. We selected a combination of dried apples, apricots, raisins, cherries, cranberries, dates, pecans, and walnuts—a total of 15,000 lbs to approximate the amount of conventional fruits and nuts that HCA includes per year in its fruitcakes. The cost of the organic ingredients was more than twice the cost of the conventional ingredients ($72,980 for organic ingredients versus $33,473 for conventional ingredients).

[72] Packaged Facts, "The Gluten-Free Food and Beverage Market: Trends and Developments Worldwide, 2d Edition" (April 2009), p. 5–6.

[73] The ingredients for the HCA fruitcake were taken from information provided by the controller. Ingredients for the "Norganic" fruitcake were obtained from http://www.mondofruitcake.com/2007/09/review-old-cavendish-fruitcake.html. Ingredients for the organic fruitcake were taken from the recipe in Appendix 6-D.

[74] Ibid.

[75] Ibid.

[76] Ibid, p. 37.

[77] Packaged Facts, "Fresh and Local Food in the U.S.," (July 2009).

[78] Ibid, p. 24.

[79] Ibid, p. 30–31.

[80] Ibid, p. 49.

[81] Ibid, p. 6.

[82] *See* Virginia Department of Agriculture and Consumer Services, "Buy Virginia Grown," available at virginiagrown.vi.virginia.gov/.

[83] *See* West Virginia Department of Agriculture, "Food and Things Producer Guide and Directory," available at www.wvagriculture.org/Foods and Things.htm.

[84] Telephone conversation with "Cindi" at L'Esprit de Campagne, Inc., Winchester, Virginia. (www.lespritdecampagne.com) on March 2, 2010.

[85] Packaged Facts, "Gourmet/Specialty Foods" (July 2001), p. 259.

[86] Ibid.

[87] Hartman Group and Packaged Facts, "Consumers & Sustainability" (September 2009).

[88] Bob Sperber, "Partnering with Others to Make Your Product – or theirs – offers benefits to both partners," FoodProcessing.com, available at www.foodprocessing.com/articles/2008/402.html. Sperber describes one case in which a former Chicago stock broker's celiac disease and accompanying gluten sensitivity led her to develop gluten-free cookie recipes. In two years, she had established numerous retail chain accounts, a Web business, and a small bakery that she would quickly outgrow. Rather than expand into a larger manufacturing facility, she outsourced manufacturing to a company called PacMoore (www.pacmoore.com). Turning manufacturing over to a contract manufacturer allowed her to focus her strength on marketing, distribution, and product development.

[89] We did not evaluate the profitability of the farmer's operation. From a purely economic standpoint, it is difficult to imagine why the farmer would continue to lease the HCA property for farming and livestock management if the operation were not profitable.

[90] Virginia's Use Value Taxation system was adopted in 1972 as a means of preserving real estate for agricultural, horticultural, forest, and open space use. The program enables property owners to obtain preferential tax treatment by using land for agricultural purposes rather than for development or another purpose that would generate a higher market value. Information about the program is available through the Virginia Cooperative Extension, www.ext.vt.edu. *See* "A Citizen's Guide to the Use Value Taxation Program in Virginia," VCE Publication No. 448-037 (May 1, 2009), available at http://pubs.ext.vt.edu/448/448-037/448-037.html.

[91] HCA's farm probably would not be considered "small" within the context of the VCE's comment. According to the USDA, the average size of a Clarke County farm in 2007 was 137 acres. USDA, 2007 Census of Agriculture – County Data (2007), available at www.nass.usda.gov.

[92] Virginia Cooperative Extension, 2009 Land Rental Guide, available at pubs.ext.vt.edu/news/fbmu/2009/04/2009LandRentalGuide.html, most recently accessed March 20, 2010.
[93] The benefit to HCA of incorporating an increase in the market rate is greater for a longer-term lease. In a shorter-term lease (such as the current lease, which has a term of three years), the market increase will have a lesser economic effect than it would if the term were greater. From 1979 to 2009, the average term of HCA's farm leases was 4.67 years.
[94] The tenant may use the following structures and facilities: two Harvestores and the adjacent feeding system and barn; three Morton storage buildings, two granary buildings and sorting pens, and the farm garage and machinery storage building. Lease Agreement between HCA and Ronald A. Hope and Son dated April 1, 2009 (hereinafter "Lease Agreement"), paragraph 6.
[95] Lease Agreement, paragraph 7.
[96] Lease Agreement, paragraph 8.
[97] James T. Walters and James E. Johnson, Moving Toward Sustainable Forestry: Strategies for Forest Landowners, Virginia Cooperative Extension and College of Natural Resources Department of Forestry at the Virginia PolyTechnic Institute and State University (May 1, 2009), 1. Available at http://pubs.ext.vt.edu/420/420-144/420-144.html.
[98] Virginia Department of Forestry, Conservation Resource Enhancement Program, www.dof.virginia.gov (last accessed April 3, 2010).
[99] Although some foresters and even some conservationists use RoundUp and other herbicides to control weeds and invasives, we did not include the cost of any chemical treatments in our cost model.
[100] We estimated this salary using predictive tools available on www.salary.com and www.payscale.com.
[101] E-mail correspondence between the Michigan Team and Br. Brian Rooney at Spencer Abbey (March 17, 2010). According to the OCSO survey (*see* Introduction, Appendix), Assumption Abbey also has a sustainable forestry operation, but Assumption requested that we not contact them following the survey for additional information.
[102] E-mail correspondence between the Michigan Team and Fr. Brendan Freeman at New Melleray Abbey (March 20, 2010.
[103] See the description of conservation burial at the Honey Creek Woodlands website, www.honeycreekwoodlands.com/conservationburial/tabid/53/default.aspx. Honey Creek Woodlands is a conservation burial area located on the grounds of the Monastery of the Holy Spirit at Conyers, Georgia.
[104] This information was derived from data collected by the Prairie Creek Conservation Cemetery, www.conservationburialinc.org.
[105] "Casket Design," Casket & Funeral Supply Association of America, available at http://www.cfsaa.org/design.php.
[106] BC Upham, "Body-to-Bone Sector Goes Green with Bio-Cremation" (March 26, 2010), available at http://www.triplepundit.com/2010/03/body-to-bone-b2b-sector-goes-green-with-bio-cremation/.
[107] Numerous resources are available for more information about the environmental impact of modern funeral traditions. See, e.g., www.funeralresources.com.
[108] Dr. Billy Campbell, "Conservation Burial—Definition," available at www.memorialecosystems.com/ConservationBurial/tabid/110/default.aspx.
[109] F. Johnson, "Why Conservation Burial," available at www.conservationburialinc.org/?page_id=5.
[110] "Eco-burial: The Future of Death," Canadian Business Magazine (November 23, 2009), available at http://www.canadianbusiness.com/shared/print.jsp?content=20091123_10015_10015&adZ.
[111] Ibid.
[112] Katherine Lackey, "Eco-conscious rest easy going green eternally," USA Today, February 4, 2010, available at http:/www.usatoday.com/news/nation/environment/2010-02-03-green-cemeteries_N.htm
[113113] GBC, "Burial Grounds," available at http://www.greenburialcouncil.org/what-we-do/standards-setting/burial-grounds/.
[114] Ibid.
[115] Ibid.
[116] E-mail correspondence, K. Buckner to K. Campbell, Memorial Ecosystems, Inc. (March 13, 2010 and March 17, 2010).
[117] Ibid.
[118] Ibid.

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[119] F. Johnson, “Cemetery Operations, Design, and Maintenance,” available at www.conservationburialinc.org/?page_id=17.

[120] “Greenwashing” is a term that is applied to products that are marketed as sustainable when they do not benefit or may even be harmful to the environment. According to LOHAS, greenwashing occurs when marketers and businesses market their products as sustainable “in order to improve their public relation standings with the consumer or public.” www.lohas.com/glossary.html.

[121] *See* Code of Virginia, Title 54.1, chapter 23.1, available at http://www.dpor.virginia.gov/dporweb/Cemetery_Regs.pdf

[122] Salary information for the conservation biologist was obtained from www.salary.com and www.payscale.com, and reflects a salary at the 25% percentile of the average expected salary in zip code 22611.

FOOD

7

The link between humans and the environment with regards to food is very tight. A healthy environment is key for producing nutritious and fresh produce, which in turn is key for good human health. In addition, the production of food can have a negative impact on the environment, mostly due to the large amounts of energy needed for large-scale food production, transportation, and consumption.

This section assesses HCA's food consumption and offers suggestions to help HCA improve the health benefits, climate impacts, and social sustainability of its food choices. As the members of our Team are not health/nutrition experts, this section is not intended to guide the HCA community on nutrition decisions; rather, it explores opportunities for increasing fresh, local, and sustainably grown foods in the HCA community's diet and reducing the environmental impact of HCA's food consumption.

CONTEXT: THE IMPACT OF FOOD PRODUCTION

The current food production system has a significant environmental and social impact. Most food is now produced on large-scale farms using a lot of energy to water, grow, and harvest crops. These foods are then flown or trucked around the world to meet consumer demands. The transportation alone requires a great deal of fuel and thus results in significant CO_2 emissions. Other environmental impacts include land use change, habitat conversion to farmland, and water pollution. A significant amount of waste is created from the production and consumption of food, increasing environmental impacts. Another factor that has a significant impact is the packaging used to protect food, such as plastic wrap and paper.[1] Buying food that is largely unprocessed from local farmers can help mitigate the environmental impacts of food production and consumption.

In addition to having a significant environmental impact, food production implicates a number of social issues. Many industrial farms in the US use illegal immigrants for a cheap labor supply, which has a significant negative social impact. Also, US producers are often anti-labor rights patrons. Worker health and safety is also a major issue. According to the National Safety Council, 700 deaths and 120,000 disabling injuries occur each year in the food industry, mainly due to pesticide exposure.[2] On the other hand, producing food locally often leads to the growth of local farms, meaning that more labor is needed. This demand offers the chance to increase local employment opportunities.[3]

Food production and consumption also has profound economic implications. A few very large companies own most of the farmland, and thus the profits are highly concentrated. Directly purchasing food grown by local farmers or cooperatives keeps money in local communities, which helps both the farmers and the community as a whole.

METHODOLOGY AND RESULTS

The objectives of the food study were to determine generally where HCA's food was being purchased and to investigate options that may exist to increase the amount of local food used by HCA.

To determine HCA's baseline food consumption patterns, we examined food purchases for the first and third weeks of January, February, July, and August. These months were chosen to represent times of the year when various foods may or may not be in season. After we collected the data, we coded each type of food to determine what food types the purchases fall in (e.g., dairy, meat, produce). We used the analysis to identify the source of HCA's food and to estimate HCA's food budget, especially HCA's budget for produce.

Sources of Food

HCA purchases its food primarily from the following stores: Giant, Costco, Food Lion, Wal-Mart Supercenter, Martin's, and Nalls Farm Market. By totaling up the purchases made during the sample purchasing weeks, we determined that 58 percent of food (by amount of money spent) is purchased at national/regional chains versus local markets or farms. The breakdown by store is shown in Table 1.

Table 1: Percent of spending at each store

Store	Percent of Spending
Costco	30.08%
Food Lion	16.52%
Giant	3.04%
Martin's	3.24%
Monastery Mustard	10.17%
Nalls Farm Market	0.60%
Schenck Foods	27.71%
Wal-Mart Supercenter	8.65%

Produce

Fresh fruits and vegetables comprise a fairly significant portion of HCA's food budget—13% in our study. A study done of Maine agriculture showed that shifting 1 percent of total food expenditures to direct purchasing from farmers could lead to a 5 percent increase in farm sales.[4] While similar data is not available for Virginia, it is likely that by shifting some of its purchasing to local farmers, HCA could contribute to the growth of the Virginia economy.

HCA spends most of its product budget on the following produce items: apples, bananas, cucumbers, and lettuce. Of these items, apples, cucumbers, and lettuce can be grown locally. These items may even be found at a lower price than in the grocery store because the transportation costs are lower. If produce is purchased at a local farmers market, there is no middleman which can further reduce the cost.[5]

OPTIONS

Based on the information collected, we recommend that HCA (1) purchase more produce locally where possible and (2) explore the potential to produce some food for the community on HCA land.

Source Locally

Where possible, to reduce environmental, economic, and social impacts, we recommend that HCA purchase locally grown produce. There are a number of options to do so.

- Community supported agriculture (CSA) is an option that is growing in popularity. In joining a CSA, one purchases a "share." This share entitles you to a portion of a farm's produce each week. (Some CSAs operate on a weekly, bi-weekly, or monthly basis.) There are a number of CSAs in Virginia, including Smallwood's Veggieporium and Holly Brook Limousin, which is in Berryville itself. Additional CSAs can be found through Web sites such as http://www.localharvest.org.

- Another option is for HCA to purchase locally grown produce and other food items from farmers' markets in the area, such as the Clarke County Farmer's Market.[6] These are also growing in popularity around the US.

Self Production

Another option for HCA is to produce more of its own produce. Certain items (e.g., lettuce and tomatoes) could be grown on a small scale by the HCA community members. Alternatively, volunteers could be recruited to help grow larger quantities. Whatever produce HCA decides to grow itself should be grown using organic, low-impact farming techniques to reduce the impacts of agriculture in the community.

ENDNOTES

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[1] Manchester Business School, Environmental Impacts of Food Production and Consumption, Prepared for UK Department for Environment, Food and Rural Affairs, December 2006, ttp://www.ifr.ac.uk/waste/Reports/DEFRA-Environmental%20Impacts%20of%20Food%20Production%20%20Consumption.pdf (accessed March 21, 2010).

[2] GoodGuide, “Social Impacts of Food,” GoodGuide, Inc., 2010, http://www.goodguide.com/topics/2009/3/13/social_impacts_of_food (accessed March 20, 2010).

[3] Kirsten Schwinde, “Growing Local Food into Quality Green Jobs in Agriculture,” Urban Habitat, 2007, http://www.urbanhabitat.org/node/867 (accessed March 20, 2010).

[4] Jesse E. Gandee, “Economic Impact of the Maine Food System and Farm Vitality Policy Implications,” Office of Policy and Legal Analysis, Maine State Legislature, November 2002, http://www.state.me.us/legis/opla/agvitrpt.PDF (accessed March 21, 2010).

[5] Rose, Nick and Elena Serrano, “Go Local, Virginia: A Consumer’s Guide to Buying Healthful, Locally Produced Foods in Virginia,” Virginia Cooperative Extension Publication 348-127, 2009, http://pubs.ext.vt.edu/348/348-127/348-127.pdf (accessed April 8, 2010).

6 Virginia Department of Agriculture and Consumer Services, “Clarke County Farmers’ Market,” Virginia.gov, http://vagrown.vi.virginia.gov/product.aspx?pid=55967 (accessed March 19, 2010).

BUILDINGS

8

Buildings and the built environment are responsible for a wide variety of impacts on human health and the environment. According to the EPA, buildings[1,2]

- account for nearly 40% of US primary energy use, 72% of US electricity consumption, and nearly 40% of US carbon dioxide emissions;
- annually consume approximately 60% of all raw materials extracted in the US (not including food or fuel), generate a total of 170 million tons of construction and demolition debris, and generate 210 million tons of municipal solid waste;
- use 13.6% of all potable water (15 trillion gallons per year); and
- create a myriad of indoor environmental health risks.

Principles of green construction can ameliorate these impacts. The term "green construction" refers to the practice of creating structures that are environmentally responsible and resource-efficient throughout a building's life-cycle (site selection, design, construction, operation, maintenance, renovation, and deconstruction). The overall goal of green construction is to create "a wonderful building – a building that is bright and well-lit, that is warm in winter and cool in summer, that is as comfortable as it is healthy, that is energy- and resource-efficient, that is functional and long-lived, and that promotes the well-being of its occupants and the earth."[3]

This chapter briefly describes the history and use of the buildings at HCA and outlines the principles of green building design and construction that we believe may be relevant to any new construction or renovation that HCA may pursue as part of its sustainability strategy. In addition, this chapter describes a new dormitory that HCA might build that incorporates key concepts described in this chapter.

CONTEXT

Green Building Principles

A green building is a healthy facility that is designed, built, operated, and disposed of in a resource-efficient manner, using ecologically sound approaches.[4] The construction of a green building encompasses virtually every aspect of sustainability as the term is typically defined; from land use, to water and energy conservation, to waste management. In sum, sustainable buildings ideally:[5]

- are planned and sited in a way that makes appropriate use of land;
- use water, energy, lumber, and other resources efficiently;
- enhance human health;
- strengthen local economies and communities;
- conserve plants, animals, endangered species, and natural habitats;
- protect agricultural, cultural, and archaeological resources; and
- are economical to build and operate.

Unlike typical buildings, green buildings are designed within an ecological framework to reduce their overall impact on the environment. This means that green buildings are designed with the surrounding ecosystems in mind, and are operated in a manner that stays within the limitations of these natural systems.[6]

The non-profit US Green Building Council defined the parameters of a green building when it established the LEED (Leadership in Energy and Environmental Design) standard in 1991. LEED generally consists of a scoring system that considers six aspects of a building: (1) site selection, (2) water conservation and efficiency, (3) energy and atmosphere, (4), materials and resources, (5) indoor environmental quality, and (6) green design innovations. Within each category, LEED assigns point values to various building characteristics and elements.[7] The total number of points earned by a building determines the building's "greenness," which can achieve the levels (from low to high) of Certified, Silver, Gold, or Platinum. The scoring generally is performed by a certified professional and can be very expensive.

In one sense several of the key LEED categories are considered elsewhere in this report. For example, techniques and design features that can be incorporated into HCA's buildings to improve "water conservation and efficiency" (LEED category 2) are addressed in Chapter 3: Water. Indoor air quality concerns (LEED category 5) are addressed in Chapter 5: Toxics. Building features that implicate energy and atmosphere (LEED category 3), such as the design of the building envelope and energy-efficient lighting and HVAC systems), are addressed in Chapter 2: Energy. Other sustainable design and construction principles that are addressed by LEED and that HCA may wish to take into account when planning for and/or designing new or renovated buildings for the community are not covered elsewhere in this report and will be described here. These principles include: (1) site considerations; (2) building layout; and (3) construction materials.

Site considerations

Among the most important considerations when constructing a green building is the relationship of the building to the sun, water, and air.[8] Making the best use of the sun's heat and light is central to this concept. Proper orientation of a building on a site enables occupants to take advantage of the sun for heat and light, particularly in winter months when the sun is low in the sky and the weather is cooler. Proper orientation relative to trees, slopes, and other site features can help shield the building interior from excessive sunlight in the summer when the sun is high and the weather is hot.[9] Proper orientation also ensures that sunlight is available to supplement artificial lighting. Buildings that incorporate natural light use substantially less energy and provide a connection to the outdoors. Studies show that natural light also contributes to reduced building operating costs, increased worker productivity, and the health and well-being of occupants.[10]

A building's orientation relative to water also is a critical consideration when building green. Most modern houses are sited with little regard to the natural flow of water across a site. One green building principle recommends that designers site buildings with respect for the natural flow of water, creating a "comfortable route" for water to flow over and away from the building.[11]

Siting a building to take advantage of air flow sounds simple but is often disregarded in modern design. In conventional buildings ventilation to building occupants normally requires fans, dampers, and controls that artificially move outside air into a building and inside air to the outside.[12] One goal of creating a green building is to use natural air flow rather than mechanical air flow to make the indoor air the same quality as the outdoor air. Choosing a site with clean outdoor air and ample air flow and including lots of windows and doors that allow the air to move and mix are essential components of green design. Reliance on mechanical air exchanges, filters, and humidity controls ideally are minimized.[13]

<u>Building layout</u>: The shape, interior layout, and size of a green building are as important as how the building is oriented on the site. The layout affects the airflow and solar penetration within a building's interior space, and therefore impacts the amount of energy required to heat and cool the building. For example, as a general matter, sustainable buildings ideally should be situated so that the long side of the building is on an east-west axis. Orienting the building east to west minimizes solar loads on the east and west surfaces, especially during the summer.[14] Moreover, in the southern half of the United States, buildings ideally should be relatively long and narrow to further minimize the solar loads on the east and west surfaces.[15]

Building size also is critical to sustainable design. Green buildings should not be bigger than necessary, because in addition to requiring more energy for heat and cooling bigger buildings require more land and more lumber. In fact, while the green building movement in North America has improved the energy efficiency of houses over the past two decades, the typical house built today still requires almost as much energy to heat and cool as one built in 1960 simply because it's bigger.[16] Smaller houses require fewer materials, less land, and less energy.

Finally, green buildings endorse concepts of flexible design. Sustainable buildings are designed so that they can be used for multiple uses and multiple ways over the life of the building. For example, in sustainable buildings, common spaces can be subdivided and reconfigured to accommodate alternative uses. Walls, furniture, and interior components are chosen so that they can be disassembled and erected in new configurations as demand for the space requires.[17]

Building materials: Traditional criteria for selecting building materials include strength, cost, appearance and suitability. Principles of green construction add environmental impact, durability, and toxicity to the traditional list.[18] To minimize the environmental impact of materials, green buildings principles incorporate the "reduce, reuse, and recycle" concept. Renovation is preferred (when possible) to demolition and new construction. Local suppliers are preferred to lower the emissions cost of obtaining materials. Building materials are salvaged and reused to minimize the need to extract and process raw materials and ship new material long distances. Salvage also reduces the economic and environmental impact from waste disposal.[19]

Using new building materials with recycled-content also enhances sustainability. Examples of construction materials that can be readily found with recycled content include drywall (many utilize recycled paper and post-industrial gypsum), insulation (including cellulose, mineral wool, fiberglass, and recycled cotton insulation), plastic lumber, countertops and other hard indoor surfaces, glass tiles, landscaping materials, carpet and carpet padding, and steel.[20] And of course obtaining building materials from local sources improves the sustainability of a structure because it saves energy that otherwise might be required to transport the material long distances to reach the building site.

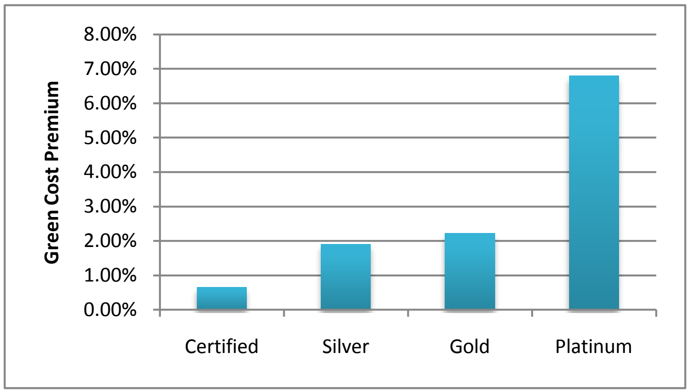
Finally, materials should be selected to maximize the building's longevity. Durable materials will last longer than less sturdy materials, and therefore will extend the useful life of a building and reduce the need for significant renovations that may result in large amounts of construction debris being disposed in landfills.

Green Buildings v. Conventional Buildings

Experts have debated whether green buildings are more costly to build and if the benefits from energy and other resource-use savings over time outweigh the extra costs. Recent studies have shown that green buildings that have received LEED certification on average use 26% less energy than the national average.[21] Studies also have shown that buildings owners must pay a capital cost premium for the construction of new LEED buildings, and that the cost premium increases as the level of LEED certification increases. *See* Figure 1. Still, many believe that replacing underperforming buildings with new green buildings makes good financial sense. One researcher concluded that--in California at least--the average energy savings from green buildings exceeded the cost premium.[22] Operation and maintenance costs also may be lower for green buildings, possibly by as much as 25%.[23]

In addition to achieving significant energy savings, most green buildings have a longer useful life than non-green buildings (longevity is a component of LEED's total life-cycle evaluation). In 2002, the Packard Foundation demonstrated a strong positive correlation between building life and level of greenness (as the green certification level increased, so did the lifespan of the building.)[24] According to this study, a conventional building is expected to last 40 years, a LEED Silver building for 60 years, and a Gold or Platinum building even longer. A longer life equates to less capital costs associated with capital improvements and reinvestments. Higher longevity also increases the period for payment streams, such as energy and O&M costs, and captures greater savings that accrue over time.

Figure 1: Average green cost premium according to level of LEED certification



Source: USGBC, Capital E Analysis[1]

Reducing a property owner's carbon footprint is another benefit of building green facilities. Most scholars and industry practitioners agree that buildings, especially commercial buildings, are a major contributor to global warming. According to the University of Michigan's Center for Sustainable Systems, the combustion of fossil fuels by commercial buildings generated roughly 305 million tons of CO_2eq in 2005. This represented approximately 17% of all CO_2 emissions in the US for that year.[25] Green building improves energy efficiency, which reduces energy consumption and reduces a building's carbon footprint.

METHODOLOGY

To evaluate building conditions and materials, the project team conducted a building inventory during the site visit in May 2009. During the inventory, the team evaluated (1) the use of each building or area, (2) methods of wall, floor, and ceiling construction, (3) window and door type, (4) roofing type, and (5) insulation (if observable). In addition, the team interviewed the Cellarer and other members of the community to understand the history and uses of the building. Responses to the HCA Survey that the Team administered in August 2009 provided additional insight into the community's perspective on the HCA buildings and facilities.

RESULTS

As a result of research and interviews, the Team learned that the multiple buildings in the monastic enclosure were constructed over a long time period beginning in the 18th century. The oldest buildings in the enclosure are the Cool Springs Mansion and St. Joseph's Scriptorium, which were constructed in 1784 and served as a plantation home before the monks arrived in 1950. *See* Figures 2 and 3. After the monks purchased the property, they constructed the Old Dormitory and cloisters from unfaced cement block to provide living quarters for the community. *See* Figures 4 and 5. A few years later, the monks constructed the existing chapel and chapter room. These simple buildings housed the community for more than 25 years.

Figure 2: Cool Springs Mansion (c.1784)

Figure 3: St. Joseph's Scriptorium (c.1784)

Figure 4: Old Dormitory (c.1950)

Figure 5: The Cloisters (C. 1950)

By 1978, the community had expanded and aged, and the monks therefore constructed a new refectory, infirmary, and sleeping quarters. *See* Figure 6. *S*hortly thereafter, in 1981, the community added Northwest Dormitory, Novitiate Chapel, and Senior Wing for additional living space. (*See* Figures 7 and 8.) This configuration housed the community for another 20 years. In 1999, the community added an elevator and renovated the chapel, chapter room, bell tower, and lower level library. Figure 9. A schematic showing the footprint of the sprawling complex and the relative location of each of the building areas is shown in Figure 10.

Figure 6: The Kitchen and Refectory Wing (c.1978)

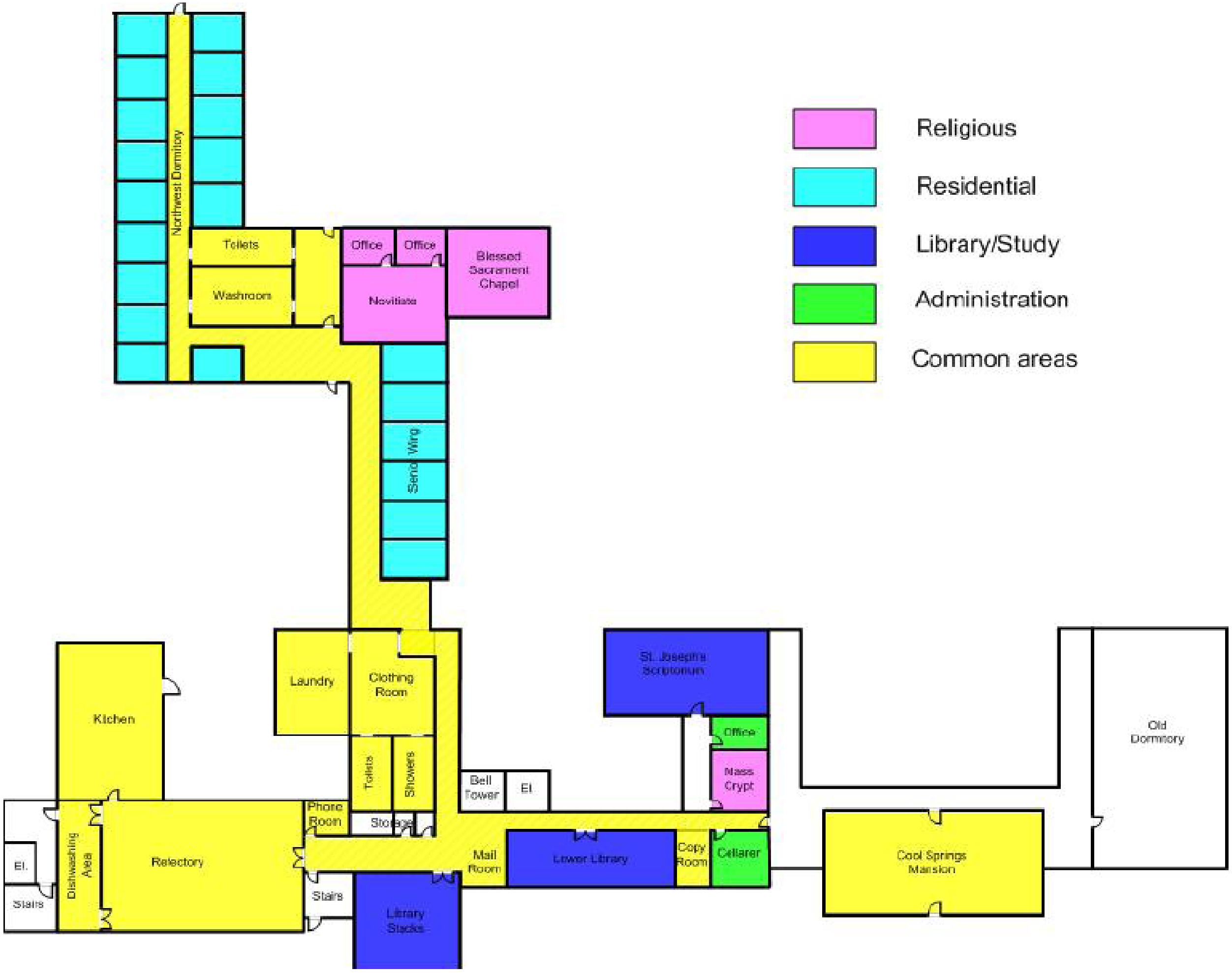
Figure 8: The Northwest Dormitory (c. 1981)

Figure 7: The Novitiate Chapel (c. 1981)

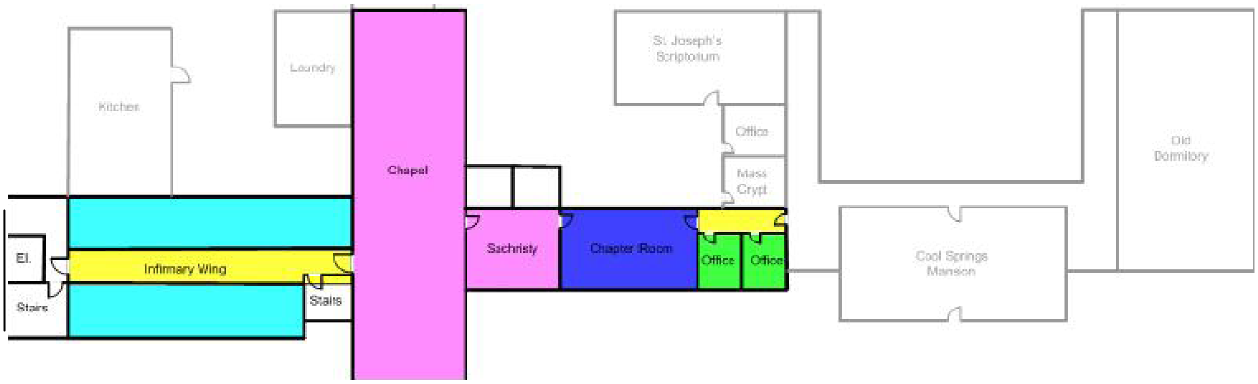
Figure 9: View of Elevator and Bell Tower (c. 1999)

Figure 10: Layout of HCA Buildings, with Uses

Lower Level



Upper Level



Although most of HCA's buildings generally are in good condition, some of the buildings have fallen into disrepair. Moisture and mold have been identified in the mansion, St. Joseph's Scriptorium, and Old Dormitory. In addition, a structural report prepared for HCA in January 2009 reported that in certain areas of the buildings the framing is inadequate to support the loading requirements. Exterior finishes, including certain areas of the cloisters, are in need of maintenance and paint.[26]

Examples of Green Building Design

Two case studies illustrate the principles of green building in a context somewhat similar to HCA's.

Figure 11: The Campus of the IHM Motherhouse in Monroe, Michigan

Source: www.ihmsisters.org

Figure 12: The IHM Motherhouse, Monroe, Michigan

Source: www.ihmsisters.org

The IHM Motherhouse.[27] The Immaculate Heart of Mary Motherhouse is situated on 280 acres of property along the River Raisin in Monroe, Michigan. *See* Figure 10. The historic 380,000 square feet complex was built in the 1930s for many years had provided housing (especially retirement care and special needs housing) for the Servants of the Immaculate Heart of Mary (SSIHM). In the late 1990s, the Sisters recognized that their order was aging and diminishing, and they set out to restore the historic Motherhouse using environmentally responsive sustainable design.

The SSIHM Sisters spent several years planning the renovation with architects, designers and other experts. As part of the renovation, the community "recycled" the existing building instead of building an entirely new one. *See* Figure 12. The design was intentionally flexible and multi-functional so that the building could be used not only for the Sisters' immediate retirement needs but also would be attractive and adaptable to the needs of others beyond the IHM community. Large, bright, meeting spaces; arts, music and reading areas; and activity and service center areas were incorporated into the structure. Specific green building elements that the Sisters included in the renovation included the following:

- Windows, doors, equipment, and other items were salvaged from the building for re-use.
- The buildings are heated by geothermal heating and cooling systems.
- Water is conserved through the use of graywater recycling systems and low-flow and water-conserving fixtures.
- The building incorporates high-efficiency and high-performance compact fluorescent lighting, occupancy sensors, natural light control programmed lighting, and energy efficient insulated glass.
- Architectural elements maximize daylight and fresh air
- Sustainable (i.e., non-toxic, renewable (when possible)) materials and finishes were used to avoid chemical exposure.
- Landscaped courtyards provide protected outdoor spaces and enable disabled residents to access the outdoors.

In addition to the building restoration/renovation, SSIHM is in the process of restoring its property. The community has converted five acres of lawn to meadow and prairie to improve the biodiversity of the site and protect existing natural habitats. (The natural areas also reduced costs and emissions associated with mowing.) In addition, the Sisters are protecting mature forest areas and an endangered oak savanna ecosystem on the property.

Construction on the building renovation began in 2001. The renovation was completed and received LEED-certification in 2003. The total cost of the renovation was $58 million, but this cost is exceptionally high in part because the Motherhouse is a very large and very old building, and in part because the structure literally was re-built from the ground up. The building is approximately 376,000 square feet and houses approximately 200 community members, almost two-thirds of whom require supportive care. To illustrate the scope of the project, more than 300 bathrooms were added to the building during the renovation. Each and every window, door, and item of furniture was removed, renovated, and returned to the structure (if possible).

<u>The Benedictine Women of Madison, Wisconsin</u>.[28] This order was founded in 1953, when a number of Benedictine sisters from Iowa moved to Madison, Wisconsin to build a monastery and a Catholic girls' high school. In 1966, they closed the school and opened Saint Benedict Center, a retreat and conference facility, in the former high school building. By 2006, they were ready to replace the 60,000 square foot high school building ("Benedict House") with a 34,300 square foot, energy-efficient, "right-sized" monastery that has 50% less space but is much more in line with their spiritual mission and vision of sustainability. (The new monastery is not a residence.)

Figure 13: Former Benedict House

Source: www.hoffman.net/clients

The renovation of Benedict House is notable for several reasons. First, 97.5% of the original building was recycled into the new building. Thus, of the original 8,650 tons of material in the original structure, approximately 12 tons were disposed of in a landfill, 9 tons were donated to Habitat Restore, and the remaining 8,629 tons were built into the new building. Second, the site planning included several features (such as rain gardens, all native landscaping, porous concrete parking areas, green roofs, and rain barrels) to reduce storm water runoff from the site to 13% below pre-renovation levels.

Figure 14: New Holy Wisdom Monastery

Source: www.hoffman.net/clients

In addition, the structure included some of the same "green building" components as the IHM Motherhouse, such as geothermal heating and cooling systems, active solar energy generation, and energy-efficient appliances and fixtures. Following the renovation, the community determined that water usage was 53.9% below LEED baseline and energy use was 59.2% below LEED baseline. The new Holy Wisdom Monastery was completed in 2010 and received a LEED-Platinum rating. The total cost of the new monastery was $8.5 million.

OPTIONS

Green building is a complex discipline that requires long-term planning and the assistance of architects and other experts. Designing a green building to replace or supplement the HCA complex therefore would be far beyond the scope of this report or the expertise of the Michigan Team. Nevertheless, we developed a conceptual model of a new dormitory and cloister to illustrate how green building principles might be applied at HCA. A screenshot of the model is depicted in Appendix 8-A and contains site considerations, architectural features, and design elements that incorporate the green building principles described in this Chapter.

The New Dormitory and Cloister

As shown in Appendix 8-A, the conceptual new dormitory that we designed is located in the basic building footprint of the existing Old Dormitory. The building consists of two stories and is connected to Cool Springs Mansion and St. Joseph's Scriptorium by a new cloister and covered walkway. The small offices and the Mass Crypt that currently connect St. Joseph's to the main monastery building have been removed so that the cloister is open to the rest of the courtyard. Removing these offices would eliminate the need to repair the roof leaks and remove mold that has formed in these offices. *See* Figure 16.) In addition, the removal would eliminate the cost associated with heating and cooling one of the worst energy-performing areas of the monastic enclosure. We envision that St Joseph's Scriptorium might be converted to another use (e.g., a Mass Crypt, small chapel, or meditation pavilion), because it is the Team's understanding from interviews with the HCA community that the building is seldom used for reading or listening to music. If the building is converted to another use, the books, recorded music, and other items that currently are in the building (if still useful) could be consolidated with materials in the Lower Level Library.

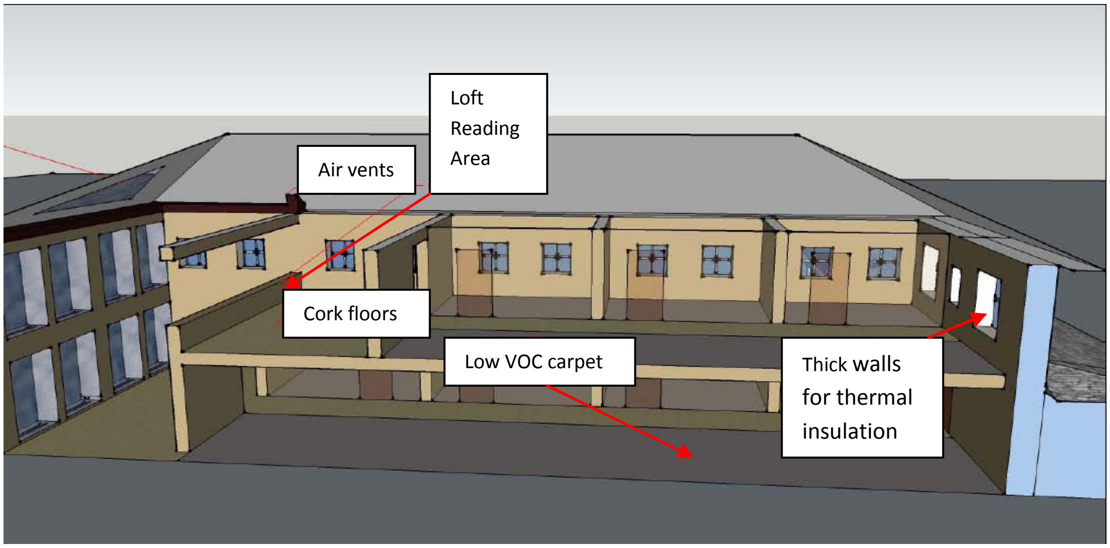
Figure 15: Mold in small office space adjacent to St. Joseph's Scriptorium

The Michigan Team advocates for constructing the new dormitory in the basic footprint of the existing Old Dorm (if feasible). One reason for this location is that, according to green building principles and as illustrated by the new monastery constructed by the Benedictine Women of Madison, buildings and building materials ideally should be recycled rather than disposed. It is possible that the foundation, subfloor, and perhaps even some wall materials could be incorporated into the new structure if the new dormitory were constructed in the footprint of the Old Dormitory.

In addition to potentially reusing portions of the Old Dormitory, constructing the New Dorm in the footprint of the Old Dorm seems consistent with HCA's tradition and heritage. According to HCA's Cellarer, the Old Dormitory was constructed literally by hand, block by block, by the monks who founded HCA in the early 1950s. Preserving as much of the Old Dormitory as possible therefore has sentimental appeal. Of course, the foundation, subfloor, and other structural elements of the Old Dorm would reusable only if they are sound and would support the new structure. In addition, the windows, roof, and virtually all interior features of the Old Dorm probably would have to be disposed and replaced with more energy efficient models.

The interior of the new dormitory is divided into two basic types of space. *See* Figure 16. The south end of the building contains a vaulted space that might be used as a common room or community study area. A loft on the second floor of the building overlooks the common room and might be used as a library or reading room. The remainder of the building is divided into individual rooms with private baths, much like the rooms in the current Senior Wing.

Figure 16: Interior view of conceptual New Dormitory



The Team has not attempted to determine how many individual rooms might fit within the space shown. However, if the community were to construct a new dormitory that is large enough to house the current community (other than the members who currently live in the Infirmary Wing), HCA might be able to find an alternative use for the Northwest Dormitory. For example, the space could be reserved for novices, visitors, or volunteers. Alternatively, the space could be demolished and the building materials could be incorporated (if possible) into the new dormitory or donated. Removing the Northwest Dormitory would eliminate some of the sprawl associated with the monastery complex, and would reduce energy consumption by eliminating a relatively energy inefficient portion of the HCA facility. Determining whether to demolish the Northwest Dormitory of find an alternative use for the space would require HCA to evaluate the overall sustainability of the choice by weighing the impact of the building from an energy standpoint against the impact of the demolition from a waste standpoint, and comparing the costs and benefits of each of the potential options.

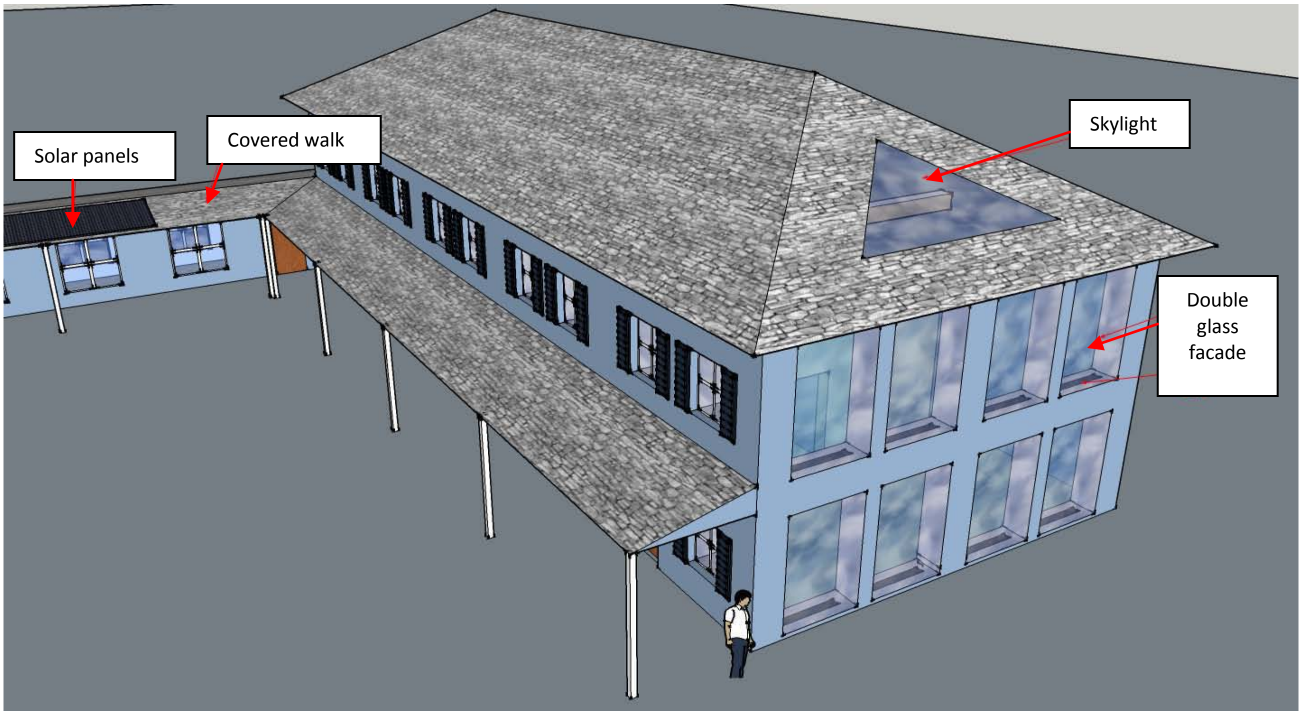
Although not depicted specifically in the model, the new dormitory of course would include building elements and materials that minimize the building's environmental footprint. As described in Chapter 2, windows, doors, insulation, and other features have a tremendous impact on the amount of energy needed to heat and cool interior spaces. Any new spaces at HCA should be constructed to minimize heat losses and gains through the building envelope. Roof and wall insulation with appropriate R-values, double- or triple-paned windows, and a thermally resistant roof system should be incorporated to maximize energy efficiency. Likewise, Chapter 3 describes the impact that inefficient bathroom fixtures can have on the amount of water used and discharged by the community. Low-flow showerheads and faucets, high efficiency toilets and urinals, and/or even composting toilets should be installed to minimize water use.

In addition, the new dormitory incorporates sustainable interior finishes. The common space and hallways feature renewable cork flooring rather than nonrenewable materials. Individual rooms are carpeted with material made from wool or other natural fiber, which, unlike conventional carpet fiber, does not contain volatile chemicals (VOCs) that may collect within the indoor air space. Interior surfaces are painted with a low-VOC, light-reflecting paint to allow maximum penetration of sunlight deep into the interior of the building.

The new dormitory depicts several specific features for improving energy efficiency. One key feature is the wall mass, which as depicted in Figure 16 is thicker than the walls of a conventional building. Thick walls provide heavy thermal mass for the building envelope that reduce heat loss to offset the heat loss from window area. The new dormitory design incorporates many windows because each of the individual rooms needs at least one window so that the resident can control airflow and temperature (on mild days). Even efficient window designs are less efficient than insulated wall space, but heat loss is minimized nonetheless because the walls in the new dormitory design are thicker than usual.

Another key feature of the new dormitory is the double glass façade that is depicted in the south-facing wall of the building. See Figure 17. The two-story double glass façade allows the maximum amount of light to penetrate the interior space, thereby enhancing the use of daylight for lighting purposes. A skylight, with optional venting and shading capabilities, in the southern end of the building also allows sunlight to penetrate the building. The open design of the building, especially the vaulted common space and second story loft, enables the daylight to penetrate deep into the building and minimizes the use of artificial lighting.

Figure 17: New dormitory showing double glass facade



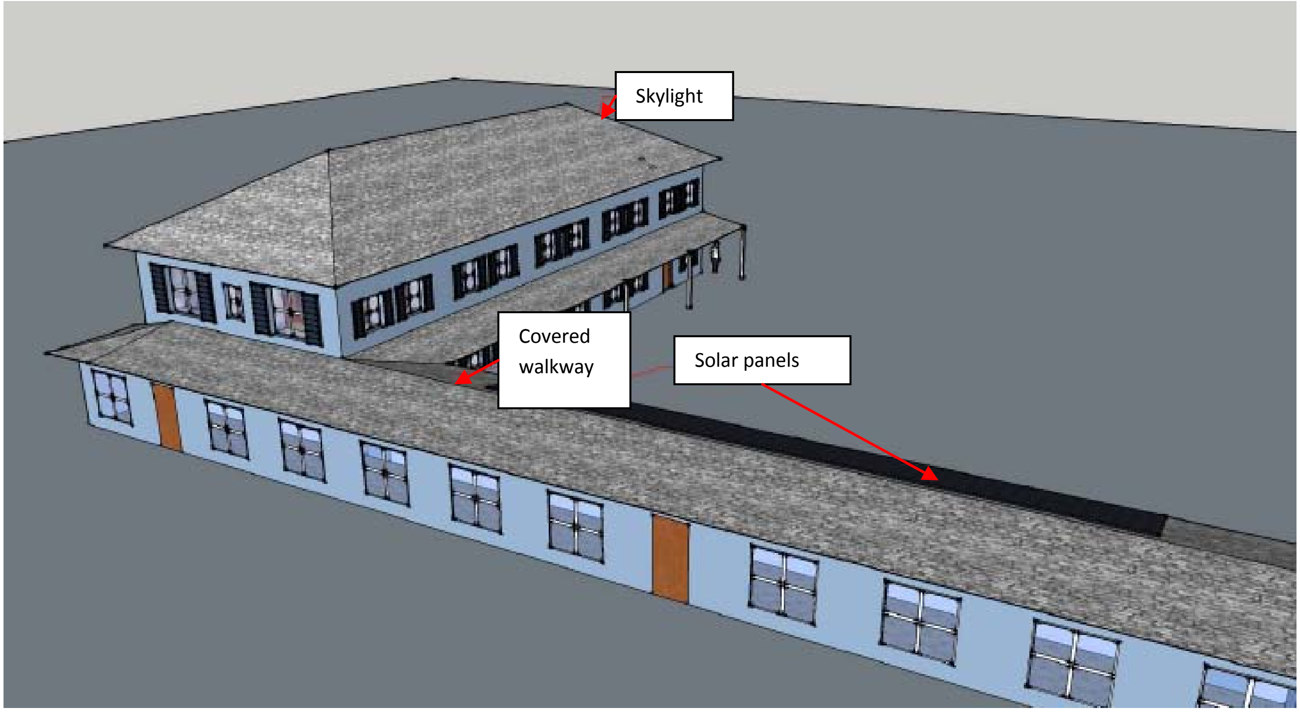
The double glass façade also helps to control the temperature within the building. The windows in the double glass façade consist of two sheets of triple-pane, low-E glass with about 6-12 inches of airspace between them. Solar radiation that penetrates the glass is reflected back and forth between the heavily-coated panes of glass, which causes the pocket of air that is trapped in the interstitial space to become heated. This design takes advantage of natural convection currents by manipulating when the warm air between the two sheets of glass is allowed to rise (warmer air naturally rises). In warm weather, the heated air in the interstitial space passes through air vents between the two stories of windows and expelled into the attic of the building. As the warm air rises, it pulls cooler air from the basement through those same vents into the interstitial space, which insulates the building interior from the hot outdoor air. In cooler weather, the vents are closed, and the heated air is retained between the glass panes to radiate heat into the building and insulate the interior space from the cold outside air. This double façade acts like a wall while allowing a large amounts of natural light to penetrate the interior space.

The skylight also helps to control the temperature within the building. Like the façade, the skylight can be vented in the summer to easily release the hot air that rises to the ceiling of the building. When the vent is open, the warm air pulls cooler air from the north end of the building into the room, ultimately creating a natural convection current. When solar radiation is at its peak in the summer, the skylight can be shaded to reflect the unwanted radiation. In the cooler months, the vent is closed and shading is retracted to maximize the amount of penetrating sunlight and warm air in the inside space. This building also could incorporate elements of passive solar design by using material that absorbs radiant heat and evenly disperses that heat throughout the building (*see* Option 5 in Chapter 3: Energy.).

The open design of the building maximizes the heating and cooling effect of these two features. As described above, the natural tendency of warm air to rise and the axiom "nature abhors a vacuum" work together to ensure that the air that is warmed by the sun and the cool basement air circulate throughout the new dormitory. Warm air rises and draws cooler air up, which literally causes a cycle of air within the interior space. The façade and skylight therefore help to condition the air throughout the interior of the building using only the energy of the sun and the movement of air.

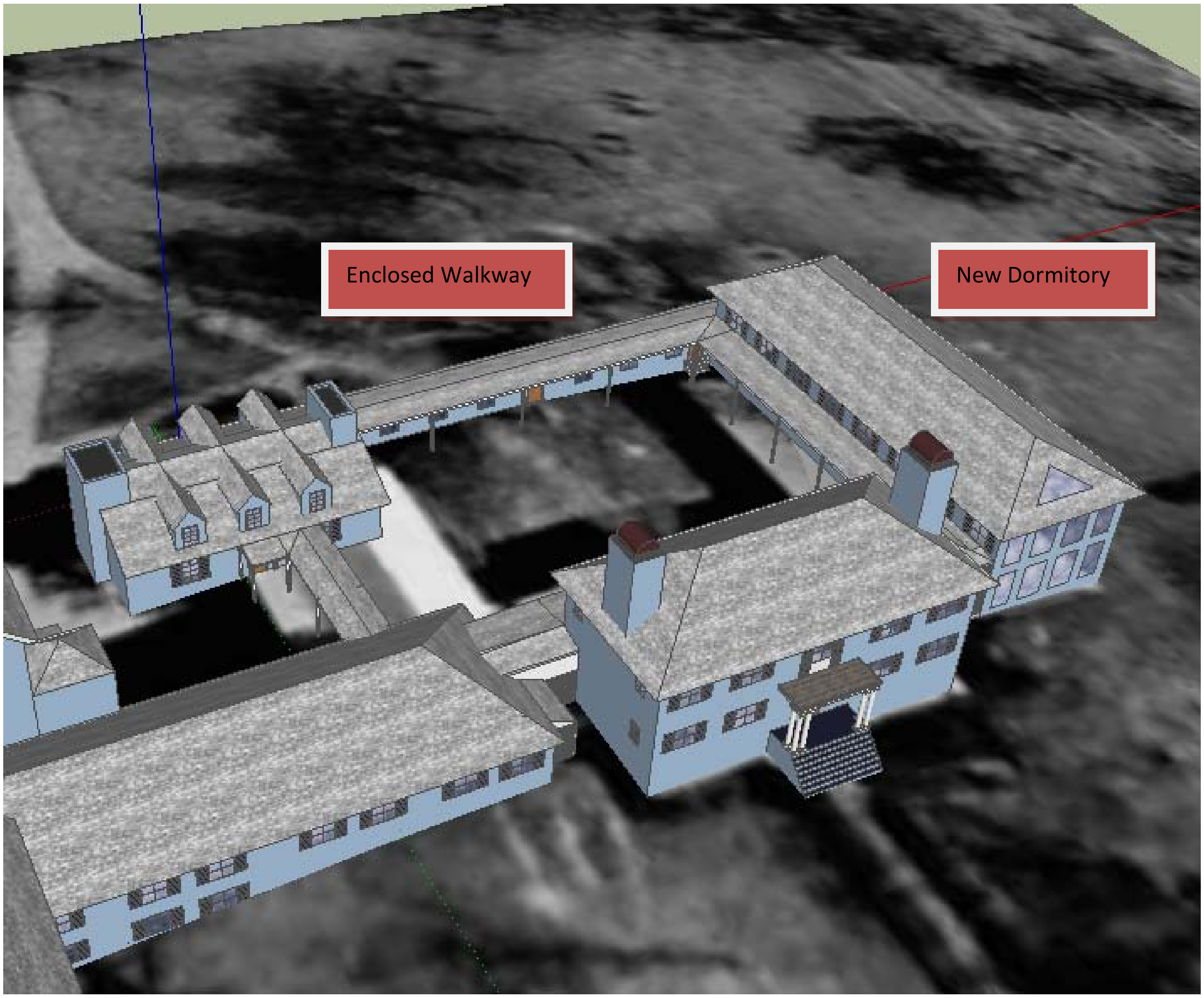
A third feature of the new dormitory is the new covered walkway at the northern end of the cloister area. The concept depicts a walkway around the entire cloister area, as is traditional in Cistercian monasteries, but at the northern end of the cloister one-half of the walkway is enclosed. *See* Figure 18. One feature of this walkway is that enclosure provides shelter between the new dormitory and St. Joseph's Scriptorium, but the thick, insulated walls moderate the interior temperature without requiring an external energy source. Another feature of the walkway is that the roof of the open section (closest to the cloister) is pitched at a 15-20 degree angle. A 15-20 degree pitch is the optimum angle for the solar panels that are installed along the length of the roof. These panels can be used to generate electricity for interior and exterior lighting in this area.

Figure 18: Conceptual covered walkway



Green building offers an exciting opportunity for the community to carefully consider the current and future needs of the community and the unique and special site that has been home to the monastery for so many years, and then bring together many of the concepts and ideas that are discussed throughout this report to create a more sustainable built environment. Many more opportunities exist for incorporating green building principles into any future renovation or new construction that the community may consider. The conceptual new dormitory is offered solely to illustrate a few of the concepts discussed in this chapter. As such, the Team did not attempt to estimate construction costs, nor did we define the details that would necessarily be required in a professional conceptual plan.

Appendix 8-A: Screenshot of HCA Model showing Conceptual new dormitory



ENDNOTES

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[1] "EPA Green Building Strategy," EPA-100-F-08-073 (November 2008), available at www.epa.gov/greenbuilding.

[2] "Green Building Facts," U.S. Green Building Council, available at www.usgbc.org/Resources/GreenBuildingFacts.

[3] Lopez Barnett, D. and W. D. Browning, *Primer on Sustainable Building* (Rocky Mountain Institute Green Development Services, 1998), 5.

[4] Charles J. Kibert, *Sustainable Construction: Green Building Design and Delivery* (Hoboken, New Jersey: John Wiley & Sons, Inc., 2005), 25.

[5] Barnett and Browning, *A Primer on Sustainable Building*, 5.

[6] Kibert, *Sustainable Construction*, 108-110.

[7] Kibert, *Sustainable Construction*, 75.

[8] Shay Salomon, *Little House on a Small Planet* (Guilford, Connecticut: They Lyons Press, 2006), 77-93.

[9] These principles suggest, for example, that in mild climates buildings should be long and thin along the east-west axis, so that the longer southern face of the building displays more surface area to the sun and the shorter east and west walls allow the sun to penetrate deep into the building interior. C. Snell and T. Callahan, *Building Green* (Asheville: Lark Books, 2005), 55.

[10] Kibert, *Sustainable Construction*, 188-189.

[11] Snell and Callahan, *Building Green*, 57.

[12] Kibert, *Sustainable Construction*, 191-92.

[13] Snell and Callahan, *Building Green*, 65.

[14] Kibert, *Sustainable Construction*, 187.

[15] Ibid.

[16] Salomon, *Little House on a Small Planet*, x.

[17] Ethan Soloman, "Whole Building Design Guide: Planning," National Institute of Building Sciences (June 2, 2009), available at http://www.wbdg.org/design/dd_planning.php.

[18] Kibert, *Sustainable Construction*, 240-48

[19] US Environmental Protection Agency, "Factsheet: Reclaimed Building Materials," available at www.epa.gov/greenhomes/SmarterMaterialChoices.htm.

[20] Ibid.

[21] C. Turner, "Energy Performance of LEED for New Construction Buildings," prepared for the US Green Building Council by New Buildings Institute (March 2008), available at http://www.newbuildings.org/downloads/Energy_Performance_of_Leed-NC_Buildings-Final_3-4-08b.pdf.

[22] G. Kats, "The Costs and Benefits of Green Buildings," A Report to California's Sustainable Building Task Force by Capital E (October 2003), available at http://www.usbgc.org/docs/news/news477.pdf.

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[25] Factsheets: Commercial Buildings," The University of Michigan's Center for Sustainable Systems (2009), available at http://css.snre.umich.edu/facts/factsheets.html.

[26] Structural Concepts, Inc., Report of Structural Investigation of Holy Cross Abbey (January 15, 2009).

[27] The information in this section was obtained during a visit to the IHM Motherhouse in March 2009 and from the website maintained by the IHM Sisters, www.ihmsisters.org.

[28] The information in this section was obtained from websites maintained by the Benedictine Women of Madison, www.benedictinewomen.org, and the architect who designed the building, Hoffman LLC, http://www.hoffman.net/clients/clients_hw.htm.

A HOLISTIC PERSPECTIVE ON SUSTAINABILITY AT HCA

In each chapter of this report, the University of Michigan Team has provided context explaining why each chosen focus area is integral to creating a more sustainable HCA. In addition, the Team detailed the methodologies used to study each focus area, then presented the results of those studies. Finally, the Team used those results to build suites of options, within each topic-area, to guide HCA toward sustainability, both from an environmental and economic perspective.

In this section, the Team presents these options from a holistic perspective, using a narrative to communicate a vision of a sustainable HCA. This narrative is not meant to advocate for a particular suite of options. Rather, the narrative offers an idea of what HCA could look like as the community moves toward a new era of sustainability. Ultimately, HCA must make the final decision on which options best meet the community's environmental goals, monastic values, and financial constraints.

Following the narrative, the Team presents a comprehensive list of options from each topic-area covered in previous sections. These options are arranged in three tiers according to their feasibility, cost, and required commitment from community and staff. This list is meant to be used as a reference tool to help guide the community's decision making.

Narrative: Lovers of the Place

As the autumn sun begins to rise over Northern Virginia, a white-tail deer grazes undisturbed in the wildflower meadow south of the Retreat House. Close by, HCA's recently installed wind turbine whirs as it spins in the dawn breeze—providing nearly 30% of the community's power, without contributing to climate change or releasing damaging air pollutants. Meanwhile, Brother Samuel, the community's newest postulant, prays with the community at the morning Lauds service.

After Lauds, Brother Samuel walks to the Retreat House garden, where he joins fellow community members and retreatants in harvesting organically grown spinach, sweet potatoes, beets, onions, and herbs for the community's lunch. He enjoys working in the garden, knowing that the activity makes the community more self-sufficient, and he looks forward to a lunch filled with fresh, healthy, and delicious garden vegetables.

Just before lunch, Brother Samuel washes his hands in the community bathroom, not noticing the recently installed faucet aerators that conserve water with every use. As the water drains out of the sink, it flows, not into a septic system, but rather into HCA's new graywater system, which reuses sink water to irrigate a specially designed, ornamental garden. Shortly after Brother Samuel leaves the bathroom, the high-efficiency fluorescent lights shut off automatically, thanks to motion occupancy sensors. The community added these sensors to help save electricity in frequently used areas throughout the monastic enclosure.

After lunch, Brother Samuel takes a walk down to the Shenandoah River. He pauses along the new riverbank path and gazes up at the eagle's nest through his binoculars. He wonders how the young eagle, born this past spring, is faring in its first autumn. He is grateful for the increased accessibility of the riverfront, which has encouraged him to spend more time outside, enjoying the natural wonder and tranquility of the Shenandoah Valley. As he continues walking, he is impressed by the apparent success of HCA's stream bank restoration program. The new plantings along the river are thriving, and there are no signs that cattle have waded into the river. He looks down the shoreline and imagines how much healthier the river is becoming as a result of the restoration project.

Later in the afternoon, Brother Samuel attends a conservation burial service presided over by the pastor from the local Methodist Church. Brother Samuel appreciates the solemnity of these touching services. After the service, he expresses condolences to the family, and the deceased man's daughter thanks him for allowing her father to be buried in such a natural and holy setting.

Just before Vespers, Brother Samuel walks around the monastic enclosure, collecting trash and recyclables from bins and cans along the way. Ultimately, he deposits the trash into one bin and all of the recyclables into a separate bin. In doing so, he is struck by the potential impact of such a simple act. HCA's waste management program is expected to reduce the amount of material the community sends to the landfill by as much as 10,000 pounds per year.

At dinner, Brother Samuel is delighted to eat more garden-grown greens with his pasta. But the best part of dinner is dessert—a delicious apple crisp made with fresh, organic apples obtained as part of the community's share in a local community-supported agriculture program.

Following dinner, Brother Samuel empties the community's food scraps into a bucket so they can be added to the compost pile near the community garden in the morning, and then loads dishes into an ultra-efficient, ENERGY STAR dishwasher. As the dishwasher is running, he sprays and wipes down countertops with a non-toxic, environmentally-friendly cleaning solution.

After Compline, Brother Samuel collects a load of laundry from the laundry room on his way to bed. He is pleased to recall that washing clothes in cold water saves HCA nearly $800 per year. Leaving the room, he gives thanks that the old, moldy walls have been replaced and that he is now able to breathe easier as a result. Finally, after a busy day, he retires to his bedroom, where he prays silently and looks forward to the next day's labor: working with others to produce a variety of organic bakery products in the newly refurbished, energy-efficient bakery.

Options: A Three-Tiered Approach

The aforementioned narrative is only one future scenario out of many that are possible for HCA. In reality, there are multiple alternative futures that HCA can achieve depending on the various options the community decides to adopt. In order to make it easy for HCA to view all of the proposed options that have previously been discussed and help them envision a more sustainable monastery, the Team has displayed the entire collection of options in Tables 1–3 below.

The Team realizes that HCA will not be able to adopt all of these options or immediately implement the majority of them. In light of this, the Team has categorized the list of proposed options according to a tiered system.

- Tier one represents sustainability initiatives that are relatively inexpensive, feasible to implement in the near future, and/or do not entail a significant amount of effort on behalf of the community and staff.
- Tier two alternatives are generally more costly, moderately difficult to implement, and require more time to complete.
- Tier three incorporates expensive and elaborate options that will potentially take a significant amount of time and/or resources to implement.

The left-hand columns in each table provide a brief description of each option. The right-hand columns indicate where additional details about each option can be found. Please note that these tiers are somewhat arbitrary, as some options may be easier or more difficult for HCA to implement than the given tier status may suggest. Nonetheless, the series of tables serve as a compendium and a general guide for the HCA community as they consider which options to pursue.

Table 1: Tier One Options

Tier One Options (no particular order)	Additional Details
Construct wide vegetated buffers around sinkholes with native perennial grasses	Land Use Options, pg. 53
Convert some areas of lawn into no-mow wildflower meadows	Land Use Options, pg. 53
Prohibit the use of pesticides, herbicides, sewage sludge, excess artificial fertilizer and excess manure in current and future farm leases	Land Use Options, pg. 53
Limit the use of vehicular or ATV traffic in the 100-year floodplain	Land Use Options, pg. 53
Create a new vegetable garden maintained by organic agricultural methods	Land Use Options, pg. 53
Remove and/or control the spread of invasive species on the property	Land Use Options, pg. 53
Use native plants adapted to the Shenandoah Valley ecosystem in all future plantings	Land Use Options, pg. 53
Plant more trees, especially along the road towards (and surrounding) the Retreat House, along the main road, and the road to Westwood House	Land Use Options, pg. 53
Hire appropriate local ecologists/botanists/biologists to perform comprehensive botanical and habitat surveys of the property to identify zones of ecological significance	Land Use Options, pg. 53
Enlist the help of local volunteer or environmental groups to perform restoration work, as well as to conduct annual monitoring of biodiversity and water quality	Land Use Options, pg. 53
Adopt/continue various energy conservation behaviors (community and staff)	Energy Options, pg. 103
Replace traditional incandescent light bulbs with compact fluorescent lamps (CFLs)	Energy Options, pg. 104
Install occupancy sensors	Energy Options, pg. 104
Install smart power strips	Energy Options, pg. 106
Improve weatherization (e.g. caulk and weather-strip windows)	Energy Options, pg. 114
Wrap water heaters with insulating jackets	Energy Options, pg. 107
Adopt/continue various water conservation behaviors (e.g. take short showers)	Water Options, pg. 171
Install low-flow showerheads	Water Options, pg. 159
Install sink faucet aerators	Water Options, pg. 161
Consider purchasing a high-efficiency, commercial dishwasher	Water Options, pg. 168
Install flow-metering devices and monitor water usage	Water Options, pg. 171
Install a drip irrigation system for the Butterfly Garden	Water Options, pg. 170
Hire a professional consultant to determine whether possible siting of septic systems in the floodplain poses a risk to water quality	Water Options, pg. 174
Contract with Waste Management to provide comprehensive recycling	Solid Waste Options, pg. 204

Tier One Options (no particular order)	Additional Details
Engage in official composting to capture all food scraps and yard waste	Solid Waste Options, pg. 206
Discontinue burning trash at the farm headquarters	Solid Waste Options, pg. 207
Adopt/continue various waste prevention practices	Solid Waste Options, pg. 208
Develop formal management systems for e-waste	Solid Waste Options, pg. 209
Develop formal management system for pharmaceutical waste	Solid Waste Options, pg. 210
Remove and recycle waste from informal dump sites located on the property	Solid Waste Options, pg. 211
Professionally remove/cover any damaged asbestos tiles	Toxics Options, pg. 223
Conduct a comprehensive asbestos assessment	Toxics Options, pg. 223
Avoid purchasing pressed wood products containing phenol resins	Toxics Options, pg. 223
Use air conditioning and dehumidifiers to reduce humidity and formaldehyde emissions	Toxics Options, pg. 223
Use low VOC paint for repainting surfaces	Toxics Options, pg. 223
If lead-based paint (purchased pre-1978) must be removed for any renovation purposes, hire a trained professional	Toxics Options, pg. 224
Install carbon monoxide detector	Toxics Options, pg. 223
Test for radon every five years	Toxics Options, pg. 224
Hire a trained professional to inspect, clean, and tune-up the central heating system annually to discover and repair any leaks	Toxics Options, pg. 224
Change filters on central heating and cooling systems and air cleaners per manufacturer's directions	Toxics Options, pg. 224
Use more environmentally-friendly household chemicals and cleaners	Toxics Options, pg. 224
Properly dispose of household chemicals and cleaners by taking them to the landfill on special household hazardous waste collection dates	Toxics Options, pg. 224
Remove mold with soap and water in areas that are mildly contaminated	Toxics Options, pg. 225
Invite and educate guests at the Retreat House and gift shop to conserve energy through signage	Economies Options, pg. 259
Eliminate the range in the contribution amount that HCA suggests for retreats and suggest a single contribution that more than covers HCA's costs	Economies Options, pg. 259
Raise the price of fruitcake $2 per unit to better reflect market prices	Economies Options, pg. 269

Tier One Options (no particular order)	Additional Details
Raise the rental rate per acre on the farm property to better reflect the rental market for agricultural land in northern Virginia	Economies Options, pg. 279
Reduce Retreat House payroll expense to the fullest possible extent through flexible staffing and reducing the weekday retreat by one day	Economies Options, pg. 260
Prepare for declining demand for fruitcake by focusing on creamed honey, which has more favorable margins and upward trending sales	Economies Options, pg. 270
Introduce new honey flavors and upgrade packaging to increase competitiveness	Economies Options, pg. 270
Seek annual gifts from retreatants	Economies Options, pg. 260
Solicit contributions from retreatants for a building fund	Economies Options, pg. 260
Display gift shop merchandise in public areas (e.g. lobby of Retreat House)	Economies Options, pg. 262
Advertise gift shop in local and regional church bulletins	Economies Options, pg. 262
Offer discounts on gift shop merchandise purchased before or at the conclusion of a retreat	Economies Options, pg. 262
Create a book club for individuals that regularly attend retreats or patronize the gift shop	Economies Options, pg. 263
Establish a program for used book sales at the gift shop	Economies Options, pg. 263
Create and maintain a database of gift shop customer e-mail addresses, which can be used to notify customers of seasonal sales, the arrival or new items, etc.	Economies Options, pg. 265
Consider involving additional members of the community in the gift shop operation and expanding hours of operation	Economies Options, pg. 265
Carry more of HCA's bakery products (including the Truffles and the Fraters) and display them prominently	Economies Options, pg. 265
Purchase locally-grown, organic food (community-supported agriculture or a farmers' market) and/or grow organic food on the property via a small garden	Food Options, pg. 302

Table 2: Tier Two Options

Tier Two Options (no particular order)	Additional Details
Resurrect Cool Spring as a critically important feature of the landscape	Land Use Options, pg. 53
Restore the Shenandoah shoreline by prohibiting cattle access to this area, revegetating eroded banks, creating a riparian buffer at least 300’ wide, and monitoring restoration progress	Land Use Options, pg. 53
Restore the natural hydrology of streams by removing waste, prohibiting cattle access, revegetating eroded banks, creating a stream buffer at least 100’ wide, and monitoring restoration progress	Land Use Options, pg. 53
Construct a simple, yet formal, trail along the shoreline, with access from the Bishop’s House, the Retreat House, and the Westwood House.	Land Use Options, pg. 53
Protect the water quality of Cool Spring by constructing a wetland upgrade where there used to be a pond, and by designating surrounding land as an ecologically sensitive groundwater “recharge zone”	Land Use Options, pg. 53
Construct a more pedestrian-friendly trail that loops around Cool Spring and the adjacent pond, and pave the trail with ADA accessible paving material (e.g. crushed, decomposed granite).	Land Use Options, pg. 53
Divert rainwater from all building into raingardens (especially the Retreat House)	Land Use Options, pg. 53
Require current/future farm tenant to practice organic food production methods	Land Use Options, pg. 53
When the lease with the current farm tenant expires, consider providing a vocational opportunity for innovative, ecologically conscious young farmers by offering prospective tenants an affordable (yet fairly priced) lease	Land Use Options, pg. 53
Construct a prayer/healing garden in the footprint of the old sheep barn	Land Use Options, pg. 53
Construct a more formal cloister garden as a central, ceremonial gathering place	Land Use Options, pg. 53
Include educational and interpretive information in the landscape to educate guests, visitors, and community members about the history of the land, as well as sustainable land stewardship practices taking place at HCA	Land Use Options, pg. 53
Enlist the help of lay Cistercians, volunteers, and/or local environmental groups to assist with land-based sustainability initiatives	Land Use Options, pg. 53
Install programmable thermostats	Energy Options, pg. 110
Increase exposure to daylight by installing skylights	Energy Options, pg. 106
Install daylighting controls (e.g. automatic light dimmers and switches)	Energy Options, pg. 106
Replace old appliances with ENERGY STAR units	Energy Options, pg. 107

Tier Two Options (no particular order)	Additional Details
Replace water heaters with ENERGY STAR units	Energy Options, pg. 108
Replace or retrofit older boilers	Energy Options, pg. 111
Improve roof insulation	Energy Options, pg. 114
Replace single-pane windows with energy-efficient models	Energy Options, pg. 120
Replace toilets with low-flow models	Water Options, pg. 163
Replace urinals with low-flow models	Water Options, pg. 165
Replace commercial clothes washer with a high-efficiency model	Water Options, pg. 166
Establish a drinking water monitoring program	Water Options, pg. 173
Conduct regular septic system maintenance for all systems	Water Options, pg. 175
Reduce use of insecticides/pesticides by adopting a an integrated pest management strategy	Toxics Options, pg. 224
Hire a professional to remove mold in areas that are severely contaminated or replace the structure	Toxics Options, pg. 225
Introduce new bakery products that focus on market segments with high growth potential (e.g. gourmet/specialty, organic, and gluten-free)	Economies Options, pg. 272
Balance the seasonality of fruitcake sales by developing new bakery products for events that occur early in the year	Economies Options, pg. 272
Develop bakery products that use locally-available ingredients (e.g. apples, peaches, tomatoes, and peanuts)	Economies Options, pg. 275
Find a partner or hire an employee to develop new products and find ways to more fully utilize the bakery assets	Economies Options, pg. 277
Partner with a commercial baker who can use the bakery oven in exchange for cash or personnel	Economies Options, pg. 277
Consider an arrangement with a private label manufacturer who can manufacture fruitcakes (as appropriate) and other bakery products for sale under the HCA label	Economies Options, pg. 277
Design and introduce more sustainable packaging for bakery products	Economies Options, pg. 276
Reduce number of summer bakes to reduce cooling needs	Economies Options, pg. 266
Install fixed, insulated doors between adjacent areas in the bakery	Economies Options, pg. 266
Insulate walls of the bakery’s ingredient storage room	Economies Options, pg. 266
Create a substantive website specifically for the gift shop	Economies Options, pg. 264

Tier Two Options (no particular order)	Additional Details
Organize workshops and other themed events for retreatants/guests	Economies Options, pg. 261
Incorporate an annual percentage increase or rate schedule in future farm leases that reflects anticipated increases in the market rate	Economies Options, pg. 280
Determine whether HCA currently is paying variable costs related to the tenant's farm operation and, if so, shift the burden of those costs to the tenant	Economies Options, pg. 281

Table 3: Tier Three Options

Tier Three Options (no particular order)	Additional Details
If HCA decides to replant hardwood forest for the purpose of ecological restoration, increase the width of riparian and stream buffers first, then construct a "greenbelt" which will act as a habitat corridor to and from the floodplain forest	Land Use Options, pg. 53
Place more land in conservation easement	Land Use Options, pg. 53
Consider the option of a conservation burial ground to help protect land	Land Use Options, pg. 53
Switch to forced air with individual room thermostats	Energy Options, pg. 111
Retrofit buildings for passive solar design	Energy Options, pg. 112
Improve exterior wall insulation	Energy Options, pg. 114
Install an on-site renewable energy system (wind power and/or solar)	Energy Options, pg. 124
Consider including composting toilets and waterless urinals in the design of any new buildings	Water Options, pg. 164
Install a graywater system to recycle wash water for plant irrigation and/or flushing toilets	Water Options, pg. 169
Replace underground storage tanks with aboveground storage tanks	Toxics Options, pg. 225
Create areas for conservation burials that can be reached from a separate entrance off Castleman Road; construct walking trails and a non-denominational chapel to support the conservation burial services; restore the area to a natural forest as part of the conservation efforts	Economies Options, pg. 288
Consider constructing a new dormitory and cloister	Buildings, pg. 313

Concluding Remarks

Over the past year and a half, it has been a pleasure and an honor to help the Holy Cross community achieve its goal of identifying ecologically-responsible methods of managing its land, buildings, industries, and other resources. As a culmination of the Team's combined efforts, it is our hope that this report can help guide not only the HCA community and its guests, but also assist other monasteries and religious institutions. Ideally, these other religious institutions will find value in the content of this report as they initiate, evaluate, and/or modify their own sustainability efforts, thereby enhancing environmental stewardship throughout numerous communities, maximizing positive impact on society, and venerating God's gift of creation.

Throughout the process, the Team has endeavored to make connections between the global environmental challenges of our age and the unique challenges faced by the HCA community. Similarly, the Team has deeply considered the connections between focus areas, with the knowledge that the best options are often those that exhibit synergies and address multiple challenges. Thus, while the report is divided into topic area sections, the methodologies, analyses, and options proposed in this report were conceived from a systems perspective, with the intention of encouraging a more holistic, integrative view of the monastery in its local, regional, and global contexts. As such, it is the Team's great hope that this report will help the HCA community to more clearly understand its role within the global ecosystem, and from that understanding, to build a shared commitment to adjust daily habits, to mitigate environmental impacts through improved design and technology, to become more responsible consumers in the global marketplace, and to generate income in an ecologically responsible manner.

In reality, this project is only one of many steps in a long road toward sustainability. Considering this, we hope the proposed options will serve as a foundation for subsequent steps and the development of an implementation plan that will help HCA move toward a more sustainable future—one in which the community will be able to fully celebrate their role as stewards of the land and lovers of the place.

APPENDICES

APPENDIX 0-A: SUMMARY OF OCSO SUSTAINABILITY SURVEY RESPONSES

As part of the HCA Sustainability Project, the Michigan Team developed and administered a questionnaire to identify the various sustainability initiatives conducted by other OCSO monasteries in the United States. Questionnaires were mailed or e-mailed to all of the OCSO houses in the US, and fifteen out of the sixteen monasteries responded (listed below). A matrix that summarizes the various past/present sustainability initiatives for all of the monasteries, along with individual summaries of each house's response, starts on the next page.

Trappistine Monasteries

- Mount Saint Mary's Abbey (Wrentham, MA)
- Our Lady of Angels Monastery (Crozet, VA)
- Our Lady of the Mississippi Abbey (Dubuque, IA)
- Our Lady of the Redwoods Monastery (Whitethorn, CA)
- Santa Rita Abbey (Sonoita, CA)

Trappist Monasteries

- Abbey of the Genesee (Piffard, NY)
- Abbey of Gethsemani (Trappist, KY)
- Abbey of the Holy Trinity (Huntsville, UT)
- Abbey of New Clairvaux (Vina, CA)
- Assumption Abbey (Ava, MO)
- Mepkin Abbey (Moncks Corner, SC)
- Monastery of the Holy Spirit (Conyers, GA)
- New Melleray Abbey (Peosta, IA)
- Saint Benedict's Abbey (Snowmass, CO)
- Saint Joseph's Abbey (Spencer, MA)
- Our Lady of Guadalupe Abbey (Lafayette, OR) – did not respond

A Wind Turbine at Mount St. Mary's Abbey

OCSO American Monasteries

Sustainability Initiatives (Past/Present)	MSMA	OLAA	OLMA	OLRM	SRA	AG	AHT	ANC	AA	AG	MA	MHS	NMA	SJA	SBM
Adopted Environmental Policies			X												
Attend Environmental Conferences		X													
Biomass-based heating system													X	X	
Buy/Eat Organic Produce	X		X	X	X	X					X		X		
Developed Riparian Buffers														X	
Developed and Follow a Financial Sustainability Plan/Business Strategy												X		X	
Energy-Efficient Equipment/Appliances		X		X	X	X								X	
Energy-Efficient Lighting/Windows		X		X		X		X						X	
Follow Green Building Practices (new construction & renovation)											X	X			
Forest Stewardship Program and/or Sustainable Harvesting		X	X	X					X				X	X	
Geothermal Heating/Cooling	X		X								X				
Habitat Restoration				X										X	
Added Insulation to Walls/Roofs				X	X										X
Land Conservation Easements or Greenbelt Program Participation							X					X			
Low-Flow Appliances and/or Other Water Conservation Practices	X	X		X				X							X
Members of/Involved with Environmental Organizations		X		X		X									
Organic Gardening			X	X		X					X		X		
Organic or Environmentally-Responsible Farming			X				X				X		X	X	
Organic Ranching (cattle)													X		
Provide Environmental Education to Outside Community and/or Retreatants											X				
Use Hybrid Vehicles						X									
Recycle and/or Compost	X	X		X	X	X		X						X	
Solar Panels					X			X							
Wind Power System	X														

Acronyms: MSMA – Mount St. Mary's Abbey; OLAA – Our Lady of Angels Abbey; OLMA – Our Lady of the Mississippi Abbey; OLRM – Our Lady of the Redwoods Monastery; SRA – Santa Rita Abbey; AG – Abbey of Gethsemani; AHT – Abbey of the Holy Trinity; ANC – Abbey of New Clairvaux; AA – Assumption Abbey; AG – Abbey at the Genesee; MA – Mepkin Abbey; MHS – Monastery of the Holy Spirit; NMA – New Melleray Abbey; SJA – St. Joseph's Abbey; SBM – St Benedict's Monastery

TRAPPISTINE MONASTERIES

Mount Saint Mary's Abbey (Wrentham, Massachusetts)

Past/Current Sustainability Initiatives

- Installed a 100-kW wind turbine in December of 2009, which provides most of the electricity for the Abbey and the candy production facility
- Incorporated a geothermal heating/cooling system into the design of their new candy production facility
- Practice water conservation (especially in the summer months)
- Engage in comprehensive recycling
- Allow a local organic farmer to use their land in exchange for fresh vegetables

Potential/Future Sustainability Initiatives

- Install solar panels on dormitory room to heat water for the Abbey; will supply all hot water needs

Motivation for Engaging in Sustainability Initiatives

- According to Sr. Mariann Garrity, "While these efforts no doubt have an economic benefit, we are adopting them because they reflect Cistercian simplicity, and they allow us to use the gifts of creation."

Ecological/Environmental Improvements Resulting from Initiatives

- Specifics were not provided, but Sr. Mariann Garrity did report that the wind turbine and the continuous "whoosh" of the blades is a constant reminder that they "…have gone the ecological route."

Economic Aspects of the Initiatives

- As a result of installing their wind turbine, the community received their first "no payment due" electric bill this year.

Challenges Associated with the Initiatives

- No challenges were noted. Regarding the wind turbine, the Abbey has not experienced resistance. According to Sr. Mariann Garrity, "…[E]very member of the community, and all of our neighbors, love the wind turbine."

Connection Between Cistercian Spirituality and Sustainability

- Sr. Mariann Garrity claimed, "Yes, we believe there is a spiritual mandate to address sustainability. Our life has the value of Christian witness, and part of that witness is to live simply, to care for the gifts of creation. Sustainability is an ethical, human voice. We embrace many aspects of it because it allows us to be mindful of the needs of others, and to express our concern for a just world."

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or formal approach/policy regarding sustainability initiatives.

Our Lady of the Angels Monastery (Crozet, Virginia)

Past/Current Sustainability Initiatives

- Engage in comprehensive recycling
- Regularly reuse approximately 2,000 gallons of water in their cheese production facility
- Frequently attend local conferences/meetings regarding responsible forestry and land management
- Are active members of a concerned citizens group focused on the ecological health of the Moorman River
- Developed a forest stewardship program
- Incorporated energy-efficient radiant heating and lighting into recent additions to the monastery
- Recently built a greenhouse

- Upgraded equipment and systems in their cheese production facility to increase efficiency and reduce energy use

Potential/Future Sustainability Initiatives

- Engage in large-scale sustainable tree harvesting
- Produce biomass for sale
- Expand their vegetable/fruit garden to increase food supply

Motivation for Engaging in Sustainability Initiatives

- According to the community's sub-prioress and grounds manager, Sr. Kay Kettenhofen, "The Rule of St. Benedict contains within itself a degree of the rationale behind sustainability—the care of goods and property for the welfare and the spiritual and human needs of the community."

Ecological/Environmental Improvements Resulting from Initiatives

- The forest stewardship program has made the woodlands more attractive to people and protected native habitats for wildlife.
- As a result of attending various conferences, the community has enhanced their ecological awareness and knowledge.

Economic Aspects of the Initiatives

- The community has received some income from the harvesting of timber, but it has been difficult for them to assess any economic gains at the present time.

Challenges Associated with the Initiatives

- Because of the small size of the community (10 nuns), it has been difficult for them to balance monastic life, the demands of their cheese industry, and environmental efforts. Ultimately, lack of time and funding has been the largest obstacle to engaging in additional initiatives.

Connection Between Cistercian Spirituality and Sustainability

- According to Sr. Kay Kettenhofen, "We must be responsible for what we have in our care. However, balance must be kept and sustainability must not lose sight of the good of the persons concerned."

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or formal approach/policy regarding sustainability initiatives, but they do "attempt to meet present [community's] needs and situations in a manner of responsible stewardship."

Our Lady of the Mississippi Abbey (Dubuque, Iowa)

Past/Current Sustainability Initiatives

- Manage a 200-acre organic farm to generate revenue (corn, soybeans, hay, and oats)
- Maintain an organic orchard and vegetable garden to supply food for the community
- Use a geothermal heating and cooling system to service their confections factory and half of the Abbey
- Responsibly manage a 350-acre woodland/prairie and plant trees yearly
- Have adopted an official farmland policy focused on committing to ecologically sound farming practices

Potential/Future Sustainability Initiatives

- Nothing mentioned

Motivation for Engaging in Sustainability Initiatives

- According to Sr. Sherry Peach, the community embraces various sustainability initiatives in order to demonstrate "good stewardship of God's creation" and to promote the "wellbeing of the sisters."

Ecological/Environmental Improvements Resulting from Initiatives

- Organic farming practices have led to "healthy soil" and the responsible management of their woodlands/prairie has helped protect native habitat for wildlife.

Economic Aspects of the Initiatives

- The various initiatives have "paid for themselves," according to Sr. Sherry Peach.

Challenges Associated with the Initiatives

- It has been difficult to identify knowledgeable individuals outside of the community to help with organic farming methods and management of the land.

Connection Between Cistercian Spirituality and Sustainability

- Sr. Sherry Peach indicated that there is a connection between Cistercian values/beliefs and sustainability, but she did not expand upon this affirmative response.

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program. However, they do have an official farmland policy, which states: *As Cistercian Nuns of Our Lady of the Mississippi Abbey, we believe that our land and the ecological environment is a gift from God and that in keeping with the Rule of St. Benedict, we are responsible to reverence this gift, and as good stewards, to enhance it for the benefits of the surrounding local community as well as for future generations. Through ecologically sound practices, we hope to improve land diversity and promote soil, water, and energy conservation. We want to maintain and enhance our woodlands, croplands, orchards, pastures and wetlands and encourage a variety of wildlife. We will implement biological practices that will foster and develop a sustainable land base and look towards possible alternatives uses of our land. As Cistercians, we desire that this endeavor preserve the delicate balance of work, prayer, and contemplative leisure while also providing a supplementary economic bas to our self support. We commit ourselves to co-creating and preserving a space of beauty and quiet solitude for community and guests. We resolve to draw up and implement a just policy for purchase and disposal of land that will favor family farms, and require easements for good ecological use of the land. We, the community of Our Lady of the Mississippi Abbey, trust that the Creator will bless the work of our hands and bestow on us the wisdom and grace we need to be faithful to the policy and that we have accepted on this 21st day of March in the year 1991.*

Our Lady of the Redwoods Monastery (Whitethorn, California)

Past/Current Sustainability Initiatives

- Have been recycling since the 1970s
- Primarily eat organically produced food from their garden and purchase organic products from a food cooperative in the Sacramento area
- Work with a restoration group to monitor and create fish habitat by placing fallen trees in the river (salmon spawn and travel to the ocean via this river)
- Installed double-paned windows and insulation in their new senior wing in order to conserve energy/heat
- Installed low-flow appliances and a more efficient pumping system to conserve water and energy
- In the late 1980s, the community and a local citizen founded the Sanctuary Forest Group (land and water trust) in an effort to preserve the monastery's pure old growth forest parcels; they have engaged in regular restoration efforts since this time (e.g., burning, thinning, and clearing understory).
- Following a large storm in 1996, they sustainably harvested, milled, and sold several large fir trees (and were licensed by Smartwood); presently, they do not harvest trees from the forest because they want to refrain from logging in general.

Potential/Future Sustainability Initiatives

- Presently, through the land and water trust, the community is helping to raise money for a $50,000 water conservation project aimed at increasing flows in the Metole River.

Motivation for Engaging in Sustainability Initiatives

- According to Sr. Kathy de Vico, “All life is sacred. We take from Creation for our nourishment, but we must do our part in giving back. Monastic life invites us to be at one with God, ourselves, one another, and Creation. It’s part of a spiritual practice. Monastic life is union with all of life.”

Ecological/Environmental Improvements Resulting from Initiatives

- Preservation of old growth forest
- Restoration of river and creeks

Economic Aspects of the Initiatives

- Community groups work for free and retreatants volunteer to assist with forest restoration and the opening/closing of the garden; thus, there is little expense associated with these endeavors.
- The installation of energy-efficiency and water conservation appliances has significantly reduced the heating bill.
- Milling and selling the trees (following the storm) provided revenue for the community.

Challenges Associated with the Initiatives

- Nothing mentioned

Connection Between Cistercian Spirituality and Sustainability

- According to Sr. Kathy de Vico, “From the Rule of St. Benedict, we believe in treating the tools of the monastery as sacred tools of the altar—everything is sacred. We are also ‘lovers of the place’ which gets manifested in how you respected everything and everyone around you. Jesus showed how we have to give ourselves for the life of the world, not just take.”

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific program or a formal approach/policy related to sustainability; however, they are committed to being stewards of the land and working with local environmental groups.

Santa Rita Abbey (Sonoita, Arizona)

Past/Current Sustainability Initiatives

- Installed solar panels for heating water and their facilities
- Recently purchased energy-efficient appliances (e.g., new furnace) and compact fluorescent light bulbs
- Renovating and building with better insulation
- Buy organic fruits and vegetables when possible
- Engage in recycling
- Hired a groundskeeper to ensure that the grounds are maintained, safe, and accessible for community members and guests

Potential/Future Sustainability Initiatives

- Nothing mentioned

Motivation for Engaging in Sustainability Initiatives

- According to Sr. Victoria Murray, “We consider it our call and responsibility to respect, nurture, and care for our planet and the human family. Good stewardship is part of our Cistercian Constitutions and we reverence the presence of God in all of creation by this effort to be good stewards.”

Ecological/Environmental Improvements Resulting from Initiatives

- By maintaining the grounds, the community has dramatically reduced the risk of grass fires, which are a serious threat in that part of the country.

Economic Aspects of the Initiatives

- The solar heating panels have been very successful. Within five years of acquiring them, the community was able to recoup the costs of the purchase and installment of the panels from their heating fuel savings.

Challenges Associated with the Initiatives

- The major obstacle has been cost, but the community has been active in pursuing grants to help cover their expenses.

Connection Between Cistercian Spirituality and Sustainability

- According to Sr. Victoria Murray, “Our call as Christians asks of us a deep respect and love for all God’s creation. We are all one in Christ and his presence fills every atom of the universe. So when we are invited to [demonstrate] good stewardship in our Constitutions, it is an invitation to live sustainably out of love.”

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or formal approach/policy regarding sustainability initiatives; however, they “…are all in agreement that it is a way of living that we want to live, as best we can” (Sr. Victoria Murray).

TRAPPIST MONASTERIES

Abbey of Gethsemani (Trappist, Kentucky)

Past/Current Sustainability Initiatives

- Engage in recycling
- Replaced old windows with more energy-efficient models
- Planted a larger garden to increase organic food supply
- Purchased modern equipment for their industries to make them more energy efficient and user friendly for their aging community
- Installed new energy-efficient boilers and chillers
- Allow Nature Conservancy to perform controlled burns around the property
- Enforce strict control over all-terrain vehicles (ATVs) on their land, which have historically damaged natural areas
- Recently purchased a hybrid vehicle (Toyota Prius)

Potential/Future Sustainability Initiatives

- Replace two gas-engine golf carts with electric models

Motivation for Engaging in Sustainability Initiatives

- The community decided to engage in these initiatives as a result of general “consciousness from the Church” and as a result of employee input.

Ecological/Environmental Improvements Resulting from Initiatives

- Prohibiting ATV use on the property has protected sensitive habitat areas, and the prescribed burns have maintained healthy ecosystems on the property and prevented wildfires.

Economic Aspects of the Initiatives

- The new energy-efficient equipment and renovations have reduced monthly expenses.

Challenges Associated with the Initiatives

- Cost was reported as the primary challenge.

Connection Between Cistercian Spirituality and Sustainability

- The community claims that "the Holy Father has made recent statements about the need to be good stewards of [e]arth's resources, [and] it's a Gospel value to respect God's creation which he allows us to use."

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or a formal approach/policy regarding sustainability initiatives.

Abbey of the Holy Trinity (Huntsville, Utah)

Past/Current Sustainability Initiatives

- Enrolled in the Greenbelt program in order to preserve their farmland in perpetuity and dramatically reduce property taxes
- Refrain from using pesticides

Potential/Future Sustainability Initiatives

- No specific sustainability initiatives were mentioned

Motivation for Engaging in Sustainability Initiatives

- The community claimed that they refrain from using pesticides because they feel it is their responsibility to ensure that their products (hay and grains) are free of contaminants/poisonous substances, and the primary reason the community decided to participate in the Greenbelt program was to decrease their tax burden.

Ecological/Environmental Improvements Resulting from Initiatives

- By not using insecticides, the community has reduced pollution that enters nearby waterways and ensured that products are fit for human and animal consumption.

Economic Aspects of the Initiatives

- The community's property taxes decreased dramatically—from $144,000 per year to approximately $9,000 per year—after enrolling in the Greenbelt program.

Challenges Associated with the Initiatives

- The community needed to consult with county officials and advisors to decide whether or not to participate in the Greenbelt program.

Connection Between Cistercian Spirituality and Sustainability

- The community believes that they are "…entrusted by the Lord to be stewards of the manifold gifts He has given [and that] the land, water, minerals, and crops all are His creations, and with them comes a divine mandate to use them with care and profit."

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or a formal approach/policy regarding sustainability initiatives.

Abbey of New Clairvaux (Vina, California)

Past/Current Sustainability Initiatives

- Engage in recycling
- Installed two solar panel systems

- Converted to a micro sprinkler system for orchards, which conserves water
- Installed energy-efficient light bulbs in all facilities

Potential/Future Sustainability Initiatives

- Nothing mentioned

Motivation for Engaging in Sustainability Initiatives

- No specific response was provided

Ecological/Environmental Improvements Resulting from Initiatives

- The use of the new sprinkler system has dramatically reduced water use for irrigation.

Economic Aspects of the Initiatives

- A brief response indicated that the sustainability initiatives have been economically successful, but no specific details were included.

Challenges Associated with the Initiatives

- Due to cost, the community had to be very selective about what initiatives they could adopt.

Connection Between Cistercian Spirituality and Sustainability

- According to the community's cellarer, Fr. Harold, conserving energy and water to improve and sustain the natural environment fall in line with Cistercian stewardship of the land.

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or a formal approach/policy regarding sustainability initiatives.

Assumption Abbey (Ava, Missouri)

Past/Current Sustainability Initiatives

- Recently implemented a sustainable forestry program

Potential/Future Sustainability Initiatives

- Nothing mentioned

Motivation for Engaging in Sustainability Initiatives

- No specific reason provided

Ecological/Environmental Improvements Resulting from Initiatives

- The overall health of the woodlands has improved since the unsustainable/commercial management practices were discontinued.

Economic Aspects of the Initiatives

- It will take several years of growth before the new program bears any financial return.

Challenges Associated with the Initiatives

- No specific challenges were indicated

Connection Between Cistercian Spirituality and Sustainability

- The community indicated that there is a connection between Cistercian values/beliefs and sustainability, but did not expand upon this affirmative response.

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or a formal approach/policy regarding sustainability initiatives.

Mepkin Abbey (Moncks Corner, South Carolina)

Past/Current Sustainability Initiatives

- Created a native-plant botanical garden
- Serve as a habitat for plants and grass seed native to the coastal area of South Carolina
- Used various green building practices when expanding the monastery in 2000 and 2001 (a geothermal heating/cooling system was installed and sustainable building materials were used)
- Currently using green building practices to construct a new retreat house
- Grow and sell organic mushrooms
- In 2009, created an organic vegetable garden to increase organic food supply for the community
- Conducted a course for local area residents on gardening with native plants
- Provide education/information to retreatants and guests about eating more healthy, natural foods

Potential/Future Sustainability Initiatives

- Nothing mentioned

Motivation for Engaging in Sustainability Initiatives

- Regarding their focus on native plants and developing gardens, the community had three primary motivations for these endeavors: (1) to prevent native plants and animals from going extinct and to educate the public about how native plants can be appropriately used in landscaping; (2) to be more self-reliant and start growing as much of their own food as possible; and (3) to be part of the “grown locally” movement.

Ecological/Environmental Improvements Resulting from Initiatives

- As a result of the community’s initiatives, they have provided habitat and food for native animals and have been a source of native plant materials for groups wanting to do restoration work.
- They have also improved the greater environment by attempting to eat food that is grown by the Mepkin community or locally.

Economic Aspects of the Initiatives

- Selling native plants and grass seed has generated some income, and the native plant gardening/landscaping course produced some revenue. Once the botanical garden is fully developed, the community also hopes to generate income via this activity.

Challenges Associated with the Initiatives

- Regarding educating people about using native plants for landscaping, the community reported that it has been challenging to counter the public’s general attitude that aesthetics are more important than sustainable practices (i.e., using native plants).

Connection Between Cistercian Spirituality and Sustainability

- According to Fr. Guerric Heckel, “The prophetic monastic tradition should model sustainable living, which goes hand in hand with our rule [of St. Benedict].”

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or a formal approach/policy regarding sustainability initiatives

Monastery of the Holy Spirit (Conyers, Georgia)

Past/Current Sustainability Initiatives

- Conducted a financial sustainability study five years ago
- Presently engaged in implementing phase one recommendations—building a new visitor center according to various LEED standards
- Sold multiple conservation easements to preserve approximately 1,000 acres of land in a natural state and generate financial reserves

Potential/Future Sustainability Initiatives

- As part of the third phase, the community will install more energy-efficient air conditioning systems in its facilities.

Motivation for Engaging in Sustainability Initiatives

- The community has been primarily dependent on donations to pay all of its operating expenses for several years. The financial sustainability study was undertaken to assist the community in identifying a path that would help them return to self-sufficiency.

Ecological/Environmental Improvements Resulting from Initiatives

- Via the easements, land is being restored to native habitat; some of the easements also entail stream and wetland mitigation efforts.

Economic Aspects of the Initiatives

- At this point, phase one recommendations from the financial sustainability study are not complete so the community cannot determine any economic benefits.
- The community generated a significant amount of income from selling the conservation easements.

Challenges Associated with the Initiatives

- Fundraising to cover the phase one recommendations (and future ones) has been challenging.

Connection Between Cistercian Spirituality and Sustainability

- No response was provided

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or a formal approach/policy regarding sustainability initiatives.

New Melleray Abbey (Peosta, Iowa)

Past/Current Sustainability Initiatives

- Manage a large organic farm (cultivate cereal grains, alfalfa, hay, corn, and soybeans)
- Raise and sell approximately 100 head of cattle (certified organic beef)
- Created a large organic garden to provide food for the community
- Engage in sustainable forest harvesting (1,700 total acres) to sell wood outright and to produce various products, such as caskets
- Use biomass (unusable wood scraps/chips) for primary heating system

Potential/Future Sustainability Initiatives

- Nothing mentioned

Motivation for Engaging in Sustainability Initiatives

- The community has embraced organic farming/ranching and sustainable forestry because they are practices that allow them to be stewards of the land and still generate income to help sustain themselves.

Ecological/Environmental Improvements Resulting from Initiatives

- No specific response provided

Economic Aspects of the Initiatives

- No specific response provided

Challenges Associated with the Initiatives

- Organic farming is labor-intensive and now requires a secular farm manager in addition to help from multiple monks.

Connection Between Cistercian Spirituality and Sustainability

- According to Br. Placid, "the land is God's creation and needs to be respected and cared for. Being a Cistercian means being a steward of the land."

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or a formal approach/policy regarding sustainability initiatives

Saint Joseph's Abbey (Spencer, Massachusetts)

Past/Current Sustainability Initiatives

- Engage in sustainable forest harvesting and have adopted a forest management program for the community's 1,200 acres of woodlands that has been recognized by the American Tree Farm System
- With their 360-acre farm, the community rotates crops and regularly uses cover crops after harvesting corn to contribute to soil enrichment and prevention of erosion; however, their farming practices are not organic.
- Participate in the Wildlife Habitat Incentive Program, designating a border of approximately 100 feet around almost all of the community's hay fields which has subsequently been turned into brush land (native habitat)
- With forestry activities, SJA observes a 100-foot buffer zone around bodies of water to prevent contamination
- In 1982, the Abbey installed a wood-burning furnace and boiler that is able to heat all of the buildings and provide most of the steam needed to run their commercial activities (Trappist Preserves). Unusable "green" wood scraps/chips serve as the fuel source and are burned twice.
- Replaced incandescent light bulbs with energy-efficient bulbs in all of their buildings
- Engage in recycling and divert compostable materials (e.g., food scraps)
- Hired an environmental consultant to oversee their environmental awareness programs and update the community on new legislative initiatives and programming options
- In 2009, conducted a wind turbine feasibility study
- While repairing a dam on the property, extensive measures were taken to protect an endangered freshwater mussel that resided downstream from the project.
- With regard to financial sustainability, over the last two years, the community has developed marketing plans for its two main industries (Trappist Preserves and Holy Rood Guild) to ensure their long-term profitability. This has entailed hiring a part-time marketing professional and redeveloping the Abbey's Web site.

Potential/Future Sustainability Initiatives

- Most likely, the community will install a 1.5 to 2.0 megawatt wind turbine on the property in the near future.
- Actively researching other business activities that are environmentally friendly and less labor intensive (for an aging population)

Motivation for Engaging in Sustainability Initiatives

- According to Br. Brian Rooney, St. Joseph's Abbey decided to engage in the aforementioned sustainability initiatives for economic, environmental, spiritual, and "quality of life" reasons.

Ecological/Environmental Improvements Resulting from Initiatives

- Specifics were not provided; however, it was indicated that in general, the various activities had significant, positive effects on the environment.

Economic Aspects of the Initiatives

- The dam repair project and related environmental protective measures were costly, but overall, almost all of the initiatives have resulted in significant savings or were a nominal expense in light of the benefits.

Challenges Associated with the Initiatives

- No specific response was provided

Connection Between Cistercian Spirituality and Sustainability

- No response provided; unfortunately, the interviewer failed to ask this question during verbal communication

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific program or a formal approach/policy related to sustainability.

Saint Benedict's Monastery (Snowmass, Colorado)

Past/Current Sustainability Initiatives

- Added insulation to the chapel and other monastery facilities
- Installed new irrigation sprinkler systems for ranch land, which has reduced water use

Potential/Future Sustainability Initiatives

- Nothing mentioned

Motivation for Engaging in Sustainability Initiatives

- The motivation behind the sustainability initiatives was to save money and conserve energy and water (especially during drought years).

Ecological/Environmental Improvements Resulting from Initiatives

- New irrigation system has reduced water use from local creek

Economic Aspects of the Initiatives

- As a result of the insulation, the community is using less heating oil, which saves them money.

Challenges Associated with the Initiatives

- No specific response provided

Connection Between Cistercian Spirituality and Sustainability

- According to the community, Cistercian monasteries "try to be good stewards of the land."

Presence of a Comprehensive Approach/Program to Sustainability

- The community does not have a specific sustainability program or a formal approach/policy regarding sustainability initiatives.

Abbey at the Genesee (Piffard, New York)

- The responses provided by the community were very general and loosely connected to financial sustainability. The answers described the Abbey's current financial struggles and the general (nondescriptive) changes they plan to make regarding their business activities (i.e., strengthening relationships with retail vendors).

APPENDIX 0-B: SUMMARY OF HCA SUSTAINABILITY SURVEY RESPONSES

GENERAL QUESTIONS ABOUT SUSTAINABILITY

What is your definition/interpretation of sustainability within the context of this project?

GENERAL THEMES – Question #1

- **Improve the quality of monastic life** by improving buildings and "the way we do things," by refocusing spirituality so that "all our daily activities are spiritual activities," by re-ordering activities so that less energy is demanded from the smaller community of monks, and by enhancing the community's relationships with one another and those drawn to the monastic lifestyle
- **Enhance the economic viability and financial stability** of the present and future community
- **Maintain balance and harmony** between monastic activities (business operations, general way of life, etc.) and the environment and change practices that do not yield "ecological goodness" or have a positive impact on the environment
- **Fully embrace their role as stewards of God's creation**, realize the sacred, respect God's gift of the earth, enhance the community's relationship with the physical environment, and safeguard the land

Do you feel that sustainability is compatible with Cistercian values? Can you please explain your answer?

GENERAL THEMES – Question #2

- **All respondents marked "yes,"** sustainability and Cistercian values are compatible
- **Cistercians were pioneers in careful, responsible land and water use**. Conservation and careful management of natural resources has always been valued and part of Cistercian culture and history.
- **Cistercian values and *Constitutions and Statutes* reflect conscientious management of land**, care and respect for God's creation, and the importance of being "lovers of the brethren and the place." These values convey to the monks a sense of belonging and dignity, express the monks' bond with all that God has entrusted to their care, and enable the monks to "transcend many material values in order to better understand and practice spiritual values" according to one anonymous respondent.
- **The Cistercian commitment to a life of simplicity and poverty** is reflected in the community's tradition of working within a natural setting, using earth's resources wisely, and recognizing the importance of the mundane and care of the physical environment. Both the Cistercian lifestyle and the practice of sustainability call for "consistent application of disciplined mindfulness to high values."

What are the key characteristics of a sustainable HCA as you envision it? Appendix 1 provides various elements of sustainability for your reference.

GENERAL THEMES – Question #3

- **Primary/key characteristics** mentioned from the choices in Appendix 1:
    - Well-maintained buildings, thriving economies, renewable energy, open space preservation, energy conservation/efficiency, limited traffic from outside, waste recycling, renovate interior/common areas
- **Additional characteristics** mentioned in the survey responses include:
    - Unbroken continuity to religious practices
    - Attracting new aspirants and members
    - Sufficient personnel to carry out duties and obligations of monastic life without undue burden on any particular monk

  - Local and/or organic food through community-supported agriculture
  - Forest plan and implementation
  - New and improved walking paths, including improved access to riverfront for monks and retreatants
  - Stream bank and riparian protection (minimize polluted runoff)
  - Implementation of agricultural best-practices
  - Freedom from chemical exposure
  - Wildlife habitats and preserves
  - More profitable use of land and the farm
  - Upgraded human waste systems (for improved health and ecological reasons)
  - Upgraded residential areas, improved ventilation
  - Recognition of cultural, architectural, and historical improvements
  - Beautiful, livable, simple spaces
  - Fiscal practices that call for wise spending/purchasing and minimize waste to combat consumerism

Please list some actions, activities, changes, and/or programs that you believe would be most successful in helping create a sustainable HCA.

GENERAL THEMES – Question #4

- **Recruit new members**
  - Adopt a more proactive appeal to new members
  - Improve visibility of the monastery
- **Implement more sustainable land uses**
  - Reduce area that requires mowing
  - Introduce alternative landscaping
  - Introduce organic farming
    - Introduce a community-supported agriculture program staffed by Lay Cistercians (with community liaison)
    - Appoint a resident farmer/land manager
- **Reduce energy use and introduce renewable fuels**
  - Install windmills and/or solar panels
  - Inventory energy usage and implement energy conservation practices
- **Produce healthier products** that may be more marketable
- **Upgrade/renovate buildings**
  - Build a new church (when feasible)
  - Renovate living quarters
  - Increase insulation
- **Increase environmental awareness** within and outside the community
  - Raise awareness about chemical use and exposure within the community
  - Expand understanding of the intersection between environmentalism and spirituality
  - Organize a presentation for the superiors of eastern monasteries
  - Create an outreach program geared toward individuals in Clark and Frederick Counties

In your opinion, what are the community's primary motivations/reasons for pursuing sustainability at HCA?

GENERAL THEMES – Question #5

- **Economic considerations/reasons**
  - HCA's situation is "precarious"; hopefully this project will provide a less bleak scenario
- **Sustainability will help with recruitment**
  - Recruits need to see a "decent monastic complex"

  - Recruits must be “like-minded”; expressing a commitment to sustainability will enhance HCA’s ability to attract recruits with similar values
- **Moral obligation/spiritual importance of environmental stewardship**
  - The world is fragile and the relationship between human beings and nature is delicate. These connections require care and nurturing. Caring for HCA is an extension of this responsibility. It will enable HCA to be passed on to those whom God calls to be the future generation of monks.
- **HCA needs a facelift**
  - The community needs new areas for meditation, contemplation, and relaxation

Do you foresee any obstacles in creating a sustainable HCA? If YES, what are they?

GENERAL THEMES – Question #6

- **Most respondents marked “yes”** and provided an explanation
- **Explanations included the following:**
  - Fear of taking the actions required to implement sustainability initiatives and fear of changes taking place too quickly, and thus a tendency to reject ideas (prefer gradual process)
  - Comfort with the status quo and a tradition of resistance to change
  - Financial concerns, especially for major capital expenditures
  - Limited personnel for implementation due to the age of the monks, the lack of new vocations, and the lack of persons within the community who are qualified to implement sustainability initiatives
  - Ignorance and misinformation—monks need to grow in their understanding of how sustainability fits with the monastic vocation

If you answered “yes” to Question #6, please offer your opinion for how we might be able to overcome these obstacles.

GENERAL THEMES – Question #7

- **Maintain communication** through meetings and proceed in a gradual/transparent way
  - Show that sustainability does not threaten the monastic lifestyle and in fact will benefit the community
  - Include lay persons, staff, and employees in the process to clarify objectives
  - Draw attention to and educate the community about the Catholic Church’s teachings related to environmental sustainability
- **Establish contact and create relationships** with outside agencies
  - Identify other organizations that have successfully implemented sustainability programs
  - Identify agencies that can help the community remain informed on sustainability issues
  - Assist HCA with identifying funding sources/grants

TARGETED AREAS OF SUSTAINABILITY

Do you personally try to conserve natural resources in your daily life (e.g., reduce waste, recycle, and/or decrease water and energy use)? If YES, what specific actions do you take and why?

GENERAL THEMES

- **Most respondents marked “yes”** and provided an explanation
- **Examples of conservation actions include:**
  - Water conservation behaviors (reusing rinse water, cutting down on laundry wash and dry cycles, reducing shower time, collecting shaving water in the sink instead of letting the faucet run, etc.)
  - Energy conservation behaviors (replacing incandescent light bulbs with energy-efficient bulbs, shutting

off lights/appliances when not needed, setting heat and A/C at conservative temperatures)
  - Transportation efficiency (combining trips off the monastery property when possible)
  - Reduce/reuse/recycle behaviors (reusing plastic shopping bags, reducing paper usage, recycling cardboard)

Do you have a personal relationship with the land and/or feel a sense of environmental stewardship for the farmland, woodlands, and the Shenandoah River that borders the property? Can you please explain your answer?

GENERAL THEMES

- **Most respondents marked "yes"** and provided explanation. Only one respondent marked "no."
- Several respondents expressed a history or current practice of **walking in/experiencing nature on the property** and appreciating its beauty, spiritual relevance, and importance as God's sacred creation.
- A few respondents indicated that **HCA land/nature is just as important as the physical religious structures and buildings on the property**. One stated that he feels that the land is a living gift from God and must be protected. Another indicated that the land speaks to him and nourishes his human soul, particularly as the seasons change.

Are there certain business practices that you feel are particularly important to the community and HCA's long-term financial stability? If YES, what are they?

GENERAL THEMES

- **General characteristics of HCA's ideal business practices** include:
  - Industry that has a high profit margin but low labor intensity
  - Industry that supports the community but is not an end in itself
  - Industry that is generally agrarian, not industrial
- A few respondents stated that the **current industries are particularly important** to the community (the bakery, guest house, gift shop, and farm).

Do you have any suggestions for new business ventures that the community might be able to pursue? If so, what are they?

GENERAL THEMES

- Suggestions included:
  - **Wind farms** to sell energy
  - Restoration of the **vegetable gardens and the orchard**
  - Promotion of products that are **uniquely Holy Cross**
  - **Organic farming** (one respondent suggested that ranching/raising cattle is not very lucrative and that the land could be used in other more profitable ways)
  - **Community garden plots**
  - **Forestry programs** that fit in line with agrarian character
  - Open up **Civil War battlefield areas** for tours and historical talks
  - Sell **cemetery plots** to selected individuals
  - **Construct a meeting hall** for groups and day visitors

Do you have any preferences/suggestions on how we can keep HCA members involved in the project and/or updated regarding progress with it? If YES what are they?

GENERAL THEMES

- **Provide periodic status reports** and a hard copy report at the end of the project that shows facts, figures, and practical results. One respondent suggested videos and other educational materials to further inform the community.

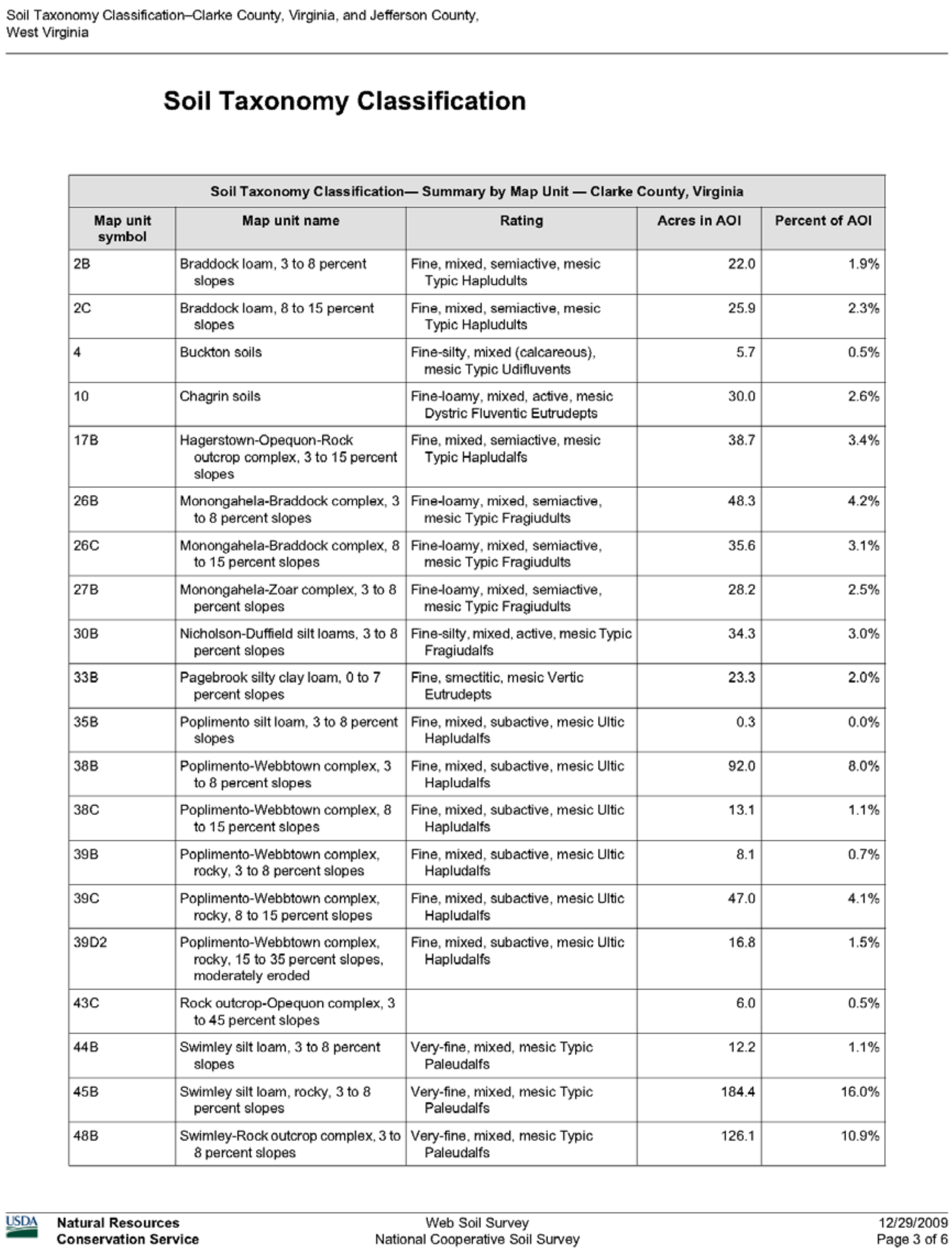
- **Communicate and coordinate** through Fr. James, joint councils, and via community meetings
- **Connect with outside agencies** and identify resources to support recommendations and broaden the underlying authority for recommendations
- **Present findings in an organized, easy to understand manner**
    - List actions required by law
    - Show options for improving conditions and implementing sustainability initiatives and explain the required steps
    - Estimate the necessary costs and the timeline for implementation
    - Explain the benefits of the suggested actions and how long it will take to reap the rewards
- One respondent suggested **a panel of outside lay advisors**, integrally connected to the community, to assist in the implementation effort. Two monks suggested continued connection with University of Michigan beyond 2010.

Do you have any other thoughts, ideas, or information that may help us in developing a sustainability plan for HCA? If so, can you please explain?

GENERAL THEMES

- Consider **different business options** (fruitcakes are no longer marketable)
- Look at alternatives for developing **recycling programs/systems**
- The Team should be **patient, understanding, and forthright** when interacting with community
- Possibly have a **suggestion box** or another system in which monks can pass along ideas and suggestions throughout the process

APPENDIX 1-A: SOIL TAXONOMY



Soil Taxonomy Classification–Clarke County, Virginia, and Jefferson County, West Virginia

Soil Taxonomy Classification

Soil Taxonomy Classification— Summary by Map Unit — Clarke County, Virginia				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
2B	Braddock loam, 3 to 8 percent slopes	Fine, mixed, semiactive, mesic Typic Hapludults	22.0	1.9%
2C	Braddock loam, 8 to 15 percent slopes	Fine, mixed, semiactive, mesic Typic Hapludults	25.9	2.3%
4	Buckton soils	Fine-silty, mixed (calcareous), mesic Typic Udifluvents	5.7	0.5%
10	Chagrin soils	Fine-loamy, mixed, active, mesic Dystric Fluventic Eutrudepts	30.0	2.6%
17B	Hagerstown-Opequon-Rock outcrop complex, 3 to 15 percent slopes	Fine, mixed, semiactive, mesic Typic Hapludalfs	38.7	3.4%
26B	Monongahela-Braddock complex, 3 to 8 percent slopes	Fine-loamy, mixed, semiactive, mesic Typic Fragiudults	48.3	4.2%
26C	Monongahela-Braddock complex, 8 to 15 percent slopes	Fine-loamy, mixed, semiactive, mesic Typic Fragiudults	35.6	3.1%
27B	Monongahela-Zoar complex, 3 to 8 percent slopes	Fine-loamy, mixed, semiactive, mesic Typic Fragiudults	28.2	2.5%
30B	Nicholson-Duffield silt loams, 3 to 8 percent slopes	Fine-silty, mixed, active, mesic Typic Fragiudalfs	34.3	3.0%
33B	Pagebrook silty clay loam, 0 to 7 percent slopes	Fine, smectitic, mesic Vertic Eutrudepts	23.3	2.0%
35B	Poplimento silt loam, 3 to 8 percent slopes	Fine, mixed, subactive, mesic Ultic Hapludalfs	0.3	0.0%
38B	Poplimento-Webbtown complex, 3 to 8 percent slopes	Fine, mixed, subactive, mesic Ultic Hapludalfs	92.0	8.0%
38C	Poplimento-Webbtown complex, 8 to 15 percent slopes	Fine, mixed, subactive, mesic Ultic Hapludalfs	13.1	1.1%
39B	Poplimento-Webbtown complex, rocky, 3 to 8 percent slopes	Fine, mixed, subactive, mesic Ultic Hapludalfs	8.1	0.7%
39C	Poplimento-Webbtown complex, rocky, 8 to 15 percent slopes	Fine, mixed, subactive, mesic Ultic Hapludalfs	47.0	4.1%
39D2	Poplimento-Webbtown complex, rocky, 15 to 35 percent slopes, moderately eroded	Fine, mixed, subactive, mesic Ultic Hapludalfs	16.8	1.5%
43C	Rock outcrop-Opequon complex, 3 to 45 percent slopes		6.0	0.5%
44B	Swimley silt loam, 3 to 8 percent slopes	Very-fine, mixed, mesic Typic Paleudalfs	12.2	1.1%
45B	Swimley silt loam, rocky, 3 to 8 percent slopes	Very-fine, mixed, mesic Typic Paleudalfs	184.4	16.0%
48B	Swimley-Rock outcrop complex, 3 to 8 percent slopes	Very-fine, mixed, mesic Typic Paleudalfs	126.1	10.9%

Natural Resources Conservation Service
Web Soil Survey
National Cooperative Soil Survey
12/29/2009
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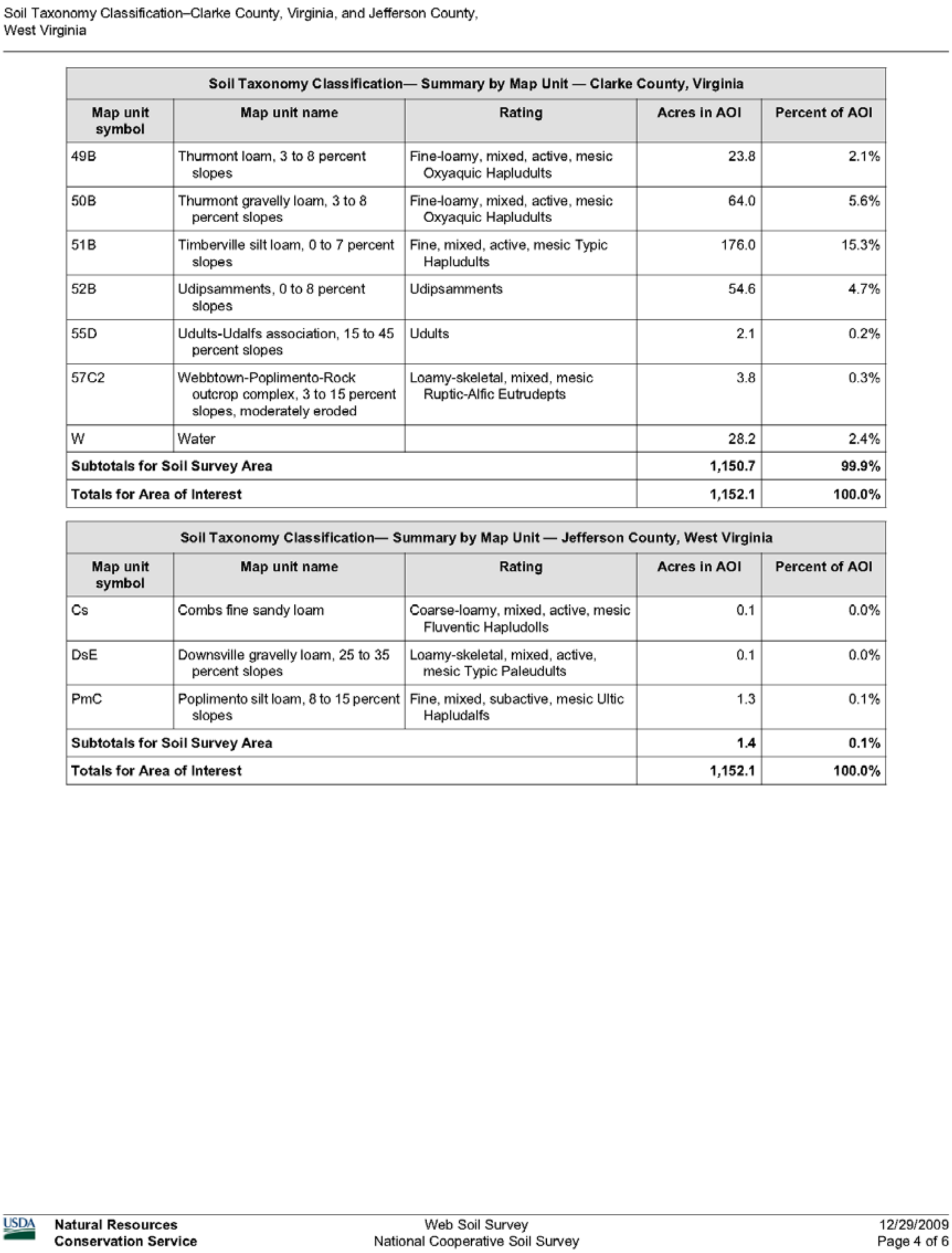

Soil Taxonomy Classification–Clarke County, Virginia, and Jefferson County, West Virginia

Soil Taxonomy Classification— Summary by Map Unit — Clarke County, Virginia				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
49B	Thurmont loam, 3 to 8 percent slopes	Fine-loamy, mixed, active, mesic Oxyaquic Hapludults	23.8	2.1%
50B	Thurmont gravelly loam, 3 to 8 percent slopes	Fine-loamy, mixed, active, mesic Oxyaquic Hapludults	64.0	5.6%
51B	Timberville silt loam, 0 to 7 percent slopes	Fine, mixed, active, mesic Typic Hapludults	176.0	15.3%
52B	Udipsamments, 0 to 8 percent slopes	Udipsamments	54.6	4.7%
55D	Udults-Udalfs association, 15 to 45 percent slopes	Udults	2.1	0.2%
57C2	Webbtown-Poplimento-Rock outcrop complex, 3 to 15 percent slopes, moderately eroded	Loamy-skeletal, mixed, mesic Ruptic-Alfic Eutrudepts	3.8	0.3%
W	Water		28.2	2.4%
Subtotals for Soil Survey Area			**1,150.7**	**99.9%**
Totals for Area of Interest			**1,152.1**	**100.0%**

Soil Taxonomy Classification— Summary by Map Unit — Jefferson County, West Virginia				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
Cs	Combs fine sandy loam	Coarse-loamy, mixed, active, mesic Fluventic Hapludolls	0.1	0.0%
DsE	Downsville gravelly loam, 25 to 35 percent slopes	Loamy-skeletal, mixed, active, mesic Typic Paleudults	0.1	0.0%
PmC	Poplimento silt loam, 8 to 15 percent slopes	Fine, mixed, subactive, mesic Ultic Hapludalfs	1.3	0.1%
Subtotals for Soil Survey Area			**1.4**	**0.1%**
Totals for Area of Interest			**1,152.1**	**100.0%**

USDA **Natural Resources Conservation Service**

Web Soil Survey
National Cooperative Soil Survey

12/29/2009
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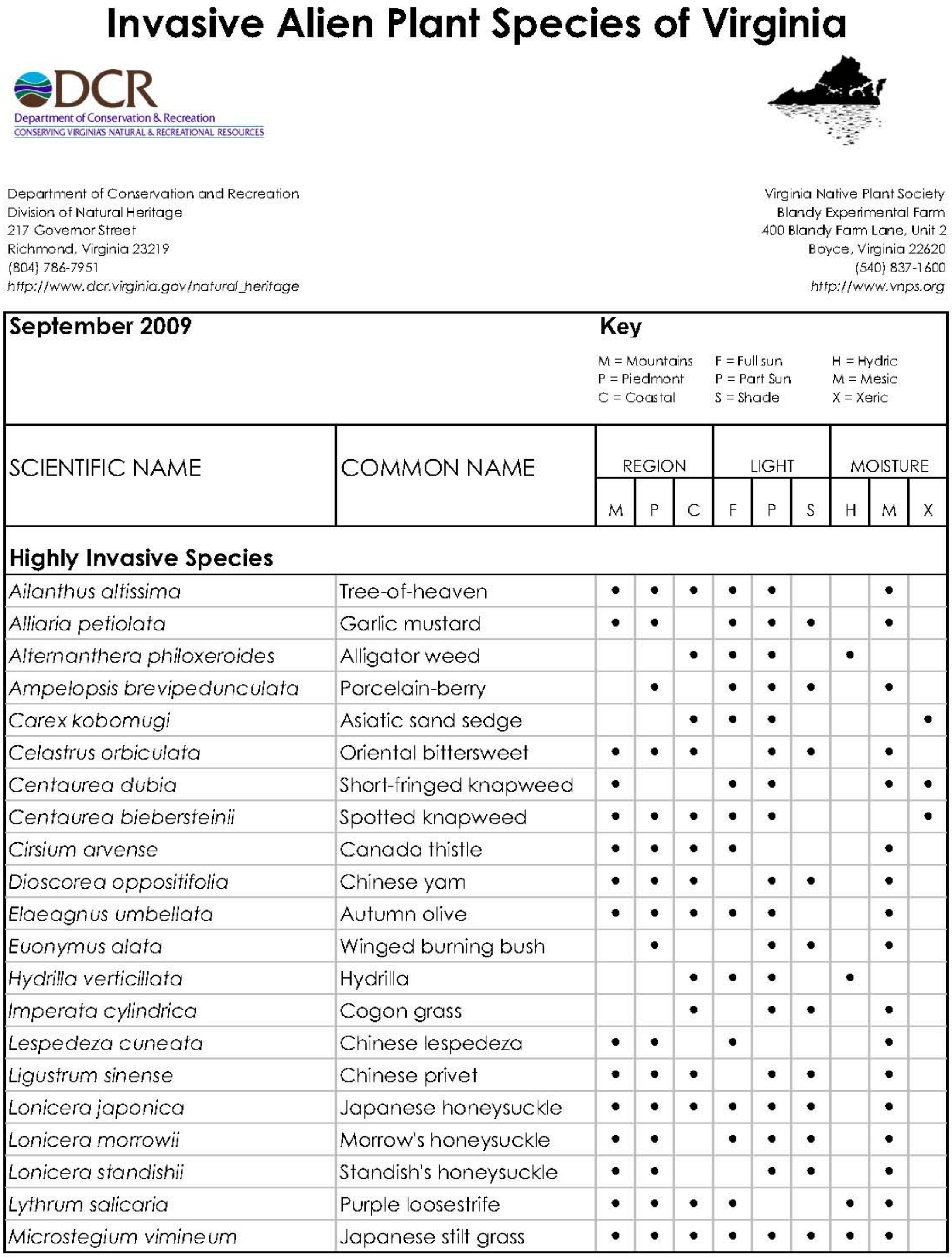
APPENDIX 1-B: INVASIVE SPECIES IN VIRGINIA



Invasive Alien Plant Species of Virginia

DCR
Department of Conservation & Recreation
CONSERVING VIRGINIA'S NATURAL & RECREATIONAL RESOURCES

Department of Conservation and Recreation
Division of Natural Heritage
217 Governor Street
Richmond, Virginia 23219
(804) 786-7951
http://www.dcr.virginia.gov/natural_heritage

Virginia Native Plant Society
Blandy Experimental Farm
400 Blandy Farm Lane, Unit 2
Boyce, Virginia 22620
(540) 837-1600
http://www.vnps.org

September 2009

Key

M = Mountains
P = Piedmont
C = Coastal

F = Full sun
P = Part Sun
S = Shade

H = Hydric
M = Mesic
X = Xeric

SCIENTIFIC NAME	COMMON NAME	REGION			LIGHT			MOISTURE		
		M	P	C	F	P	S	H	M	X
Highly Invasive Species										
Ailanthus altissima	Tree-of-heaven	•	•	•	•	•			•	
Alliaria petiolata	Garlic mustard	•	•		•	•	•		•	
Alternanthera philoxeroides	Alligator weed			•	•	•		•		
Ampelopsis brevipedunculata	Porcelain-berry		•		•	•	•		•	
Carex kobomugi	Asiatic sand sedge			•	•	•				•
Celastrus orbiculata	Oriental bittersweet	•	•	•		•	•		•	
Centaurea dubia	Short-fringed knapweed	•			•	•			•	•
Centaurea biebersteinii	Spotted knapweed	•	•	•	•	•				•
Cirsium arvense	Canada thistle	•	•	•	•				•	
Dioscorea oppositifolia	Chinese yam	•	•	•		•	•		•	
Elaeagnus umbellata	Autumn olive	•	•	•	•	•			•	
Euonymus alata	Winged burning bush		•			•	•		•	
Hydrilla verticillata	Hydrilla			•	•	•		•		
Imperata cylindrica	Cogon grass			•		•	•		•	
Lespedeza cuneata	Chinese lespedeza	•	•		•				•	
Ligustrum sinense	Chinese privet	•	•	•		•	•		•	
Lonicera japonica	Japanese honeysuckle	•	•	•	•	•	•		•	
Lonicera morrowii	Morrow's honeysuckle	•	•		•	•	•		•	
Lonicera standishii	Standish's honeysuckle	•	•			•	•		•	
Lythrum salicaria	Purple loosestrife	•	•	•	•			•	•	
Microstegium vimineum	Japanese stilt grass	•	•	•	•	•	•	•	•	

September 2009

Key

M = Mountains
P = Piedmont
C = Coastal

F = Full sun
P = Part Sun
S = Shade

H = Hydric
M = Mesic
X = Xeric

SCIENTIFIC NAME	COMMON NAME	REGION			LIGHT			MOISTURE		
		M	P	C	F	P	S	H	M	X
Highly Invasive Species - continued										
Murdannia keisak	Aneilema		•	•	•	•		•		
Myriophyllum aquaticum	Parrot feather	•	•	•	•			•		
Myriophyllum spicatum	European water-milfoil	•	•	•	•			•		
Phragmites australis	Common reed		•	•	•	•		•	•	
Polygonum cuspidatum	Japanese knotweed	•	•	•	•	•			•	
Polygonum perfoliatum	Mile-a-minute		•		•	•	•		•	
Pueraria montana	Kudzu vine	•	•	•	•	•	•		•	
Ranunculus ficaria	Lesser celandine			•		•	•		•	
Rosa multiflora	Multiflora rose	•	•	•	•	•			•	
Rubus phoenicolasius	Wineberry	•	•	•		•	•		•	
Sorghum halepense	Johnson-grass	•	•	•	•	•			•	
Vitex rotundifolia	Beach vitex			•	•					•
Moderately Invasive Species										
Acer platanoides	Norway maple	•	•	•	•	•			•	
Agropyron repens	Quack grass	•	•	•	•	•			•	
Agrostis tenuis	Rhode Island bent-grass	•	•		•	•			•	
Akebia quinata	Five-leaf akebia		•	•	•	•	•		•	
Albizia julibrissin	Mimosa	•	•	•	•	•			•	
Allium vineale	Wild onion	•	•	•	•	•			•	
Artemisia vulgaris	Mugwort	•	•	•	•	•			•	•
Arthraxon hispidus	Jointed grass	•	•	•	•	•	•	•	•	
Arundo donax	Giant reed		•	•	•	•		•	•	
Berberis thunbergii	Japanese barberry	•	•	•	•	•	•		•	
Carduus nutans	Musk thistle	•	•	•	•				•	
Cassia obtusifolia	Sickle pod		•	•	•	•			•	•
Centaurea jacea	Brown knapweed	•	•		•	•			•	•
Cirsium vulgare	Bull-thistle	•	•	•	•				•	
Convolvulus arvensis	Field-bindweed	•	•	•	•	•			•	
Dipsacus laciniatus	Cut-leaf teasel	•			•				•	
Dipsacus sylvestris	Common teasel	•	•	•	•			•	•	
Egeria densa	Brazilian water-weed	•	•	•	•	•		•		

September 2009

Key

M = Mountains F = Full sun H = Hydric
P = Piedmont P = Part Sun M = Mesic
C = Coastal S = Shade X = Xeric

SCIENTIFIC NAME	COMMON NAME	REGION			LIGHT			MOISTURE		
		M	P	C	F	P	S	H	M	X
Euonymus fortunei	Wintercreeper			•		•	•	•	•	
Moderately Invasive Species - continued										
Festuca elatior (F. pratensis)	Tall fescue	•	•	•	•	•			•	
Foeniculum vulgare	Fennel		•	•	•			•	•	•
Glechoma hederacea	Gill-over-the-ground	•	•	•		•	•		•	
Hedera helix	English ivy		•	•	•	•	•		•	
Holcus lanatus	Velvet-grass	•	•	•	•	•		•	•	
Humulus japonicus	Japanese hops	•	•	•	•	•	•	•	•	
Ipomoea hederacea	Ivy-leaved morning-glory	•	•	•	•	•		•	•	
Ipomoea purpurea	Common morning-glory	•	•	•	•				•	
Iris pseudacorus	Yellow flag	•	•	•	•	•		•		
Ligustrum obtusifolium	Blunt-leaved privet		•	•			•		•	
Lonicera maackii	Amur honeysuckle	•	•			•			•	
Lonicera tatarica	Tartarian honeysuckle	•	•		•	•			•	
Lysimachia nummularia	Moneywort	•	•	•	•	•	•	•	•	
Melia azedarach	China-berry		•	•	•	•			•	
Paulownia tomentosa	Princess tree	•	•	•	•	•			•	
Phleum pratense	Timothy	•	•	•	•	•			•	
Phyllostachys aurea	Golden bamboo		•	•	•	•			•	
Poa compressa	Canada bluegrass	•	•	•	•	•	•		•	•
Poa trivialis	Rough bluegrass	•	•	•	•	•	•	•	•	
Polygonum cespitosum	Bristled knotweed	•	•	•	•	•	•	•	•	
Populus alba	White poplar	•	•	•	•	•			•	
Rumex acetosella	Red sorrel	•	•	•	•	•			•	
Rumex crispus	Curled dock	•	•		•				•	•
Setaria faberi	Giant foxtail		•	•	•	•			•	
Spiraea japonica	Japanese spiraea	•	•			•	•	•	•	
Stellaria media	Common chickweed	•	•	•	•	•	•		•	
Veronica hederifolia	Ivy-leaved speedwell	•	•	•	•	•	•		•	
Wisteria sinensis	Chinese wisteria		•	•		•	•		•	
Xanthium strumarium	Common cocklebur	•	•	•	•	•			•	•

September 2009

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H = Hydric
M = Mesic
X = Xeric

SCIENTIFIC NAME	COMMON NAME	REGION			LIGHT			MOISTURE		
		M	P	C	F	P	S	H	M	X
Occasionally Invasive Species										
Agrostis gigantea	Redtop	●	●	●	●	●			●	
Ajuga reptans	Bugleweed	●	●	●	●	●			●	●
Arrhenatherum elatius	Oatgrass	●	●	●	●	●			●	
Commelina communis	Common dayflower	●	●	●	●	●			●	
Conium maculatum	Poison hemlock	●	●	●	●	●			●	
Coronilla varia	Crown-vetch	●	●	●	●				●	●
Dactylis glomerata	Orchard grass	●	●	●	●	●			●	
Elaeagnus angustifolia	Russian olive	●	●	●	●	●			●	
Elaeagnus pungens	Thorny elaeagnus		●	●		●			●	
Eragrostis curvula	Weeping lovegrass	●	●	●	●				●	●
Euphorbia esula	Leafy spurge	●	●			●	●		●	
Ipomoea coccinea	Red morning-glory	●	●	●	●				●	
Lapsana communis	Nipplewort	●			●	●			●	
Lespedeza bicolor	Shrubby bushclover	●	●	●	●	●			●	
Lonicera fragrantissima	Sweet breath of spring		●		●	●			●	
Lonicera x bella	Bell's honeysuckle	●	●	●	●	●			●	
Lotus corniculatus	Birdsfoot trefoil	●	●	●	●	●			●	●
Melilotus alba	White sweet clover	●	●	●	●	●			●	
Melilotus officinalis	Yellow sweet clover	●	●	●	●	●			●	
Miscanthus sinensis	Silver grass	●	●	●	●	●			●	
Morus alba	White mulberry	●	●	●	●	●			●	
Pastinaca sativa	Wild parsnip	●	●	●	●	●			●	
Perilla frutescens	Beefsteak plant	●	●	●		●	●		●	
Trapa natans	Water chestnut			●	●			●	●	
Ulmus pumila	Siberian elm		●		●	●			●	
Viburnum dilatatum	Linden viburnum		●		●	●			●	
Vinca minor & V. major	Periwinkle	●	●	●	●	●	●		●	
Wisteria floribunda	Japanese wisteria			●		●	●		●	

APPENDIX 1-C: CONTACT INFORMATION

Riparian Buffers

- Northern Virginia Regional Council (NOVA): Four Mile Run Ecosystem Restoration Guidelines http://www.novaregion.org/DocumentView.aspx?DID=2150
- Virginia Department of Conservation and Recreation: Riparian Buffers http://www.dcr.virginia.gov/chesapeake_bay_local_assistance/ripbuff.shtml
- Conservation Reserve Enhancement Program (CREP) http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=cep
- U.S. Environmental Protection Agency (EPA): Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness http://www.epa.gov/ada/pubs/factsheet/riparianbuffer.pdf

Shenandoah River/Chesapeake Bay Water Quality

- Friends of the Shenandoah River http://www.fosr.org/
- Virginia Department of Environmental Quality Total Maximum Daily Loads (TMDL)

  http://www.deq.state.va.us/tmdl/
- Chesapeake Bay Program http://www.chesapeakebay.net/

Groundwater Stewardship/Karst

- Clarke County, VA Comprehensive Plan http://www.clarkecounty.gov/government/planning/comprehensive_plan.html
- VA Deparment of Conservation and Recreation (DCR): Living on Karst http://www.dcr.virginia.gov/natural_heritage/livingonkarst.shtml
- Cave Conservancy of the Virginias http://www.caveconservancyofvirginia.org/

Stormwater Management

- Center for Watershed Protection http://www.cwp.org/
- Low Impact Development http://www.lowimpactdevelopment.org/
- EPA Low Impact Development http://www.epa.gov/nps/lid/

Soils

- Natural Resource Conservation Service (NRCS) Web Soil Survey

  http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
- Lord Fairfax Soil and Water Conservation District http://lfswcd.org/
- NRCS Soil Food Web http://soils.usda.gov/sqi/concepts/soil_biology/soil_food_web.html

Ecological Restoration

- Society for Ecological Restoration International (SER) http://www.ser.org/
- Ecological Society of America http://www.esa.org/

Sustainable Agriculture

- Rodale Institute http://www.rodaleinstitute.org/
- Council for Agricultural Science and Technology (CAST) http://www.cast-science.org/
- Holistic Management International http://www.holisticmanagement.org/
- Polyface Farms http://www.polyfacefarms.com/
- National Sustainable Agriculture Information Service (A.T.T.R.A.) http://attra.ncat.org/

Native/Invasive Plants

- VA DCR http://www.dcr.virginia.gov/natural_heritage/nativeplants.shtml
- Virginia Native Plant Society http://www5.smart.net/~planter/invasive.html

Land Conservation

- American Farmland Trust http://www.chesapeakebay.net/
- The Nature Conservancy, Virginia Chapter http://www.nature.org/wherewework/northamerica/states/virginia/
- Clarke County Conservation Easement Commission http://www.clarkecounty.gov/

APPENDIX 2-A: EXPLANATION OF KEY ENERGY-RELATED CONCEPTS

Box 1: Further Explanation of Energy Systems

An energy system is defined as the set of energy production and consumption processes that allow end-use consumers to achieve their energy-use goals. Energy systems are typically categorized by: (1) the end-use energy product, such as electricity, batteries, heating oil, or gasoline and (2) how those products store and transfer energy from original energy sources. The original energy source, or *source*, is defined as the form from which the energy is originally harnessed. Coal, petroleum, and the sun are examples of sources that are used to harness and transfer energy. Many of the end-use products that are refined or produced from these sources are often called "energy carriers" because they can store potential energy from the source and deliver that energy in a form that is easily transferred, or carried, to an end-use consumer.

There are many types of sources that are harnessed and converted into energy carriers. These sources can be divided into two categories: renewable and nonrenewable. Nonrenewable sources are typically natural resources that cannot be replenished at a rate necessary to sustain its level of consumption. Such resources typically exist in a fixed amount or are consumed at a rate faster than the rate at which the earth's systems can replenish them. Conversely, renewable sources are continuously recreated and are often components of the earth's natural cycles. For example, energy harnessed from flowing water is renewed by the earth's hydrologic cycle. Biomass, which can be burned as fuel or converted to liquid biofuels such as biodiesel and ethanol, is another example of a renewable source. Biomass, typically agricultural crops and timber, follows continuous ecological growth patterns of each viable species of vegetation based on that species adaptation to the earth's climate cycles. The table on the next page gives examples of renewable and nonrenewable sources and the energy carriers that are used to harness and transfer the energy from those sources.

An energy system defines the complete relationship, and the processes that form the relationship, between the energy in the original source and the service provided to the end-use consumer from harnessing and transferring that energy. Most energy systems contain similar processes or steps for delivering end-use energy products to the consumer. These processes are outlined on the next page and summarized in the figure on the following page.

1. First, the source of energy must be extracted from the earth (e.g., coal, petroleum, natural gas, etc.) or harnessed from natural cycles (e.g., wind, solar, water, etc.) for use.

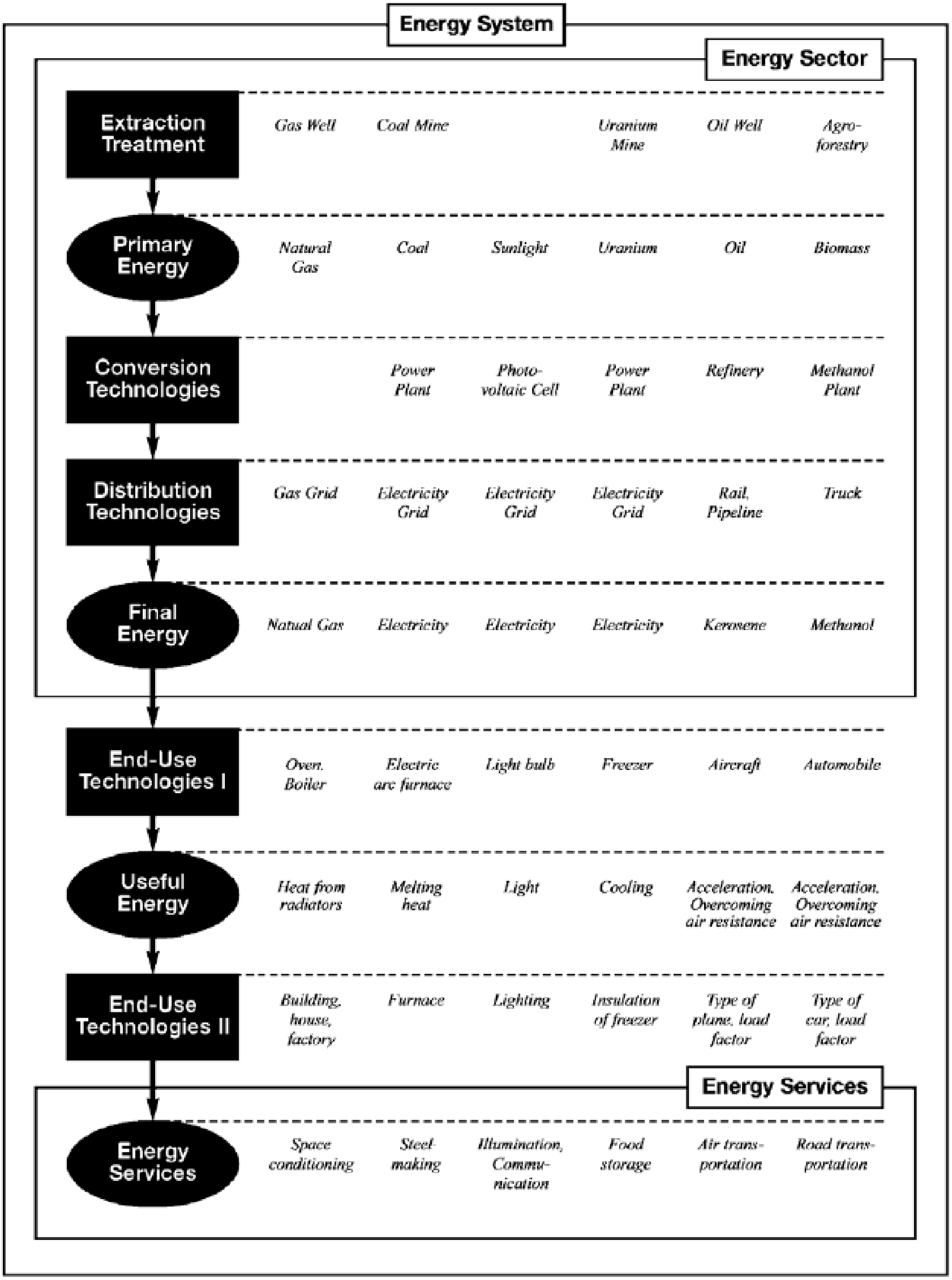
2. Many times, that source must be converted or refined into a standardized form that can be used in existing energy infrastructures. This form is typically defined as an "energy carrier." End-use petroleum products serve as a good example for demonstrating this process. Petroleum, as a source of energy, is a raw material that is extracted from the earth and refined into energy carriers (such as gasoline and heating oil) to transfer the stored energy of the petroleum so that the energy can be utilized by transportation vehicles, boilers, and furnaces. Some energy sources, such as coal and natural gas, are natural energy carriers because the form in which the energy is stored can be directly used by energy infrastructure. Those sources typically skip this step.

3. In most energy systems, energy carriers must be delivered to the point of end-use consumption. For example, gasoline and diesel must be delivered to fuel stations where consumers can fill their vehicles; coal must be delivered to power plants where it will be burned to generate electricity; and natural gas must be transferred through a pipeline network so that households can run their boilers, furnaces, and water heaters.

4. Finally, the energy carrier must be utilized to create work, or the service desired from consuming the energy product. For example, a car must combust gasoline in order to transport passengers; the coal must fire a power plant to generate electricity; and the natural gas must be burned to heat the ambient air and water within a household.

Energy systems become less efficient as the number of processes and form transfers it takes to deliver the end-use energy product to the consumer increases. According to the first law of thermodynamics, energy cannot be created nor destroyed. However, energy can take different forms (chemical, mechanical, electrical, thermal, etc.), some of which are easier to harness as energy carriers for the purpose of end-use consumption than others. It is important to note that, according to the second law of thermodynamics, every time energy changes form, some of the energy within the system is lost during the transfer. Therefore, energy systems that require multiple processes and transfers of energy forms are overall less efficient than energy systems that require less processes and transfers of energy forms.

Renewable Source	Energy Carriers from Renewable Source	Non-Renewable Source	Energy Carriers from Nonrenewable Source
Biomass	Biomass is an energy carrier when it is used for combustion. This includes the combustion of wood and straw products.	**Natural Gas**	Natural gas can be transported through pipelines without being refined. Thus, natural gas can act as an energy carrier when combusted)
Biomass	Biofuels are created when biomass is converted to ethanol or biodiesel. These fuels can replace petroleum-based fuels such as gasoline and traditional diesel.	**Liquid Natural Gas (LNG)**	Natural gas is difficult to transport outside of pipeline infrastructure. LNG is a condensed form of natural gas that allows for easy truck and ship transport.
Solar Radiation	Batteries can store electricity that is generated from the sun, but this is very expensive	**Petroleum**	Transportation fuels such as gasoline and diesel.
Wind	Not applicable because storing energy from wind is very difficult and costly.	**Petroleum**	Household fuels, such as heating oil and propane, that power furnaces, boilers, hot water heaters and appliances.
Water	Dammed water has potential energy that, when released, can turn turbines to create electricity.	**Coal**	Coal is both a source and energy carrier because it is easily transported and can be burned without refining processes.
Geothermal	Not applicable because steam from the earth must be used immediately.		

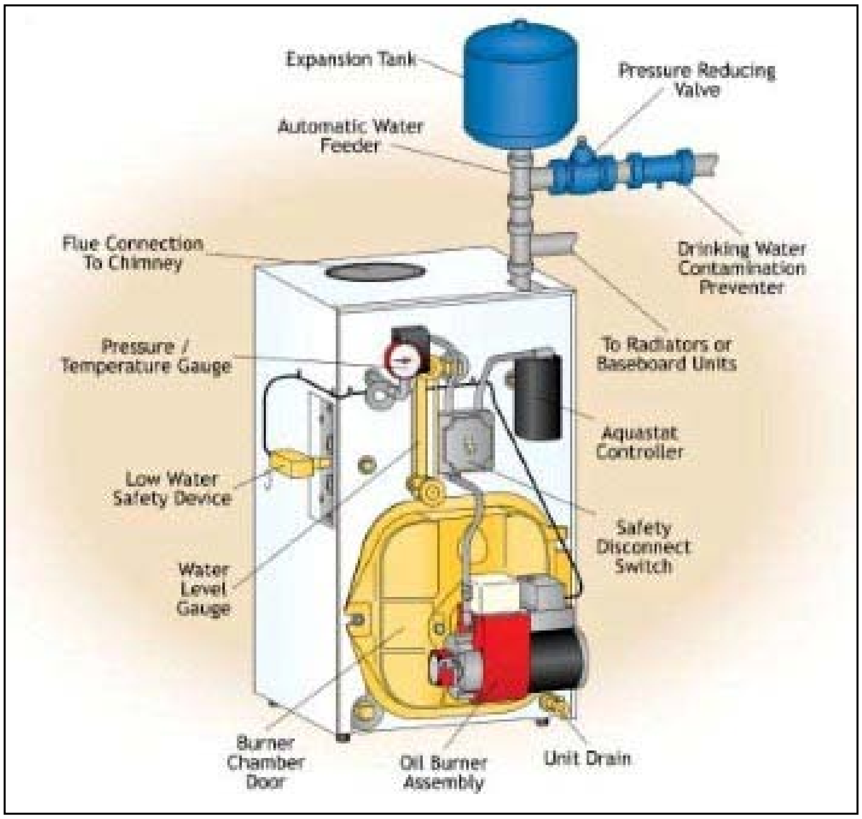


Extraction Treatment	*Gas Well*	*Coal Mine*		*Uranium Mine*	*Oil Well*	*Agro-forestry*
Primary Energy	*Natural Gas*	*Coal*	*Sunlight*	*Uranium*	*Oil*	*Biomass*
Conversion Technologies		*Power Plant*	*Photo-voltaic Cell*	*Power Plant*	*Refinery*	*Methanol Plant*
Distribution Technologies	*Gas Grid*	*Electricity Grid*	*Electricity Grid*	*Electricity Grid*	*Rail, Pipeline*	*Truck*
Final Energy	*Natual Gas*	*Electricity*	*Electricity*	*Electricity*	*Kerosene*	*Methanol*
End-Use Technologies I	*Oven, Boiler*	*Electric arc furnace*	*Light bulb*	*Freezer*	*Aircraft*	*Automobile*
Useful Energy	*Heat from radiators*	*Melting heat*	*Light*	*Cooling*	*Acceleration, Overcoming air resistance*	*Acceleration, Overcoming air resistance*
End-Use Technologies II	*Building, house, factory*	*Furnace*	*Lighting*	*Insulation of freezer*	*Type of plane, load factor*	*Type of car, load factor*
Energy Services	*Space conditioning*	*Steel-making*	*Illumination, Communication*	*Food storage*	*Air transportation*	*Road transportation*

Source: UNDP, “Sustainable Energy Strategies: Materials for Decision-Makers,” 2005

Box 2: Further Explanation of HCA's Boiler Systems

All space heating within the monastic enclosure is generated from boilers that run on fuel oil. Simply put, a boiler is a device that burns fossil fuels (in this case, oil) to heat water that is carried throughout the building in pipes. The pipes at HCA, which are located in the baseboards of exterior walls, have very low thermal resistance and therefore emit heat as the hot water or steam passes through them. The pipes are located at the baseboard because warm air rises. The diagram below provides a schematic for the inner workings of a boiler that runs on heating oil.



Source: Boiler Right

Fuel oil boilers come with costs and benefits. One benefit of this system is that it is closed looped, which means that the water or steam in the pipes is constantly recycled. As the hot water or steam passes through the baseboard pipes, it cools and condenses into cool water. The cooled water returns the to boiler where it is heated and sent through the baseboard pipes again. Another benefit is that the combustion of fossil fuels, like oil, is very efficient.

Although electric boilers have a higher annual fuel utilization efficiency (AFUE) rating (which is the ratio of heat output of the unit compared to the total energy consumed to run the unit) than fossil fuel boilers, this rating can be misleading. When accounting for the total life cycle energy losses accrued in the generation and distribution of electricity, which averages 33% efficiency nationwide, the energy factor for electric boilers is significantly lower than those that run on fossil fuels.[1] However, electric boilers can often be cheaper to run if the price of electricity is lower

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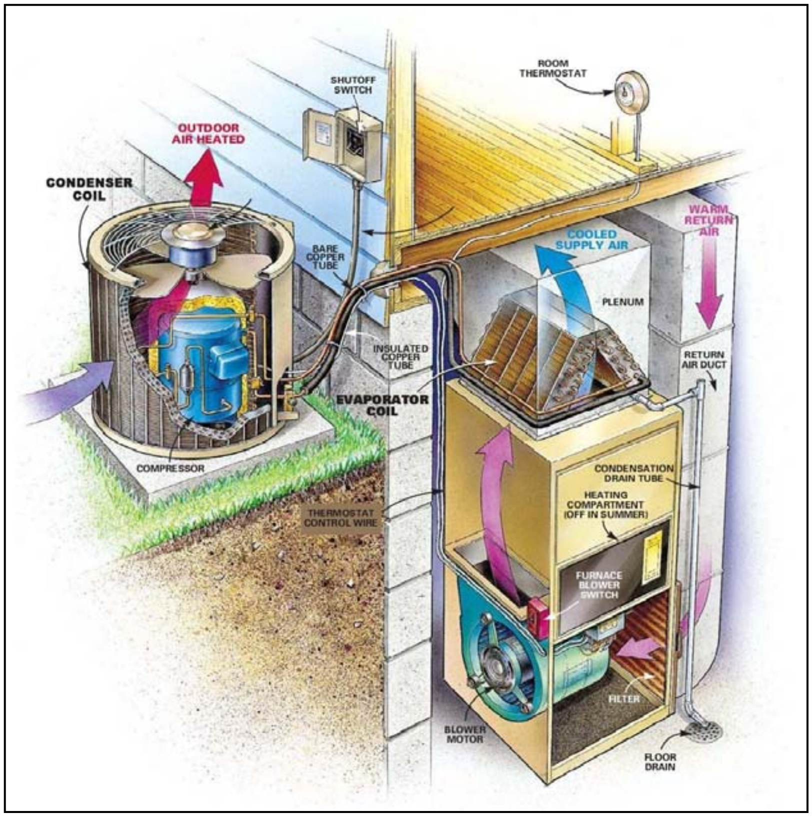
[1] U.S. Energy Information Administration. "Carbon Dioxide Emissions from the Generation of Electric Power in the United States." U.S. Department of Energy, http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2report.html (accessed January 4, 2010).

per Btu than natural gas or fuel oil. At an average price of 3.9 cents per kilowatt-hour and $1.85 per gallon of fuel oil, electricity is cheaper per Btu ($11.43) than fuel oil ($1.85) for HCA's energy consumption needs. Another disadvantage to using an oil boiler is that combustion requires a flue, which causes heat to be lost. This heat loss causes the overall efficiency of the unit to decrease, whereas an electric boiler does not have this problem.

Box 3: Further Explanation of HCA's Central Air System

The monastic enclosure is also cooled by three central air conditioning systems in select locations. Any air conditioning (A/C) unit, whether a centralized system or a window unit, works according to the same basic steps. First, an A/C unit uses a high-pressure pump that is driven by an electric motor to compress low-pressure refrigerant gas into a high-pressure and high-temperature gas. Next, this high-pressure gas passes through a condensing coil inside the unit as a fan blows air to cool the refrigerant gas and transform it back into a liquid state. This transformation causes a heat transfer from the refrigerant gas to the air that is blown by the fan. A metering device then dispenses refrigerant liquid into an evaporator coil where the refrigerant evaporates from a liquid to a gas inside the coil. This transformation absorbs heat and cools the surface of the evaporator coil. As the surface cools, so does the indoor air that is blown across the cooling coil.[2]



Source: DuctPro

Like other central air conditioning systems, HCA's units require an integrated system for properly dispersing the cooled air throughout the conditioned space. As the figure to the right shows, once the warm air passes through an air filter, which cleans the air, a large electric motor is needed to blow the air through a system of ducts that allows the air to pass through the evaporator coil and be carried to condition a room. In a central system like the ones found at HCA, the evaporator coil is on the upper floor, so quite a bit of energy is needed to blow that air vertically (as shown in the figure). The conditioned air is released on the upper floor because cool air tends to sink and conditions the ground floor as is passes through the levels of the building.

One benefit of a central air conditioning system is that it can cool a large building area more efficiently than a window unit. An intricate duct system only requires one large, efficient electric motor to power the blower whereas the multiple window units that would be needed to condition the same building area would be required to run multiple small, and less efficient, electric motors. A central system also creates a better airflow within the building, which allows

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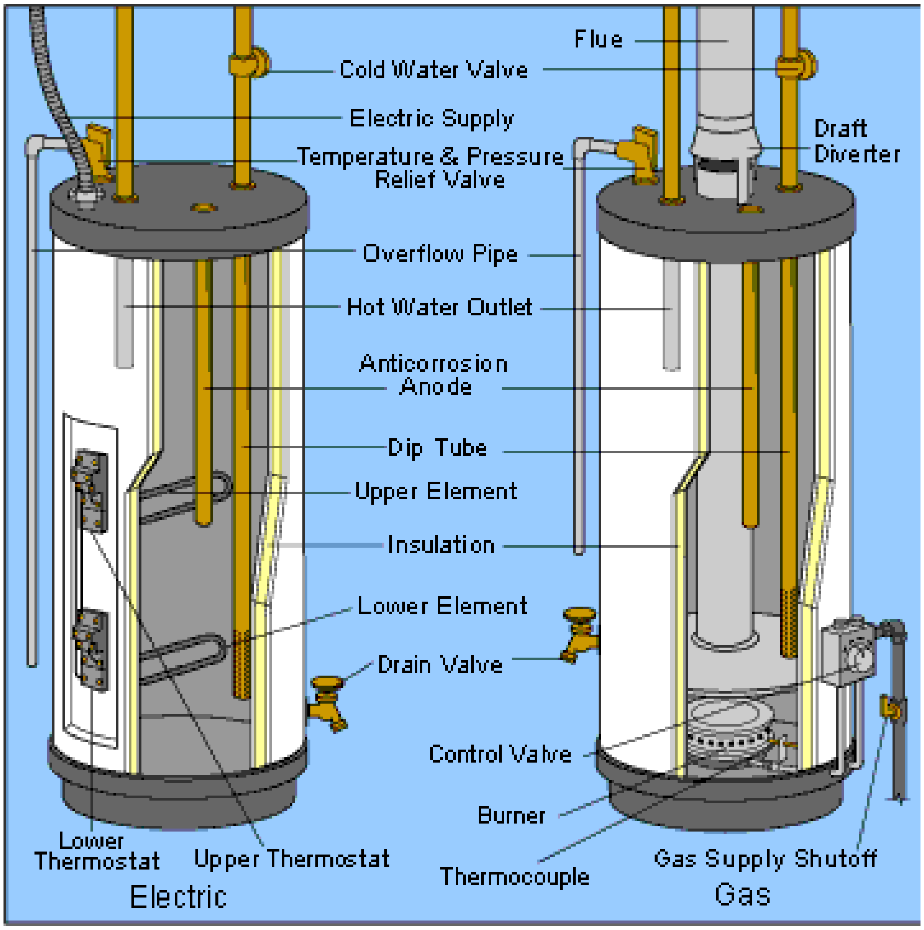
[2] "Air Conditioning Diagnosis, Inspection, Repair Guide." InspectAPedia, http://www.inspectapedia.com/aircond/aircond1123.htm (accessed January 4, 2010).

for better air filtering. However, a central system can use considerably more energy than a window unit when only one room or a smaller building area must be cooled. For example, one room would only need one window unit, which would need significantly less electricity to be powered than a central system would. HCA's central air conditioning systems target the most commonly used building areas, which makes a central system a more efficient choice for the community.

Box 4: Further Explanation of HCA's Water Heating System

Conventional storage water heaters use more energy that other systems such as tankless and solar water heaters. This inefficiency is a result of the storage water heater's design. Storage water heaters all use an energy source—such as electricity, natural gas, or fuel oil—to generate heat that warms cold water. In all storage models, cold water enters the bottom of the unit and is immediately in contact with the heat generated by hot electric coils powered by electricity or a flame that is lit by a fossil fuel. Once the water is heated, it is stored in a high-pressure tank and exits the top of the unit when hot water is needed. However, the stored water can become cool if not used immediately. Therefore, the stored water must be constantly heated in the tank, which wastes water even when a hot water tap is not running.



Source: HomeTips, LLC.

In general, electric water heaters tend to have a higher recovery efficiency (how efficient the energy is transferred to the water) than those that run on fossil fuels. This is mainly because fossil fuel water heaters also have energy losses that are related to venting problems that are caused from increasing air pressure that results from the combustion of fossil fuels.[3] The American Council for an Energy-Efficient Economy (ACEEE) reports that the average conventional electric storage water heater has an average energy factor of 0.90, whereas a conventional oil-fired storage unit has an average energy factor of 0.55.[4] Like with electric boilers, the efficiency rating of an electric water heater is misleading due to the life cycle energy losses that occur in the generation and distribution of electricity. An electric water heater at times may be cheaper to run, but that does not mean that it uses less energy over its life cycle. The efficiency of storage water heaters can be improved by increasing the R-Value of the tank walls, which holds in heat and keeps the stored water hot. The diagram below provides schematic for how electric and fossil fuel storage water heaters work. It is important to note that water heaters that run on fuel oil and natural gas have a similar design.

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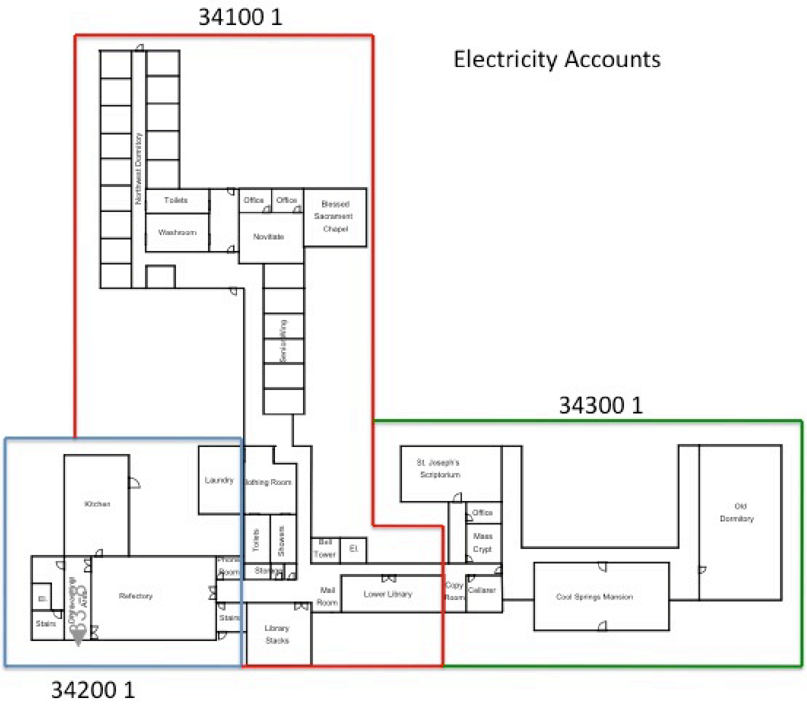
[3] Office of Energy Efficiency & Renewable Energy. "Energy Savers: Conventional Storage Water Heaters." U.S. Department of Energy, http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12980 (accessed January 4, 2010).

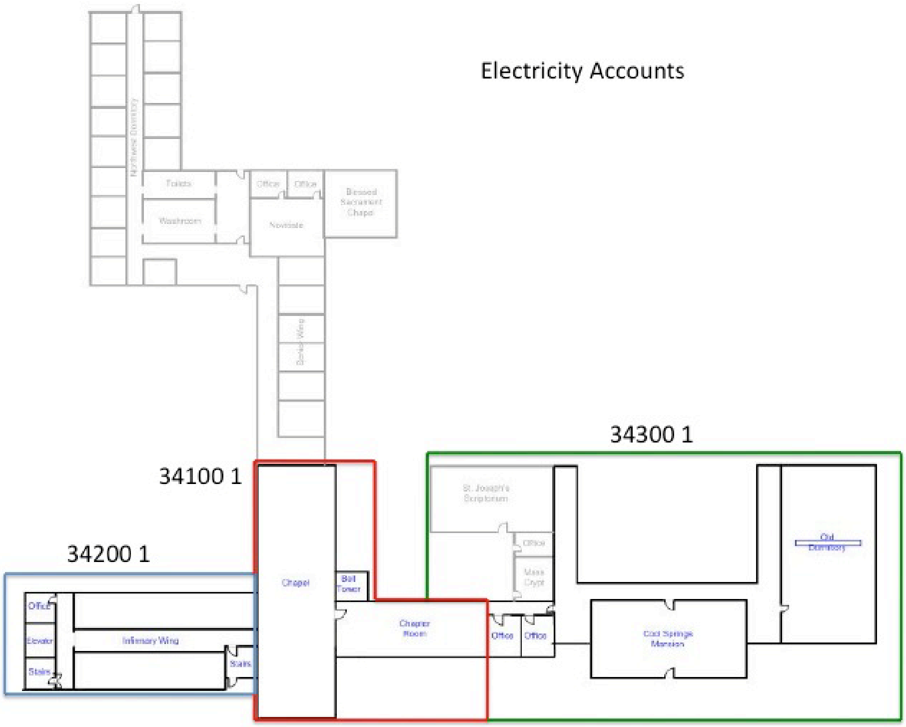
[4] American Council for an Energy Efficient-Economy. "Consumer Guide to Home Energy Savings: Water Heating." American Council for an Energy Efficient-Economy, http://www.aceee.org/Consumerguide/waterheating.htm (accessed January 4, 2010).

APPENDIX 2-B: ENERGY SYSTEM MAPS

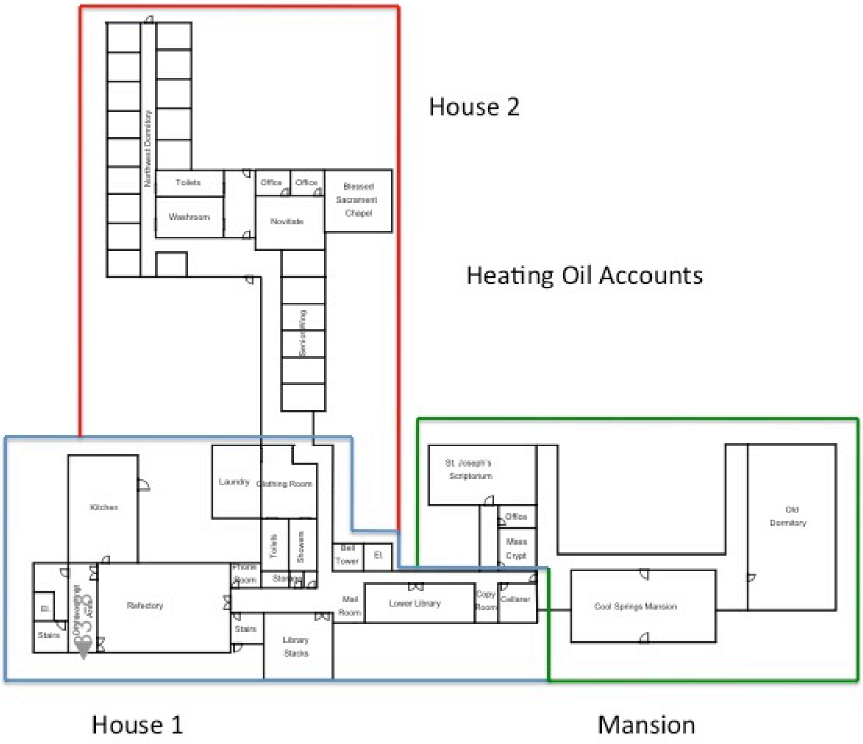
Map 1: Electricity accounts for ground level of monastery



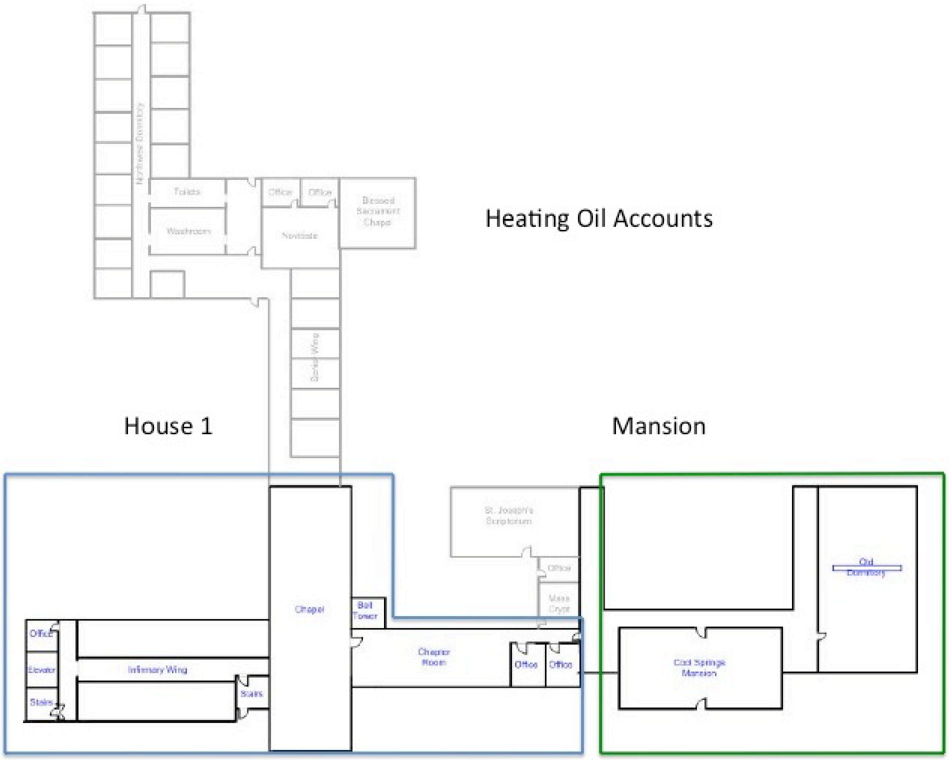
Map 2: Electricity accounts for upper level of monastery



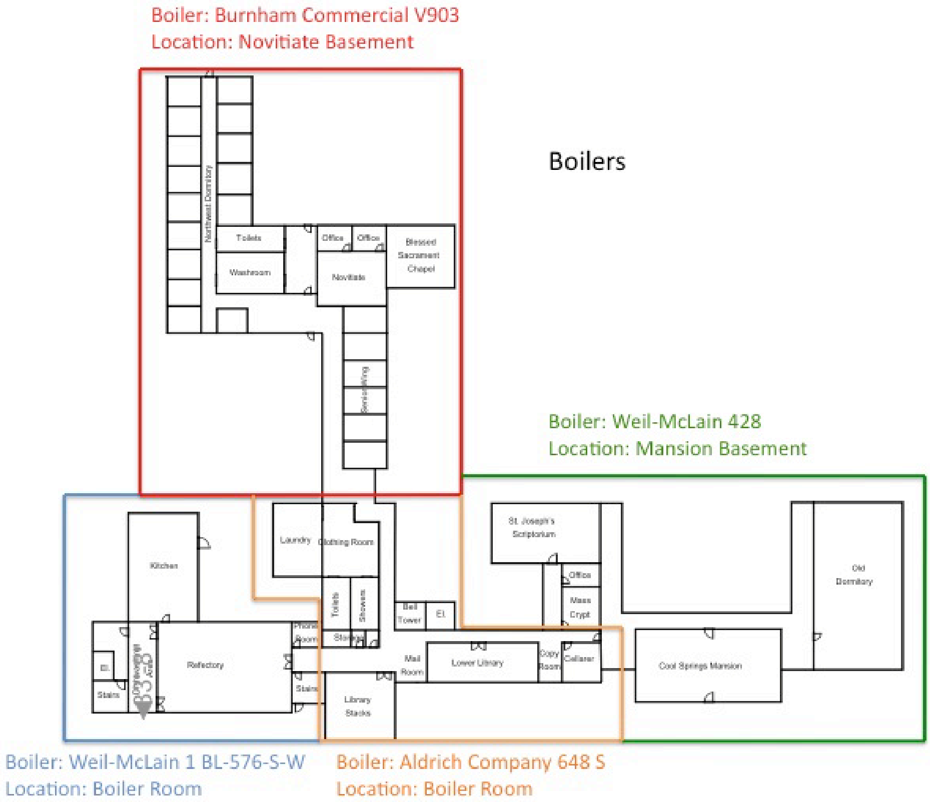
Map 3: Fuel oil designations by tank for ground level of monastery



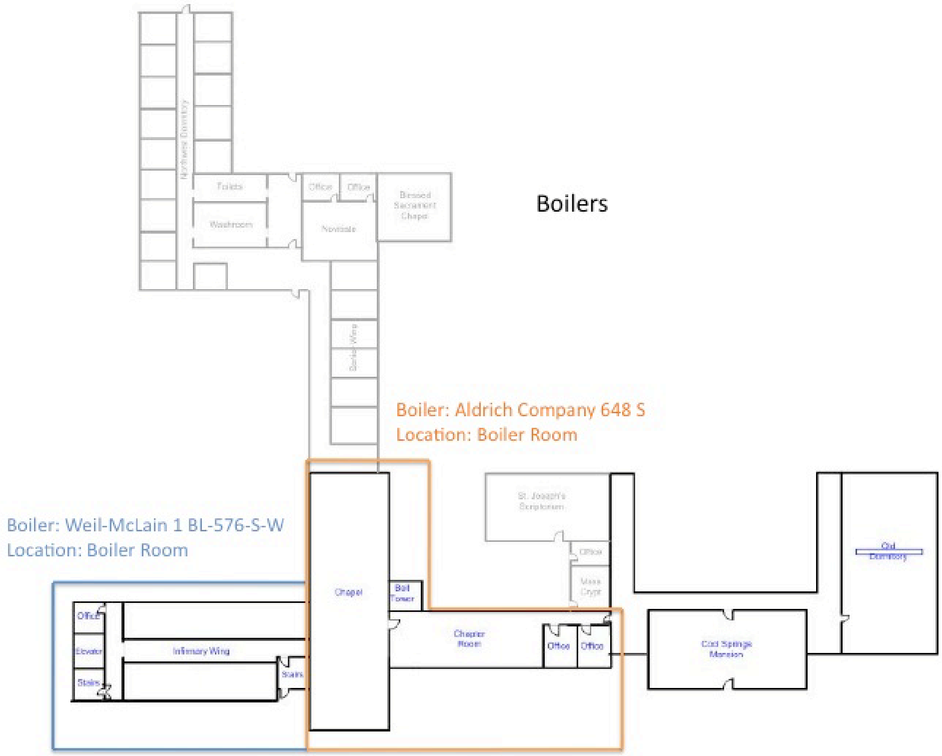
Map 4: Fuel oil designations by tank for upper level of monastery



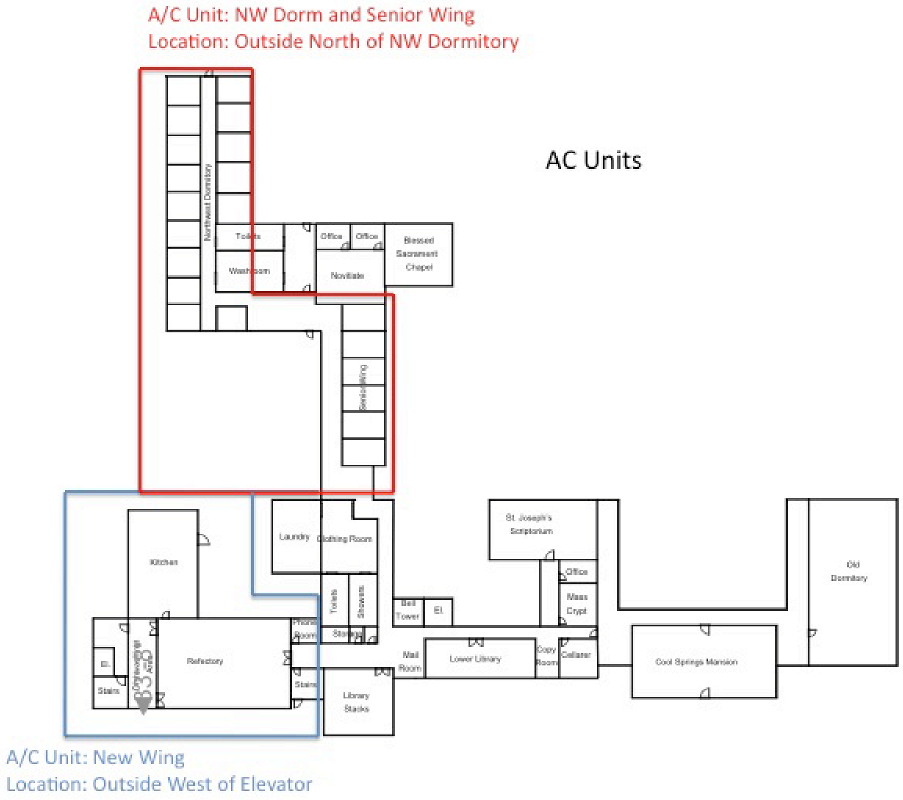
Map 5: Boiler designations for ground level of monastery



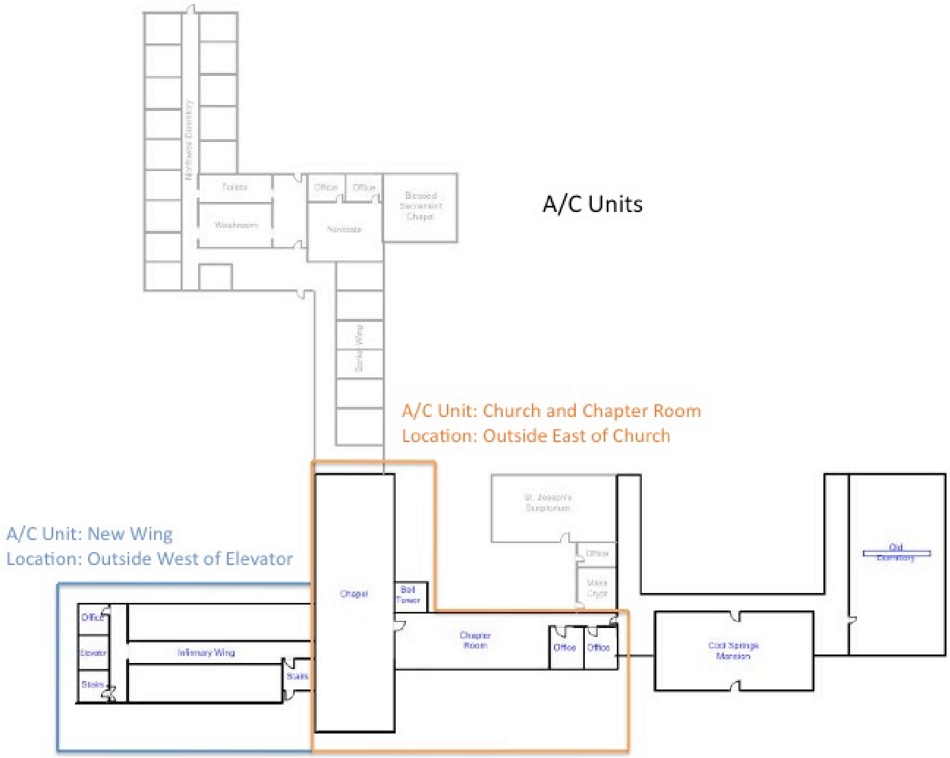
Map 6: Boiler designations for upper level of monastery



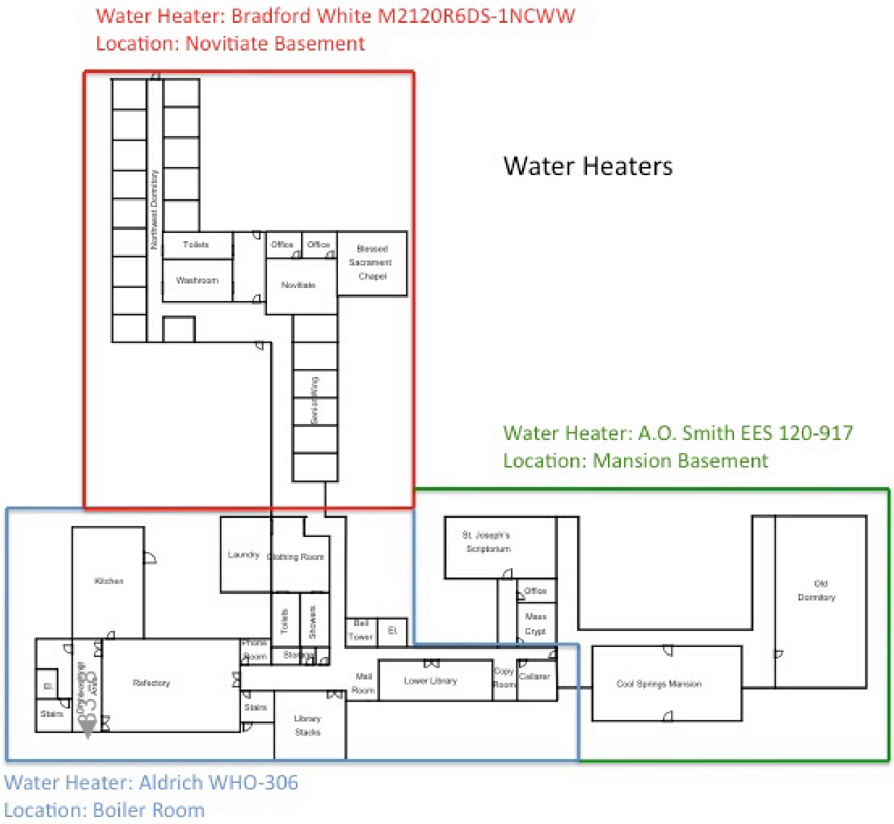
Map 7: Air conditioning designations for ground level of monastery



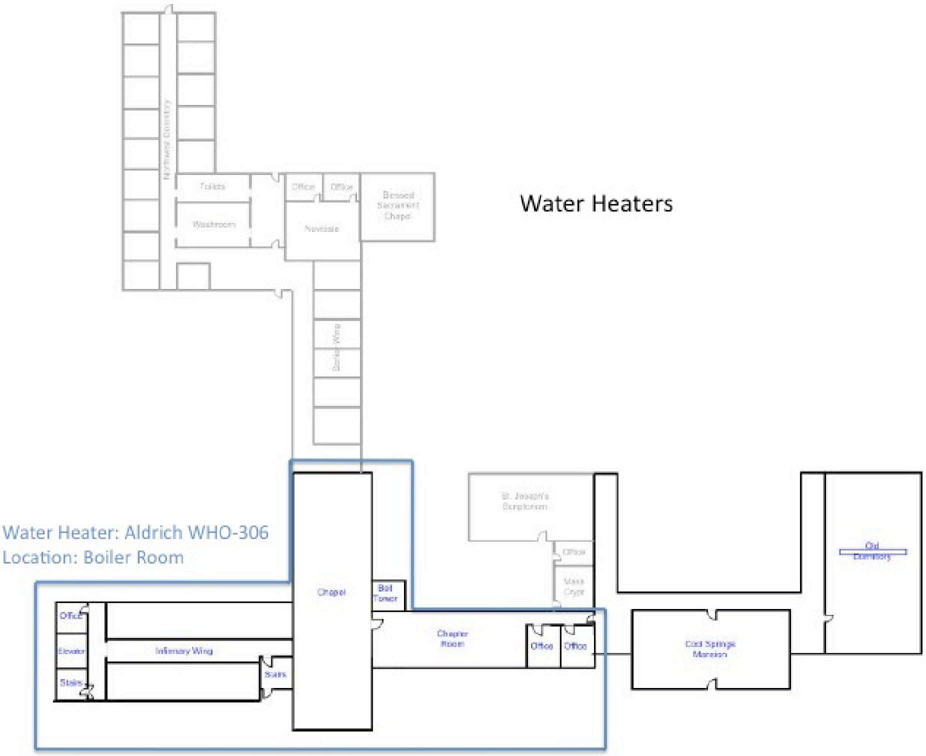
Map 8: Air conditioning designations for upper level of monastery



Map 9: Water heater designations for ground level of monastery



Map 10: Water heater designations for upper level of monastery



APPENDIX 2-C: EXPLANATIONS OF ENERGY METHODOLOGIES

Exhibit 1: Examples of how the HCA Sustainability Team estimated electricity consumption

Device	Methodology	Accuracy Rating
Clothes Washers and Dryers	Called the manufacturer to find the number of minutes the average cycle took. Then surveyed the community to determine the average number of loads of laundry done in a week using the device. Multiplied this average by 52 and the time per load.	Good
Water Heaters	Adjusted the average energy consumption for each unit (as designated on the Energy Guide label) by a person-use index (PUI). Using the information from the HCA community water survey, the PUI weights the hot water consumed by the community in comparison with the national average for use of similar sized hot water heaters.	Fair
Lighting	Assumed that lighting comprises 15% of all electricity based on study by US Energy Information Agency.	Poor
Air Conditioning	Assumed that the incremental electricity that was consumed above the average consumption in the base month April was due to space cooling.	Poor

Exhibit 2: Example of how the HCA Sustainability Team divided days between fuel oil deliveries by month

Delivery Date	Fuel Volume Delivered (gallons)	Tank Stock w/ Delivery (gallons)	Fuel Used Since Last Delivery (gallons)	Number of Days of Heating Oil Use in Month											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/16/03	950.0	2,323.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
4/1/03	1,690.0	1,794.0	2,219.0	15	28	31	1								
4/8/03	740.0	2,534.0	0.0				7								
9/9/03	2,476.6	3,927.6	1,083.0				22	31	30	31	31	9			
1/14/04	0.0	1,373.0	2,554.6	14								21	31	30	31
2/17/04	2,000.0	2,036.0	1,337.0	17	17										
5/4/04	1,122.4	2,046.4	1,112.0		12	31	30	4							
6/15/04	0.0	1,529.0	517.4					27	15						
8/16/04	2,653.3	3,949.3	233.0						15	31	16				
3/18/05	2,517.1	2,607.1	3,859.3	31	28	18					15	30	31	30	31
8/24/05	2,737.7	4,000.0	1,344.8			13	30	31	30	31	24				
1/4/06	276.5	2,138.3	2,138.2	4							7	30	31	30	31
3/20/06	1,960.0	1,960.0	2,138.3	27	28	20									
3/28/06	644.5	2,330.5	274.0			8									
8/8/06	2,116.2	3,961.2	485.5			3	30	31	30	31	8				
1/16/07	1,366.8	3,113.0	2,215.0	16							23	30	31	30	31
3/23/07	851.0	1,921.0	2,043.0	15	28	23									
9/13/07	3,267.8	3,982.8	1,206.0			8	30	31	30	31	31	13			
4/21/08	1,000.0	1,584.0	3,398.8	31	29	31	21					17	31	30	31
8/15/08	500.0	789.0	1,295.0				9	31	30	31	15				
8/16/08	1,383.6	2,172.6	0.0								1				
10/30/08	1,827.4	4,000.0	0.0								15	30	30		

Exhibit 3: Number of gallons assigned to each month according to days between deliveries

Delivery Date	Fuel Volume Delivered (gallons)	Average Daily Usage (gal/day)	Number of Gallons of Heating Oil Used per Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1/16/03	950.0													
4/1/03	1,690.0	29.6	444	828	917	30	-	-	-	-	-	-	-	-
4/8/03	740.0	0.0	-	-	-	-	-	-	-	-	-	-	-	-
9/9/03	2,476.6	7.0	-	-	-	155	218	211	218	218	63	-	-	-
1/14/04	0.0	20.1	282	-	-	-	-	-	-	-	422	624	603	624
2/17/04	2,000.0	39.3	669	669	-	-	-	-	-	-	-	-	-	-
5/4/04	1,122.4	14.4	-	173	448	433	58	-	-	-	-	-	-	-
6/15/04	0.0	12.3	-	-	-	-	333	185	-	-	-	-	-	-
8/16/04	2,653.3	3.8	-	-	-	-	-	56	117	60	-	-	-	-
3/18/05	2,517.1	18.0	559	505	325	-	-	-	-	271	541	559	541	559
8/24/05	2,737.7	8.5	-	-	110	254	262	254	262	203	-	-	-	-
1/4/06	276.5	16.1	64	-	-	-	-	-	-	113	482	498	482	498
3/20/06	1,960.0	28.5	770	798	570	-	-	-	-	-	-	-	-	-
3/28/06	644.5	34.3	-	-	274	-	-	-	-	-	-	-	-	-
8/8/06	2,116.2	3.7	-	-	11	110	113	110	113	29	-	-	-	-
1/16/07	1,366.8	13.8	220	-	-	-	-	-	-	316	413	426	413	426
3/23/07	851.0	31.0	464	867	712	-	-	-	-	-	-	-	-	-
9/13/07	3,267.8	6.9	-	-	55	208	215	208	215	215	90	-	-	-
4/21/08	1,000.0	15.4	477	446	477	323	-	-	-	-	261	477	461	477
8/15/08	500.0	11.2	-	-	-	100	346	335	346	167	-	-	-	-
8/16/08	1,383.6	0.0	-	-	-	-	-	-	-	-	-	-	-	-
10/30/08	1,827.4	0.0	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 2-D: DATA TABLES

Data Table 1: IPCC's list of greenhouse gases

Industrial or Common Name	Designation	Chemical Formula	Atmospheric Lifetime (years)	100-yr GWP Factor
Carbon dioxide		CO_2	N/A	1.0
Methane		CH_4	12.0	25.0
Nitrous oxide		N_2O	114.0	298.0
Substances controlled by the Montreal Protocol				
CFC-11		CCl_3F	45.0	4,750.0
CFC-12		CCl_2F_2	100.0	10,900.0
CFC-13		$CClF_3$	640.0	14,400.0
CFC-113		CCl_2FCClF_2	85.0	6,130.0
CFC-114		$CClF_2CClF_2$	300.0	10,000.0
CFC-115		$CClF_2CF_3$	1,700.0	7,370.0
Halon-1301		$CBrF_3$	65.0	7,140.0
Halon-1211		$CBrClF_2$	16.0	1,890.0
Halon-2402		$CBrF2CBrF_2$	20.0	1,640.0
Carbon tetrachloride		CCl_4	26.0	1,400.0
Methyl bromide		CH_3Br	0.7	5.0
Methyl chloroform		CH_3CCl_3	5.0	146.0
HCFC-22		$CHClF_2$	12.0	1,810.0
HCFC-123		$CHCl_2CF_3$	1.3	77.0
HCFC-124		$CHClFCF_3$	5.8	609.0
HCFC-141b		CH_3CCl_2F	9.3	725.0
HCFC-142b		CH3CClF2	17.9	2,310.0
HCFC-225ca		$CHCl_2CF_2CF_3$	1.9	122.0
HCFC-225cb		$CHClFCF_2CClF_2$	5.8	595.0
Hydrofluorocarbons				
HFC-23		CHF_3	270.0	14,800.0
HFC-32		CH_2F_2	4.9	675.0
HFC-125		CHF_2CF_3	29.0	3,500.0
HFC-134a		CH_2FCF_3	14.0	1,430.0
HFC-143a		CH_3CF_3	52.0	4,470.0
HFC-152a		CH_3CHF_2	1.4	124.0
HFC-227ea		CF_3CHFCF_3	34.2	3,220.0
HFC-236fa		$CF_3CH_2CF_3$	240.0	9,810.0
HFC-245fa		$CHF_2CH_2CF_3$	7.6	1,030.0
HFC-365mfc		$CH_3CF_2CH_2CF_3$	8.6	794.0
HFC-43-10mee		$CF_3CHFCHFCF_2$	15.9	1,640.0
Perfluorinated compounds				
Sulphur hexafluoride		SF_6	3,200.0	22,800.0
Nitrogen trifluoride		NF_3	740.0	17,200.0
PFC-14		CF_4	50,000.0	7,390.0
PFC-116		C_2F_6	10,000.0	12,200.0
PFC-218		C_3F_8	2,600.0	8,830.0
PFC-318		$c\text{-}C_4F_8$	3,200.0	10,300.0
PFC-3-1-10		C_4F_{10}	2,600.0	8,860.0
PFC-4-1-12		C_5F_{12}	4,100.0	9,160.0
PFC-5-1-14		C_6F_{14}	3,200.0	9,300.0
PFC-9-1-18		$C_{10}F_{18}$	1,000.0	7,500.0
Trifluoromethyl	sulphur	SF_5CF_3	800.0	17,700.0

Industrial Designation or Common Name (cont.)	Chemical Formula (cont.)	Atmospheric Lifetime (years) (cont.)	100-yr GWP Factor (cont.)
Fluorinated ethers			
HFE-125	CHF_2OCF_3	136.0	14,900.0
HFE-134	CHF_2OCHF_2	26.0	6,320.0
HFE-143	CH_3OCF_3	4.3	756.0
HCFE-235da2	$CHF_2OCHClCF_3$	2.6	350.0
HFE-245cb2	$CH_3OCF_2CHF_2$	5.1	708.0
HFE-245fa2	$CHF_2OCH_2CF_3$	4.9	659.0
HFE-254cb2	$CH_3OCF_2CHF_2$	2.6	359.0
HFE-347mcc3	$CH_3OCF_2CF_2CF_3$	5.2	575.0
HFE-347pcf2	$CHF_2CF_2OCH_2CF_3$	7.1	580.0
HFE-356pcc3	$CH_3OCF_2CF_2CHF_2$	0.3	110.0
HFE-449sl (HFE-7100)	$C_4F_9OCH_3$	3.8	297.0
HFE-569sf2 (HFE-7200)	$C_4F_9OC_2H_5$	0.8	59.0
HFE-43-10pccc124 (H-Galden	$CHF_2OCF_2OC_2F_4OC$	6.3	1,870.0
HFE-236ca12 (HG-10)	$CHF_2OCF_2OCHF_2$	12.1	2,800.0
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCH$	6.2	1,500.0
Perfluoropolyethers			
PFPMIE	$CF_3OCF(CF_3)CF_2OC$	800.0	10,300.0
Hydrocarbons and other compounds – Direct Effects			
Dimethylether	CH_3OCH_3	0.0	1.0
Methylene chloride	CH_2Cl_2	0.4	8.7
Methyl chloride	CH_3Cl	1.0	13.0

Source: IPCC, Fourth Assessment Report, 2007

Data Table 2: Estimated power generation (kWh) from 10 kW Bergey unit at 18 meters

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	1.20	0.53	0.53	0.53	0.30	0.35	0.35	0.35	0.30	0.53	0.75	0.75	**0.54**
1	1.20	0.53	0.53	0.53	0.53	0.30	0.35	0.35	0.30	0.53	0.98	0.75	**0.57**
2	1.20	0.75	0.75	0.75	0.53	0.30	0.30	0.30	0.30	0.53	0.98	0.75	**0.62**
3	1.20	0.75	0.53	0.75	0.53	0.30	0.30	0.30	0.30	0.53	0.75	0.75	**0.58**
4	0.98	0.75	0.53	0.75	0.75	0.30	0.30	0.30	0.30	0.53	0.75	0.98	**0.60**
5	0.98	0.75	0.53	0.75	0.75	0.30	0.30	0.30	0.30	0.53	0.75	0.98	**0.60**
6	0.98	0.75	0.53	0.75	0.53	0.30	0.30	0.30	0.30	0.30	0.75	0.75	**0.54**
7	0.98	0.75	0.53	0.75	0.53	0.30	0.30	0.35	0.30	0.30	0.75	0.75	**0.55**
8	0.98	0.75	0.53	0.53	0.53	0.30	0.35	0.35	0.30	0.30	0.53	0.75	**0.51**
9	0.98	0.75	0.53	0.53	0.53	0.30	0.35	0.35	0.30	0.53	0.53	0.75	**0.53**
10	0.75	0.75	0.53	0.53	0.53	0.35	0.35	0.35	0.30	0.30	0.53	0.98	**0.52**
11	0.75	0.53	0.53	0.53	0.30	0.35	0.20	0.35	0.35	0.30	0.75	0.75	**0.47**
12	0.75	0.30	0.30	0.30	0.20	0.15	0.10	0.15	0.20	0.30	0.53	0.75	**0.34**
13	0.75	0.30	0.30	0.30	0.15	0.10	0.05	0.10	0.15	0.35	0.75	0.98	**0.36**
14	0.98	0.53	0.30	0.35	0.15	0.10	0.10	0.10	0.10	0.20	0.75	1.20	**0.40**
15	0.75	0.30	0.30	0.35	0.20	0.10	0.10	0.10	0.10	0.20	0.53	0.98	**0.33**
16	0.53	0.30	0.35	0.35	0.20	0.15	0.10	0.10	0.15	0.20	0.35	0.53	**0.28**
17	0.53	0.30	0.35	0.35	0.20	0.15	0.10	0.10	0.15	0.20	0.35	0.30	**0.26**
18	0.53	0.30	0.30	0.30	0.35	0.15	0.15	0.10	0.15	0.20	0.20	0.30	**0.25**
19	0.53	0.30	0.30	0.30	0.35	0.20	0.15	0.10	0.15	0.20	0.35	0.30	**0.27**
20	0.75	0.30	0.30	0.30	0.35	0.20	0.15	0.10	0.15	0.35	0.35	0.30	**0.30**
21	0.98	0.30	0.30	0.30	0.35	0.20	0.15	0.15	0.20	0.35	0.30	0.53	**0.34**
22	0.98	0.30	0.30	0.30	0.35	0.35	0.20	0.15	0.35	0.30	0.53	0.75	**0.40**
23	1.20	0.53	0.53	0.53	0.30	0.35	0.20	0.20	0.30	0.53	0.75	0.75	**0.51**
Avg	**0.89**	**0.52**	**0.44**	**0.49**	**0.39**	**0.25**	**0.22**	**0.23**	**0.24**	**0.36**	**0.60**	**0.72**	
Total	**21**	**12**	**10**	**12**	**9**	**6**	**5**	**5**	**6**	**9**	**15**	**17**	
Monthly Output	**663**	**347**	**324**	**350**	**293**	**179**	**164**	**167**	**174**	**265**	**435**	**537**	

Key: White = less than 25% of average hourly demand
Orange = 5%-15% of average hourly demand
Pink = 15%-25% of average hourly demand
Red = 25% or more of average hourly demand

Data Table 3: Estimated power generation (kWh) from 10 kW Bergey unit at 43 meters

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	1.95	0.98	0.98	0.98	0.75	0.53	0.30	0.53	0.75	0.98	1.58	1.20	**0.96**
1	1.95	1.20	0.98	0.98	0.98	0.75	0.53	0.53	0.75	0.98	1.58	1.20	**1.03**
2	1.95	1.20	1.20	1.20	0.98	0.75	0.75	0.75	0.75	0.98	1.58	1.58	**1.14**
3	1.95	1.20	0.98	1.20	1.20	0.75	0.53	0.75	0.75	0.98	1.58	1.58	**1.12**
4	1.95	1.20	0.98	1.20	1.20	0.75	0.53	0.53	0.75	0.98	1.58	1.58	**1.10**
5	1.95	1.20	0.98	1.20	1.20	0.75	0.53	0.53	0.75	0.98	1.20	1.58	**1.07**
6	1.58	1.20	0.98	1.20	0.98	0.75	0.53	0.53	0.75	0.75	1.20	1.58	**1.00**
7	1.58	1.20	0.98	1.20	0.98	0.75	0.53	0.53	0.75	0.75	1.20	1.20	**0.97**
8	1.58	1.20	0.98	0.98	0.98	0.75	0.53	0.53	0.75	0.75	0.98	1.20	**0.93**
9	1.58	1.20	0.98	0.98	0.98	0.53	0.53	0.53	0.53	0.75	0.98	1.58	**0.93**
10	1.58	1.20	0.98	0.98	0.98	0.53	0.30	0.53	0.53	0.75	0.98	1.58	**0.91**
11	1.20	0.98	0.75	0.98	0.75	0.30	0.35	0.30	0.53	0.75	1.20	1.58	**0.80**
12	1.20	0.75	0.75	0.75	0.30	0.20	0.20	0.20	0.30	0.53	0.98	1.58	**0.64**
13	1.20	0.75	0.53	0.53	0.20	0.15	0.10	0.15	0.20	0.53	1.20	1.58	**0.59**
14	1.58	0.75	0.53	0.53	0.20	0.15	0.15	0.15	0.20	0.30	1.20	1.95	**0.64**
15	1.20	0.75	0.53	0.53	0.35	0.15	0.15	0.15	0.15	0.35	0.75	1.58	**0.55**
16	0.98	0.75	0.53	0.53	0.35	0.20	0.15	0.15	0.20	0.35	0.53	0.98	**0.47**
17	0.98	0.75	0.53	0.53	0.30	0.20	0.15	0.15	0.20	0.35	0.30	0.75	**0.43**
18	0.98	0.75	0.53	0.53	0.30	0.35	0.20	0.15	0.20	0.35	0.30	0.75	**0.45**
19	0.98	0.53	0.75	0.75	0.53	0.35	0.20	0.15	0.20	0.30	0.30	0.75	**0.48**
20	1.20	0.53	0.75	0.75	0.53	0.35	0.35	0.15	0.35	0.30	0.53	0.75	**0.54**
21	1.58	0.75	0.75	0.75	0.53	0.30	0.35	0.20	0.35	0.53	0.75	0.98	**0.65**
22	1.58	0.75	0.75	0.75	0.53	0.30	0.35	0.35	0.30	0.75	0.98	1.20	**0.71**
23	1.95	0.98	0.98	0.75	0.75	0.30	0.35	0.30	0.53	0.98	1.20	1.58	**0.89**
Avg	**1.51**	**0.95**	**0.82**	**0.86**	**0.70**	**0.45**	**0.36**	**0.37**	**0.48**	**0.66**	**1.03**	**1.33**	
Total	**36**	**23**	**20**	**21**	**17**	**11**	**9**	**9**	**12**	**16**	**25**	**32**	
Monthly Output	**1,121**	**636**	**607**	**621**	**520**	**326**	**267**	**272**	**345**	**494**	**738**	**986**	

Key:
White = less than 25% of average hourly demand
Orange = 5%-15% of average hourly demand
Pink = 15%-25% of average hourly demand
Red = 25% or more of average hourly demand

Data Table 4: Estimated power generation (kWh) from 20 kW Tairui unit at 18 meters

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	3.50	2.10	2.10	2.10	1.80	1.50	1.50	1.50	1.80	2.10	2.50	2.50	**2.08**
1	3.50	2.10	2.10	2.10	2.10	1.80	1.50	1.50	1.80	2.10	2.90	2.50	**2.17**
2	3.50	2.50	2.50	2.50	2.10	1.80	1.80	1.80	1.80	2.10	2.90	2.50	**2.32**
3	3.50	2.50	2.10	2.50	2.10	1.80	1.80	1.80	1.80	2.10	2.50	2.50	**2.25**
4	2.90	2.50	2.10	2.50	2.50	1.80	1.80	1.80	1.80	2.10	2.50	2.90	**2.27**
5	2.90	2.50	2.10	2.50	2.50	1.80	1.80	1.80	1.80	2.10	2.50	2.90	**2.27**
6	2.90	2.50	2.10	2.50	2.10	1.80	1.80	1.80	1.80	1.80	2.50	2.50	**2.18**
7	2.90	2.50	2.10	2.50	2.10	1.80	1.80	1.50	1.80	1.80	2.50	2.50	**2.15**
8	2.90	2.50	2.10	2.10	2.10	1.80	1.50	1.50	1.80	1.80	2.10	2.50	**2.06**
9	2.90	2.50	2.10	2.10	2.10	1.80	1.50	1.50	1.80	2.10	2.10	2.50	**2.08**
10	2.50	2.50	2.10	2.10	2.10	1.50	1.50	1.50	1.80	1.80	2.10	2.90	**2.03**
11	2.50	2.10	2.10	2.10	1.80	1.50	1.30	1.50	1.50	1.80	2.50	2.50	**1.93**
12	2.50	1.80	1.80	1.80	1.30	1.10	0.90	1.10	1.30	1.80	2.10	2.50	**1.67**
13	2.50	1.80	1.80	1.80	1.10	0.90	-	0.90	1.10	1.50	2.50	2.90	**1.57**
14	2.90	2.10	1.80	1.50	1.10	0.90	0.90	0.90	0.90	1.30	2.50	3.50	**1.69**
15	2.50	1.80	1.80	1.50	1.30	0.90	0.90	0.90	0.90	1.30	2.10	2.90	**1.57**
16	2.10	1.80	1.50	1.50	1.30	1.10	0.90	0.90	1.10	1.30	1.50	2.10	**1.43**
17	2.10	1.80	1.50	1.50	1.30	1.10	0.90	0.90	1.10	1.30	1.50	1.80	**1.40**
18	2.10	1.80	1.80	1.80	1.50	1.10	1.10	0.90	1.10	1.30	1.30	1.80	**1.47**
19	2.10	1.80	1.80	1.80	1.50	1.30	1.10	0.90	1.10	1.30	1.50	1.80	**1.50**
20	2.50	1.80	1.80	1.80	1.50	1.30	1.10	0.90	1.10	1.50	1.50	1.80	**1.55**
21	2.90	1.80	1.80	1.80	1.50	1.30	1.10	1.10	1.30	1.50	1.80	2.10	**1.67**
22	2.90	1.80	1.80	1.80	1.50	1.50	1.30	1.10	1.50	1.80	2.10	2.50	**1.80**
23	3.50	2.10	2.10	2.10	1.80	1.50	1.30	1.30	1.80	2.10	2.50	2.50	**2.05**
Avg	**2.79**	**2.13**	**1.95**	**2.01**	**1.75**	**1.45**	**1.30**	**1.30**	**1.48**	**1.74**	**2.19**	**2.48**	
Total	**67**	**51**	**47**	**48**	**42**	**35**	**31**	**31**	**36**	**42**	**53**	**59**	
Monthly Output	**2,077**	**1,428**	**1,454**	**1,449**	**1,305**	**1,041**	**964**	**970**	**1,068**	**1,293**	**1,575**	**1,841**	

Key: White = less than 25% of average hourly demand
Orange = 5%-15% of average hourly demand
Pink = 15%-25% of average hourly demand
Red = 25% or more of average hourly demand

Data Table 5: Estimated power generation (kWh) from 20 kW Tairui unit at 43 meters

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	4.90	2.90	2.90	2.90	2.50	2.10	1.80	2.10	2.50	2.90	4.00	3.50	**2.92**
1	4.90	3.50	2.90	2.90	2.90	2.50	2.10	2.10	2.50	2.90	4.00	3.50	**3.06**
2	4.90	3.50	3.50	3.50	2.90	2.50	2.50	2.50	2.50	2.90	4.00	4.00	**3.27**
3	4.90	3.50	2.90	3.50	3.50	2.50	2.10	2.50	2.50	2.90	4.00	4.00	**3.23**
4	4.90	3.50	2.90	3.50	3.50	2.50	2.10	2.10	2.50	2.90	4.00	4.00	**3.20**
5	4.90	3.50	2.90	3.50	3.50	2.50	2.10	2.10	2.50	2.90	3.50	4.00	**3.16**
6	4.00	3.50	2.90	3.50	2.90	2.50	2.10	2.10	2.50	2.50	3.50	4.00	**3.00**
7	4.00	3.50	2.90	3.50	2.90	2.50	2.10	2.10	2.50	2.50	3.50	3.50	**2.96**
8	4.00	3.50	2.90	2.90	2.90	2.50	2.10	2.10	2.50	2.50	2.90	3.50	**2.86**
9	4.00	3.50	2.90	2.90	2.90	2.10	2.10	2.10	2.10	2.50	2.90	4.00	**2.83**
10	4.00	3.50	2.90	2.90	2.90	2.10	1.80	2.10	2.10	2.50	2.90	4.00	**2.81**
11	3.50	2.90	2.50	2.90	2.50	1.80	1.50	1.80	2.10	2.50	3.50	4.00	**2.63**
12	3.50	2.50	2.50	2.50	1.80	1.30	1.30	1.30	1.80	2.10	2.90	4.00	**2.29**
13	3.50	2.50	2.10	2.10	1.30	1.10	0.90	1.10	1.30	2.10	3.50	4.00	**2.13**
14	4.00	2.50	2.10	2.10	1.30	1.10	1.10	1.10	1.30	1.80	3.50	4.90	**2.23**
15	3.50	2.50	2.10	2.10	1.50	1.10	1.10	1.10	1.10	1.50	2.50	4.00	**2.01**
16	2.90	2.50	2.10	2.10	1.50	1.30	1.10	1.10	1.30	1.50	2.10	2.90	**1.87**
17	2.90	2.50	2.10	2.10	1.80	1.30	1.10	1.10	1.30	1.50	1.80	2.50	**1.83**
18	2.90	2.50	2.10	2.10	1.80	1.50	1.30	1.10	1.30	1.50	1.80	2.50	**1.87**
19	2.90	2.10	2.50	2.50	2.10	1.50	1.30	1.10	1.30	1.80	1.80	2.50	**1.95**
20	3.50	2.10	2.50	2.50	2.10	1.50	1.50	1.10	1.50	1.80	2.10	2.50	**2.06**
21	4.00	2.50	2.50	2.50	2.10	1.80	1.50	1.30	1.50	2.10	2.50	2.90	**2.27**
22	4.00	2.50	2.50	2.50	2.10	1.80	1.50	1.50	1.80	2.50	2.90	3.50	**2.43**
23	4.90	2.90	2.90	2.50	2.50	1.80	1.50	1.80	2.10	2.90	3.50	4.00	**2.78**
Avg	**3.98**	**2.93**	**2.63**	**2.75**	**2.40**	**1.88**	**1.65**	**1.68**	**1.93**	**2.31**	**3.07**	**3.59**	
Total	**95**	**70**	**63**	**66**	**58**	**45**	**40**	**40**	**46**	**56**	**74**	**86**	
Monthly Output	**2,957**	**1,971**	**1,953**	**1,980**	**1,789**	**1,356**	**1,228**	**1,252**	**1,392**	**1,721**	**2,208**	**2,672**	

Key: White = less than 25% of average hourly demand
Orange = 5%-15% of average hourly demand
Pink = 15%-25% of average hourly demand
Red = 25% or more of average hourly demand

Data Table 6: Estimated power generation (kWh) from 35 kW Endurance unit at 30.5 meters

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	25.00	14.00	14.00	14.00	12.00	8.00	8.00	8.00	12.00	14.00	22.00	18.00	14.08
1	25.00	18.00	18.00	14.00	14.00	12.00	8.00	8.00	12.00	14.00	22.00	18.00	15.25
2	25.00	18.00	18.00	18.00	18.00	12.00	12.00	12.00	12.00	14.00	22.00	22.00	16.92
3	25.00	18.00	18.00	18.00	18.00	12.00	12.00	12.00	12.00	14.00	22.00	22.00	16.92
4	25.00	18.00	18.00	18.00	18.00	12.00	12.00	12.00	12.00	14.00	22.00	22.00	16.92
5	25.00	18.00	14.00	18.00	18.00	12.00	12.00	12.00	12.00	14.00	18.00	22.00	16.25
6	22.00	18.00	14.00	18.00	18.00	12.00	12.00	12.00	12.00	14.00	18.00	22.00	16.00
7	22.00	18.00	14.00	18.00	14.00	12.00	12.00	8.00	12.00	12.00	18.00	22.00	15.17
8	22.00	18.00	14.00	14.00	14.00	12.00	8.00	8.00	12.00	12.00	14.00	22.00	14.17
9	22.00	18.00	14.00	14.00	14.00	12.00	8.00	8.00	12.00	14.00	14.00	22.00	14.33
10	22.00	18.00	14.00	14.00	14.00	8.00	8.00	8.00	12.00	12.00	18.00	22.00	14.17
11	22.00	18.00	14.00	14.00	12.00	8.00	6.00	6.00	8.00	12.00	18.00	22.00	13.33
12	18.00	12.00	12.00	12.00	6.00	2.50	1.00	2.50	6.00	12.00	18.00	22.00	10.33
13	18.00	12.00	12.00	12.00	2.50	1.00	-	-	2.50	8.00	18.00	25.00	9.25
14	22.00	14.00	12.00	8.00	2.50	-	-	-	1.00	6.00	18.00	25.00	9.04
15	18.00	12.00	12.00	8.00	2.50	1.00	-	-	1.00	6.00	14.00	22.00	8.04
16	18.00	12.00	8.00	8.00	6.00	1.00	1.00	-	1.00	6.00	8.00	18.00	7.25
17	14.00	12.00	8.00	8.00	6.00	2.50	1.00	-	1.00	6.00	8.00	12.00	6.54
18	14.00	12.00	12.00	12.00	8.00	2.50	1.00	-	2.50	6.00	6.00	12.00	7.33
19	14.00	12.00	12.00	12.00	8.00	6.00	2.50	-	2.50	6.00	8.00	12.00	7.92
20	18.00	12.00	12.00	12.00	8.00	6.00	2.50	1.00	2.50	8.00	8.00	14.00	8.67
21	22.00	12.00	12.00	12.00	8.00	6.00	2.50	2.50	6.00	8.00	12.00	14.00	9.75
22	25.00	12.00	12.00	12.00	8.00	6.00	2.50	2.50	6.00	12.00	14.00	18.00	10.83
23	25.00	14.00	14.00	14.00	12.00	8.00	6.00	6.00	12.00	18.00	18.00	22.00	14.08
Avg	**21.17**	**15.00**	**13.42**	**13.42**	**10.90**	**7.27**	**5.75**	**5.35**	**7.67**	**10.92**	**15.75**	**19.67**	
Total	**508**	**360**	**322**	**322**	**262**	**175**	**138**	**129**	**184**	**262**	**378**	**472**	
Monthly Output	**15,748**	**10,080**	**9,982**	**9,660**	**8,107**	**5,235**	**4,278**	**3,984**	**5,520**	**8,122**	**11,340**	**14,632**	

Key: White = less than 25% of average hourly demand
Orange = 5%-15% of average hourly demand
Pink = 15%-25% of average hourly demand
Red = 25% or more of average hourly demand

Data Table 7: Estimated power generation (kWh) from 35 kW Endurance unit at 40 meters

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	29.00	18.00	18.00	18.00	14.00	12.00	8.00	8.00	12.00	18.00	22.00	22.00	**16.58**
1	29.00	18.00	18.00	18.00	18.00	12.00	12.00	12.00	14.00	18.00	25.00	22.00	**18.00**
2	29.00	22.00	18.00	22.00	18.00	14.00	12.00	14.00	14.00	18.00	25.00	22.00	**19.00**
3	29.00	22.00	18.00	18.00	18.00	14.00	12.00	14.00	14.00	18.00	22.00	22.00	**18.42**
4	29.00	22.00	18.00	22.00	18.00	14.00	12.00	12.00	14.00	18.00	22.00	25.00	**18.83**
5	25.00	22.00	18.00	22.00	18.00	14.00	12.00	12.00	14.00	14.00	22.00	25.00	**18.17**
6	25.00	22.00	18.00	22.00	18.00	14.00	12.00	12.00	14.00	14.00	22.00	22.00	**17.92**
7	25.00	22.00	18.00	18.00	18.00	14.00	12.00	12.00	14.00	14.00	22.00	22.00	**17.58**
8	25.00	22.00	18.00	18.00	18.00	12.00	12.00	12.00	12.00	14.00	18.00	22.00	**16.92**
9	25.00	22.00	18.00	18.00	18.00	12.00	12.00	12.00	12.00	14.00	18.00	22.00	**16.92**
10	22.00	18.00	14.00	18.00	14.00	12.00	8.00	12.00	12.00	14.00	18.00	25.00	**15.58**
11	22.00	18.00	14.00	18.00	14.00	8.00	6.00	8.00	12.00	14.00	18.00	22.00	**14.50**
12	22.00	14.00	14.00	14.00	8.00	2.50	1.00	2.50	8.00	12.00	18.00	22.00	**11.50**
13	22.00	12.00	12.00	12.00	2.50	1.00	-	1.00	2.50	8.00	22.00	25.00	**10.00**
14	25.00	14.00	12.00	12.00	2.50	1.00	-	-	1.00	6.00	22.00	29.00	**10.38**
15	22.00	14.00	12.00	12.00	6.00	1.00	1.00	1.00	1.00	6.00	14.00	25.00	**9.58**
16	18.00	14.00	12.00	12.00	6.00	2.50	1.00	1.00	2.50	6.00	12.00	18.00	**8.75**
17	18.00	14.00	12.00	12.00	8.00	2.50	1.00	1.00	2.50	6.00	8.00	14.00	**8.25**
18	18.00	12.00	12.00	12.00	8.00	6.00	2.50	1.00	2.50	6.00	8.00	14.00	**8.50**
19	18.00	12.00	12.00	14.00	8.00	6.00	2.50	1.00	2.50	8.00	8.00	14.00	**8.83**
20	22.00	12.00	14.00	14.00	12.00	6.00	6.00	1.00	6.00	8.00	12.00	14.00	**10.58**
21	25.00	14.00	14.00	14.00	12.00	6.00	6.00	2.50	6.00	12.00	14.00	18.00	**11.96**
22	25.00	14.00	14.00	14.00	12.00	8.00	6.00	6.00	8.00	14.00	18.00	22.00	**13.42**
23	29.00	18.00	18.00	14.00	14.00	8.00	6.00	8.00	12.00	18.00	22.00	25.00	**16.00**
Avg	**24.08**	**17.17**	**15.25**	**16.17**	**12.63**	**8.44**	**6.79**	**6.92**	**8.85**	**12.42**	**18.00**	**21.38**	
Total	**578**	**412**	**366**	**388**	**303**	**203**	**163**	**166**	**213**	**298**	**432**	**513**	
Monthly Output	**17,918**	**11,536**	**11,346**	**11,640**	**9,393**	**6,075**	**5,053**	**5,146**	**6,375**	**9,238**	**12,960**	**15,903**	

Key: White = less than 25% of average hourly demand
Orange = 5%-15% of average hourly demand
Pink = 15%-25% of average hourly demand
Red = 25% or more of average hourly demand

Data Table 8: Estimated power generation (kWh) from 6.8 kW Sharp Solar (39614) PV System

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	-	-	-	-	-	-	-	-	-	-	-	-	**-**
1	-	-	-	-	-	-	-	-	-	-	-	-	**-**
2	-	-	-	-	-	-	-	-	-	-	-	-	**-**
3	-	-	-	-	-	-	-	-	-	-	-	-	**-**
4	-	-	-	-	-	-	-	-	-	-	-	-	**-**
5	-	-	-	-	0.00	0.00	0.00	-	-	-	-	-	**0.00**
6	-	-	-	0.11	0.12	0.16	0.10	0.12	0.00	-	-	-	**0.05**
7	-	0.00	0.16	1.03	1.33	1.33	1.26	0.93	0.38	0.20	0.01	-	**0.55**
8	0.16	0.42	1.61	1.96	1.86	1.99	1.96	1.84	1.70	1.40	0.47	0.24	**1.30**
9	1.49	2.06	2.18	2.46	2.25	2.47	2.56	2.50	2.39	2.33	1.78	1.44	**2.16**
10	2.09	2.45	2.59	2.66	2.54	2.65	2.91	2.86	2.80	2.75	2.24	2.02	**2.55**
11	2.35	2.59	2.87	2.96	2.74	2.80	2.94	3.03	2.88	2.97	2.59	2.34	**2.76**
12	2.57	2.99	2.88	2.99	2.87	2.92	2.97	2.96	2.95	3.00	2.76	2.48	**2.86**
13	2.60	2.95	2.89	3.06	2.81	2.81	2.89	2.88	2.92	2.96	2.74	2.53	**2.84**
14	2.48	2.96	2.84	3.06	2.72	2.66	2.96	2.87	2.76	2.96	2.52	2.36	**2.76**
15	2.41	2.66	2.69	2.74	2.56	2.53	2.78	2.64	2.75	2.74	2.30	2.19	**2.58**
16	2.20	2.46	2.43	2.43	2.23	2.41	2.64	2.59	2.56	2.36	1.92	1.85	**2.34**
17	1.42	1.95	2.15	2.04	1.93	2.08	2.30	2.15	2.07	1.52	0.84	0.76	**1.77**
18	0.02	0.66	1.44	1.51	1.56	1.62	1.75	1.63	1.10	0.20	0.00	-	**0.96**
19	-	0.00	0.02	0.45	0.80	1.01	1.02	0.57	0.04	-	-	-	**0.33**
20	-	-	-	0.00	0.01	0.04	0.04	0.00	-	-	-	-	**0.01**
21	-	-	-	-	-	-	-	-	-	-	-	-	**-**
22	-	-	-	-	-	-	-	-	-	-	-	-	**-**
23	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Avg	**0.83**	**1.01**	**1.11**	**1.23**	**1.18**	**1.23**	**1.29**	**1.23**	**1.14**	**1.06**	**0.84**	**0.76**	
Total	**20**	**24**	**27**	**29**	**28**	**29**	**31**	**30**	**27**	**25**	**20**	**18**	
Monthly Output	**614**	**676**	**829**	**884**	**878**	**885**	**963**	**917**	**819**	**788**	**605**	**565**	

Key: White = less than 25% of average hourly demand
Orange = 5%-15% of average hourly demand
Pink = 15%-25% of average hourly demand
Red = 25% or more of average hourly demand

Data Table 9: Estimated power generation (kWh) from 7.5 kW Green Brilliance (GB54P6-190) PV System

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	-	-	-	-	-	-	-	-	-	-	-	-	**-**
1	-	-	-	-	-	-	-	-	-	-	-	-	**-**
2	-	-	-	-	-	-	-	-	-	-	-	-	**-**
3	-	-	-	-	-	-	-	-	-	-	-	-	**-**
4	-	-	-	-	-	-	-	-	-	-	-	-	**-**
5	-	-	-	-	0.00	0.00	0.00	-	-	-	-	-	**0.00**
6	-	-	-	0.13	0.15	0.20	0.12	0.15	0.00	-	-	-	**0.06**
7	-	0.00	0.20	1.26	1.63	1.64	1.56	1.15	0.47	0.25	0.01	-	**0.68**
8	0.20	0.51	1.98	2.42	2.29	2.45	2.41	2.27	2.10	1.73	0.58	0.30	**1.60**
9	1.84	2.53	2.69	3.03	2.78	3.05	3.16	3.08	2.94	2.87	2.20	1.77	**2.66**
10	2.58	3.02	3.20	3.28	3.13	3.27	3.59	3.52	3.45	3.39	2.76	2.49	**3.14**
11	2.89	3.19	3.54	3.65	3.38	3.45	3.62	3.74	3.55	3.66	3.19	2.89	**3.40**
12	3.17	3.68	3.54	3.68	3.53	3.60	3.66	3.64	3.63	3.69	3.41	3.05	**3.53**
13	3.20	3.64	3.56	3.77	3.46	3.46	3.56	3.55	3.59	3.65	3.38	3.11	**3.49**
14	3.06	3.65	3.49	3.78	3.35	3.28	3.64	3.54	3.40	3.65	3.11	2.91	**3.41**
15	2.97	3.28	3.32	3.37	3.16	3.12	3.43	3.26	3.39	3.38	2.83	2.70	**3.19**
16	2.71	3.03	2.99	3.00	2.75	2.96	3.25	3.19	3.15	2.91	2.36	2.28	**2.88**
17	1.75	2.40	2.64	2.51	2.38	2.56	2.83	2.66	2.55	1.88	1.03	0.94	**2.18**
18	0.03	0.81	1.77	1.85	1.92	2.00	2.15	2.01	1.36	0.24	0.00	-	**1.18**
19	-	0.00	0.03	0.55	0.99	1.24	1.26	0.70	0.05	-	-	-	**0.40**
20	-	-	-	0.00	0.01	0.04	0.05	0.00	-	-	-	-	**0.01**
21	-	-	-	-	-	-	-	-	-	-	-	-	**-**
22	-	-	-	-	-	-	-	-	-	-	-	-	**-**
23	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Avg	**1.02**	**1.24**	**1.37**	**1.51**	**1.45**	**1.51**	**1.60**	**1.52**	**1.40**	**1.30**	**1.04**	**0.93**	
Total	**24**	**30**	**33**	**36**	**35**	**36**	**38**	**36**	**34**	**31**	**25**	**22**	
Monthly Output	**756**	**833**	**1,021**	**1,089**	**1,082**	**1,090**	**1,187**	**1,130**	**1,009**	**970**	**746**	**696**	

Key: White = less than 25% of average hourly demand
Orange = 5%-15% of average hourly demand
Pink = 15%-25% of average hourly demand
Red = 25% or more of average hourly demand

Data Table 10: Estimated power generation (kWh) from 7.5 kW Green Brilliance (GB72P6-260) PV System

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	-	-	-	-	-	-	-	-	-	-	-	-	**-**
1	-	-	-	-	-	-	-	-	-	-	-	-	**-**
2	-	-	-	-	-	-	-	-	-	-	-	-	**-**
3	-	-	-	-	-	-	-	-	-	-	-	-	**-**
4	-	-	-	-	-	-	-	-	-	-	-	-	**-**
5	-	-	-	-	0.00	0.00	0.00	-	-	-	-	-	**0.00**
6	-	-	-	0.17	0.19	0.26	0.15	0.20	0.00	-	-	-	**0.08**
7	-	0.00	0.26	1.64	2.12	2.13	2.02	1.49	0.61	0.32	0.01	-	**0.88**
8	0.26	0.66	2.57	3.14	2.97	3.18	3.13	2.95	2.73	2.24	0.76	0.39	**2.08**
9	2.39	3.29	3.49	3.93	3.60	3.96	4.10	4.00	3.82	3.73	2.85	2.30	**3.45**
10	3.35	3.93	4.15	4.25	4.07	4.25	4.65	4.57	4.48	4.40	3.58	3.24	**4.08**
11	3.76	4.14	4.59	4.73	4.38	4.48	4.70	4.85	4.61	4.75	4.14	3.75	**4.41**
12	4.12	4.78	4.60	4.78	4.59	4.68	4.75	4.73	4.72	4.80	4.42	3.96	**4.58**
13	4.16	4.72	4.62	4.89	4.49	4.49	4.62	4.61	4.66	4.74	4.39	4.04	**4.54**
14	3.97	4.74	4.54	4.90	4.35	4.26	4.73	4.59	4.42	4.74	4.04	3.78	**4.42**
15	3.86	4.26	4.31	4.38	4.10	4.05	4.45	4.23	4.41	4.38	3.68	3.51	**4.14**
16	3.52	3.94	3.89	3.89	3.58	3.85	4.22	4.14	4.09	3.77	3.07	2.96	**3.74**
17	2.27	3.11	3.43	3.26	3.09	3.33	3.68	3.45	3.31	2.44	1.34	1.21	**2.83**
18	0.04	1.06	2.30	2.41	2.49	2.59	2.80	2.60	1.77	0.31	0.00	-	**1.53**
19	-	0.00	0.04	0.72	1.28	1.61	1.63	0.90	0.06	-	-	-	**0.52**
20	-	-	-	0.00	0.01	0.06	0.06	0.00	-	-	-	-	**0.01**
21	-	-	-	-	-	-	-	-	-	-	-	-	**-**
22	-	-	-	-	-	-	-	-	-	-	-	-	**-**
23	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Avg	**1.32**	**1.61**	**1.78**	**1.96**	**1.89**	**1.97**	**2.07**	**1.97**	**1.82**	**1.69**	**1.34**	**1.21**	
Total	**32**	**39**	**43**	**47**	**45**	**47**	**50**	**47**	**44**	**41**	**32**	**29**	
Monthly Output	**982**	**1,081**	**1,326**	**1,413**	**1,405**	**1,416**	**1,541**	**1,467**	**1,310**	**1,260**	**968**	**903**	

Key: White = less than 25% of average hourly demand
Orange = 5%-15% of average hourly demand
Pink = 15%-25% of average hourly demand
Red = 25% or more of average hourly demand

SOURCES FOR TABLES, FIGURES AND BOXES

Sources for Figures:

Figure 1: US Energy Information Administration. *International Energy Annual 2006*. Updated August 2009. US Department of Energy, http://www.eia.doe.gov/emeu/international/energyconsumption.html (accessed October 14, 2009).

Figure 2: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2008 Revision, http://esa.un.org/unpp (accessed April 10, 2010).

Figure 3: EIA, *International Energy Annual*, 2006

Figure 4: US Energy Information Administration. *U.S. Short-Term Energy Outlook***.** December 9, 2008. US Department of Energy, http://www.eia.doe.gov/emeu/ (accessed April 10, 2010).

Figure 5: US Energy Information Administration. “Topics for Petroleum Prices.” US Department of Energy, http://tonto.eia.doe.gov/dnav/pet/pet_pri_top.asp (Accessed October 14, 2009).

Figure 6: US Energy Information Administration. “Electricity: US Data.” US Department of Energy, http://www.eia.doe.gov/fuelelectric.html, (accessed April 10, 2010).

Figure 7: Source: EIA, International Energy Annual, 2006

Figure 8: EIA, “Electricity: US Data,” 2010

Figure 9: MJ Menne, CN Williams Jr., RS Vose. NOAA National Climatic Data Center Asheville, http://cdiac.ornl.gov/epubs/ndp/ushcn/ushcn_map_interface.htm, (accessed October 12, 2009).

Figure 10: Lecture by Greg Keoleian, September 11, 2007.

Figures 11-20: Data From Holy Cross Abbey

Figure 21: New Buildings Institute. “Advanced Lighting Guidelines.” New Buildings Institute, http://www.newbuildings.org/advanced-lighting-guidelines (accessed March 5, 2010).

Figure 22: Office of Energy Efficiency & Renewable Energy. “Energy Savers: Five Elements of Passive Solar Home Design.” U.S. Department of Energy, http://www.energysavers.gov/your_home/designing_remodeling/index.cfm/mytopic=10270 (accessed March 5, 2010).

Sources for Tables:

Table 1: MJ Menne, CN Williams Jr., RS Vose. NOAA National Climatic Data Center Asheville, http://cdiac.ornl.gov/epubs/ndp/ushcn/ushcn_map_interface.htm, (accessed October 12, 2009).

Table 2: Data from Holy Cross Abbey

Table 3: Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Table 4: Technology Transfer Network Clearinghouse For Inventories & Emissions. Table 1.3-1. “AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors. Volume: 1 Stationary Point and Area Sources.” U.S. Environmental Protection Agency, http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s03.pdf (accessed February 14, 2010).

Technology Transfer Network Clearinghouse For Inventories & Emissions. Table 1.5-1“AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors. Volume: 1 Stationary Point and Area Sources.” U.S. Environmental Protection Agency, http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s05.pdf (accessed February 14, 2010).

Technology Transfer Network Clearinghouse For Inventories & Emissions. Appendix H. "AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors. Volume: 1 Stationary Point and Area Sources." U.S. Environmental Protection Agency, http://www.epa.gov/oms/models/ap42/ap42-h1.pdf (accessed February 14, 2010).

Technology Transfer Network Clearinghouse For Inventories & Emissions. Table 2.1A.1. "AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors. Volume: 1 Stationary Point and Area Sources." U.S. Environmental Protection Agency, http://www.epa.gov/oms/models/ap42/ap42-h2.pdf (accessed February 14, 2010).

Table 5: Conversation with a representative at PJM Interconnector, October 25, 2009.

Table 6: U.S. Environmental Protection Agency. "Household Emissions Calculator Assumptions and References." U.S. Environmental Protection Agency, http://www.epa.gov/climatechange/emissions/ind_assumptions.html (accessed January 7, 2010).

U.S. Environmental Protection Agency. "Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle." U.S. Environmental Protection Agency, http://www.epa.gov/otaq/climate/420f05004.htm (accessed January 7, 2010).

Table 7: Data from Holy Cross Abbey

Table 8: Kibert, C. *Sustainable Construction: Green Building Design and Delivery*, 2nd edition (Hoboken, NJ: John Wiley & Sons), 2008.

Tables 9-16: Michigan Team Calculations

Table 17: Office of Energy Efficiency & Renewable Energy. "Energy Savers: Fluorescent Lighting." U.S. Department of Energy, http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=12040 (accessed March 5, 2010).

Tables 18-32: Michigan Team Calculations

Tables 33-34: National Renewable Energy Laboratory. "Wind Integrating Datasets." US Department of Energy, http://www.nrel.gov/wind/integrationdatasets/eastern/disclaimer.html?timeseries (accessed April 10, 2010).

Tables 35-38: Michigan Team Calculations

Table 39: Office of Energy Efficiency & Renewable Energy. "Rebates, Tax Credits & Financing." US Department of Energy, http://www.energysavers.gov/financial/70010.html?print (accessed February 28, 2010).

Table 40: Division of Energy. "American Recovery and Reinvestment Act." Virginia Department of Mines Minerals and Energy, http://www.mme.state.va.us/DE/ARRA-Public/ARRA.shtml (accessed January 10, 2010).

Sources for Boxes:

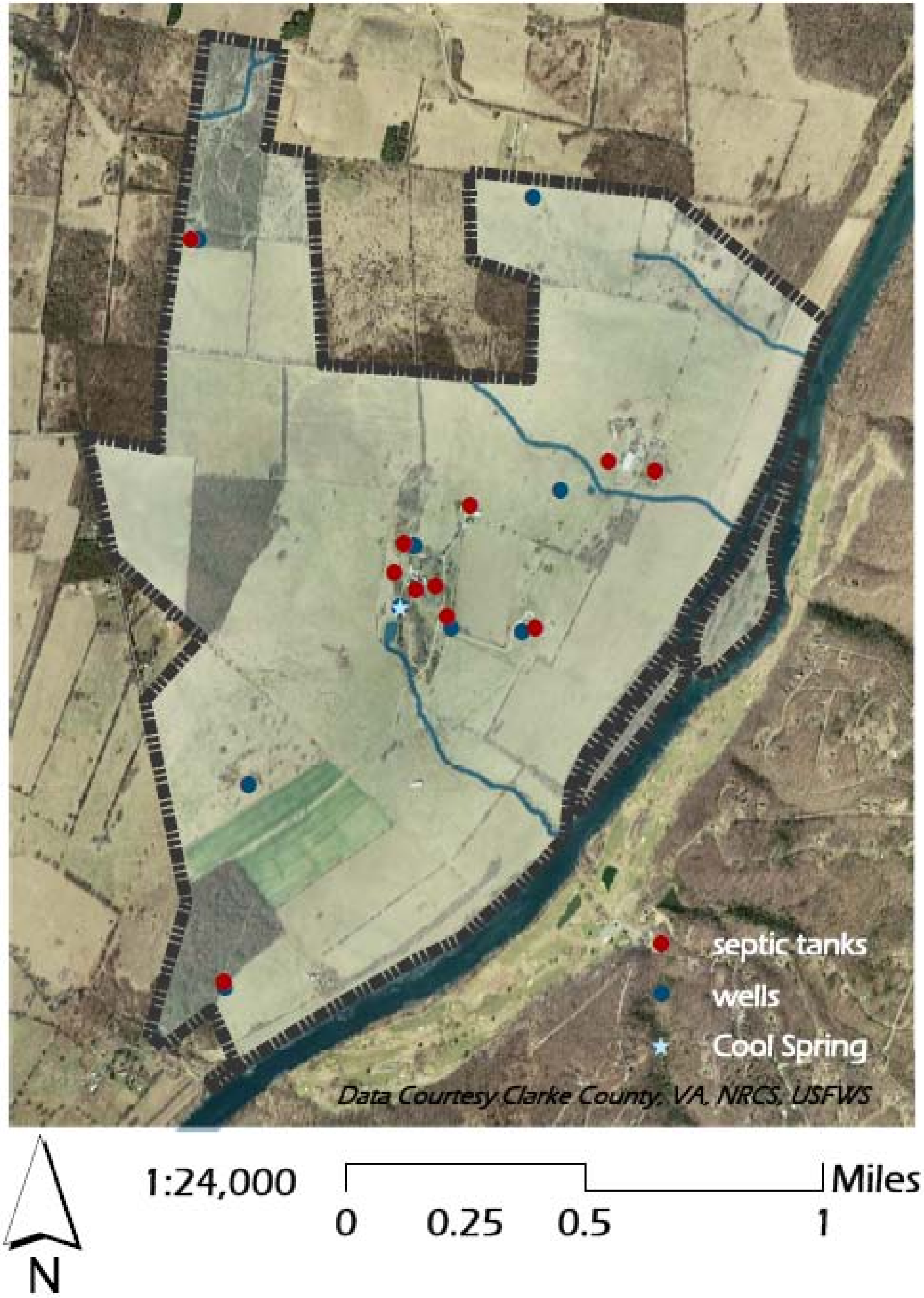
Box 1: Source: Minoru Takada, Ellen Morris and Sudhir Chella Rajan. "Sustainable Energy Strategies: Materials for Decision-Makers." UNDP/BDP Energy and Environment Group. February 1, 2005, http://www.energyandenvironment.undp.org/undp/index.cfm?module=Library&page=Document&DocumentID=5038 (accessed November 3, 2009).

Box 2: Boiler Right. "Oil Burner Diagram." Boiler Right, www.boilerright.com/residential.htm (accessed April 10, 2010).

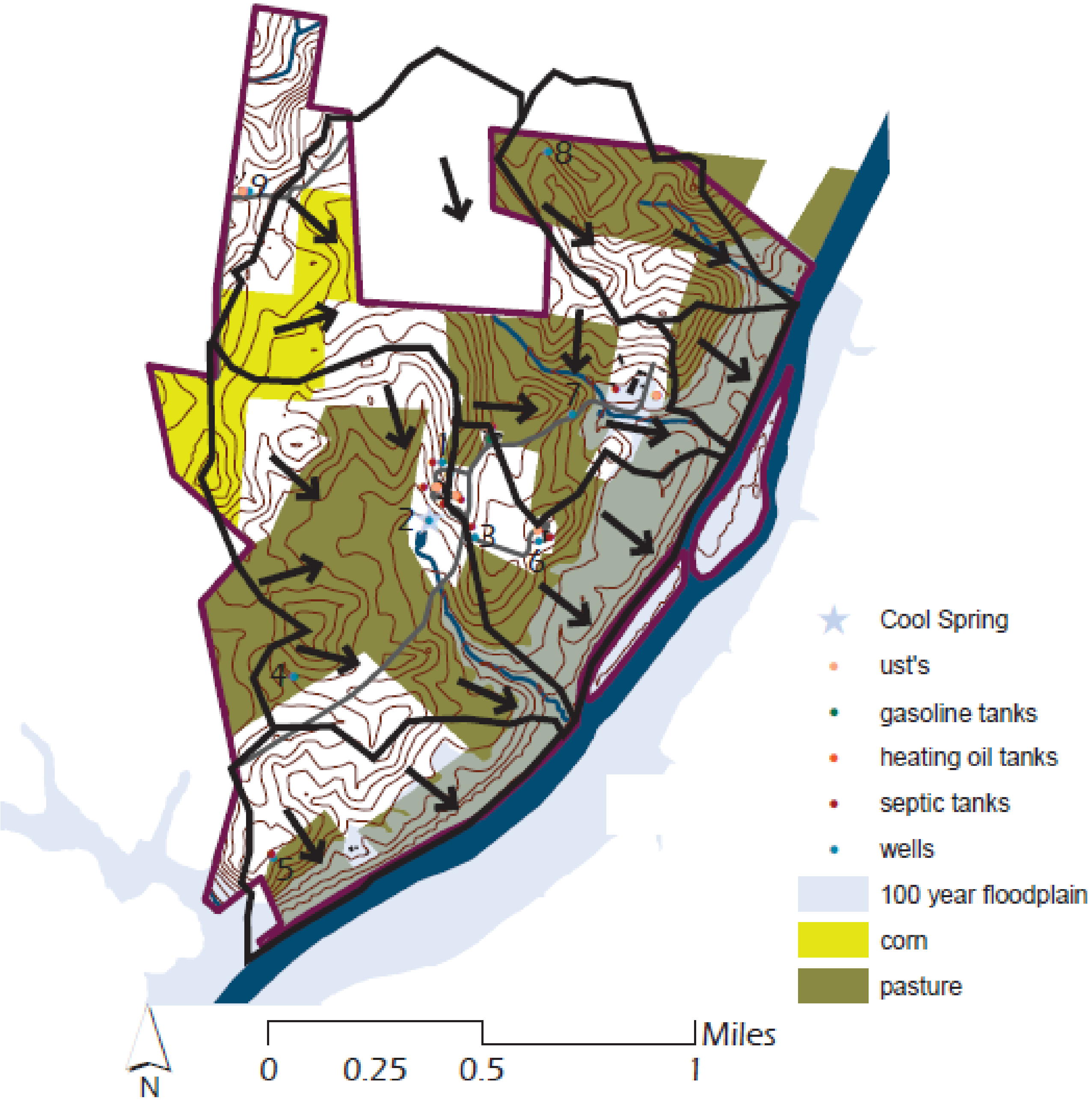
Box 3: DuctPro. "Air Conditioning: Coil Cleaning." DuctPro, www.ductpro.com/coil.php (accessed April 10, 2010).

Box 4: HomeTips, LLC. "How a Storage Water Heater Works." HomeTips, LLC, http://www.hometips.com/how-it-works/hot-water-heaters.html (accessed April 10, 2010).

APPENDIX 3-A: MAP OF HCA WELLS AND SEPTIC SYSTEMS



APPENDIX 3-B: POTENTIAL SOURCES OF WELL WATER CONTAMINATION



APPENDIX 3-C: CONTACTS AND RESOURCES LISTED BY SPECIALTY

Specialty	Organization	Contact Information
Commercial clothes washers	Wascomat Laundry Equipment	800-645-2205
Commercial dishwashers	Food Service Warehouse	Matt Spears; 303-218-9597; mspears@foodservicewarehouse.com; www.foodservicewarehouse.com
Composting toilets	Clivus Multrum, Inc.	Brian Barry; 800-425-4887; forinfo@clivusmultrum.com; www.clivusmultrum.com
Drip irrigation systems	Irrigation Association	703-536-7080; www.irrigation.org
Flow metering	American Water Works Association	800-926-7337; www.awwa.org
Flow metering	National Environmental Services Center	800-624-8301; 800-624-8301
Graywater irrigation systems	NutriCycle Systems	John Hanson; 301-371-9172; jhanson@nutricyclesystems.com; www.nutricyclesystems.com
Graywater recycling systems	AQUS Systems	502-741-1859; www.watersavertech.com
Plumbing fixtures and appliances	EPA WaterSense	www.epa.gov/watersense/index.html
Residential appliances	Sears (Winchester, VA)	540-545-7100; www.sears.com
Septic systems	Powell’s Plumbing (Clarke County, VA)	540-955-3988; www.powells-plumbing.com
Waterless urinals	Alterna Corporation	800-605-4218 x815; www.caromausa.com

APPENDIX 4-A: SUSTAINABLE MANAGEMENT OF SPECIAL MSW: E-WASTE & PHARMACEUTICAL WASTE

E-waste is a type of MSW; thus, any program that handles it can also be managed and evaluated according to the principles and prioritized activities of ISWM. First and foremost, e-waste should be prevented to the extent possible, which can entail actions such as buying equipment that can be easily upgraded or fixing current devices to avoid having to purchase new items. The next prioritized action is to donate the device for reuse or repair. In situations where local venues are not available for donating working or repairable items, electronic devices should be recycled; most municipalities have e-waste recycling collection programs and several manufacturers now willingly or have been legally mandated to accept electronic items for recycling. Given the high salvage capacity of e-waste, landfill disposal is only suggested for the specific components of an electronic device that cannot be recycled (this should only be determined and conducted by a certified demanufacturer or e-recycler given the hazardous materials that are typically contained within electronic items).[1]

Pharmaceutical waste also falls under the category of MSW, but proper management does not specifically follow ISWM principles. The first ISWM activity, prevention, does not apply nor would it ever be encouraged. However, unused medications can be recycled in many communities. In various US states, free community-based medical clinics can accept unused unexpired medications and redistribute them, whereas commercial pharmacies cannot.[2] There are also many community drug take-back programs that accept pharmaceutical waste and dispose of it responsibly—usually via incineration.[3] If there are no drug take-back programs available in a particular area, the FDA specifically encourages people to do the following:

1) Remove medications from their original containers
2) Mix the drugs with an undesirable substance such as coffee grounds or cat litter so that they are less attractive to children and pets
3) Put the mixture into a sealable bag or a container that can be sealed with a lid
4) Place the container in a garbage can or sack with normal trash for typical MSW pickup and disposal (landfill or incineration)

According to the FDA, medications should never be disposed of by flushing them down the toilet or other type of drain (unless the medication's label specifically says to do so) or haphazardly thrown in with other trash. Practicing safe disposal methods will prevent the buildup of trace levels of drug residues in lakes, rivers, and groundwater.[4]

---

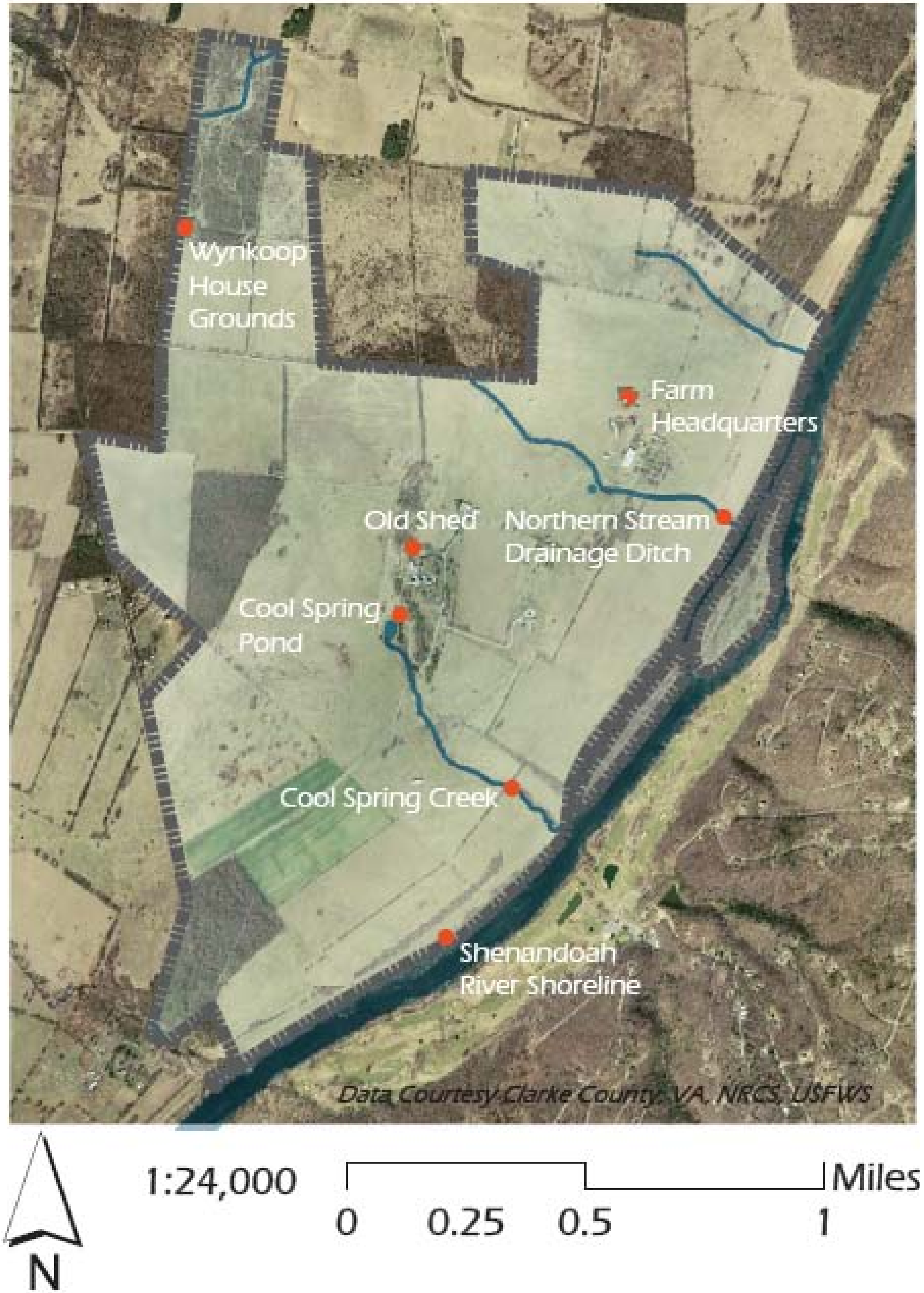
[1] United States Environmental Protection Agency. *Electronics: A New Opportunity for Waste Prevention, Reuse, and Recycling.* Washington D.C.: U.S. Environmental Protection Agency, 2001.

[2] National Conference of State Legislators, "State Prescription Drug Return, Reuse and Recycling Laws," http://www.ncsl.org/default.aspx?tabid=14425. Retrieved March 2, 2010.

[3] U.S. Environmental Protection Agency. *Pharmaceuticals,* 2010

[4] United States Federal Drug Administration, "FDA Consumer Health Information: Medication Disposal," http://www.fda.gov/downloads/Drugs/ResourcesForYou/Consumers/BuyingUsingMedicineSafely/UnderstandingOver-the-CounterMedicines/ucm107163.pdf. Retrieved January 3, 2010.

APPENDIX 4-B: MAP AND INVENTORY OF HCA'S DUMP SITES



Data Courtesy Clarke County, VA, NRCS, USFWS

Cool Spring Creek Channel

Inventory of waste items (in or near the banks of the creek)

- broken metal gate
- broken metal water/feed trough
- multiple used car/tractor tires
- nonfunctional wood/metal cart
- several sections of old wire fencing

Cool Spring Pond

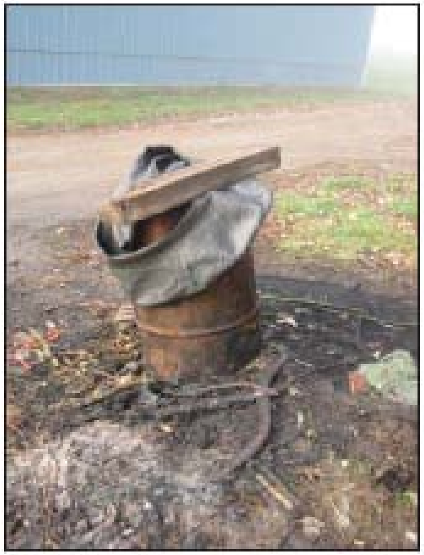
Inventory of waste items (in or near the creek)

- creosote-treated railroad ties
- metal drums
- multiple cinder blocks
- old garbage can
- old mattress box spring
- plastic buckets filled with stones
- several wood pallets

Farm Headquarters

Inventory of waste items

- metal drums (one used for burning trash)
- several inoperable vehicles and trailers
- used vehicle/tractor tires
- used and broken wood pallets



Northern Stream Drainage Ditch

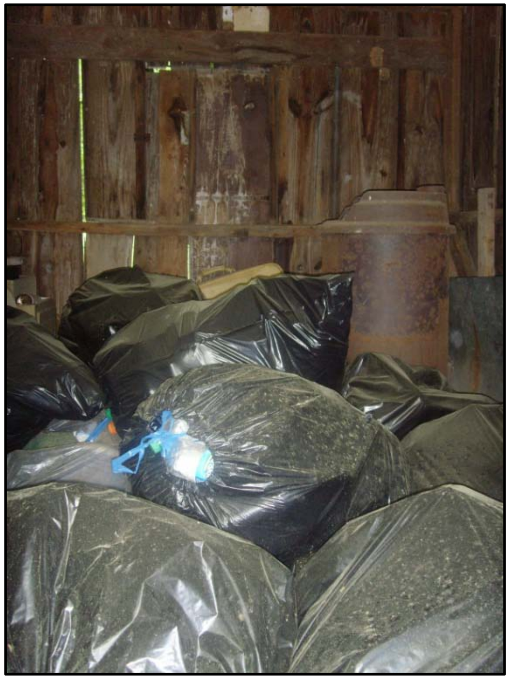
Inventory of waste items

- broken wood furniture
- large chunks of concrete and cinder blocks
- metal drums and buckets
- old wire fencing
- porcelain toilets
- pieces of particle board
- unidentifiable metal framing
- wood pallets/planks

Old Shed Near Monastic Enclosure's North Parking Lot

Inventory of waste items

- broken buckets
- inoperable wheelbarrow
- multiple bags of unspecified trash
- old wire fencing
- two metal drums
- unknown metal, large-scale piece of equipment
- used tires
- various pieces of rubber and plastic piping



Shenandoah River Shoreline (southern part of property, near Waterloo House)

Inventory of waste items

- inoperable lawnmower
- metal drums
- old bed frame
- plastic chairs
- wood scraps
- wood hunting blind (unknown if still in use and/or HCA is aware of it)

Wynkoop House (grounds)

Inventory of waste items

- broken light fixtures
- broken plastic coolers
- inoperable riding and push lawnmowers
- inoperable vehicles
- miscellaneous/unidentifiable items
- multiple old buckets
- old trailer/topper
- wire fencing
- wood scraps

Appendix 4-C: Recommended Recycling Option vs. Alternative Recycling Option

AWS can offer HCA expanded recycling services upon request, albeit these services are limited in scope compared to those offered by Waste Management. Specifically, AWS can provide HCA with a special dumpster (roll out A-frame) that contains three compartments for recyclables; thus, HCA could only recover three additional types of recyclable material. Based on the Team's analysis, HCA would need to target mixed paper, aluminum, and PETE (grade 1) plastic given the volume and environmental benefit associated with these recyclable items if the community were to use AWS's recycling services. The collection of these three types of materials would be in addition to the cardboard that HCA already recovers. Ultimately, the reason AWS can only provide collection services for a limited number of materials is because it routes all recyclables to Southern Scrap recycling company, which only accepts presorted items; it does not offer single-stream (comingled) recycling. Thus, with this alternative option, HCA would have to separate paper, aluminum, and PET plastic (as well as cardboard). In Table 7 below, the Team has compared the recommended course of action with an alternative option (AWS expanded recycling service and trash service). This alternative option includes the reduced annual fees reported by AWS.

Table 7: Recommended option vs. alternative option

Service Info	Recommended Option (WM recycling/AWS trash)	Alternative Option (AWS expanded recycling & trash services)
Schedule	• WM weekly all recyclables pickup • AWS monthly trash pickup	• AWS monthly cardboard pickup • AWS on-call select recyclables pickup (3 types) • AWS bi-weekly trash pickup
Annual Fee Breakdown	• Monthly trash pickup = $780 • Weekly recyclables pickup = $1,140 • Total Fuel charges = $310	• Bi-weekly trash pickup = $1,560 • Monthly cardboard pickup = $570 • On-call select recyclables pickup = $600 ($150 per pull; approximately four pulls per year) • Monthly rental fee, special dumpster = $1,500 • Total fuel charges = $465
Additional Upfront Expenses	• One-time delivery charge for recycling dumpster = $75 • Additional recycling bins & signage (Retreat House & gift shop) = $700	• Additional recycling bins, recycling multi-compartment stations, and signage (primarily for Retreat House & gift shop) = $1,750
Total Annual Cost	**$2,230** *(plus $775 for approx. upfront costs)*	**$4,695** *(plus $1,750 for approx. upfront costs)*
Recyclables Recovered Per Year	**9,375 lbs.** (all recyclables recovered)	**7,475 lbs.** (1,900 lbs. of recyclables still landfilled)
Total Lbs. of CO_2eq Avoided/Year	**25,209 lbs. of CO_2eq avoided**	**22,643 lbs. of CO_2eq avoided**

Appendix 4-D: Contact Information for Waste Management Options

Recycling Option Contact Info

Charlene Stevens, Sales Representative
Waste Management Inc.
1505 Moran Road
Sterling, Virginia 20166
Telephone: 401.309.7097
E-mail: csteven4@wm.com

John Morris, Account Representative
Allied Waste Services
403 Lenoir Drive
Winchester, Virginia 22603
Telephone: 540.667.7474
E-mail: jmorris2@republicservices.com

Composting Option Contact Info

Jake Grove, Unit Coordinator/Extension Agent
Virginia Cooperative Extension – Clarke County Office
101 Chalmers Court, Suite B
Berryville, VA 22611
Telephone: 540.955.5164
E-mail: jagrove@vt.edu

Mark Pennington, Assistant Scout Executive
Shenandoah Area Boy Scouts Council
107 Youth Development Court
Winchester, VA 22602
Telephone: 540.662.2551
E-mail: mark.pennington@scouting.org

E-Waste Option Contact Information

Goodwill Industries
443 Millwood Avenue
Winchester, VA 22601
Telephone: 540.723.6864
Web site: www.horizongoodwill.org

Frederick County Landfill Citizen's Convenience Center
281 Landfill Road
Winchester, VA 22602
Telephone: 540.665.5658
Web site (Frederick County Recycling Programs):
http://www.co.frederick.va.us/public_works/recycling_landfill/recycling_programs.aspx

Pharmaceutical Waste Option Contact Information

Free Medical Clinic of Northern Shenandoah River Valley

301 North Cameron Street, Suite 100
Winchester, VA 22601
Telephone: 540.536.1680

Leesburg Pharmacy
36 Catocin Circle SE
Leesburg, VA 20175
Telephone: 703.777.5333

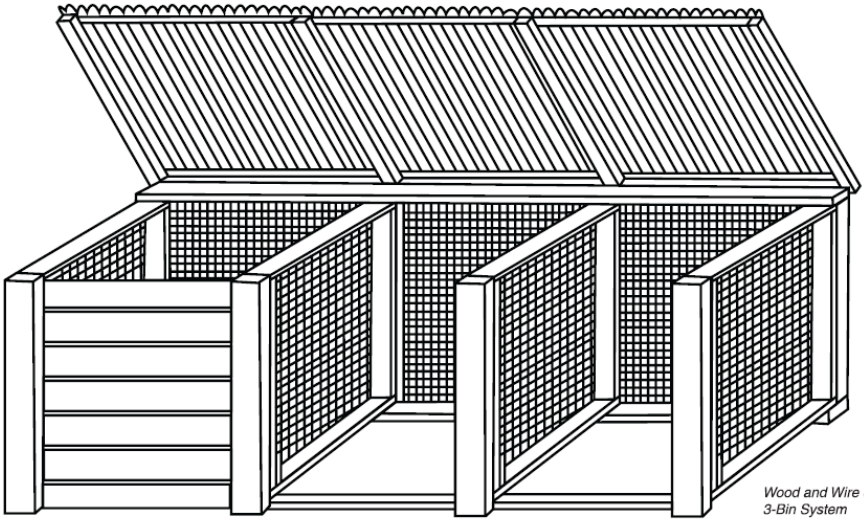
Dump Site Clean-Up Option Contact Information

Clay Ellis, Company Representative
Winchester Scrap Company (formerly known as Frederick Motors)
1302 Martinsburg Pike
Winchester, VA 22603
Telephone: 540.667.8440
*for metal scrap

Mike Clark, Owner
Clark’s Custom Iron
Telephone: 540.514.7243
*for nonmetal waste

Appendix 4-E: Constructing a Multi-Bin Composter

The multi-bin design below incorporates purchasing new materials. However, for an alternative (cheaper) design that reuses wood pallets, please go to the following Web site: http://goodcheergarden.wordpress.com/classes-2/3-bin-compost-system-using-pallets/.



Wood and Wire Stationary 3-Bin System

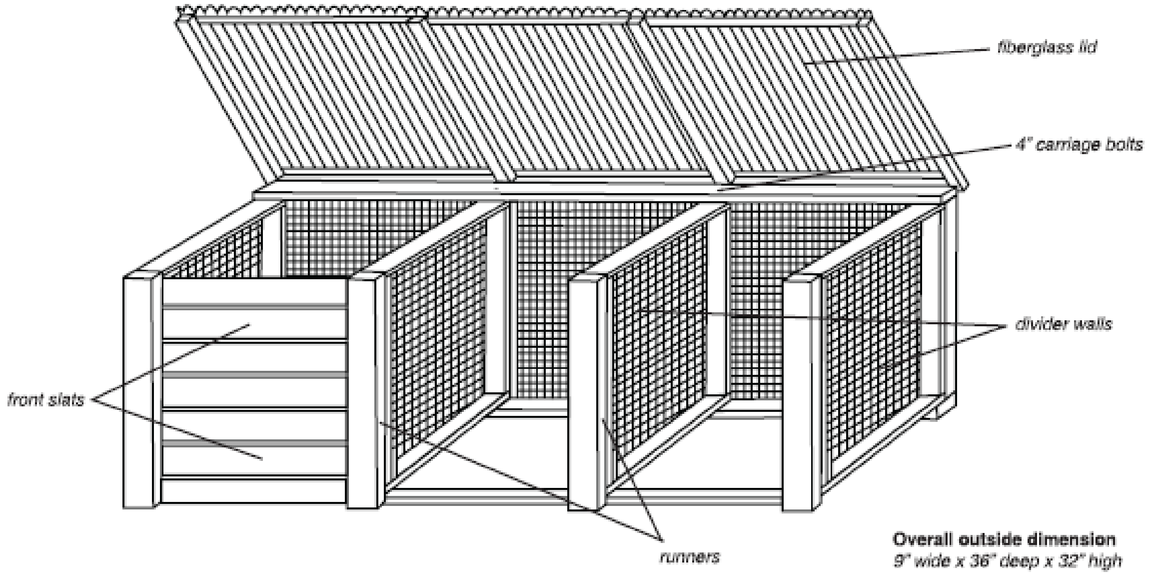
This bin system is designed as a turning unit to compost large amounts of yardwastes in the shortest period of time. It also works well for storage until enough material is collected for an entire bin. Gardeners benefit the most from this system because fresh compost is generated so rapidly.

Materials

2	18-foot cedar 2”x4”s
4	12-foot (or 8, 6 foot) cedar 2”x4”s
1	9-foot 2”x2”
2	6-foot 2”x2”s
1	16-foot cedar 2”x6”
9	6-foot cedar 1”x6”s
22	feet of 36” wide ½” hardware cloth
12	½” carriage bolts 4” long
12	washers and 12 nuts for bolts
3	lbs. of 16d galvanized nails
½	lb. of 8d galvanized casement nails
250	poultry wire staples or power stapler
1	12-foot sheet 4 oz. clear corrugated fiberglass
1	8-foot sheet 4 oz. clear corrugated fiberglass
3	8-foot lengths of wiggle moulding
40	gasketed aluminum nails for corrugated fiberglass roofing
2	3” zinc plated hinges for lid
8	flat 4 corner braces with screws
4	flat 3” T-braces with screws

Tools

Hand saw or circular power saw
Drill with ½” and 1/8” bits
Screwdriver
Hammer or power stapler with 1” long galvanized staples
Tin snips
Tape measure
Pencil
¾ socket or open-ended wrench
Carpenter’s square
Safety glasses
Ear protection

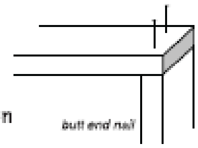


Overall outside dimension
9' wide x 36" deep x 32" high
Each bin section
35 1/8" x 36" deep x 32" high

Construction

• Build dividers

Cut two 32" and two 36" pieces from each 12-foot 2"x4". Butt end nail the four pieces into a 35" x 36" rectangle. Repeat for the other three sections. Check to make sure each divider section is square. Repeat for other three sections. Cut four 38" long sections of hardware cloth and bend back edges 1" for strength. Staple hardware cloth onto the frame tightly into place, every 4" around edge.



• Set up the dividers

Arrange dividers parallel to one another 3 feet apart. Cut four 9-foot pieces out of the two 18-foot 2"x4" boards. Place two 9-foot base boards on top of dividers. Measure, mark and center lines for the positions of the two inside dividers. Place the two outside dividers flush against the outer edge of the 9-foot 2"x4". Drill a ½" hole down the center of each junction centered 1" from the outside edge. Secure base boards with the carriage bolts, but do not tighten yet. Turn the unit right side up and repeat the process for the top 9-foot 2"x4".

Make sure the bin is square, then tighten all bolts securely. Fasten a 9'2" piece of hardware cloth securely to the back side of the bin (again, bend back 1" for strength) and staple every 4" around the frame.

• Slat guides and runners

Cut the one 16-foot cedar 2"x6" into four 36" long pieces for front slate guides. Cut lengthwise two of these boards to 4¾" wide.

Nail them flush against the edges of the two front outside dividers and baseboard. (Save the two remaining 1¼ of the rip cut boards for use as back guides.) Center the remaining 36" 2"x6" cedar boards on the front of the two inside dividers, flush with the top edge, and nail them securely.

To create back guides, cut the remaining 2"x6" into a 34" piece and then rip cut into four equal pieces, 1¼"x2". Nail the six back guides parallel to front slat guides on each side of divider, leaving a 1" gap for the slat runner. Cut the runners in between the front and back guides.

• Build the lid

Use the last 9-foot 2"x4" for the frame of the back lid. Cut four 32½" lengths of 2"x2"s and one 9-foot 2"x2". Arrange into position on ground and check for squareness. Screw in corner braces and T-braces on the bottom side of the frame. Center lid frame, brace side down on bin structure and attach with hinges. Cut wiggle board with 1/8" fiberglass to fit flush with front and back edges. Overlay pieces at least one channel wide. Pre-drill fiberglass and wiggle board for each hole. Nail on top of every third hump with gasketed nails.

Source: Pierce County, Washington – Public Works & Environmental Services (www.piercecountywa.org/composting)

APPENDIX 5-A: LIST OF POTENTIALLY HAZARDOUS SUBSTANCES AT HCA

409

Aerosols

Ajax

Aluminu-nu septic system cleaner

Amazon's mildew-away

Arm & Hammer laundry detergent

Austin's Ammonia

Auto stuff

Bar Keepers Friend lime & rust remover

Bleach

Brasso

Brite floor wax

Bruce Clean & Wax for wood floors

Capture Spot & Spill Remover

Carbora shampoo for rugs & upholstery

Cardboard, plastics, motor oil, and other wastes to dump

Chimfex chimney fire suppressant

Chlorox Wipes

Clean Shower shower cleaner

Cleanstrip

CLR calcium lime & rust remover

Dow glass & surface cleaner (Glass Plus)

Dust-Off

Easy Off Bam Bleach

Easy Off mildew stain remover

Ecolab detergent

Endust cleaning spray

Endust dusting spray

Endust no-wax cleaning & dusting spray

Febreze air freshener

Feronclean Vinyl Cleaner

Florhide floor enamel

Fuller drain line & septic tank cleaner

Gas/diesel

Glass cleaner

Glass Plus glass & surface cleaner

Glass Plus glass cleaner

Glues/adhesives

Greased Lightening multi-purpose cleaner

Green Works Natural Cleaner

Gunk silicone spray lubricant

Home 360 dish detergent

Home Trends bowl bubbles toilet cleaner

Hot Shot Flying Insect Plus

Hot Shot Wasp & Hornet Killer

Hydrogen peroxide

Johnson Wax complete furniture cleaner

Kirkland laundry detergent super concentrate

KRC7 cleaner/restorer

Limeaway

Lime-a-way

Lysol

Lysol & Bleach all purpose cleaner

Lysol basin & tile cleaner

Lysol basin tub & tile

Lysol hard water stain cleaner

Lysol spray

Medications/syringes

Mop & Glo Floor Cleaner

Mr. Clean multi-purpose cleaner

Mr. Clean

Mr. Clean fresh scent multipurpose cleaner

Murphy's Oil Soap

Niagra spray starch

Old English Polish

Orange Glo hardwood clener

Oven lubricants

Paint thinners

Paints

PlumbClean drain cleaner

Polishes

Power Plumber instant drain opener

Real-Kill Wasp & Hornet Killer

Rennza after the rain air freshener

Resolve carpet cleaner

Scoop Away cat litter

Scotch Guard cleaner

ServiStar drain & sewer opener

Shout

Smart Option laundry detergent

Soft scrub

Soft scrub bleach

Solvents

Spic & Span anti-bacterial spray cleaner

Spic & span multipurpose cleaner

Spic & Span soap mix

Spic and Span

Spray ‘n Wash

Spot Shot stain remover

Tilex mold & mildew

Tilex mold & mildew remover

Tilex mold and mildew remover

Tradco Windshield lock de-icer

Ultra Spic & Span cleaning powder

Vanisol high acid bowl cleaner

Vani-Sol High Acid Bowl Cleaner

Vani-Sol washroom cleaner

WD40

Windex

Wood finishes

APPENDIX 5-B: HINSON & JUNG, LLC REPORT

21351 Village Green Circle
Germantown, MD 20876
301 351-1113 (direct)
301 542-0100 (fax)

HINSON & JUNG, LLC

Home Inspections and

February 4, 2010

Holy Cross Abbey
Investigation #7391
901 Cool Spring Lane
Berryville, VA 22611

Inspector Peter N. Jung
Certified Mold Inspector
#0620 CMI, CMA, CAI

Atten: Father James

As a result of the Investigation #7391 I did on January 27th at the above mentioned properly, I found the following areas of concern:

Along with this written report, I have attached numbered photos to clarify the areas discussed. Photos 1-10 are with reference to the Mansion. In the basement there is asbestos floor tile. Many of the tiles are loose or broken and should be removed. In any of the buildings where there are 9”x9” floor tiles , it is likely to be asbestos tile. There is also asbestos pipe covering on the steel piping used for heating. That was also found in several other buildings. Additionally, be aware that some of the older ceiling tiles may contain asbestos. The danger with asbestos is when it is deteriorating and can cause friable air borne particles to become permanently embedded in the lungs. There are professional companies that remove asbestos products and it is an expensive procedure. With pipe covering, many times they will encapsulate rather than removing the covering.

Also in the basement there was a mold like substance found on several of the garments. I recommend that they all be removed and discarded. Please recognize that all references to mold will be described in this report as ‘a mold like substance’. Unless a sample of the visible mold is sent to a Certified Mold Lab we are not allowed to call it ‘mold’. (Not all of the photos use the term ‘mold like substance’ because of the limited space for verbiage. In every instance, where the word mold is used it means ‘mold like substance’.)

There cannot be mold without having moisture intrusion. In this building, the front wall is deteriorating (see photo 5). I do recommend improving the grading outside this building- and several other buildings. It most cases, the ground is flat and that is not helpful (see photo’s 6 and 11). There should be enough slope so that water will not pool against the foundation wall. The IRS building code says there should be one inch per foot.

There is peeling paint in multiple locations. Any paint that is older than 1978 is considered to be lead based paint. Creating lead dust is particularly harmful and should be avoided. Paint is peeling on the exterior as well as the interior (see photo 7, 20, 21, and 22). When scraping paint the proper personal protection should be worn.

The second floor of the Mansion has moisture intrusion on the ceiling and walls particularly in the closet front right side (see photos 8-10). The roof leaks should be repaired and the wet dry wall removed and replaced.

Photos 12 and 13 are of the office area above the library adjacent to the Mansion. Mold like substance found on surfaces other than wood can be cleaned with soap and water.

The Crypt Chapel, as well as the Father James office next to it, has many moisture intrusion issues. Photos 14-16 show some of the worst areas in the Chapel. Roof leaks need to be fixed and the ceiling areas with mold like substance should be removed.

The St. Joseph's Scriptorium Library has areas on the walls and the baseboard that need attention (see photos 17-19). Many of these temporary buildings have not been well constructed. Areas around windows reflect leaking and all of these ways that moisture can make its way into the structure need to be eliminated or the mold like substance will reoccur.

The Dining room- recommend that the baseboard be cleaned (see photo 23). The right rear corner (see photo 25) has mold like substance on the cinder block wall. The grading outside this room should also be improved.

A few of the residence rooms were investigated. Any of them that have a mold like substance such as that seen in photo 26, should be remediated.

The laundry/boiler room area (see photos 27-29) has significant amounts of mold like substance on the cinder block walls.

The portion of the building that contains Carol's office has structural issues. Photos 30-32 show the crack that indicates a portion of the building is separating from the larger older building. I recommend a company such as JES Construction Inc. ph 877 537-9675 . They have structural engineers and can make an evaluation and give you a free estimate.

In the Chapel there is a mold like substance on the baseboard. The filters on the ceiling may need to be cleaned. See photos 33-36.

The laundry (see photos 37-38) reflects mold like substance on the cinder block walls.

The drop ceiling in the bakery office needs to be removed and replaced. Check the area above it for the cause of the staining (see photos 39-40).

The final group of photos 41-45 were taken in the older mostly abandoned quarters for the monks. Some of the rooms are now used for gym equipment. Multiple areas of moisture intrusion has led to mold like substance.

This inspector did not take any swab samples or air samples of mold like substance from any of the areas inspected. The additional cost of having the sampling done would simply substantiate that a considerable amount of excessive mold spores exist in many areas. Remediation is recommended and some of the steps that can be done to help with this process have been listed in the above report. Please remember that until the causes for the excessive moisture intrusion are eliminated, the mold will return and continue to grow. It is not healthy for the building materials- mold lives off of any cellulose based materials. It is also not healthy for people; effects can vary considerably for individuals. Most medical studies are anecdotal.

A Radon detection device was placed in the library adjacent to the Mansion. The Radon Test Report #7391R is attached as a word doc. The average Radon concentration in that area was 2.6 pCi/L. That is well below the EPA recommended action level of 4.0 pCi/L. At some future date you may wish to have additional areas of the Abby tested.

If you have any further questions or concerns about this report, please contact me at your convenience.

APPENDIX 6-A: FRUITCAKE BAKE PROCESS SUMMARY

Time	**Activity**
Prep Work	
1-2 weeks before	[*The following description was provided by Kathy, with modifications from* the bakery manager.] Three weeks before a bake, the bakery manager and/or the bakery assistant weigh and place 30 lbs of raisins into 5-gallon buckets. A full bake requires four 5-gallon buckets of raisins. Two monks and/or volunteers sort the raisins to remove stems and foreign objects. This takes 1 hour per bucket. After they are sorted, the bakery manager adds water and sherry to the raisins and the buckets are covered and set aside to soak for 7–10 days. NOTE: The 5-gallon buckets are recycled honey containers.
	The bakery manager places chopped walnuts into 5-gallon buckets (1 bucket = 23 pounds) and weighs and places 14 pounds of chopped pecans into separate 5-gallon buckets. A full bake requires 2 buckets of walnuts and 1 bucket of chopped pecans. Two monks and/or volunteers sort the nuts to remove shells and foreign objects. This process takes 45–50 minutes per bucket.
	Two weeks before each bake, the bakery manager layers 780 pounds of fruit [2 x 13 x 30 lbs] with the nuts and raisins in a rectangular trough and mixes them together. After the fruit and nuts are mixed, the bakery manager adds pineapple juice, covers the mixture tightly, and sets it aside to soak for 7–10 days.
	When mixing bowls are freed up after a bake, the fruit/nut mixture is weighed into large mixing bowls, covered, and set aside. A full bake requires two full troughs (nine large mixing bowls) of mixed fruit and nuts.
	The bakery manager weighs and/or measures flour, sugar, eggs, spices, and flavorings into plastic containers to make it easier to prepare the batter on the day of the bake. The flour is placed into a clean unused trash can, the sugar into a 5-gallon bucket, the eggs into a 5-gallon bucket, and the other ingredients into 1-gallon or 1-pint Rubbermaid containers.
The night before	The bakery manager measures the frozen butter and shortening into three mixing bowls and allows them to defrost overnight. One full bake = 3 bowls of batter and 9 bowls of mixed fruit and nuts.
	The bakery manager arranges 1-gallon containers of decorating fruits and nuts (green and red glace cherries and whole pecan halves) on tables along with hand utensils.
The Bake – Tuesday	
3:00 a.m.	The bakery manager turns on the mixers to cream the butter, shortening, and honey. HCA has two mixers, so only two bowls can be mixed at a time. Mixing bowls are placed on rollers/casters to make them easier to move around the work space. Each mixer has a mechanical lift. Thus, to lift a bowl onto a mixer, the bowl is rolled to the mixer, connected to the lift, and mechanically lifted to the mixing paddle. The bakery manager gradually adds ingredients to make the batter. The batter mixes for a total of 30–45 minutes, depending on the temperature, humidity, and other factors. The mix speed is slow for the first half of this time period and then is fast for the last half of the mixing time (after all of the ingredients have been added).
4:30 a.m.	By 4:30 a.m., two bowls of batter have been mixed (and removed from the mixer) and the bakery manager has begun to mix the remaining bowl of batter. Fr. Robert arrives to begin combining the finished batter with the mixing bowls of fruit/nut mix. The bowls of fruit are placed one by one onto the floor scale. Fr. Robert “zeroes out” the scale to ensure that the scale weighs only the batter. Then Fr. Robert uses the mechanical lift to pour 51–52 pounds of batter from one batter bowl (approximately 1/3 of the contents) into each bowl of fruit. If too much batter escapes the batter bowl, Fr. Robert uses a scoop to take it out of the bowl on the scale and returns the extra to the batter bowl. When three bowls of fruit/nut mixture have been filled with batter from one batter bowl, the bakery manager scrapes out the batter bowl to make sure all of the batter has been used. The mixture is then rolled off the floor scale over to the unused mixer, where the batter is mixed with the fruit/nut mix for approximately five minutes. To use the mechanical lift, Fr. Robert must move the lift away from the scale, move the mixing bowl to the lift, lift the mixing bowl with the mechanical lifting device, and move the lift back to the scale. The mixing bowls are tipped while on the lift using a chain/crank device. Although apparently not terribly strenuous, much of this activity occurs in a bent-over position.
5:10 a.m.	By 5:10 a.m., six bowls of fruit/nut mix have been mixed with two bowls of batter. The bakery manager removes the remaining batter from the mixer and moves it to the lift to fill the remaining three bowls of fruit. Fr. Robert brings the empty batter bowls to the washing area and sprays them with hot water from a hose. The rinse water is tipped into the floor drain. Fr. Robert also begins to wash mixing paddles, plastic containers, and other small utensils using hot soapy water from the sink. The bakery manager spends extra moments wiping down the equipment and the exposed parts of the mixing bowls with a damp cloth.

	NOTE: During the mixing process, the bakery manager uses a small amount of spray lubricant when he installs mixing paddles on the mixers. The lubricant is Haynes Light-Duty Sanitary Lubricating Spray.
6:00 a.m. to 6:15 a.m.	All batter and fruit/nut mix has been combined, covered, and set aside for the depositor. The bakery manager wipes down the mixers with a damp cloth and washes the remaining paddles, plastic containers, and other small utensils. Fr. Robert mops the floors with a solution of Spic & Span and water.
6:15 a.m. to 6:30 a.m.	The bakery manager takes a break for breakfast. Fr. Robert returns to the monastery for Mass and breakfast.
6:30 a.m.	The bakery assistant arrives and begins to insert accordion-pleated paper liners into baking pans. HCA uses two baking pan arrangements: (1) a single pan that is filled individually and then placed on trays for baking (each tray holding 12 pans) and (2) straps holding three pans that are filled together then placed on trays for baking. All pans have the same shape and size, and all pans require a paper liner. However, prior to filling the pans, the bakery assistant places half of a plastic Easter egg over the hole in the single pans to prevent excessive batter from being deposited in the hole. The three-pan straps do not need the plastic Easter eggs because someone at HCA fashioned a tool (using pop bottles and wooden door knobs, among other things) to prevent the batter from being deposited in the hole.
8:00 a.m.	Two volunteers arrive (both retreatants). The bakery assistant trains one volunteer to seal honey containers. The bakery manager asks the other volunteer (who appears experienced) to pour honey into the recently cleaned-out mixing bowls as prep for making creamed honeys a few days after the bake.
8:10 a.m.	Br. Efrain, Br. Christopher, and Fr. Robert arrive. The bakery assistant has opened the containers of decorating cherries and nuts. Br. Christopher squeezes water onto the tables to make it easier to slide the pans.
8:25 a.m.	The bakery manager tips the first bowl of batter into the depositor using the hydraulic lift. Fr. Robert weighs an empty pie tin on the table scale, zeroes-out the scale, and then deposits a volume of batter onto the tin. The purpose of this weighing is to calibrate the depositor, which deposits batter only by volume, so that it deposits HCA's desired batter weight into each pan.
8:30 a.m.	Two additional retreatants arrive. Fr. Robert begins to deposit batter into the prepared cake pans, using a foot pedal to deposit the correct amount. Br. Efrain smoothes out the batter using a rubber spatula, removes the plastic half Easter egg, and moves the pan to Br. Christopher. Br. Christopher uses a modified drill press to smooth the batter and then moves the pan to the decorators. Three volunteers decorate cakes with cherries and pecans. (Fr. Robert occasionally stops filling pans to let the others catch up.) As the cake decorators finish placing cherries and nuts on the top of the batter, the bakery manager moves the filled pans to rolling racks near the door to the bake room. The bakery manager moves around and facilitates the process (e.g., brings pans closer to Fr. Robert, tips more batter into the depositor, etc.). The bakery assistant starts washing up. Note: The drill "bit" on the leveler is fitted with a roller device that smoothes the batter as the drill turns. The rollers are covered with plastic baby bottle liners. HCA uses four baby bottle liners to cover the leveler rollers during a full bake. By 8:45 a.m., the bakery manager has emptied two of the nine bowls of batter into the depositor and one of the three baking racks is ready for the oven. Manpower summary: • 1 depositor (sitting) • 1 smoother (standing) • 1 leveler (sitting) • 3 cake decorators (standing) • 1 person to move filled pans to baking rack (standing/walking) • The bakery assistant and the bakery manager: Facilitation (standing/walking)
8:45 a.m.	The bakery manager preheats the oven. The oven is fully heated (300 degrees F) by 9:45 a.m.
8:55 a.m.	Three of the 9 batter bowls have been emptied into the depositor. All of the single pans have been filled. Fr. Robert switches to the three-pan straps, filling each of the three pans and then passing the strap of pans to Br. Efrain. For the rest of the process, Br. Efrain not only smoothes the batter manually, but also brings straps of pans from the prepared pan rack to Fr. Robert. The process slows down.
9:20 a.m.	Six of the nine bowls of batter have been placed in the depositor.
9:35 a.m.	The bakery manager takes over for Br. Christopher, who takes a five-minute break. When he returns, Br. Christopher resumes his work at the leveler and the bakery manager relieves Fr. Robert, who also takes a five-minute break.
9:50 a.m.	The bakery manager and one volunteer begin to load the trays of filled cake pans into the preheated oven. The process requires two persons, one on each side of the trays. They move the trays from the rack to the ledge,

	then push the trays into the oven as the conveyor comes around.
9:55 a.m.	One of the volunteers turns to sealing honey containers.
10:00 a.m.	All nine bowls of batter have been placed into the depositor.
10:15 a.m.	All pans have been filled and the filled pans have been loaded into the oven. Fr. Robert deposits the remaining batter into five loaf-shaped pans and begins to clean the equipment. The loaf cakes will be kept at the bakery for the staff and volunteers. Br. Christopher removes the rollers from the drill press and cleans the equipment. The volunteers and the bakery assistant place the remaining decorating fruit and nuts into their large containers, which the bakery assistant then places on rolling carts and moves to the cold room. Two of the volunteers wash down the tables. The bakery manager, the bakery assistant, Fr. Robert, Br. Efrain, and one of the volunteers wash the dishes and utensils. The other two volunteers move on to seal honey containers.
10:25 a.m.	Br. Christopher fills the reservoir of the pump sprayer with brandy. Br. Efrain and one of the volunteers place wax paper liners and accordion pleated collars in empty fruitcake tins. After the tins are lined, the tables of tins are moved into the main working area and the tins are covered with a sheet.
11:00 a.m.	Volunteers leave the bakery. The bakery manager and others finish cleaning up the bakery and then depart.
12:15 p.m.	The cakes are removed from the oven by gravity conveyor. The pans are manually pushed from the conveyor trays inside the oven onto the conveyor, which moves the trays of cakes toward the rolling racks. Two persons manually move the pans from the conveyor to the rolling racks. The racks are rolled into the work room, and the cakes are inverted onto trays set on the work tables. Two persons turn the cakes right side up, and then the trays once again are placed on the rolling racks, and the cakes are left to cool.
1:30 p.m.	The bakery manager uses the pump sprayer to spray each cake with brandy. After the brandy process is completed, the bakery manager fills the pump sprayer with a glaze consisting of honey, sugar, and water.
2:15 p.m.	Br. Christopher begins to spray the glaze onto the cooled cakes. Three other monks wash the pans in hot water, place them on racks, and move them next to the oven to dry. The bakery manager assists with the washing up and also cleans the equipment to prepare it for the next bake. The depositor, leveler, and other equipment is cleaned, moved to the side of the room, and covered with a cloth.
2:45 p.m.	As the last dishes are washed, the bakery manager and Br. Christopher move the cool glazed cakes from the work table to the rolling racks. The bakery manager uses a mop to spread a cleaner/bleach/water solution onto the work tables. The solution is left on the work surfaces for a few minutes, and then the bakery manager squeegees the solution onto the floor. Br. Christopher mops the floor with a bleach/water solution, scrapes up any sticky bits, and pushes the wash water to the floor drain. By the time the cleaning process has been completed, the work tables and floor have been mopped or wiped down at least three times.
3:15 p.m.	After the tables and floor are clean and dry, the bakery manager brings out the table scale and plastic wrap to set up the room for the next day. Only the bakery manager and Br. Christopher remain, and only for a few minutes more. [The bakery manager notes that the pans usually are not completely washed and put away until 4:00 p.m.]
Packaging – Wednesday	
7:45 a.m.	The bakery manager turns on the hot plates to warm them. Fr. James arrives and he and the bakery manager begin to wrap cakes in plastic wrap. The plastic wrap is a 50 gauge, 16” wide plastic film from Robbie Mfg. Inc. (#RM701 Custom). Each cake is wrapped in a square of plastic approximately 16” x 16”.
8:00 a.m.	Fr. Robert, Br. Efrain, and two volunteers arrive. Br. Efrain and Fr. Robert place the wrapped cakes on a hot plate to seal the plastic. Br. Efrain operates four hot plates, each of which holds one cake, and Fr. Robert operates three hot plates, each of which holds two cakes. After the plastic is sealed, Fr. Robert and Br. Efrain weigh the cakes on one of the two table scales and place the cakes in a prepared tin. Two volunteers place a candy pad and an HCA insert on top of the cakes and close the lid. A third volunteer moves the closed tins to plastic crates for transport to the shipping room at the main monastery building.
8:30 a.m.	Br. Christopher and Br. Joseph Vantu arrive to help wrap the cakes in plastic. The bakery manager facilitates the process (e.g., by preparing additional empty tins with wax paper liners and accordion pleated collars, moving trays of cakes higher on the rolling racks to make it easier for the wrappers to take the cakes off the racks, and closing lids and loading the tins in plastic crates as necessary). An additional volunteer begins to assist with preparing the tins, placing the candy pad and insert, closing the lids, and moving them to the plastic crates. Manpower summary: • 3 wrappers (two standing, one seated) • 2 weighers (both standing) • 4 finishers (all standing) • The bakery manager The bakery manager reports that this workforce is smaller than usual. The work force usually includes an

	additional monk, an additional volunteer, and the bakery assistant (who decided to take the day off). In addition, the bakery manager reports that the work force includes only 2 finishers.
9:15 a.m.	All cakes are packaged in tins and ready for transport to the shipping room. Fr. Robert begins washing down the tables. Twelve cakes have been broken or determined to be over- or underweight and will be made into fraters. The bakery manager states that the number of fruitcakes lost to fraters varies from as few as 0 to as many as 12 in a full bake.
9:20 a.m.	Six stacks of plastic crates are moved to the loading dock at the bakery. Two monks transfer the crates from the loading dock to the bed of a pickup. Two monks stand in the bed of the truck to receive the racks. Three stacks of crates fit in the truck bed at a time. Br. Christopher and Fr. Robert (in the cab) and Fr. James, Br. Efrain, and the bakery manager (in the truck bed) drive the truck to the loading dock at the monastery and unload the cakes into the shipping room. The truck and monks make two trips to transport all of the cakes to the shipping room.
9:30 a.m.	All cakes are transferred to the shipping room and the monks take a 15–20 minute break.
9:45 a.m.	Monks resume working in the shipping room. The boxing crew consists of Br. Christopher, Br. Efrain, and 2 volunteers. One volunteer assembles boxes from flat, die-cut box forms and stacks them in groups of eight. Br. Christopher moves cakes (in tins) from the plastic crates to a work table. Br. Efrain and one volunteer place the cakes in the prepared boxes, close the boxes, and seal the boxes with shipping tape. The tape is made from adhesive-backed paper and is measured out automatically by a tape dispenser that is set to dispense one piece of tape of the appropriate length at a time. Br. Efrain and the volunteer alternate the use of the tape dispenser. After the boxes are sealed, Br. Christopher moves the boxes from the work table and stacks them in the cake inventory.
11:40 a.m.	All cakes are boxed and stacked in inventory. The monks and one volunteer straighten up the shipping area and depart. The bake is complete.

APPENDIX 6-B: DETAILS OF METHODOLOGY

The Monastery Fruitcake

The carbon profile for the monastery fruitcake includes upstream transportation, manufacturing, in-process transportation, and downstream transportation.

Upstream Transportation

During each bake, HCA combines 37 different ingredients—a total of over 1,640 pounds of fruit, nuts, flour, sugar, eggs, and other items—to produce approximately 675 fruitcakes. HCA obtains the ingredients from various suppliers and receives most of the ingredients in UPS freight shipments. HCA picks up a few of the ingredients from local retailers using a pickup truck. In addition to ingredients, HCA uses several different packaging elements to prepare the fruitcake for shipment to customers. HCA obtains the packaging from several suppliers and receives most of the components in UPS freight shipments.

HCA purchases most of its ingredients and packaging from a few key vendors. HCA's vendors, their locations, and the approximate weight of the ingredients that the vendor supplies for one bake are summarized in Table 1. HCA's packaging vendors, their locations, and the approximate shipment weights are summarized in Table 2.

Table 1: Fruitcake ingredient vendors

Vendor	Ingredient Type	Vendor Location	Total Wt per Bake (lbs)	Total Weight in Shipments (lbs)
Paradise Fruit	Glace fruit, cherries, etc.	Plant City, Florida	810	7,710
Purcell Mtn. Farms	Dates	Moyie Springs, Idaho	66	360
Renfroe	Walnuts and pecans	Pensacola, Florida	125	1,015
Ruhl & Son	Raisins, dry ingredients, flavorings, butter, etc.	Hanover, Maryland	529	1,619
Gunters	Honey	Berryville, Virginia	27	1,590
Schenck	Pineapple Juice, Sherry	Winchester, Virginia	66	660
Virginia ABC Stores	Brandy	Berryville, Virginia	18	63
Total			1,640	13,017

Source: HCA

Table 2: Fruitcake packaging vendors

Vendor	Packaging Element	Vendor Location	Qty for bake(pc)	Qty shipped (pc)
Alcoa	Baking cups, collars, wax baking paper, etc.	Richmond, Virginia	624	Various
Independent Can Co.	Fruitcake tins	Belcamp, Maryland	624	Various
Progressive Printing	Printed marketing enclosure	Springfield, Virginia	624	Various
APS Packaging	Plastic wrap	Fairfield, New Jersey	624	Various
Corrugated Container	Cardboard shipping boxes	Winchester, Virginia	624	Various
Software Forms	Shipping labels	Totawa, New Jersey	624	Various

Source: HCA

For each fruitcake ingredient or packaging component that HCA receives through UPS freight, we calculated the carbon output of the energy used to bring the ingredient or item to HCA by using two key calculations. First, we calculated freight units (ton-miles) for transporting enough of each ingredient or packaging component for one fruitcake bake. Freight units are a function of the weight of the shipment (in tons), the shipping distance (in miles), and the quantity of the ingredient used in the bake. Second, we estimated carbon output resulting from each transportation event. We calculated carbon output by multiplying the freight units by the emission factor that UPS publishes for air freight (1.42 lbs CO_2eq per ton-mile).

We used a slightly different formula for calculating upstream carbon emissions from fruitcake ingredients that HCA picks up from local retailers. First, we used the estimated fuel efficiency of HCA's vehicle to estimate the amount of fuel that HCA used to drive to and from the retailer location. Then, we estimated carbon output resulting from HCA's transportation event by multiplying the gallons of fuel used by the appropriate carbon emission factor from Table 4. We added these two results to determine the aggregate carbon emissions from all upstream fruitcake processes.

Manufacturing Processes

Energy used during the bakery manufacturing processes consists of background electricity and heating oil used for lighting; controlling the climate within the bakery building; operating the cool room, commercial freezer, and other storage areas; and specific energy used to run HCA's appliances during a specific production process. We calculated the overall energy use for the bakery using HCA's energy bills and heating oil inventories. Because the bakery is used to make both fruitcake and creamed honey, we allocated part of the background bakery energy to fruitcake and part to honey. We made this allocation on the basis of the relative weight of each product that HCA produced in 2008.

In-process Transportation

In-process transportation was not a significant part of fruitcake production.

Downstream Processes

HCA ships as many as 16,000 fruitcakes per year to customers all over the world. For the most part, HCA relies on UPS to deliver its final products. Fruitcake deliveries consume a significant amount of transportation fuel because the density of the fruitcake makes the shipments relatively heavy and because many of the fruitcakes travel long distances to reach their ultimate destinations.

To calculate energy consumed in the downstream fruitcake shipments, we used a multi-step process. First, we used information provided by HCA to determine the total number of fruitcakes that HCA shipped to each state, territory, and foreign country in a reference year (2008). Second, because it would have been prohibitive to determine the shipment distance for each of the 5,000+ shipments that HCA made during the year, we identified a reference city within each state and foreign country and estimated the distance between the reference city and Berryville, Virginia. We generally selected relatively large cities located in the center of each state, territory, or country. We used the number of fruitcakes shipped, the shipment weight for a single fruitcake reported by HCA, and the distance to the reference city to calculate the freight units for shipments to each state and country.

Using the freight units, we estimated carbon output resulting from the shipments by multiplying the total freight units for all HCA fruitcake shipments to each state or country by the emission factor that UPS publishes for air freight (1.42 lbs CO_2eq per ton-mile, as shown in Table 4). We aggregated emissions for shipments to each state and country to calculate the total carbon emissions that resulted from shipping HCA's product to customers.

Creamed Honey

The carbon profile for HCA's creamed honey includes carbon emissions from upstream transportation, manufacturing, and downstream transportation. Making creamed honey requires fewer ingredients than fruitcake and involves a much less complicated production process. HCA picks up the honey from a local supplier and obtains flavorings and packaging components from out-of-state suppliers. Vendors of inputs to the creamed honey process are summarized in Table 8.

Table 3: HCA's creamed honey vendors

Vendor	Ingredient Type	Vendor Location	Amount per Honey Event (lbs or pc)	Total Weight in Shipments (lbs)
Gunters	Honey	Berryville, Virginia	540	1440
St. John's Botanicals	Flavorings	Bowie, Maryland	1.7	8
Ruhl & Son	Cinnamon	Hanover, Maryland	1.3	25
Subtotal			543	
Industrial Container & Supply	Containers, s-bands (for sealing)	Deer Park, New York	1050	Various
Corrugated Container	Shipping boxes, inserts	Winchester, Virginia	262	Various
Progressive Printing	Printed marketing insert	Springfield, Virginia	262	Various

The methodologies that we used to calculate upstream, manufacturing, and downstream carbon emissions for the honey-making process were very similar to the methodology we used for the fruitcake.

- We used an estimate of the fuel consumed by HCA’s pickup truck, an estimate of the vehicle fuel economy, and the emission factor from Table 4 to estimate carbon emissions from HCA’s use of the pickup truck to pick up honey from the supplier and bring it back to HCA.

- We used the weight of shipment, distance to supplier, and UPS emission factor to calculate the emissions from the UPS delivery of flavorings, packaging, and other inputs.

- For manufacturing energy, we used the time of use and the appliance specifications in Table 7 to calculate electricity consumption, and then applied the emission factor for purchased electricity from Table 4 to calculate carbon emissions from the manufacturing process. We added the appliance energy for honey production to the background energy used for lighting; controlling the climate within the bakery building; and operating the cool room, commercial freezer, and other storage areas.

- Finally, we used the number of honey units shipped, the shipment weight for a 4-pack of honey, and the distance to reference cities to calculate the freight units for honey shipments to each state and country. We applied the UPS emission factor from Table 4 to calculation downstream carbon emissions.

Fraters

The carbon profile of HCA’s fraters includes upstream transportation, manufacturing, in-process transportation, and downstream transportation. Fraters are produced at DeFluri’s Fine Chocolates in Martinsburg, Virginia approximately 8 to 10 times per year. The first production runs occur in March and April, but most of the production occurs in June, July, and early August so that a supply of fraters is available to fill sales orders in the fall for holiday delivery. Fraters typically are not produced September through February.

As noted previously, the main ingredient in the fraters is fruitcake. Most of the fruitcakes that are used for fraters cannot be sold to customers because the cakes are under- or overweight, but according to DeFluri’s HCA also uses fruitcakes that could be sold to customers when orders for fraters are greater than the available “rejected” cakes. HCA personnel deliver the fruitcakes to DeFluri’s periodically during the year so they are on hand for frater production.

An average frater production run requires approximately 80 fruitcakes. DeFluri’s slices each fruitcake into approximately 20 thick slices, and then the slices are placed onto an automated confectionary line where they are coated in dark chocolate and decorated with white chocolate striping. After the fraters have set, they are slipped into individual cellophane wrappers, heat sealed, and weighed. The wrapped fraters are then packaged in bulk cases of approximately 30 individual fraters or in decorative boxes of six individual fraters. Cases and boxes of fraters may be stored either at DeFluri's or at HCA until shipped to customers.

Ingredients

As noted previously, we allocated a portion of the upstream carbon output of the fruitcake to fraters to reflect energy and emissions from the use of the fruitcake in fraters. Specifically, we determined from HCA's records that approximately 690 fruitcakes per year are made into Fraters. (This number is roughly consistent with DeFluri's estimate that each of the 9 production runs in 2009 involved 80 fruitcakes (720 fruitcakes total).) For purposes of calculating emissions, therefore, we allocated approximately 7% (46/675 * 100) of the emissions resulting from the upstream stage of each fruitcake bake to fruitcakes that were converted to fraters.

To calculate the carbon output of the chocolate used as an ingredient in fraters, we learned from DeFluri's that approximately 110 pounds of chocolate is applied to fruitcake slices during each frater production run. DeFluri's orders the chocolate from Guittard Chocolate Company in Burlingame, California, but it is shipped to DeFluri's in 2,500 lb shipments (50, 50-lb cases) by Hess Trucking Company (a freight company) from a warehouse in Scranton, Pennsylvania. To calculate the energy used to transport the chocolate to DeFluri's, we calculated freight units from the delivery of the chocolate bars to DeFluri's, and then multiplied the freight units by the emission factor for truck freight in Table 4 to estimate the carbon emissions.

Manufacturing

The manufacturing energy used in the frater production process includes two components: (1) a portion of the carbon that was emitted during the fruitcake manufacturing process and (2) the energy that DeFluri's consumed to coat the fruitcake slices with chocolate. To estimate the amount of energy consumed by DeFluri's, we learned from DeFluri's that its automated chocolate line consumes 324 kW per hour of electricity, and that each frater production run takes an average of three hours. We multiplied this amount of electricity by the emission factor for purchased electricity in Table 4 to estimate the carbon emissions from DeFluri's chocolate line, and added it to the emissions from the background energy to calculate the total emissions from the frater manufacturing process.

In-process Transportation

In-process transportation is a significant part of frater production because HCA drives fruitcakes to DeFluri's and then returns completed fraters to the monastery for shipment to customers. To calculate carbon emissions associated with the transportation of the fruitcakes from the bakery to DeFluri's, we calculated the fuel consumed during one trip to DeFluri's and multiplied it by the number of trips that HCA makes to DeFluri's per year (which is 12–13 times per year, according to DeFluri's). Then, we multiplied the total amount of fuel by the appropriate carbon emissions factor in Table 4. Because HCA combines trips to DeFluri's with monthly sales calls for customers in and around Martinsburg, West Virginia, we allocated one-third of the resulting emissions to fraters.

We used the same formula to calculate carbon emissions associated with the transportation of the fraters from DeFluri's to HCA. However, we allocated only a portion of the emissions to fraters because HCA often transports both fraters and truffles from DeFluri's to HCA in a single trip. Moreover, HCA combines the frater and truffle pickups with other business activities in the Martinsburg, West Virginia area. As a result, we allocated a portion of the emissions resulting from the trips to fraters and truffles, and then divided the allocated portion between fraters and truffles on the basis of weight.

The total carbon emissions resulting from in-process transportation is the sum of (1) the emissions resulting from the transport of fruitcakes from HCA to DeFluri's and (2) the emissions resulting from the transport of fraters from DeFluri's to HCA.

Downstream

We used the number of frater units shipped, the shipment weight as reported by HCA (23 oz or 0.00072 tons), and the distance to reference cities to calculate the freight units for frater shipments to each state and country. We applied the UPS emission factor from Table 4 and aggregated emissions to each state and country to calculate the total carbon emissions that resulted from shipping HCA's fraters to customers.

Truffles

The carbon profile for HCA's truffles includes carbon emissions from upstream transportation, manufacturing, in-process transportation, and downstream transportation. As noted, HCA drives to DeFluri's Fine Chocolates in Martinsburg, Virginia to pick up truffles that DeFluri's has made. HCA picks up the truffles approximately 24 times per year, mostly in the fall. The truffles have been packed into decorative boxes, labeled, and tied with a stretch tie at the time that HCA picks them up. In addition, about half of the boxes of truffles have been placed into cardboard shipping boxes and are ready for shipment.

Ingredients

Truffles come in several varieties and are flavored with amaretto, espresso, blackberry puree, cranberry, and other ingredients that DeFluri's obtains from a wide variety of suppliers. To simplify the emissions analysis, however, we assumed that all of the ingredients that DeFluri's uses to make the truffles are provided by Guittard, the supplier of the chocolate, from its warehouse in Scranton, Pennsylvania. Thus, to calculate the carbon emissions resulting from transporting the ingredients for the truffles to DeFluri's, we calculated the freight units from the delivery of enough chocolate bars to DeFluri's to produce the truffles, and then multiplied the freight units by the emission factor for truck freight in Table 4 to estimate the carbon emissions.

Manufacturing

Unlike fraters, which are made partly from a product (fruitcake) produced by HCA, truffles are manufactured entirely at DeFluri's. To estimate the amount of energy consumed by DeFluri's, we multiplied the amount of energy consumed by DeFluris' automated chocolate line by the amount of time DeFluri's spends producing truffles for HCA (approximately 22 hours per year). We multiplied this amount of electricity by the emission factor for purchased electricity in Table 4 to estimate the carbon emissions from the truffle manufacturing process.

In-process Transportation

As in the case of fraters, in-process transportation is a significant part of the truffles' preparation because HCA must drive the finished truffles to the monastery for distribution to customers. As noted above, because HCA transports both fraters and truffles from DeFluri's to HCA, we allocated a portion of the emissions resulting from the return trips to fraters and a portion to truffles on the basis of weight.

Downstream

Finally, we used the number of truffle boxes shipped, the shipment weight as reported by HCA (1.3 lbs or 0.00064 tons), and the distance to reference cities to calculate the freight units for truffle shipments to each state and country. We applied the UPS emission factor from Table 4 and aggregated emissions to each state and country to calculate the total carbon emissions that resulted from shipping HCA's truffles to customers.

APPENDIX 6-C: COMPARISON OF FRUITCAKE PRICES

Company Name	Product	Qty	Item Wt.	Units	Total Wt.	Price	Price/oz
America's Finest Fruitcake	Regular fruitcake in tin or box	1	20	oz	20	$ 24.99	$ 1.25
Assumption Abbey	Regular fruitcake in tin or box	1	32	oz	32	$ 29.50	$ 0.92
Assumption Abbey	Regular fruitcake in tin or box	1	32	oz	32	$ 39.95	$ 1.25
Benedictine Abbey Gift Sho	Regular fruitcake in tin or box	1	32	oz	32	$ 19.00	$ 0.59
Claxton Fruit Cake	Regular fruitcake in tin or box	1	32	oz	32	$ 18.25	$ 0.57
Claxton Fruit Cake	Regular fruitcake in tin or box	3	16	oz	48	$ 25.45	$ 0.53
Claxton Fruit Cake	Regular fruitcake in tin or box	5	16	oz	80	$ 33.75	$ 0.42
Claxton Fruit Cake	Regular fruitcake in tin or box	10	16	oz	160	$ 59.45	$ 0.37
Claxton Fruit Cake	(Nut-free)	1	30	oz	30	$ 15.95	$ 0.53
Claxton Fruit Cake	(ClaxSnax)	20	1.5	oz	30	$ 19.95	$ 0.67
Collin Street Bakery	Regular fruitcake in tin or box	1	30	oz	30	$ 23.65	$ 0.79
Collin Street Bakery	Regular fruitcake in tin or box	1	46	oz	46	$ 34.50	$ 0.75
Collin Street Bakery	Regular fruitcake in tin or box	1	78	oz	78	$ 54.45	$ 0.70
Collin Street Bakery	(sliced)	1	30	oz	30	$ 28.75	$ 0.96
Georgia Fruitcake Company	Regular fruitcake in tin or box	4	16	oz	64	$ 32.00	$ 0.50
Georgia Fruitcake Company	Regular fruitcake in tin or box	2	16	oz	32	$ 21.50	$ 0.67
Georgia Fruitcake Company	(vac pack)	1	32	oz	32	$ 24.50	$ 0.77
Georgia Fruitcake Company	(vac pack with bourbon)	1	32	oz	32	$ 26.50	$ 0.83
Georgia Fruitcake Company	Regular fruitcake in tin or box	10	16	oz	160	$ 62.00	$ 0.39
Georgia Fruitcake Company	Regular fruitcake in tin or box	5	32	oz	160	$ 62.00	$ 0.39
Gethsemani Farms	Regular fruitcake in tin or box	1	40	oz	40	$ 33.50	$ 0.84
Gethsemani Farms	Regular fruitcake in tin or box	3	20	oz	60	$ 49.50	$ 0.83
Gethsemani Farms	Regular fruitcake in tin or box	6	20	oz	120	$ 95.00	$ 0.79
Gethsemani Farms	Regular fruitcake in tin or box	1	80	oz	80	$ 58.50	$ 0.73
Gourmet Southern Fruitcak	Regular fruitcake in tin or box	1	16	oz	16	$ 15.95	$ 1.00
Gourmet Southern Fruitcak	Regular fruitcake in tin or box	1	32	oz	32	$ 27.95	$ 0.87
Gourmet Southern Fruitcak	Regular fruitcake in tin or box	12	16	oz	192	$ 144.00	$ 0.75
Gourmet Southern Fruitcak	Regular fruitcake in tin or box	12	32	oz	384	$ 240.00	$ 0.63
Harry and David	Regular fruitcake in tin or box	1	32	oz	32	$ 29.95	$ 0.94
Heritage Baking Company	Regular fruitcake in tin or box	1	40	oz	40	$ 25.75	$ 0.64
Heritage Baking Company	(no box)	1	40	oz	40	$ 24.50	$ 0.61
Knaub Farms	Regular fruitcake in tin or box	1	16	oz	16	$ 6.95	$ 0.43
Knaub Farms	Regular fruitcake in tin or box	1	32	oz	32	$ 10.95	$ 0.34
Knaub Farms	(holiday gift box)	1	32	oz	32	$ 12.95	$ 0.40
Knaub Farms	Regular fruitcake in tin or box	1	48	oz	48	$ 22.95	$ 0.48
Old Cavendish	Regular fruitcake in tin or box	1	40	oz	40	$ 40.00	$ 1.00
Old Cavendish	Regular fruitcake in tin or box	1	16	oz	16	$ 20.00	$ 1.25
Old Cavendish	Regular fruitcake in tin or box	2	40	oz	80	$ 75.00	$ 0.94
Old Cavendish	(shaped like a Xmas tree)	1	68	oz	68	$ 55.00	$ 0.81
Trappist Abbey Fruitcake	Regular fruitcake in tin or box	1	16	oz	16	$ 16.95	$ 1.06
Trappist Abbey Fruitcake	Regular fruitcake in tin or box	1	16	oz	16	$ 14.49	$ 0.91
Trappist Abbey Fruitcake	Regular fruitcake in tin or box	1	48	oz	48	$ 28.00	$ 0.58
Whitaker's Rumfru Delight	Regular fruitcake in tin or box	1	"regular"			$ 36.45	
Whitaker's Rumfru Delight	Regular fruitcake in tin or box	1	"half-size"			$ 24.00	
Whitaker's Rumfru Delight	(no nuts)	1	"regular"			$ 36.45	

APPENDIX 6-D: RECIPE FOR ORGANIC FRUITCAKE

Soak 1 lb organic dried fruit bits (apples, dates, apricots, cranberries, cherries, golden raisins, and currants) in ½ cup brandy or organic apple juice for several hours or overnight.

Beat together 1 cup organic butter and 1 cup organic sugar until creamy. Beat in 5 large organic eggs until the mixture is light and fluffy. Add ½ teaspoon cream of tartar with the eggs.

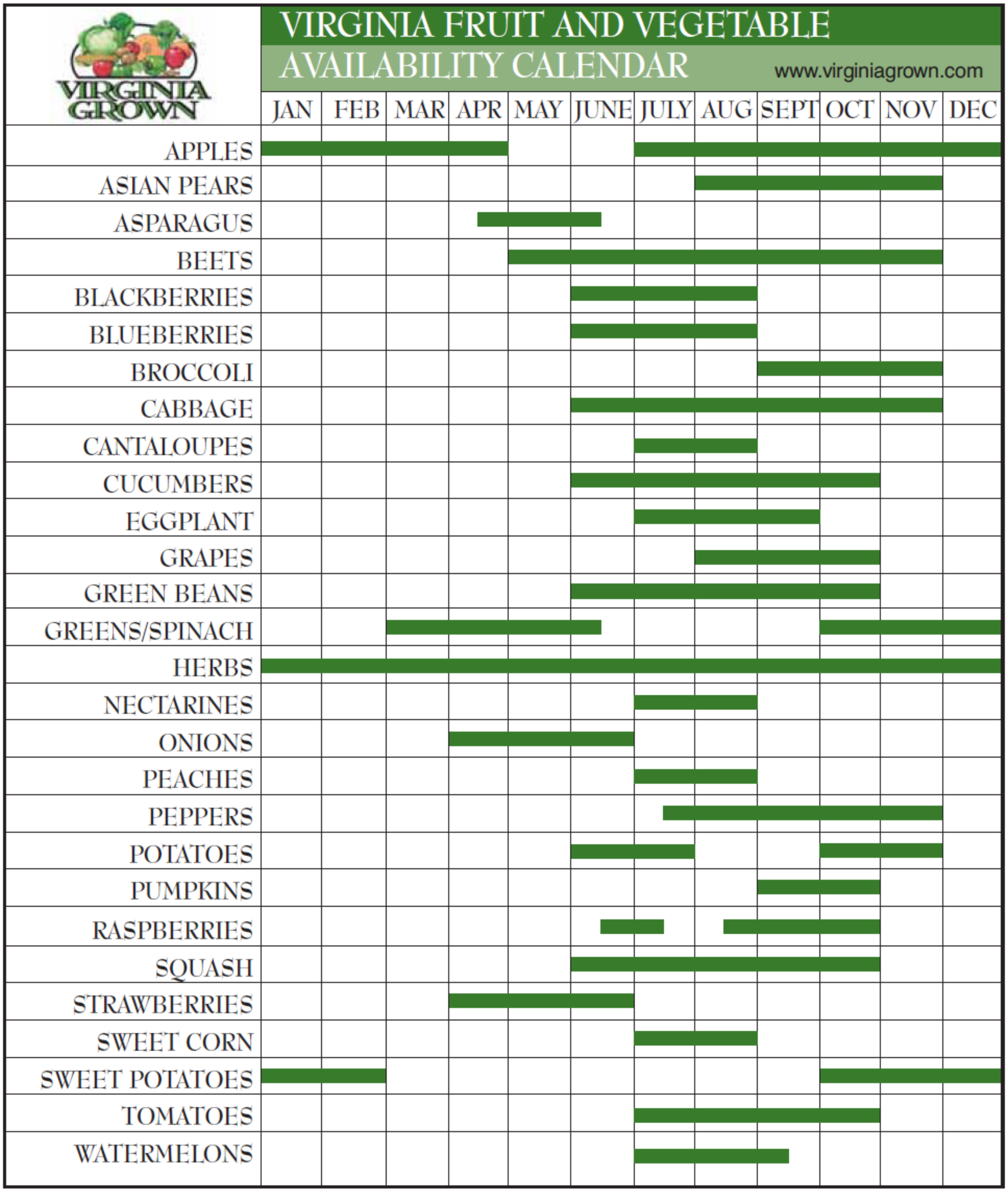
Sift together the following ingredients:

2 cups organic flour (substitute part whole wheat flour if desired)
½ teaspoon salt
½ tablespoon each of ground cinnamon, cloves, allspice, and nutmeg
1 teaspoon mace

Add the flour mixture to the butter/sugar/eggs mixture a cup at a time and stir just until blended. Stir in the soaked fruit and 1 lb organic walnuts and/or pecans, chopped, until just mixed.

Place batter in a greased loaf pan lined with parchment paper. Decorate with pecan halves. Bake at 275°F for 1 hour until done, until a testing straw comes out clean (do not overbake). Let cool on a rack for a half hour, and then remove from pans. Brush the outside of the cake with brandy or juice until moist, and then wrap in plastic. Place in a cool place and let rest for several weeks.

APPENDIX 6-E: VIRGINIA GROWN PRODUCE



VIRGINIA GROWN

VIRGINIA FRUIT AND VEGETABLE AVAILABILITY CALENDAR

www.virginiagrown.com

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
APPLES	🟩	🟩	🟩	🟩			🟩	🟩	🟩	🟩	🟩	🟩
ASIAN PEARS								🟩	🟩	🟩	🟩	
ASPARAGUS				🟩	🟩	🟩						
BEETS					🟩	🟩	🟩	🟩	🟩	🟩	🟩	
BLACKBERRIES						🟩	🟩	🟩				
BLUEBERRIES						🟩	🟩	🟩				
BROCCOLI									🟩	🟩	🟩	
CABBAGE						🟩	🟩	🟩	🟩	🟩	🟩	
CANTALOUPES							🟩	🟩				
CUCUMBERS						🟩	🟩	🟩	🟩	🟩		
EGGPLANT							🟩	🟩	🟩			
GRAPES								🟩	🟩	🟩		
GREEN BEANS						🟩	🟩	🟩	🟩	🟩		
GREENS/SPINACH			🟩	🟩	🟩	🟩				🟩	🟩	🟩
HERBS	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
NECTARINES							🟩	🟩				
ONIONS				🟩	🟩	🟩						
PEACHES							🟩	🟩				
PEPPERS							🟩	🟩	🟩	🟩	🟩	
POTATOES						🟩	🟩			🟩	🟩	
PUMPKINS									🟩	🟩		
RASPBERRIES						🟩	🟩	🟩	🟩	🟩		
SQUASH						🟩	🟩	🟩	🟩	🟩		
STRAWBERRIES				🟩	🟩	🟩						
SWEET CORN							🟩	🟩				
SWEET POTATOES	🟩	🟩								🟩	🟩	🟩
TOMATOES							🟩	🟩	🟩	🟩		
WATERMELONS							🟩	🟩	🟩			

Virginia Department of Agriculture and Consumer Services

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NATURAL RESOURCES
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