Strategies for Sustainable Surface Water Management in Master Planned Communities in Semi-Arid to Arid Environments

By:

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ABSTRACT

Continuing concern over environmental issues and the public's embrace of sustainability has led to a greater expectation for private landowner and developers to participate in the stewardship of the environment, bio-diversity protection, increase of wildlife habitat and use of the new environmental tools for green design. This study investigates creative techniques for water conservation and surface water reuse through an evaluation of the master-planned community of Rancho Viejo de Santa Fe, located in Santa Fe New Mexico over a 10-year period, (2002 to 2012). The project analysis focuses on the level of success of surface water management at Rancho Viejo and on the effectiveness of policies and strategies to conserve water and to improve water quality and supply issues. The case study also explores the challenges of fitting a new community into a sensitive landscape in a manner that preserves the intrinsic values of the landscape, protects wildlife habitat, provides for affordability, conserves water and does so in a political environment where people are extremely protective of their community heritage, dislike change and do not trust corporate outsiders.

The first stage of this study was documented by the author in the 2003 Rancho Viejo Surface Water Management Manual, addressing the status of the sustainable components and providing recommended strategies for future development. The 2012 case study re-evaluates these strategies 10 years later, using interviews, literature review, and project site visits. The evaluation suggests that Rancho Viejo achieved the goals of reducing potable water usage (40% below County requirements), established an on-site waste water treatment plant for supplying reuse water for irrigation and preserved 50% of open space for aquifer recharge and habitat preservation. This case study confirms that a collaborative planning process, innovative and tested technical strategies for sustainable site design and construction, and a strong homeowner educational program can result in the following benefits:

1) an expedited approval process,
2) significant reduction in potable water use,
3) reduced infrastructure costs,
4) protection of water recharge areas,
5) protection of open space vegetation and habitats,
6) achievement of marketing and economic goals and
7) desirable, aesthetically-pleasing, healthier, cooler, and livable neighborhood and community.

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I. INTRODUCTION

When this study began in 2002, examples of projects where private landowners and developers took a major role in stewardship of the environment were uncommon. Few models of proven sustainable community design in arid environments existed. Today, private developer/public agency partnerships occur more often and are used to achieve a new vision for sustainable master-planned communities that have a greater focus on water conservation, bio-diversity protection, wildlife habitat and acceptance of new environmental tools for sustainable design. This change in the approach to community development has created new opportunities for innovative, green land-planning and water-conserving landscape design.

Rancho Viejo was one of the earliest projects benefiting from this vision of environmental stewardship and collaboration. The project was first conceived in 1996, when the sustainability and smart growth movements were just starting to achieve national attention. Some initiatives within the movement were making progress, but were limited in what they could achieve because of government regulations and a lack of understanding of such new approaches to community development. The Green Building Council's LEED green building standards were a significant contribution to the general movement towards sustainable design, but at the time were limited to only commercial buildings. Today's LEED standards and the Sustainable Initiatives program (SITES) offers guidance for sustainable new development and new construction standards for site design and stormwater management.

This type of sustainable development, also referred to as green development, leads to environmentally sound and resource-efficient buildings and communities by using an integrated approach to design that is sensitive to natural resources and their protection. At Rancho Viejo, this green-development approach relied heavily on a committed relationship between city planners and the developer from the onset, leading to the creation of a master plan that allowed for thoughtful development, minimized disruption of ecosystem and habitat and provided water conservation opportunities.

The changes in corporate and developer relationships with their environment have occurred, in part, as a response to diverse corporate constituents such as shareholders, the public, potential home buyers, and public agencies; to take advantage of new market opportunities; to meet competition; and to act on an emerging corporate ethic towards the environment. Community developers are pursuing sustainable planning approaches for four key reasons: 1) it's the right thing to do, 2) it improves public and civic image, 3) it accelerates jurisdictional approvals, or 4) it fills an unmet market demand (Kellenberg 2004). There are also potential benefits of significantly lowering maintenance costs over time, improved sales, reduced energy consumption, and sometimes lower development costs and a more positive position in the community. The environmental benefits of limiting disturbance of natural systems, lowering energy and resource consumption, reducing pesticides, herbicides and water required to maintain an aesthetically pleasing sustainable landscape, to name a few, are extra incentives to consider a Green development and water conserving approach to new community and land development.

This case study of Rancho Viejo confirms that private and public landowners and developers can have an important role in the process of protecting natural resources, native landscapes, and bio-diversity. The study discussion of the design and development process, the successes and challenges, and lessons learned explain the significance of Rancho Viejo living model of successful sustainable community design in arid environments and an ongoing laboratory for research and replication.

Sustainable site design and management strategies related to water conservation, still need to be being tested in a variety of environments and political and economic climates. It is imperative that we continue this progress by evaluating the long term success and challenges of the implemented systems in real communities. By showcasing projects representing different geographic regions, sizes, types, and stages of development, we can demonstrate the feasibility of creating sustainable, water-conserving communities virtually anywhere.

A. Research Focus

Four key issues help define how a project's location affects the sustainability of the project over its lifetime: transportation, site selection, site design and stormwater management (USGBC, 2009). This study mainly focuses on the evaluating the strategies of site design and managing stormwater surface water runoff[1] as a resource for communities located in semi-arid to arid environments.

[1] Surface water runoff is stormwater, typically from rainfall or snowmelt that does not infiltrate into the ground from storm events, and runs off impervious surfaces into landscapes, swales, waterways or channeled into storm sewers

Rancho Viejo de Santa Fe, is a master planned, green community located just south of Santa Fe, New Mexico, and is the main focus of this study. The study records the perceptions, successes and unique challenges, over a ten year test period of applying green building and sustainable design strategies for surface water management and reuse. Due to the integrated nature of sustainable design strategies, the study also addresses the design impacts of sustainable site selection, site design, water efficient landscapes and water use reduction, and landscape management.

The research methods employed included the collection and analysis of information including developer vision and goals, financial aspects, the design and decision making process, literature research, archival research of key documents on Rancho Viejo de Santa Fe, published reviews and case studies, internet searches, interviews of key participants in the community, number visits to the community over the past ten years and the time spent working as a designer on the project from 1998 to 2004.

The goal of this study is to contribute to the understanding of water conservation strategies and surface water management systems, and how the implemented strategies withstand and respond to changes in management, weather patterns, economic downturns, and changes in public policy over time. This study proposes that many of the strategies conducted at Rancho Viejo can also be successfully applied to master-planned communities in arid or non-arid environments. As a case study, this review of Rancho Viejo documents the progress being made in developing sustainable communities using innovative planning, planting, water-conserving site design and construction techniques and educational programs to improve the understanding of the benefits of using surface water as a resource.

B. Research Questions

The 2012 re-evaluation study addresses the following specific questions:

1. How much of the sustainable site design, construction techniques and recommended strategies outlined in the 2003 SWM Manual were implemented and to what extent?
2. How did climate changes and other environmental factors influence the design process and approach?
3. How has the planning process and site design process contributed to the protection of habitat and natural resources at Rancho Viejo?
4. What were the successes and challenges of incorporating these strategies at Rancho Viejo over the first 10 years of its development in supplying each community with enough water to sustain an attractive, low water-use and native landscape?
5. What other factors have influenced the success of the planning and design process and implementation strategies proposed?
6. What other new and progressive strategies are being explored to improve the success of surface water management in other residential communities in arid environments?

C. Project Background and History

1. Project Developers and Planners

In 1981, The Rancho Viejo Partners, LLC purchased the Jarrott Ranch and other small properties just south of Santa Fe, New Mexico. In 1989, an early attempt at a master plan for 2000 acres of the site was developed. However, the design reflected the typical low density sprawl pattern, which may have been the cause of development halting soon after the initial start (Porter, 2003). In 1996, 21,000-acres of the original parcel were sold to SunCor New Mexico Inc., a wholly-owned subsidiary of Pinnacle West Capital Corporation based in Tempe, Arizona. The 1996 agreement gave SunCor development rights on 2,500 acres there plus an option for development of 10,000 more acres. This resulted in the formation of SunCor Rancho Viejo Development Corporation.

In 1997, representatives for the new owners of the Rancho Viejo land-holding and Santa Fe County planners talked informally about how to change the pattern of sprawl in Santa Fe County and found they had shared key common values. The discussion focused on the visual and environmental values of the land; clustering development in villages in the tradition of New Mexican settlements; including affordable housing and jobs for locals; providing adequate water; and helping establish an ongoing community-development process that would provide an alternative to sprawl, which is an inefficient use of landscape, infrastructure and services. Once this common vision was established, county staff worked in concert with the developer to achieve approval for a new district and the Community College District Plan, and to encourage future green community developments within the County. The area's traditional zoning ordinances limit density, but the College District Plan fosters creation of contemporary versions of traditional New Mexico villages at Rancho Viejo, with higher densities required in village areas and minimum floor-area ratios to insure building mass in village centers. As part of this approval process, Santa Fe County also required the developers to build a sewage-treatment plant, which was maintained by SunCor - Ranchland Utility Company.

2. Project Background and Vision

The study area, Rancho Viejo de Santa Fe, is an 11,000-acre zoned development within the 18,000-acre Community College District (CCD), (Figure I-1). Simultaneous to the planning of the Community College District Plan in 1998, the developer began the planning designs for the first 350-unit village at the new community of Rancho Viejo[2]. This project was used to test the practicality of the vision for both village and the CCD plan. The success of the first village proved that land stewardship and village development can be profitable and gave the Santa Fe County commissioners the confidence to support what was a new approach at the time to community development without fear of stifling economic growth (Porter, 2003).

The development program called for 13,000 dwellings, seven Villages (proposed density of 3.5 developable units/acre minimum), community friendly streets, 50% open space, 15% affordable housing, with an estimated build-out by 2030 (Figures I-2, I-3). Unlike other community developments in the region during that time, the plan allows the topography of the land to determine its use at Rancho Viejo. Rancho Viejo is sited in a basin bisected by arroyos (dry creeks) and landscape that originally consisted of pine covered slopes. 5,500 acres of open space were preserved as part of the design and made up a part of the 50% open space required by the CCD Plan. The preserved open space was dedicated to community parks and the preservation of steep hillsides and arroyos, and provides for aquifer recharge, preserved habitat systems and scenic view corridors. Level open meadows are zoned as village development areas whose boundaries are delineated by arroyos, and village centers require mixed-uses around plazas and public spaces. The development vision placed a great emphasis on the sense of community and strived to create spaces and villages to encourage a sense of neighborhood. Within each village, a pedestrian-oriented community gathering space was incorporated, similar to the traditional Spanish plazas (Thomas, 2012).

The design process was employed that allowed planners and landscape architects to create community by visualizing it. Rancho Viejo, goals, abstract ideas, principles and policies were converted into drawings that people could look easily understand – not only as renderings, but also by mapping the land to illustrate the values that were important to them. It reportedly took nine months for the planning committee to visualize the direct relationship between the pattern of development and the topography of the land, which may never have been realized if Rancho Viejo hadn't been developed as a demonstration village and the study plans prepared by the planning team of Design Workshop, Inc. (Porter, 2004). At ultimate build-out, the seven proposed villages are expected to comprise over 16,000 housing units. The project components developed with the first ten years, in order of development, includes three villages: Rancho Viejo Village 1 (North and South), Windmill Ridge (North and South) and La Entrada.

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[2] For this study, the references to Rancho Viejo will represent the entire Rancho Viejo de Santa Fe community.

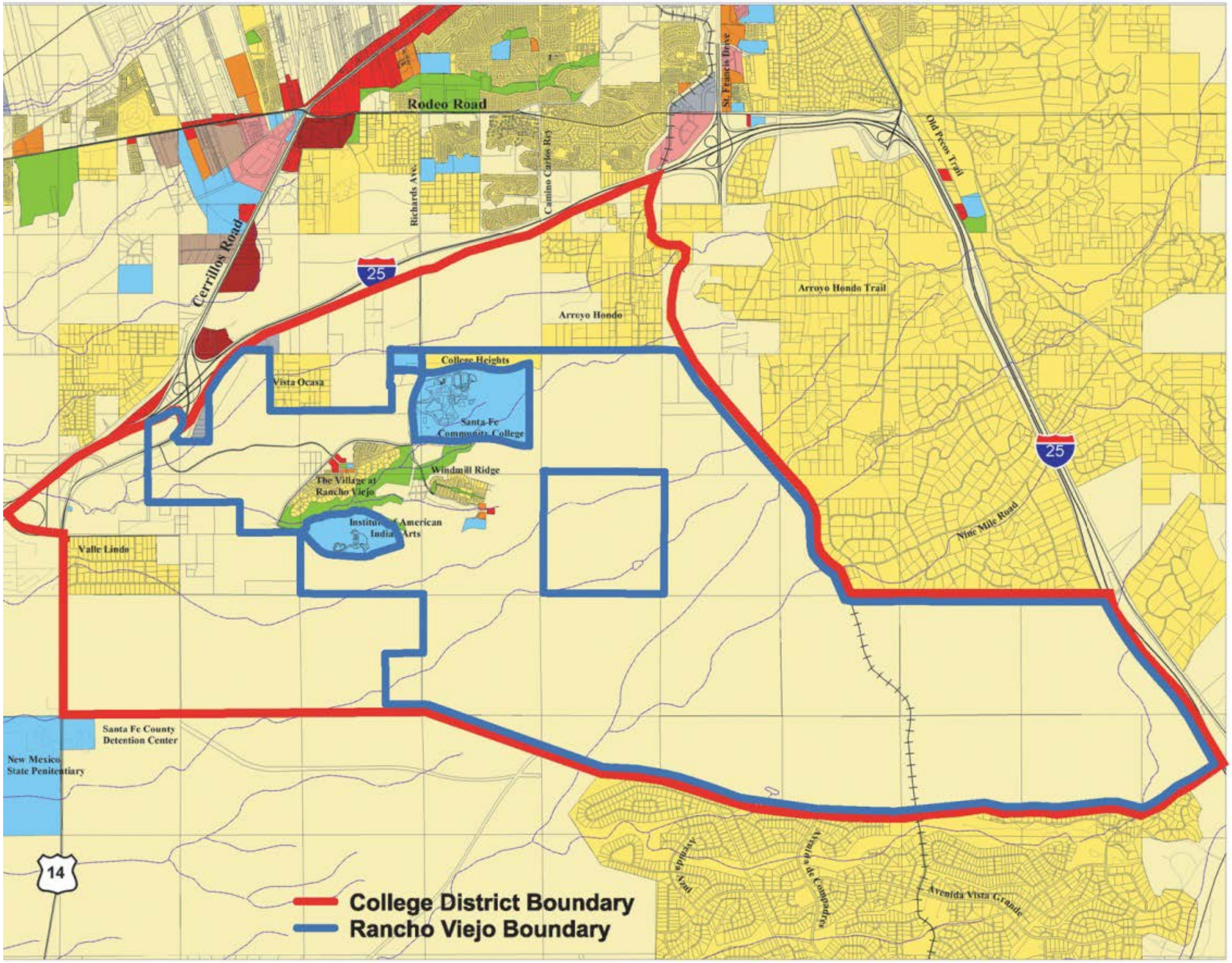

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Figure I-1 Rancho Viejo and Community College District Boundary Map

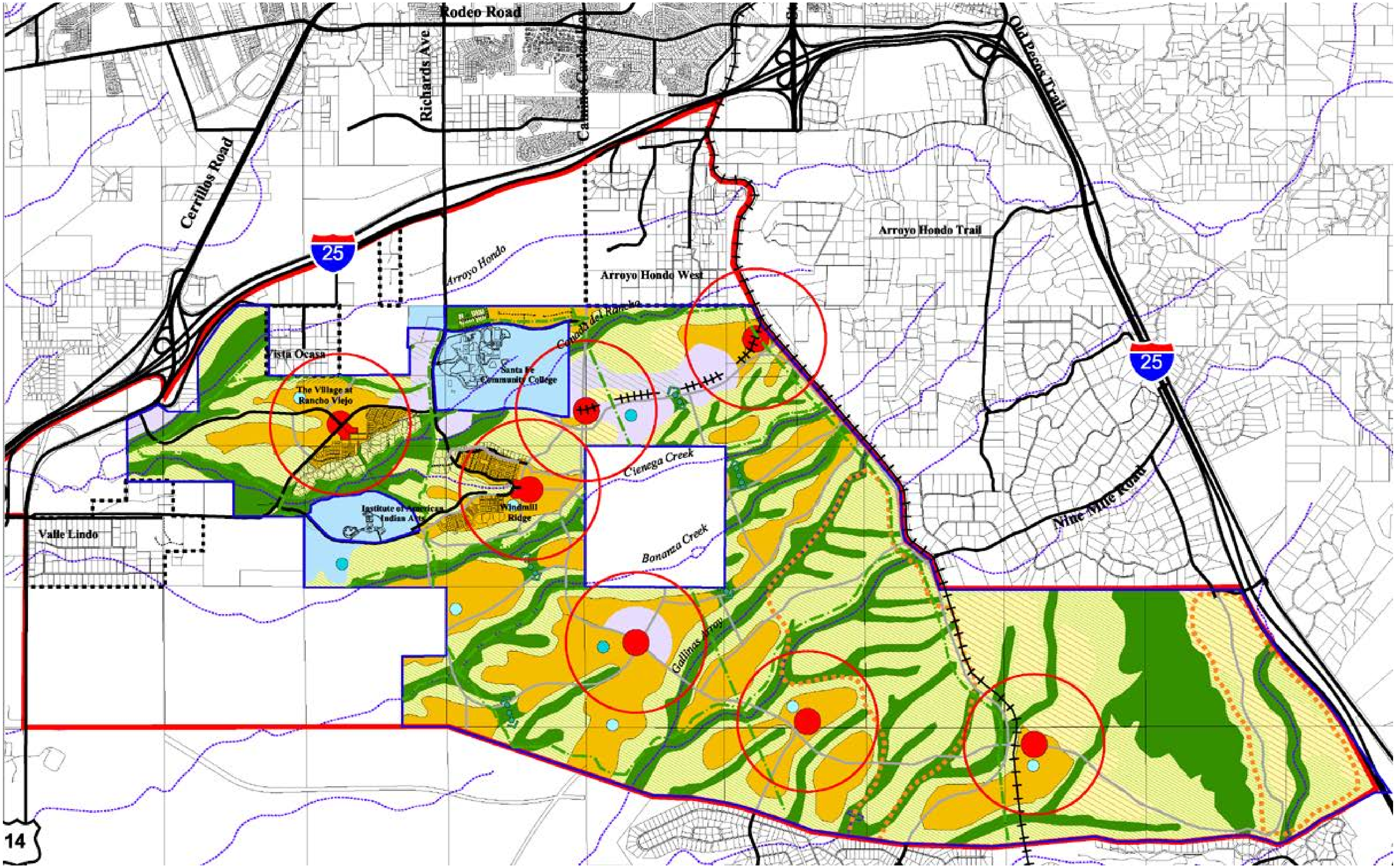

Figure I-2 Rancho Viejo Villages District Plan (2001)

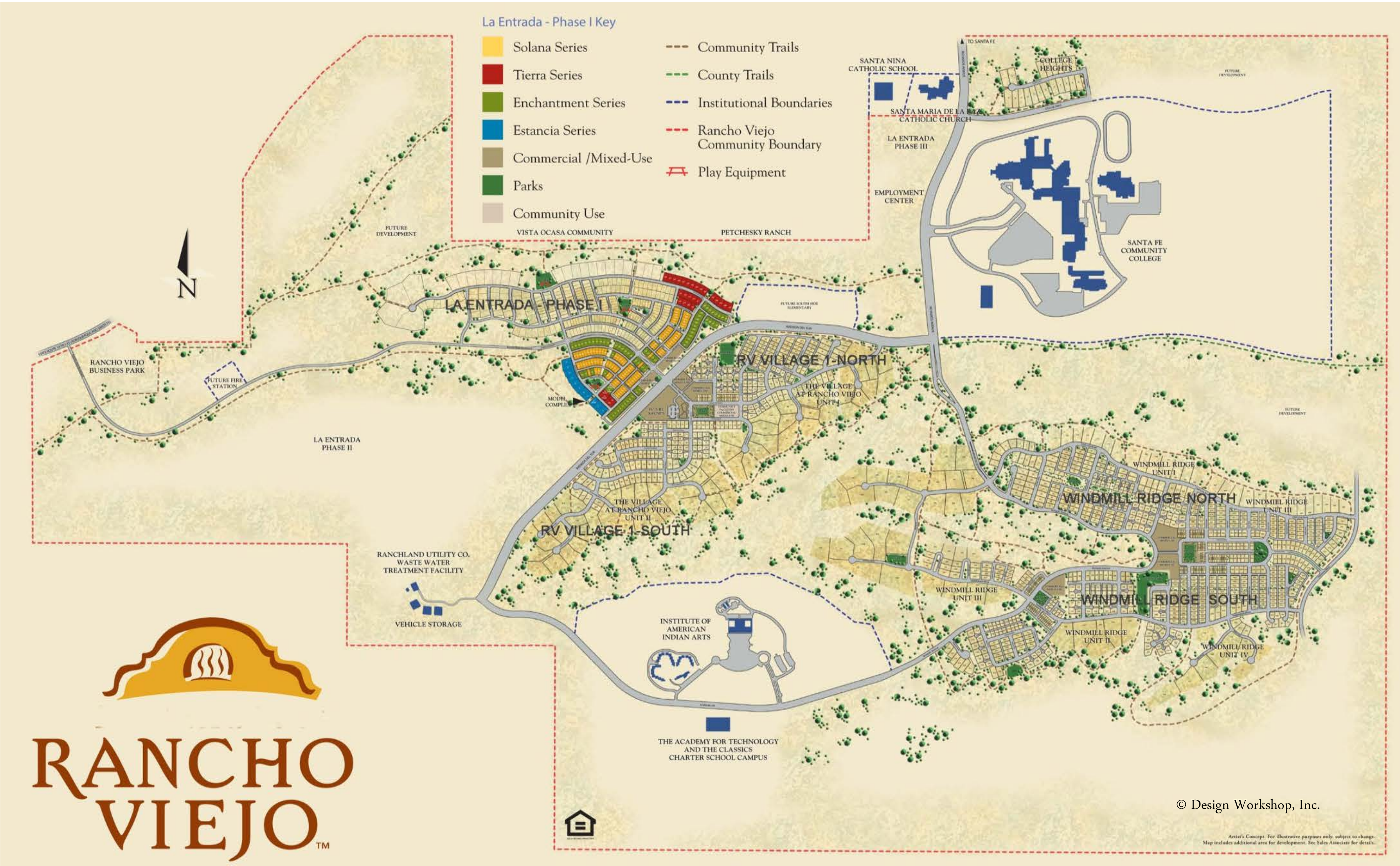

Figure I-3 Rancho Viejo Villages 1, Windmill Ridge and La Entrada Plan (2010)

D. Site Influences

Soils, topography, climate and exposure to the elements had a significant impact on the development of the vision and subsequent design of the Rancho Viejo developed areas and open spaces and influenced plant selection, irrigation needs, soil stabilization techniques, water infiltration and catchment system design. Santa Fe lies within the middle Rio Grande Valley in the central mountains of New Mexico. This region varies considerably in both temperature and precipitation depending on how close the development is to the mountains or valleys.

Climate: Santa Fe has a mild, arid[3] or semiarid, continental climate characterized by light precipitation totals, abundant sunshine, low relative humidity, and a relatively large annual and diurnal temperature range. The moisture regimes range from semi-arid to arid and the temperature regimes from mesic to frigid. In areas with measurable slope, aspect can account for great variability in climate. The Rancho Viejo community sits on elevations that range from about 6100 to 7300 feet in one of the non-draining basins or inland sea areas. The temperatures are milder (warmer) than usual for the elevation (Chronic, 1987). Summers are warm to hot with high temperatures averaging around 86 degrees Fahrenheit. The winters are moderately cool to cold with mean annual temperatures ranging from about 40 to 54 degrees Fahrenheit (NRCS, 2011).

Mean annual precipitation ranges from 9 to 20 inches, which falls with great variability from month to month and year to year, however, one-third of the annual average falling in the months of July to September. Most summer precipitation falls as heavy rain during brief, isolated, high-intensity convective thunderstorms, which are usually accompanied by strong, gusty winds and occasionally bursts of hail (Soil Survey 2004). At the time of the 2003 study, the average annual total precipitation was about 14.29 inches. Of this, about 8.52 inches, or 60 percent typically fell in May through September. The growing season for most landscape plantings falls within this period. Thunderstorms occur on about 47 days each year, and most occur in July. On an average, 10 days per year have at least 1 inch of snow on the ground, averaging around 17 inches of snowfall annually. From 2004 to 2010 the average annual precipitation varied from a low of 12.57 inches to high of 15.29 in 2010, but in 2011 the total precipitation dropped to 10.29 inches. 2012 also brought similar drought conditions, which has seriously impacted all the non-irrigated planting areas and reduced the amount of surface water available for reuse on site (NRCS, 2012). One result of the extended drought is a shortage of treated effluent available for irrigation due to a reduction in stormwater and a reduction of grey water from homes resulting from a successful potable water conservation program. During severe drought conditions, there is also a shortage of rainwater to replenish cisterns and other catchment systems, resulting in more potable water being required to sustain the native and low-water use plantings (Ross, 2012).

The Land: The Rancho Viejo land system consists of three primary land types: arroyos or dry gulches that are preserved in the high desert open spaces; wooded hillsides where the low-density residential development is tucked into existing forests; and flat, upland areas that are primary village areas. As a result of the CCD Plan and Rancho Viejo's planning and design process, more than half of the land was left as open space (DWI, 2007). The villages were designed with a development pattern that protects the arroyo open space system critical to the scenic character of the landscape and the natural groundwater system. Rancho Viejo's developable areas and adjacent arroyos soils generally consist of sandy silt and/or clay, many of which exist over a sand and pebble gravel lenses of silty clay soils.

In some areas, the dense silty sand and clays can lead to undesirable movement, erosion and settlement and surface ponding. In response, most of the residential homes have been constructed on 1-4% slopes, well-drained soils with very low water capacity. The variation in the amount of clay in the soil has often negatively impacted the success of the landscape restoration efforts, the in-ground infiltration systems and effectiveness of other surface water management systems (Appendix E). The adjacent 5-25% sloped land areas are comprised of even more excessively drained soils with very low water capacity. Their sandy loam to loam top soil extends to about a 5 foot depth with gravel loam and coarse sand below. The sloping areas naturally support low water use native vegetation such as *Pinus edulis*, *Juniperus monosperma*, *Bouteloua hirsuta* and *Bouteloua gracilis*.

Native Plants: The water table is over 200 feet below the surface in most locations on site. The well-drained subgrade makes it difficult to sustain non-native plant life without extensive irrigation or soil amendments. The native landscape at Rancho Viejo is predominantly high desert hillsides, rugged arroyos, and sweeping grasslands. Typical plants found in this high desert plant community include:

[3] A region is said to be arid when it is characterized by a severe lack of available water, to the extent of hindering or even preventing the growth and development of plant and animal life. A desert is a landscape or region that receives very little precipitation. Deserts are defined as areas with an average annual precipitation of less than 50cm/year, or as areas where more water is lost by evapotranspiration then falls as precipitation.

piñon pine, one-seed juniper, chamisa, Apache plume, banana yucca, narrowleaf yucca, blue grama grass, and buffalo grass.

Preservation and integration of the native vegetation and materials throughout the entire community was critical to creating a sense of place at Rancho Viejo (Image 1.1). Native vegetation was used for habitat enhancement and the reintroduction of native birds to the site. The sustainable development and landscape design approach at Rancho Viejo was intended to create a seamless transition from surrounding undisturbed native landscapes to the more urban environment that bind the community development together.

Image 1.1 Rancho Viejo Open Space

E. New Mexico Water Resources and Water Rights

New Mexico has always had periods of water shortages, some longer lasting than others. As the state's population and water demands continue to increase, the likelihood that water shortages will occur with greater frequency and result in significant economic and environment harm will increase as well unless we significantly improve our water management processes. When demand exceeds available water supply, the gap between water supply and demand must be reduced by either finding new water sources, or reducing water demands. For many decades, New Mexicans have been acquiring new water sources and developing new methods of accessing and increasing their water supply, including dams, reservoirs, drilling deeper wells, pumping groundwater over long distances, desalination, and other strategies, which are anticipated to become even more expensive, energy intensive and environmentally challenging in the future.

It wasn't until the 1980's that incentives for water conservation began to appear in state statutes. Like many states in the western mountain region, New Mexico water laws require that water that isn't consumed or rainfall that isn't used where it falls within the residential lot line must be return to the aquifer so the next person downstream who owns the rights can use it. Water captured from an individual's private property, and therefore is not allowed at this time to be permanently retained or detained on site for more than 24 hours before returning it to the aquifer. This requirement confirms the need for more effective on-lot catchment and reuse systems that can capture and retain water for landscape irrigation and other uses.

New Mexico's population uses groundwater for 90% of its drinking water. In 2003, New Mexicans were using a total of more than 4 million acre-feet of water per year, which translates into 1 million gallons of water per person per year. In some parts of the state, water was being taken out faster than the land could replenish it. During 1996-2000, and again in 2002 and 2004, Santa Fe and the surrounding area experienced very dry years.

In 2000, the city of Santa Fe's Mayor Larry Delgado proposed a Water Plan with the goal of prioritizing and starting conservation measures to significantly reduce the water demand. This Water Plan called for a revised water shortage emergency and conservation ordinances, expansion of the Home Conservation Assistance Program, development of a comprehensive public information campaign and continued enforcement efforts. The City of Santa Fe was already a very water conserving community when Rancho Viejo was first being developed. Santa Fe had one of the lowest per capita water use rates in the west. However, given that Santa Fe is located in a semi-arid environment and water supplies were becoming scarcer, the City aggressively pursued more demand reduction measures such as the development of a Conservation Implementation Plan in 2001.

In 2003, the State Engineer and Governor's office developed the State Water Plan, which was submitted and accepted by the Interstate Steam Commission as part of the strategy to meet the ever-increasing demands for water with its finite water supplies. The purpose of the States Regional Water Plan is to assess the available supply of clean, usable surface water and groundwater, to determine the present and future demand for water, and to recommend methods for meeting the projected demand through conservation, management, and/or acquisition of water or water rights. There are 16 water planning regions in New Mexico, established by the Interstate Stream Commission (ISC). Each region can write its own water plan for the ISC to accept and integrate into a statewide water plan.

Santa Fe falls within the Jemez y Sangre Regional Water District. Additionally, the City implemented a comprehensive conservation program, documented in the "Water Conservation and Drought Management Plan of 2005," which combined several different elements, including specific water conservation requirements, water rate conservation incentives, water use audits, water offsets for new development, and general conservation education for the public. With the intent to reduce *per capita* water use, the City of Santa Fe instituted emergency water conservation measures that included, among other provisions, restrictions on residential and commercial outdoor watering and water-saving measures in commercial and public spaces (City of Santa Fe, 2009).

The region's surface supply comes from two main sources: (1) the Rio Grande and Rio Chama, which flow into the region from the north and (2) tributary streams derived from melting snow from the higher peaks that flank the region on the east and west. Most regional surface water is used for agriculture, although the City of Santa Fe receives about 40 percent of its water supply from snowmelt and other precipitation that is captured in dams in the Santa Fe River watershed above the City. A significant amount of the surface water in the region evaporates directly into the atmosphere or indirectly through transpiration from vegetation (NMOSE, 2003).

Although there are some requirements to ensure water availability for new developments, there are many exemptions to the existing requirements, and different types of local agencies follow different procedures. Water planning is typically conducted at local, regional, and statewide levels and historically has not been well connected to land use plans and regional water plans within the same river basins, and may not always be consistent with each other. The current methods of evaluating water supply for new development also do not consistently account for the cumulative, long-term impacts of previously approved subdivisions. Local and regional land use planning tends to make only broad assumptions about growth, water availability and water infrastructure needs, without accounting for the effects of the new water use on existing users or on other values associated with the water.

F. Water Conservation and Sustainable Development Design Process

Unique to this project was the sustainable development strategy where water conservation was built into the overall development process along with clustered developments to preserve open space.

The development of Rancho Viejo was guided by Smart Growth principles, as outlined in the community's Vision Plan, which places great emphasis on:

- conserving water,
- protecting the environment,
- creating affordable housing and
- fostering economic vitality.

The community design demonstrates the full range of land stewardship, village design, affordability and sustainability principles which were documented also in the Community College District (CCD) Plan (Appendix G). Rancho Viejo's (RV) overall strategies for water conservation and reuse followed the principles of green development and established goals to conserve water at the community, village, neighborhood and home lots scales.

U.S. Green Building and LEED (Leadership in Energy and Design) strategies played a major part in the development of the Rancho Viejo community. Examples of the key strategies implemented include: reduced development footprints through clustered development to reduce paved surfaces, minimized disturbance of natural resources and maximize vegetated open space; shaded constructed surfaces with plant materials; preservation of natural stormwater channels and minimized runoff volumes; water efficient landscaping and use of native plant materials; water harvesting, graywater reuse systems, and aquifer recharge systems; construction phasing for soil erosion control and energy efficient home construction and appliances. In the context of managing stormwater, green infrastructure systems, (defined in this study as man-made systems that mimic natural approaches), were proposed in the form of bioswales, bio-detention ponds and permeable pavements.

Community Scale strategies included the protection of the arroyo recharge areas, protection of the hillside and open space vegetation to reduce erosion, prohibiting individual wells and septic tanks, and the clustering/concentration of development to reduce the area of disturbance and the amount of paved surfaces. Low density housing was developed in the more forested hillsides to preserve as much of the open space habitats and vegetation as possible. Village Scale strategies included a concentration of development on flat land, utilizing arroyo corridors for recharging ground water and to provide views, recreation and habitats. Other strategies included integrated drainage and infiltration systems with parks and open space, larger estate homes sighted into hillside vegetation, establish landscape zones to minimize irrigation needs, and irrigate common areas with treated effluent from on-site treatment plant. Rancho Viejo's holistic approach to water management is diagrammed in the sketch titled "A Water Plan for Future Generations" (Figure I-5). When all components are in place, the system will capture surface water for reuse and any wastewater will be treated to a high quality level and recharge the effluent into the aquifer.

Neighborhood Scale strategies included harvesting surface water runoff on roadways and open space parks, utilizing treated effluent for common area irrigation, monitoring phasing and site grading to minimize unnecessary disturbance of land and reduce topsoil erosion and subsequent silting of adjacent arroyo's, utilizing low water use shade trees in the streetscapes, and native and xeric plantings, limiting building envelopes in hillside construction, utilizing native vegetation to restore areas disturbed by the grading process and cool season turfs for higher use areas around plazas and playfields (Figure I-4).

Home and Lot Scale standard features in the first villages included underground rainwater cisterns, rain barrels, low water-use front yard landscaping, low water-use fixtures and appliances, and hot water circulating systems installed within the homes. In addition, the homeowners were required to meet the water conservation restrictions outlined in the Village Covenant, which limits the amount of irrigated landscape to 1,000 sq. ft., requires a landscape plan review for any new landscaping, requires all third party estate lots to include water harvesting, allows only native grasses for lawn areas and does not allow any swimming pools. Swimming pools are not allowed and this was found to influence home buyers decisions to purchase a home in the Rancho Viejo community. In 2003, Rancho Viejo launched a rain-water harvesting program for all new residences and retrofitting existing homes in the community. The rainwater harvesting program was one of the first programs of its kind, for a major subdivision in Santa Fe (Pino, 2012).

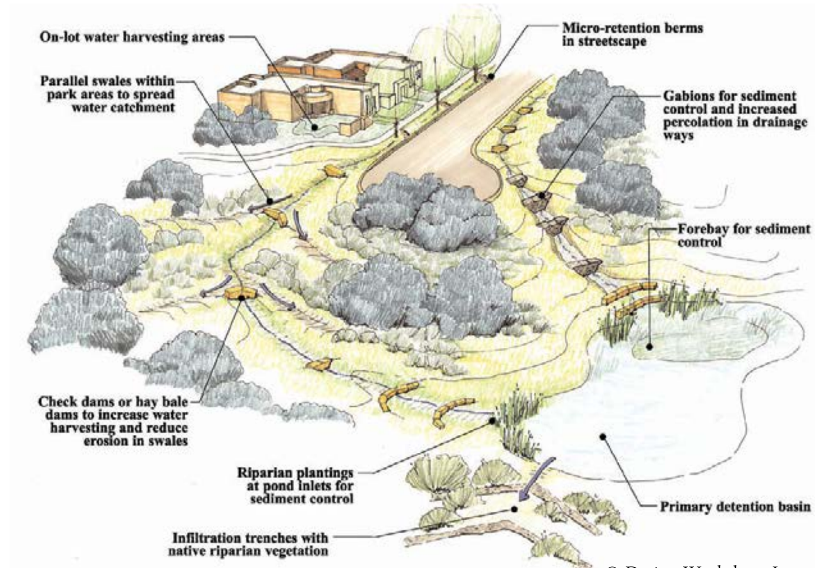

Figure I-4 Neighborhood Water Harvesting

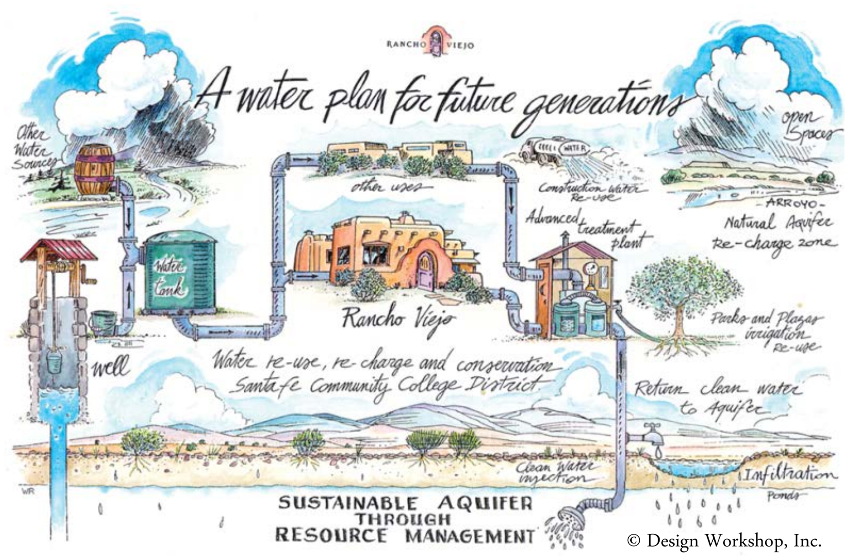

Figure I-5 Rancho Viejo Water Master Plan Diagram

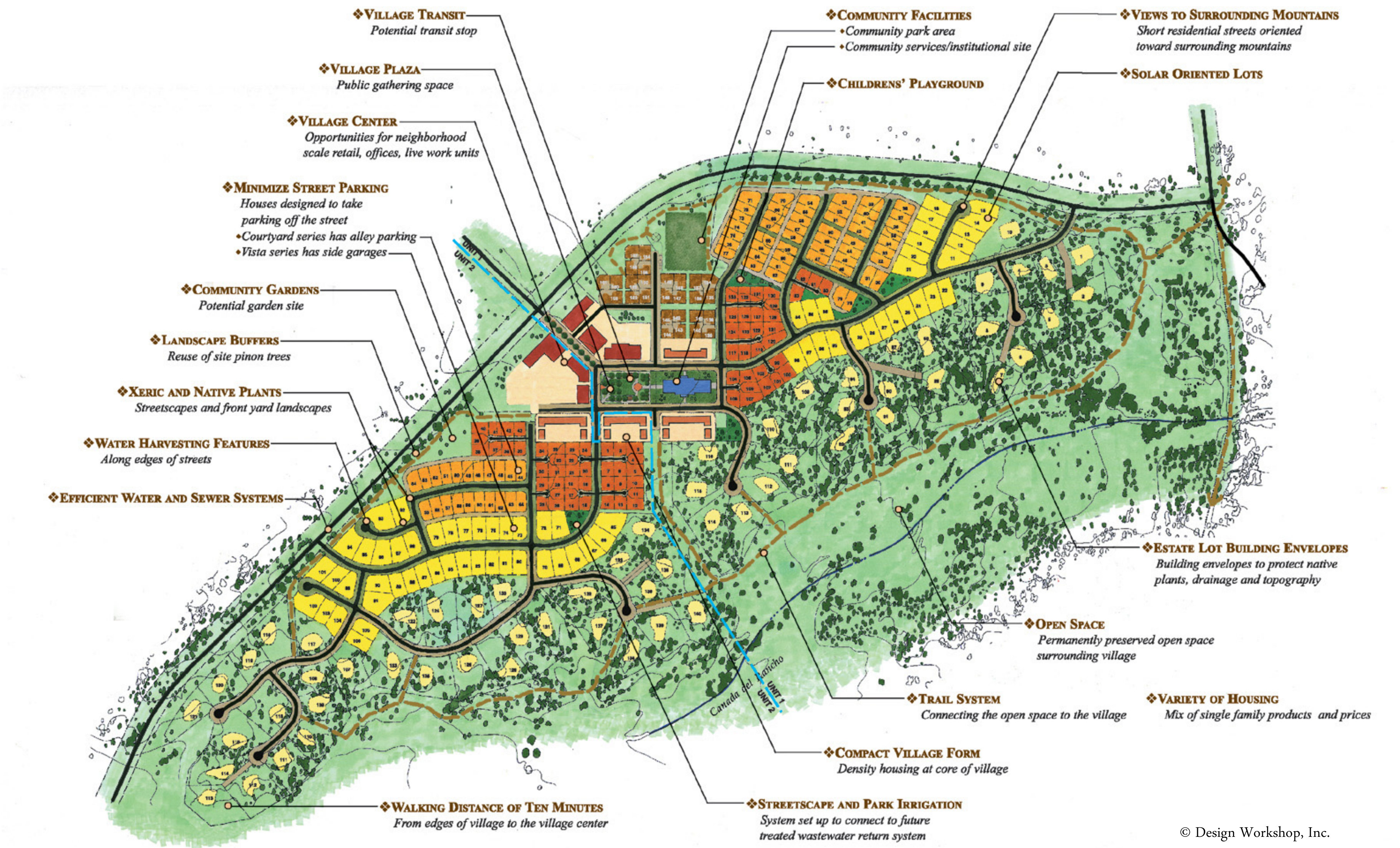

Figure I-6 Water Conservation Strategy Plan – Village 1 (Rancho Viejo North and South)

II. METHODOLOGY

The methods used to develop this case study included archival research of key documents on Rancho Viejo de Santa Fe, published reviews and case studies, internet searches, numerous visits to the community over the past ten years and the time spent working as a designer on the project from 1998 to 2004. In addition, awards descriptions and interviews with the designers, developers of the community, residents and users, landscape maintenance managers and HOA managers were used.

The objectives of the original study and the 2012 re-evaluation are:

- Determine which of the original surface water management and landscape vision goals have been achieved since 2002
- Document the perceptions, unique constraints, project success and limitation
- Document the lessons learned
- Present new strategies available to improve the sustainability of the surface water management and reuse onsite.

A. Summary of the 2003 Initial Study and Design Process

In November 2002, the developers and design team established the Rancho Viejo water conservation vision, which strives to "embrace the surrounding natural landscape as the foundation for Rancho Viejo's design; to utilize principles of ecological planning and sustainability; to recapture for future generations, the community and environmental patterns that have made historic Santa Fe a unique and special place" (Appendix F). From the onset, the project planners recognized that natural rainfall in New Mexico was a precious resource not to be wasted, but must be sustainably managed to sustain the project and the surrounding community and district. Surface water management was recognized as the tool to manage the rainfall runoff for beneficial purposes, including reduction of development costs, improved environments and habitats, return of water to the aquifer and potential increased sales performance.

As part of bringing the vision to reality, the 2003 Rancho Viejo Surface Water Management (SWM) Manual was developed as an early means of measuring the success of conserving natural resources. This document set the stage for the project team to be pro-active, improving and streamlining the process of designing, engineering and constructing a drainage system that serves as a community amenity.

The original study started in late 2002, after the Community College District Plan was approved by the County and the first community village, Rancho Viejo North, was under construction. The study was then set aside in 2004, due to the author's professional demands and was resumed in 2011. The delay created an opportunity to revisit the Rancho Viejo project and observe what had transpired since the start of construction in 1998.

The SWM Manual is only one of five documents that make up the Rancho Viejo Water Plan. The other four plans are: The Water Master Plan, which includes the overall water budget and plans for reuse and aquifer recharge of treated effluent (Figure I-5); The Landscape Vision Plan documents the culture and specifications for low water use native landscapes; The Common Area Landscape and Irrigation Plan describes the use of native landscapes and graywater irrigation systems in the village parks and open space areas to minimize irrigation; and The Domestic Conservation Plan describes the wise use of water within individual homes. An extra tool created in the later stages of the initial study was the Rancho Viejo's Water and Wastewater Management Plan, which was designed to address supply and recharge of the aquifer and the technologies necessary to achieve a conjunctive approach to providing these goals and strategies.

Work Sessions: The development teams' water management goals and strategies were a product of bi-weekly work sessions with the primary project team members, starting in November 2002 and led by the author. As an outcome of these discussions, the Water Management Philosophy was defined as: "Natural rainfall is a precious resource and should be managed to sustain the project and the surrounding community and district. Surface water management is the opportunity to manage the rainfall runoff for beneficial purposes including reduction of development costs, increased sales performance, improved environments and habitats, and a return of water to the aquifer," (Appendix F). The primary benefits identified by the team during the work sessions included: potential reduction in development costs; increased sales performance for a more environmentally responsible development; improvement of the environment and habitats; and return of water to the aquifer.

The "lessons learned" discussions with the developer, contractors and design team centered on the viability of the surface water management and related site preparation and landscape construction techniques tested on the first two villages constructed. This discussion resulted in the development of site management and construction standards for each stage of site stormwater and drainage design and management from when water hits the roof to where it leaves the site and identification of the next steps in improving drainage and runoff reuse onsite. More meetings were held with the project civil engineer, who addressed specific issues of grading, the drain system design, and erosion control; with Tall Grass Restoration, the firm that assisted in evaluating native grass restoration efforts; and with staff from the Santa Fe County and State of New Mexico Environment Department, who provided valuable information on the potential changes to the State Water Plan and their support for our efforts.

Principles and Goals of Surface Water Management: Three widely accepted practices and principles of a sustainable surface water management program were critical in developing the strategies outlined in the SWM Manual: 1) Capture water as close to where it falls as is practical 2) reuse water as close to the source as possible and in the best manner, and 3) avoid creating concentrated runoff and subsequent erosion and sediment transportation (Appendix F). These principles guided implementation in the first three villages constructed at Rancho Viejo and were used to evaluate the success of the development.

The developers of Rancho Viejo established seven major goals for surface water management:

1. Maximize the usable land on residential lots.
2. Reduce the impact on natural resources, mainly water, soils and native plants
3. Capture the sites' potential energy and resources through the collection and reuse of site stormwater runoff.
4. Create storm-water management systems that are sustainable, functional and when visible to the public, aesthetically pleasing.
5. Meet new NPDES requirements for water management.
6. Work towards returning storm-water to the aquifer and receiving water credits for achieving this.
7. Establish a process to strategically improve the surface-water management system in each phase of development.

In addition, there are three goals from the Rancho Viejo Landscape Vision Document related to sustainable strategies that are reviewed in this study:

1. To limit disturbance of open space areas, maintaining the character of the land and preserving native plants
2. To create an aesthetically pleasing and sustainable landscape,
3. To use water resources efficiently and sustainably, by reducing the use of potable water for common area irrigation, utilizing the landscape and streetscape grading to capturing and reusing storm water.

The 2003 study addressed the questions of:

1. How does Rancho Viejo define sustainability and what are the developer's vision and goals for surface water management and reuse?
2. What was unique in the project vision and planning process that contributed to the successful development of this Green community?
3. What benefits can be gained from this process?
4. What regulatory guidelines must be met for water management on site?
5. What strategies and techniques should be implemented to meet the goals established by the developers for current and future development on site?
6. What are the lessons learned from the testing of stormwater drainage and water harvesting systems, erosion control methods and associated landscape design techniques of the first 5 years that Rancho Viejo was under development?

Documentation: One of the tools used to document the findings was a checklist/matrix, which identifies recommended strategies and specific details of how to and what was actually implemented to meet the goals and vision of Rancho Viejo, the State of New Mexico water use guidelines, requirements of the NPDES and EPA regulations, LEED standards and other green building guidelines available at the time of the study.

The 2003 Surface Water Manual Checklist is organized by:

1.0 Village Master Plan –Preliminary grading process and schematic drainage plan.

2.0 Architecture – Roof design and materials, roof drain distribution systems, and maintenance of these systems.

3.0 Lot Design – Water distribution Systems including natural catchment and constructed ground water storage systems; Planting design, irrigation design, and hardscape design; Lot sediment and erosion control; and the maintenance and monitoring of these systems.

4.0 Village Roadways and Open Space – Roadway hardscape, curb and gutter design, grading of shoulders and parkways, culverts and outfalls, and the maintenance of these systems. Open space design including soil conservation, planting of roadways and adjacent drainageways, detention basin design, and the maintenance of these systems.

As part of the 2003 manual's development process, implemented details were reviewed, new approaches for the surface-water management systems were researched and tested, lessons learned were documented, and goals for future developments were established as standards for each surface drainage source. The next steps in improving the efficiency, sustainability, and aesthetics of the system (Appendix F), are also identified as part of the implementation process. The key recommendations for improvement included preparation of lot grading plans, drainage and erosion control plans for each phase of development, recommendations for collaboration with the contractors to protect the native landscape, coordination with engineers for non-traditional drainage swale design and lot grading, use of erosion control techniques such as crimping, ladders, riffles to slow water flows, redesign of rooftops to allow for water catchment, increased monitoring of erosion control systems, and more frequent maintenance of culvert and swales, and more appropriate maintenance of native landscapes to ensure their survival and establishment.

The Rancho Viejo Surface Water Management Manual was reviewed and approved by the developer and project team for use in the development and implementation process in July, 2003.

Literature Review: The methods used to develop the original case study included archival research of key documents on Rancho Viejo de Santa Fe, published reviews and internet searches, and award descriptions. Literature reviews mainly focused on sustainable community planning processes, strategies and technologies such as rainwater harvesting, green infrastructure, green streets, and sustainable irrigation technology being tested that improve site water conservation and surface water management and reuse. The cases studied in 2003, allowed the author to review similar projects in semi-arid or arid climates. These studies were used to guide the design guidelines and recommendations for future design, construction and management at Rancho Viejo.

B. Summary of the 2012 Re-evaluation Study Process

The 2012 study re-evaluates the goals and strategies put forth in the 2003 Surface Water Management Manual documents the changes, successes and challenges of installing and maintaining the water conservation methodology proposed.

The 2012 Re-evaluation Study addresses the following research questions:

1. How much of the sustainable site design, construction techniques and recommended strategies outlined in the 2003 SWM Manual were implemented and to what extent?
2. How did climate changes and other environmental factors influence the design process and approach?
3. How has the planning process and site design process contributed to the protection of habitat and natural resources at Rancho Viejo.
4. What were the successes and challenges of implementing these strategies at Rancho Viejo over the first 10 years of its development in supplying each community with enough water to sustain an attractive, low water-use and native landscape?
5. What other factors have influenced the success of the planning and design process and implementation strategies proposed?
6. What other new and progressive strategies are being explored to improve the success of surface water management in other residential communities in arid environments.

The methodology used to re-evaluate the Rancho Viejo case study in 2012 included:

1. Twelve interviews of key representatives from the past and current owner/development companies, the communities Home Owners Associations (HOA) managers, the lead home sales/qualifying broker and landscape committee member/homeowner, landscape maintenance contractor and representative homeowners from the three major Rancho Viejo villages (Appendix C).
2. Site observation photographic documentation
3. Literature and comparable project case study reviews. The literature review conducted during the 2012 re-evaluation study allowed the author to review other case studies for the lessons learned and innovative strategies they had tested to incorporate the principles of sustainability and specifically water conservation in the site design of residential developments in the west.
4. Identification and evaluation of other influencing factors affecting the successful implementation of the surface water management strategies including:
   a. Impact of Climate and Soils
   b. Economic Changes
   c. Public Agency Requirements
   d. Homeowner Satisfaction and Perception
   e. Educating the Team and Homeowners
5. Applying LEED Strategies
6. Summary of Innovation

III. LITERATURE REVIEW

A. Introduction

Sustainability was just becoming a popular concept when Rancho Viejo was first conceived. *The Brundtland Report*, published just eight years prior by the United Nations World Commission, defined sustainability as, "a development that meets the needs of the present without compromising the needs of the future generation to meet their own needs." Sustainability really didn't receive global attention until it was addressed at the 1992 Earth Summit. In 1996, at the start of the Rancho Viejo planning process, this broad definition was refined to describe sustainable communities as those that protect and preserve important resources, reduce necessary consumption of global resources and recycle their used resources. This definition was used to guide the development philosophy of Rancho Viejo, which strives to contribute to the harmonious long-term growth of Santa Fe through planning, patient development and respect for the land and its resources. They further refined this philosophy to a working approach for developing the surface-water management system at Rancho Viejo, which was to go beyond the basic strategies of sustainable design and instead strive to re-establish the natural processes necessary to sustain ecologic, soil and cultural systems.

The increase in published resources on sustainability strategies for green communities has grown considerably since the start of this study in 2003. However, landscape architects and engineers can only go so far in achieving sustainability. Other professionals, developers and leaders are needed to change water use habits and desires that can persuade the residents of residential communities that strive for a green status. A sustainability plan is, in essence, a road map that lays a foundation for sustainable planning and land-based water management. It defines and illustrates an organizational philosophy toward sustainability through an established vision and policy, goals, strategies, and metrics to improve practices associated with watershed management, energy use, transportation, solid waste, water consumption, and other areas (Rio Rancho, 2003).

In *Developing Sustainable Planned Communities*, the authors challenge the readers to visualize an entire community conceived and constructed in harmony with nature. Whether referred to as a "green" or "environmentally sensitive," a sustainable community can produce environmentally friendly, economically profitable, and socially sustainable developments that benefit residents, developers, and the planet (Franco, Gause, Heid, Kellenberg, Kingsbury, McMahon, Schweitzer, Slone, & Rose (2007). It is the responsibility of the profession to persuade people that living landscapes are an investment of water (and other resources) to reap the environmental services of air-cleansing, water-purifying, soil-holding, heat-reducing they provide. It is not enough simply to use less water in the landscape; the water we do use must provide more benefits while using less. Kevin Sorvig refers to this as land-based water management, which approaches water not as a substance, but as a system at a watershed level (Sorvig, 2012).

In the article, "Nature in the City," Harrison suggested a holistic knowledge of the impact of landscape design and management practices on overall ecosystem function was essential to ensure that landscapes, especially those that are structured in residential land uses, are conceived and managed in a sustainable manner (Harrison, Limb, & Burgess, 1987). Another holistic approach is in the search for sustainability is the concept of "Deep Design," which demands that we look beyond the visually obvious or superficial. In Forman and Godron's seminal book *Landscape Ecology*, they describe deep design as a concept that is firmly bedded in the ideas of landscape ecology that focuses on the site's structure, its functions and processes of change over time (Forman & Godron 1986, p. 11). In his article, "Can Floating Seeds Make Deep Forms," Lyle, however, questions the imagery or scenery concepts generated by the traditional definitions of landscape and argues that the definition of landscape should be: "Landscape is the visible manifestation of an ecosystem." To generate deep form requires a rational understanding of natural systems in combination with intuitive imagery, and resulting in a design process that combines high levels of both analytical and creative thinking. The right and left sides of the brain come into alternating play, each feeding off the other (Lyle 1991, p. 40).

B. Water Management

In a 2012 article in *Landscape Architecture Magazine*, Kevin Sorvig, author and resident of Santa Fe, New Mexico, described water as the new oil. He notes that as early as 1998, Senator Paul Simon predicted that future wars will be about water more than oil. Fresh water is a precious rarity and around 80 percent of the world's populations today live in areas facing near-term threats to "water security." Climate change is anticipated to decrease water availability and often living landscapes contribute to drought and worse problems rather than solving them. This is not always the case with a healthy, sustainable landscape which can provide environmental services and water resource assets. Sustainable community planning and landscape design have contributed to a decrease in water waste and have offered up some interesting water conservation and management strategies. The green building industry movement has discovered and rediscovered dozens of ways to conserve, protect and enhance water on site using porous paving, structural soils, green roofs and green walls, constructed wetlands, graywater collection (Sorvig, 2012).

Stormwater and surface water management have critical implication for water quality and quantity. In watershed that include urban drainage systems. Large volumes of polluted stormwater are directed into expensive infrastructure systems often overwhelming the systems. Kristina Hill, in "Urban Design and Urban Water Ecosystems," discusses the potential for a greening of infrastructure using roofs, roads and right-of-ways to filter pollutions from stormwater before they enter the larger water systems. Of particular interest was her use of a typology of upland, network and shoreline sites to convey a hierarchy of urban stormwater management to convey and receive stormwater runoff. Small scale retention of stormwater is especially effective in reducing flows lower in the watershed. She proposes that the mimicry of ecological functions that existed prior to development may be the best way for an upland site to serve the purpose of improving regional infiltration and reducing downstream effects (Hill, 2009).

The opportunity to use street right-of-ways to alter the public landscape and improve hydrologic function is a strategy proposed by many of the authors reviewed. Hill (2009) states that by reviewing the network of systems that handle surface water from upland sites into channelized networks of flow, including curbs, ditches, underground infrastructure and other systems, we have an excellent opportunity to intervene in these flows to reduce the downstream impacts. Systems such as vegetated swales provide detention and filtration back into the aquifers. Even in locations with limited land resources, planning and design efforts can strategically use open space to capture and filter stormwater or surface water runoff.

Similarly, Sorvig proposes that carefully graded landscapes can harvest precipitation rather than creating runoff problems. Landscapes can take mildly polluted water such as graywater and filter it through their system yielding purified water to aquifers or the atmosphere (Sorvig, 2012). Some of these systems are based on ancient water management system, but with modern technology become very effective techniques for green infrastructure and water harvesting. Other literature supports innovative solutions that use open space or landscape as an alternative surface water management mechanism to harvest the benefits of this resource.

Innovative design, although developed in a specific environment can often translate to successful ideas in other climates and geographies. The case study by Justus Kitha and Anna Lyth of an arid location in Kenya, proposed green infrastructure that serves to reduce stormwater runoff and subsequent flooding as well provides wildlife habitat. These approaches to stormwater management and climate adaption may be applicable to other communities with expansive open space and limited capital resources (Lyth and Kitha 2011). Julie Nakashima's article, "Developers Creating New Ways to Deal with Stormwater Runoff," describes the innovative stormwater capture systems being installed in places like San Antonio, which include a series of vaults built beneath the pedestrian streetscape to collect and store site-generated runoff and graywater, serving as a water supply to maintain a constant water level in adjacent rain gardens and replace water lost due to evapotranspiration. These are sometimes called bio-canals and are used to create more of an urban architectural aesthetic (Nakashima, 2007).

Green Infrastructure is a concept originating in the United States in the mid-1990s that highlights the importance of the natural environment in decisions about land planning. Benefits of green infrastructure typically include clean water, healthy soils, more open space, and the potential to provide shade. The United States Environmental Protection Agency (EPA) has extended the concept to apply to the management of stormwater runoff at the local level by using natural systems, or engineered systems that mimic natural systems, to treat polluted runoff. The term Green Infrastructure is used to describe how networks of natural ecosystems also function as crucial community infrastructure, providing ecosystem services and improving environmental sustainability. In the context of managing stormwater, green infrastructure can be defined as man-made systems that mimic natural approaches. Green roofs, bioswales, bio-retention ponds and permeable pavements are a few key examples of local green infrastructure, and all work by turning hard asphalt surfaces into green, absorbent ones. Bioswales and retention ponds can absorb water and channel or hold excess run-off, cleansing pollutants in the process. However, even just adding extra trees, which consume large quantities of water, can help in achieving this goal. Evergreens and conifers were found to intercept 35 percent of water hitting them. While single-purpose gray stormwater infrastructure is largely designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while delivering many other environmental, social, and economic benefits, according to the EPA (EPA, 2012).

Other approaches suggested for water management include Incentive and Choice water-budget laws versus Command & Control Regulations. Jim Knopf in his presentation "Stop Overwatering!" at the 2000 Xeriscape Conference in New Mexico recommended Budget-based regulations which managing water-use directly, by establishing a generous water budget for communities that is based on actual experience in maintaining various landscapes types. The budgets are based on gallons of water applied per square foot of landscape areas, and the water providing agency quickly becomes a partner in wise use of water. Budgets can be fixed (based on average monthly conditions) or they can vary with the weather during the billing period (Knopf, 2000).

C. Soil Improvement

The New Mexico Office of the State Engineer and Soil Conservation Service records indicate that New Mexico's soils typically lack the organic matter necessary to provide sufficient plant nutrients and water retention. Native plants tend to need less organic matter than adapted plants, but most plants benefit from the addition of some organic matter, such as compost, into the soil. Compost helps sandy soils retain water and helps clay-dominated soils drain faster. When water mixes with compost in soil, the resultant carbonic acid dissolves the 18 essential elements typically found in compost so that plant roots can more easily take up these nutrients. Compost also aerates the soil so that plant roots can maintain their optimal moisture content. In these improved conditions, the insects, microorganisms and mycelium found in healthy soil can thrive, so plants can establish themselves quickly in the landscape (Chaplinski, 2011).

In the handbook, *The Case for Sustainable Landscapes*, they report that the undervaluation of soils is one of the most significant failings of the conventional development approach. For example, a frequent consequence of standard construction practices is compaction of the soil, which seriously damages soil structure by shrinking the spaces between soil particles available for air and water. If not restored, compacted soil can start a spiral of degradation. Compacted soil particles restrict a plant's root growth and its access to nutrients, and soils are less able to absorb water, which reduces the recharge of groundwater and aquifers. Sustainable practices of stewardship such as improving soil conditions can reverse the effects, preserving and restoring ecosystems so they function in ways that promote both human well-being and the continued existence of other species on the planet. Removing existing vegetation disturbs soils and has other consequences as well. Without vegetation, a site loses its natural capacity for stormwater management, filtration, and groundwater recharge. Reduced vegetative cover also affects soil health, because vegetation maintains soil structure, contributes to soil organic matter, and prevents erosion and sediment runoff (ASLA, 2009).

A key contributor to the degradation of the native landscapes is the typical mass grading approaches to site development. David Venhuizen, in his presentation on *Innovative Ways to Conserve Water*, states that mass grading smoothes out the hydrologic roughness of the landscape, which causes more runoff and less infiltration and therefore, less moisture being stored in soil and subsequently a greater need for larger infrastructure systems. Low impact development strategies aim to retain/restore site hydrology, and bioretention-based stormwater systems restore hydrologic roughness to the site, capturing and holding water in a way that is more similar to native conditions (Venhuizen, 2006).

D. Rainwater Harvesting

In many cities and towns around the country, the trend has been to undervalue our rainfall, treating it as waste to be funneled directly from roof gutters to storm sewers. In older cities, this stormwater flows into combined sewer/stormwater systems that flow to water treatment plants, thus raising the cost of purifying drinking water. Rather than getting rid of stormwater runoff as quickly as possible, a sustainable approach to stormwater management is to find ways to capture it on site and use it for irrigation, groundwater recharge and drinking water. A sustainable approach to landscape design would reduce or eliminate the use of potable water or the drawing off of natural surface water for irrigation once plants are established. The challenge with this is getting homeowners to understand this process for their own landscapes and training HOA managers and landscape maintenance contractors in this practice. At Rancho Viejo, this was a repeating issue in the management of the native grasses that were to be weaned off of water once established. By the second year, there was no one designated to follow up with the landscape maintenance team to ensure the specification for this cutting back of water was properly implemented.

There is considerable literature supporting the use of rooftop rainwater harvesting, along with other outdoor water reuse practices to reduce the demands on municipal water systems and our aquifers. One major resource reviewed was from The New Mexico Office of the State Engineer (NMOSE). New Mexico has had, since the start of the original study at Rancho Viejo, significant water challenges, which has led to renewed interest statewide in the concept of rainwater harvesting and the use of cisterns. During the hottest summer months in New Mexico, more than half of the total metropolitan water use in residential neighborhoods in Albuquerque goes toward landscape irrigation.

In their 2009 Report, "Roof Reliant Landscaping," the NMOSE proposes the use of a wise and efficient use of the state's water resources and encourage the harvesting, collection and use of rainwater from residential and commercial roof surfaces for on-site landscape irrigation and other on-site domestic uses. The report states that the collection of water harvested in this manner should not reduce the amount of runoff that would have occurred from the site in its natural, pre-development state. Harvested rainwater may not be appropriated for any other uses. They use the term "rainwater harvesting" primarily to describe a landscaping strategy designed to capture rooftop precipitation for irrigation of the landscape, reducing the need for supplemental potable water.

As the agency charged with administering the state's water supply, the New Mexico Office of the State Engineer was promoting in this report a variety of water conservation strategies. One strategy they felt had excellent potential for significant water conservation is the Roof-Reliant Landscaping method which emphasizes the use of xeriscape techniques (NMOSE, 2009). This is primarily describing a system of capturing natural precipitation from roofs and the rain and runoff that falls on plants and ground surfaces, which are then routed to a cistern system for reuse in the landscape. The NMOSE is encouraging homeowners to transition their structures and landscapes to this type of system which in the long term, creates totally roof-reliant landscapes that require no supplemental irrigation, including surface water or groundwater. Plants that require no supplemental water are called "precipitation only" plants. Landscapes are defined as "primarily" roof-reliant when the associated plants get over 75% of their water from natural precipitation off a nearby roof during the first five years after the plants have been installed. This approach requires some knowledge of appropriate native and adapted plant material and water-conserving landscaping techniques is crucial, and may require similar more guidelines for homeowners to ensure these systems can be maintained over time (NMOSE, 2009). One key issue with installing these systems is maintenance and resale of homes with these systems. New homeowners do not always understand the management of water harvesting systems that come with their homes, failing to and promptly abandon them.

E. Irrigation

No matter how great the waterwise landscape, it cannot save water, if it is overwatered. To save water, both the design and the irrigation must be waterwise. New Mexico, California and other states of the arid Southwest have often dealt with the need to be waterwise as a challenge for freshwater resources scarcity has only been exacerbated by prolonged periods of drought in recent years. The use of inefficient irrigation systems is cited by the Sustainable Sites Initiative's, "Case for Sustainable Landscapes" as a major contributor to the imbalance of our water resources. They state that irrigation of unsustainable landscapes accounts for more than a third of residential water use, which is more than 7 billion gallons of potable water per day nationwide. With the compaction of soil a common condition in developed areas, the infiltration rates of water are significantly reduced, causing much of the water used to irrigate lawns to end up as runoff or evaporation instead of filtering down to recharge the water table (SITES, 2009). Irrigation efficiency, however, has also made impressive progress since Rancho Viejo was first designed and is one of the most-improved industries when it comes to water conservation. It has pushed water-saving standards and practices that have led to innovations such as smart controllers and leak-sensing systems. A case study of Utah's Daybreak community by Ales Ulam, describes a new sophisticated irrigation emitter that is used to monitor and control water usage to such a fine degree that there is virtually zero runoff onto curbs or into gutters, and trees that are fitted with radio frequency microchips to provide a living database that catalogs the tree's age, health status and size and as a result has significantly reduced tree mortality rates (Ulam, 2010).

F. Effectiveness of Water Conservation Programs

Understanding water use patterns, and stormwater management according a study by Andrea Hart in 2009, has been explored in professional literature for many years as communities have contended with decreasing supplies or increasing demands from growing populations. Within the United States, many of the water use studies have focused on the arid Southwest, which has experienced significant population growth and subsequently strained water resources (Hart, 2009). This interest has led to hundreds of scholarly and practitioner articles on topics such as investigating tested and new strategies for water resource management, reducing water use, the spread and effect of low-flow appliances and the effect of bans on certain water practices.

Peter Gleick's (2011) study showed that water taken from the Colorado River watershed now meets some or all the needs of almost 35 million people living both within and outside of the actual basin, including Las Vegas, Phoenix St. George, Cheyenne, Denver, Albuquerque, Salt Lake City, Los Angeles, San Diego, and Tijuana. From 1990 to 2008, total municipal water deliveries from the Colorado River basin increased by more than 600,000 acre-feet (from 2.8 to 3.4 million acre-feet; deliveries from all sources rose from about 6.1 to 6.7 million acre-feet), a rate much slower than population growth. If water deliveries had increased at the same rate as population growth, they would have grown by almost two million acre-feet – an amount of water simply not available for delivery.

During the same period, per-capita water delivery rates declined dramatically in many populated areas, such as Albuquerque (38%); Southern Nevada/Las Vegas

(31%); Phoenix (30%); and San Diego County (29%). Southern California agencies delivered 4% less water in 2008 than they did in 1990, despite delivering water to almost 3.6 million more people. In fact, 28 water agencies in five different states delivered less *total* water in 2008 than they did in 1990 despite population growth in their service areas. And almost every one of the water agencies included in the study experienced declines in per-capita deliveries. Projecting future water demands should take into account the successes achieved in cities where there are many examples of water conservation in practice that could be adopted or emulated by the less water efficient providers (Gleick, 2011).

G. Aesthetics

There are many notable projects that elevate stormwater management to an art form and the best examples use this resource as the central organizing principle for the site development. In Stuart Echol's study, "Artful Rainwater Design in the Urban Landscape," he explores the idea of designing new stormwater management techniques that focus on non-point source pollution, water balance, and small-storm hydrology can be used to create projects resulting in greater user satisfaction and perceived value. He examines in this study exemplary artful rainwater designs and draws attention to the valuable project attributes common to artful rainwater design projects by clarifying specific project approaches that can enhance the value of stormwater management systems. The article includes specific project examples to illustrate these project attributes and design possibilities. Echols notes that more and more national and municipal regulations demand that stormwater runoff quantity and quality be addressed in site design to ensure a beneficial impact on natural systems. Additionally, some forward-thinking and innovative municipal officials and designers recognize that on-site stormwater treatment systems can be designed in such a way to create site amenities; the rainwater itself, therefore, becomes a feature that can engage, educate, and even entertain visitors (Echols, 2007).

Cost often is a factor in how surface water is handled and at times may limit the opportunity for creating artful runoff gardens or green streets. Weaving together the sculptural presence and an ecological process is something we can strive more for in the future. Making the surface water management process visible works best in less arid climates where evapotranspiration is desirable. In New Mexico, the goal is to capture as much of the surface water as possible to return it to the aquifer or use it to nourish plantings and natural stream systems, however, homeowners can collect and retain rainfall captured on their lots. This is an opportunity for creative integration of native landscape and natural catchment systems.

Integrated-site stormwater solutions, particularly through site planning, grading design, and planting with native species, has resulted in many successful and varied landscape designs. However, in his article, "The Experience of Sustainable Landscapes,“ Robert Thayer states that at the opposite end of the spectrum, applying a native arroyo stream bank plant association, for example, verbatim to a more urban drainage swale ignores the fundamental addition of human use to the ecological equation. Making such a constructed ecosystem look "natural" does not necessarily improve its sustainability. Sustainable landscapes represent a higher level of complexity than typical residential landscapes and incorporate ecological relationships that may be difficult to observe. It is therefore more important to give them a look of creative interpretation, which is where the landscape architects are critically needed (Thayer, 1989).

H. Designing for Future Sustainable Landscapes

In the past ten years, new resources have emerged to aid professionals in aligning land development and management practices with the functions of healthy ecosystems, and evaluating successful design strategies for water management and other sustainable practices.

Low-Impact Development (LID) is a stormwater management approach that seeks to manage runoff using distributed and decentralized micro-scale controls. LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Instead of conveying and treating stormwater solely in large end-of-pipe facilities located at the bottom of drainage areas, LID addresses stormwater through small-scale landscape practices and design approaches that preserve natural drainage features and patterns. Several elements of LID—such as preserving natural drainage and landscape features are also part of the Green Infrastructure approach (CWP, 2011).

Green Infrastructure refers to natural systems that capture, cleanse and reduce stormwater runoff using plants, soils and microbes. On the regional scale, green infrastructure consists of the interconnected network of open spaces and natural areas (such as forested areas, floodplains and wetlands) that improve water quality while providing recreational opportunities, wildlife habitat, air quality and urban heat island benefits, and other community benefits. At the site scale, green infrastructure consists of site-specific management practices (such as interconnected natural areas) that are designed to maintain natural hydrologic functions by absorbing and infiltrating precipitation where it falls (CWP, 2011).

Environmental Site Design (ESD), also referred to as Better Site Design (BSD), is an effort to mimic natural systems along the whole stormwater flow path through combined application of a series of design principles throughout the development site. The objective is to replicate forest or natural hydrology and water quality. ESD practices are considered at the earliest stages of design, implemented during construction and sustained in the future as a low maintenance natural system. Each ESD practice incrementally reduces the volume of stormwater on its way to the stream, thereby reducing the amount of conventional stormwater infrastructure required. Example practices include preserving natural areas, minimizing and disconnecting impervious cover, minimizing land disturbance, conservation (or cluster) design, using vegetated channels and areas to treat stormwater, and incorporating transit, shared parking, and bicycle facilities to allow lower parking ratios (CWP, 2011).

The LEED (Leadership in Energy and Environmental Design) Green Building Ratings System for New Construction was only just being developed when the Rancho Viejo project was conceived. LEED provides a means of assessing whether the stormwater management process implemented meets the national standard for "green" construction. For New Construction Site Development, categories includes ratings for Sustainable Site design, which addresses stormwater management and site selection; Water Efficiency, which addresses water efficient landscaping and water use reduction; and encourages innovation in design to improve water use efficiency.

In the handbook, *USGBC LEED Core Concepts*, it states that impervious surfaces are the fastest growing source of surface water degradation. This is due to both a decrease in infiltration and the buildup on landscape areas of contaminants that are concentrated in surface runoff during heavy rainfall. Increased urbanization and development typically lead to more hardscape and impervious surfaces, which in turn increase stormwater runoff which can accelerate erosion, resulting in particulates and chemicals being carried into nearby water sources such as streams and rivers. The handbook also addresses site construction methods that frequently disturb the site's natural ecological system. It states that the loss of existing habitat can be devastating due to the ecological services they provide in effective stormwater management and biodiversity of both plant and animal species. The introduction of nonnative plant species can require irrigation and chemicals, both of which threaten the quantity and quality of available water (USGBC, 2009).

Another tool for evaluation was described in the handbook, *The Case for Sustainable Landscapes*, prepared by the interdisciplinary partnership of the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center, and the United States Botanic Garden. The new evaluation system, The Sustainable Sites Initiative (SITES): Guidelines and Performance Benchmarks, provides a guideline for sustainable land practices that are grounded in rigorous science and can be applied on a site-by-site basis nationwide. The authors of the publication acknowledge that different regions of the country will have different requirements and therefore the evaluation system includes performance levels appropriate to each region as needed. Moreover, they propose that adopting such sustainable practices not only helps the environment but also enhances human health and well-being and is economically cost-effective. The impetus for creating the guidelines came from the recognition that although buildings have national standards for "green" construction, little existed for the space beyond the building skin. Modeled after the LEED® (Leadership in Energy and Environmental Design) Green Building Rating System™ of the U.S. Green Building Council, the Initiative's rating system gives credits for the sustainable use of water, the conservation of soils, wise choices of vegetation and materials, and design that supports human health and well-being. Landscape Architects have long been frustrated by the lack of such detail rating information in the LEED Rating System (ASLA, 2009). However, having two rating systems to coordinate is not particularly desirable. The U.S. Green Building Council plans to incorporate the Sustainable Sites benchmarks into future versions of its LEED® (Leadership in Energy and Environmental Design) rating system, hopefully in the near future is a positive solution.

In *The Case for Sustainable Landscapes*, the authors propose that the elements in a functioning ecosystem are so highly interconnected that unsustainable approaches to land development and management practices can have a devastating ripple effect throughout the system. They provide examples of sustainable approaches that demonstrate how thoughtful design, construction, operations, and maintenance can enhance and restore ecosystem services that would otherwise be lost. By aligning land development and management practices with the functions of healthy ecosystems, the Sustainable Sites Initiative believes that developers, property owners, site managers, and others can restore or enhance the ecosystem services provided by their built landscapes. Moreover, adopting such sustainable practices not only helps the environment but also enhances human health and well-being and is economically cost-effective (SITES, 2009).

I. Innovation

In the book, *Green Streets – Innovative Solutions for Stormwater and Stream Crossings*, prepared by the Oregon Metro, a green street design approach is proposed as a unique way of assessing sustainable street design alternative by integrating various solutions. This design approach tries to blend the natural hydrological cycle within the designed landscape and may be applicable to both new streets and existing streets. The authors suggest that a green street provides a more complete integration of necessary functions like water quality treatment along with high flow conveyance, with considerable savings when it comes to "end of pipe" treatment by reducing extra cost for stormwater pipes and treatment. The handbook communicates basic stormwater management concepts, case study examples of how this approach has been successful elsewhere, practical design solutions and methodologies and a strategy for implementation of "green" streets in the Portland metro region (Metro, 2002). Although many of the strategies proposed are often for managing large volumes of runoff, these techniques can often be modified for use in more arid environments.

Green streets is just one component of a larger watershed approach to improving the region's water quality; designed to incorporate a system of stormwater treatment within its right of way; minimizes the quantity of water that is piped directly to streams and rivers; makes visible a system of "green" infrastructure; incorporates the stormwater system into the aesthetics of the community; maximizes the use of street tree coverage for stormwater interception and temperature mitigation and air quality improvement; at points where it crosses a stream or other sensitive area, a green street is located and designed to ensure the least impact on its surroundings; and requires a more broad-based alliance for its planning, funding, maintenance and monitoring (Metro, 2002).

The basic concept of stormwater treatment, according to Metro, is not complicated. The goal is to restore the hydrological cycle as much as possible. What does become complicated is the breadth of issues involved once the land becomes urbanized.
The goals of a green street approach included:

- Maintain and restore natural processes
- Conserve, protect and restore habitat quantity and quality
- Improve water quality
- Promote local street connectivity
- Use public right-of-ways for multiple purposes
- Provide permittable cost effective solutions
- Foster unique and attractive streetscapes that protect and enhance neighborhood livability
- Educate the public and monitor environmental benefits through pilot projects.

Arthur Allen notes in the article, "Law of the (Dry) Land," that rainy places like Seattle and Philadelphia, are embracing the idea of retaining stormwater in swales, rain gardens and green roofs as innovative ways to reduce scouring floods, removing pollution from the rivers, and expanding park areas (Allen, 2012). But in the arid West, given water's scarcity, water law is structured to deal with problems of quantity, not quality. Colorado and New Mexico's Water Laws are particularly tough. Water that isn't consumed must go back into the aquifer so the next person downstream can use it. Water captured off your property therefore, is not yours to use. A new pilot project in Colorado, is testing an exception to this rule, at Sterling Ranch, a new 3,4000-acre development south of Denver, that when completed will include over 12,000 residences. The project is expected to start breaking ground in 2014 and the planners are targeting a 0.286 acre-feet of water consumption per household, which would be a dramatic reduction compared to the traditional usage in this area. This community is, therefore, being described as one of the most ecologically friendly developments in the West, where water conservation is a primary design element. Allen describes the project as focused from the beginning on minimizing water demand, with smaller individual yards and larger shared open spaces and parks that emphasize landscape solutions such as native plant use and artificial materials for soccer and baseball fields. The biggest water saving are expected to come from using rainwater collection as a primary source for the community's irrigation needs. Cisterns above and below ground will collect rainwater for houses and neighborhoods (Allen, 2012). Monitoring of the project's water use will be a key element of the project scope.

J. Project Case Studies

The literature review of comparable projects focused on well-established community developments in the U.S. which appear to incorporate principles of sustainable or green development including tested water management and conservation strategies. At the time of the first study in 2003 there were few pure examples of sustainable development that met all the criteria of sustainable communities, including economic, soil and environmental features.

As part of the literature review and evaluation process, four sustainable master-planned community projects were selected and reviewed in more depth. These communities are all located in semi-arid to arid environments in the western United States and share similar strategies to water management planning and design. Interviews, literature reviews and community websites were used to collect the summary information and provide insight into lessons learned and innovative strategies in water management that have been tested over time being used to manage and reuse surface water runoff in similar environments.

All the master-planned communities studied are located in the Western region of the United States. They all include new development in dryer climates with an average of less than 15 inches of rainfall per year. Most of the literature and data on these communities indicate that they were developed through a highly collaborative process with the public agencies and community, and all were attempting to employ innovative techniques in sustainable landscape design to improve water conservation.

The results of this research was 1) similar strategies were being implemented with varying levels of success in these communities and have been tested over time, 2) strategies that were successful or created more challenges at Rancho Viejo, typically had similar results in these example communities, 3) most of these communities were the first to incorporate cutting edge sustainable design systems such as green infrastructure, bioswales, large tracts of native landscapes, habitats and historic drainage corridors preserved.

The key elements of the precedent project reviews are organized by their approaches to:

- Master Planning
- Water Management
- Site Landscape Design (Streetscape, Lot Design)
- Innovations - Lessons Learned

Figure III -1 charts out the key sustainable characteristics and innovations of each of these communities in addition to the case study summaries presented.

Village Homes in Davis, California

The oldest of the communities reviewed was Village Homes in Davis, California. This 70-acre site fit into the broader definition of green development. It is now an established community with mature vegetation, fruit and nut tree orchards and residents who have a great appreciation for the unique community. This community originally encountered much resistance which uses natural swales instead of traditional stormwater drains, energy efficient design, solar energy and efficient irrigation systems for common areas.

Master Planning: The Village Homes community, located in Davis, California was designed in the 1970's and consists of 242 family residences on a 60-acre project site. Although small by comparison to the other projects reviewed and not located in a semi-arid environment, Village Homes was one of the first sustainable communities to incorporate green infrastructure, and therefore was a significant model for surface water management at Rancho Viejo. It was also one of the first projects to embrace the social and environmental responsibilities by combining natural ecology and social ecology into an integrated vision of people, nature, economy and community (Francis, 2002). The designers and developers used a participatory approach to develop the initial planning concepts for the community. Through sensitive site planning the best, most productive Class I agricultural soils on site were preserved. Through site analysis the designers were able to locate ground water recharge basins within areas where recharge could be facilitated by existing pockets of gravel. All streets are oriented east-west and all lots are oriented north-south. The orientation helps the houses with passive solar designs and makes full use of the sun's energy (Francis, 2002).

Water Management: Village Homes was one of the first communities to incorporate bioswales and other green infrastructure systems. The common areas incorporate innovative natural drainage system, a network of creek beds, swales, and pond areas that allow rainwater to be absorbed into the ground and percolated back into the water table, rather than carried away through storm drains (Francis 2002). During the dry summers these drainage areas become passive recreation areas. The low-technology drainage systems, saves infrastructure costs, and creates pleasant natural area for the community. As a result, conventional storm sewers were not required, saving nearly $200,000 in development costs which were used to install the landscape improvements including walkways, gardens, and other landscape amenities (Francis, 2002).

The neighborhood is designed to conserve water through drought-tolerant landscape plantings and reduced use of turf areas. Standard irrigation hydro-zones were established in areas with the heaviest use, such as play fields. The shared common spaces or green spaces are provided between houses. Several natural creeks and ponds on the property help to irrigate the vegetable gardens, orchards, and vineyards that provide residents with bountiful harvests of almonds, figs, zucchini, and many other crops. These streams and ponds form a system of natural filters that negate the need for an expensive storm-water sewer system. The common spaces are maintained jointly by the families who share them. Costs of maintenance are kept low by some cash crops such as the almond harvest, and by the natural drainage system that keeps watering costs at a minimum. The gardeners and the Homeowners Association oversee crops and efforts such as the control of mosquitoes and other pests; they stock year-round creeks with mosquito fish and design the rest of the streams to drain within two or three days. The management of the major agricultural field work, such as the vineyards is contracted out.

Site Landscape Design: Greenbelt commons, central green, vineyards, orchards, drainage swales, agricultural lands, private gardens, turf areas for sports, community garden and streetscape areas make up the open spaces. 25 percent of the site consists of public and community open space. These areas are all traffic-protected and many areas include edible and native landscape plants. Much of the open space of Village Homes is an agricultural landscape owned by residents. This edible landscape has created a diverse and somewhat overgrown character to the neighborhood, but is a unique character. Although homeowners do not appear to be concerned about the overgrown character, there have been reports of non-residents complaining about the appearance.

While many of Village Homes' features have become more standard practice in community planning the unique holistic approach to design has not been widely adopted. However, most, if not all, of the design and planning principles employed are directly applicable to other projects. Especially transferable is the project's emphasis on participation, open channel drainage, the diversity of open space types, shared communal space, the child-oriented landscape, and hydrozoning of irrigation and plantings (Francis, 2002).

Innovations:

- One of first sustainable communities to incorporate green infrastructure.
- Project places heavy emphasis on open space as the organizing framework for the community
- Creative natural drainage system consisting of a network of creek beds, swales, and pond areas that allow rainwater to percolated back into the water table, rather than carried away through traditional storm drains.
- Commons spaces are maintained jointly by families who share them.
- Neighborhood Agriculture - Community vegetable gardens, orchards and vineyards and other crops.
- Use of solar energy and energy conservation incorporated into all design elements – natural heating and cooling through passive and active systems.
- Restricted use of turf areas to conserve water and hydrozoning of irrigation.
- Residents involved in the maintenance and management of community open spaces.

Lessons Learned:

- The strong environmentally and social values of the original homeowners are now being rapidly replaced by new homebuyers who see the strong property values and quality of living (Francis, 2002).
- Common open spaces within the community lack intimacy and do not seem to be very well utilized as designed.
- Blurred boundary between private and public realms makes it difficult for some homeowners and visitors to determine what common spaces they may use or where they are allowed harvest fruits, for example.
- Increase of insects and other pests on site due to large amount of vegetation and agriculture crops.
- Streets are designed to limit impervious paving but they are too narrow for emergency vehicles to turn around.
- Plant material is left natural and has become so overgrown, blocking views to the homes and creating potential security issues for homeowners.

Community of Civano in Tucson, Arizona

Master Planning: Civano is an 818-acre sustainable master-planned community development located on the southeast side of Tucson, Arizona with an undeveloped area of the Sonoran Desert environment. The community is a result of the collaboration between the developer, city's Metropolitan Energy Commission, local builders and Office of the Governor of Arizona. In addition, the Arizona Energy Office provided funding for planning. In 1991, the City of Tucson approved rezoning of the land to be developed into the master-planned community. The rezoning stipulated aggressive resource conservation goals and performance requirements for the purchaser and developer. In 1996 the land for the development was purchased from the State Land Trust for the development of Civano. The vision for the 6000 resident community emphasized the protection of the sensitive desert environment, sustainable solar design and water conservation. The terms of the purchase agreement require the developer to participate in Tucson's Integrated Method of Performance and Cost Tracking (IMPACT) System for Sustainable Development, documenting their sustainability performance requirements. Construction began in 1997, and according to the developer, required mass grading for the first phase of development to accommodate drainage changes, and to allow for higher housing densities than if the existing grade were adjusted on a house-by house basis. This approach displaced native plants which were replanted within the community or reintroduced into other open space areas (Buntin, 2010).

Water Management: Rainfall in Tucson averages only 12 inches per year, in similar rain patterns as Santa Fe and Albuquerque, which made stormwater runoff an important influence on the landscape design. During the early construction and planning phases of the project, negotiations were undertaken with the City of Tucson to bring grey water processed at the City of Tucson wastewater treatment plant to the community. This grey water supply was offered to all residents who purchased homes in Civano, with an initial cost of $5000 per household to be connected to the system and a recurring tap fee of around $12/month for each grey water system. Each house has both potable and reclaimed water lines. All homes are connected to the community water re-use program and although voluntary, to date, most homes use recycled water. Green design materials and construction methods incorporating low-water use planting, roof and landscape water harvesting and water reclamation sustainable strategies have been implemented. In the "2010 IMPACT Report," the assessment indicated that while the use of reclaimed water may be cost effective for larger facilities such as school, which use the reclaimed water to irrigate turf play areas, it was shown in past years to be an inefficient and costly approach on the residential lots with homeowners paying more for reclaimed water than potable (Whitmer, 2010).

The builder also developed a four tier system for reducing potable water usage in regards to landscaping. In general, the system defines Tier 1: xeriscaping, Tier 2: limited use of turf or other high water usage plants, Tier 3: rainwater harvesting systems to provide irrigation, and Tier 4: customer education program in coordination with Tucson Water to provide educational materials to help homeowners in maintaining this low-water use landscape system (Whitmer, 2010). Many houses in Civano also have rainwater collection systems that consist of large rainwater storage cisterns connected to the roof gutter system of the house. These gutters are designed to funnel water into the cisterns where it can be stored and later used for irrigation or spills from scuppers directly into the planting beds on the private lots. However, due to the low rainfall, on-site reclaimed water is required to supplement the irrigation.

The community has a water conservation goal set for residential consumption, which is not to exceed 40 gallons per capita per day per household, which is a potential 65 percent reduction in potable water usage. To date, the potable water usage at the first two communities developed at Civano averages around 59 percent. Without the grey water systems, this gain might be erased in times of heavy drought or even during periods of low rainfall. This is seen in the Civano Phase II development where homes without the grey water systems only achieve a 37% reduction in potable water use (Buntin, 2010).

The community invested in a series of gabions, a system of steel cages filled with rocks, to be placed in the wash that runs through the development. These natural obstructions create de-facto water retention ponds along the wash, allowing for groundwater recharge and natural watering of the adjacent landscape including an existing mesquite Bosque. The design directs water towards planting areas and slows down the flows through a series of small check dams. This system allows stormwater to percolate into the soil and irrigates vegetation through the site, while surface water pooling is reduced. Curb cuts in the street medians allow runoff to flow into planted medians.

Site Design: Approximately 65 percent of the major existing trees at Civano were salvaged and replanted on site. The program has so far saved over 2,400 plants and nearly 500 mature trees (Buntin, 2012). The extensive salvage effort far exceeds the City of Tucson's requirements, and was done to compensate for the loss of undisturbed desert land. Ninety-five percent of the plants have survived the transplanting process, providing shade along the sidewalks and along the open drainage areas throughout the site (Ewan, 2001). Civano's public areas and common areas are landscaped using native and "near-native" plants, however, they allow the appropriate turf grasses for playing fields. Linear parks run through the community, which are also designed with non-native turf grasses. All other landscaped areas of Civano are mulched with decomposed granite where plantings do not exist. Turf is prohibited in front lot areas and within the public right of way. Only non-seeding grasses are permitted in these areas. Turf is permitted in enclosed lot areas if no turf or spray irrigation abut walls or fences. Homeowners are allowed to select a unique variety of mostly native plants and wildflowers for their landscapes from a recommended list of natives and "near-natives". A list of prohibited plants is also available. The results is a diverse and interesting landscapes that conserve water and are designed to protect vistas and solar access for all residents, encourage water conservation, eliminate highly invasive and allergenic plants, and preserve the desert character of the site.

Innovations:

- Civano was able to keep development costs down by gaining Federal and State tax exemptions and rebates for their sustainable efficiency.
- The collaborative planning and development process included public/private partnerships with the City of Tucson, and environmental and sustainable groups.
- The Civano Nursery located within the community continued offers homeowners and builders assistance with required landscape designs and plant materials.
- Narrower streets with shade trees will help create livable neighborhoods and result in a cooler microclimate.
- Public Infrastructure: The City is considering helping fund construction of reclaimed water distribution lines and bike paths.
- Compliance with sustainable goals are tracked through the City's Integrated Method of Performance and Cost Tracking for Sustainable Development (IMPACT)

Lessons Learned: There are some concerns that these lawn areas drain into the adjacent Pantano Wash, allowing fertilizers and grass seed to migrate into the intermittent stream system. Urban was preservation is a growing interest in Arizona. Historically, these washes were channelized and conserved a part of the metropolitan flood control system rather than part of the desert ecosystem. Low-density development is also planned along the wash that may create challenges in protecting the wash ecosystem and wildlife habitat. Edge treatment of large parcels of natural desert is a highly debated issue**.** It is to be noted, residential sales and construction were very poor in alignment with current market conditions.

High Desert Community in Albuquerque, New Mexico

High Desert illustrates how a sustainable community will vary in the design and water management strategies based on the public agencies involvement, local climate and water resources and vision of the developer.

Master Planning: Similar to Santa Fe, this residential community is located in sensitive high desert environment, where concerns about disturbance of views, generation of stormwater runoff, and disruption of habitat connectivity generated significant controversy during it planning process. Master planning at High Desert used the natural landscape to determine the development's form, density and materials, and siting of structures to achieve minimal disruption of the soil structure, existing grades and natural arroyo drainage patterns while preserving the view corridors that make this community unique. Fifty percent of the site's original juniper-prairie ecotype was preserved by minimizing construction disturbance, cutting roads into the hillside instead of mass grading, and using a native plant palette for all public areas, right-of-ways and private areas outside of building envelopes. Clustering residential properties helped to buffer existing wildlife corridors and created a gradient that maximized connectivity to existing infrastructure and cultural resources, and minimized impact closer to wilderness boundaries (LAF, 2011). The site design incorporates locally-sourced materials, permeable hardscapes, native and onsite transplanted vegetation, and natural hydraulic recycling, cross-site drainage between parcels, eliminating curbs and gutters, and pairing natural stormwater arroyos with conservation open space preserved over 62% (665 acres) of pre-development hydrology.

Similar to Rancho Viejo, the High Desert planning and approval process, in collaboration with the local public agencies, changed water-conservation and landscape planting ordinances at city and state levels. The project strived to balance environmental sensitivity, community connections, aesthetics and economic viability with metrics that gauge the success of outcomes. About 150 lots still remain to be built at High Desert. The economic down turn has affected the sales of homes, but not as much as the rest of the city or county, partially due to the large population of retired homeowners (Berg, 2012).

Water Management: The community experiences infrequent but torrential rain patterns typical of the high desert, averaging about 15 inches in the lower areas of the site to almost 30 inches in the Sandia Mountains. Catchment systems were installed in some areas to store captured surface water below ground to be meter to irrigate the landscaping. Oil contaminates from service roads quickly disabled these systems, and most are no longer functioning. Surface water was also collected from the road and used to irrigate the adjacent planting areas, however the lack of control of flow direction leaves some areas over-watered and others under-watered. The developer was also required to install large stormwater collection ponds, by AMAFCA, (the Albuquerque Metropolitan Arroyo Flood Control Authority), between the existing arroyo's that cross the site. This system allows water, sediment and debris from storm events to be collected and filtered before the water's return to the aquifer and to date is apparently functioning well. The High Desert Association by AMAFCA to maintain a significant fund to ensure the system is functioning properly (Berg, 2012).

The City of Albuquerque sets the water-use requirements for the community's landscaping at High Desert. Every few years, the City measures the area of irrigated landscaping against the water metered and provides a report to the community. The whole development is 1067 acres, with a total of 1600 homes and of which 270 acres of open space (non-irrigated) and 70 acres of that are irrigated. The community is currently only using about 20% of the allocated water (Berg 2012). Large homes lots at the higher elevations require approved drainage plan that retain all surface water on the lots for infiltration into the aquifer, up to a 100 year storm event. Some homeowner's have diverted surface runoff to plant beds while others have constructed roof rain harvesting systems. Most are above ground and are easy to maintain by homeowners. As in Rancho Viejo, the residences found underground catchment systems difficult to access and expensive to replace. Only a small percentage of the homeowners have installed grey water handling system for their own homes.

Site Landscape Design: Plants must be selected from an approved list, which also includes a list of prohibited plants such as high water-use, invasive and high allergenic plant materials. Unlike Rancho Viejo, the medians, shoulders and sidewalk to curb planting areas are planted and maintained by the City of Albuquerque. Larger lots are required to maintain a native landscape. Some of the smaller lots have turf grasses but the majority installed native-type landscapes of blue grama or buffalo grass. Similar to Rancho Viejo, some homeowners have complained that the native landscape is not refined enough, while many feel the native landscape is most appropriate for the location in the high desert. Where more formal plantings occur on site, native perennials and shrubs are used for color instead of high water-use annuals. There are also issues of the more aggressively growing native plants outgrowing spaces and dominating the landscape.

Street and open space trees planted are averaging only about a 5-year life time due to the extreme stresses of very dry, wet and hot periods experienced each year, along with damage by vehicles due to the lack of curbing. Most of the streets are constructed without curbs and gutters to allow surface water to drain into the adjacent landscape areas. No permeable paving for roadways, except for service roads and trails, were used on site due to the potential for dust. Street lights are limited to intersections and cul-de-sacs to reduce night-sky glare.

Open Space Management: Natural landscape areas disturbed during the construction process were restored using stockpiled topsoil with its associated seed pool. Wildlife habitat was maximized by minimizing land disturbance and enhancing ecosystems through multifunctional open space. According to the developers, the amount of critical habitat vegetation of the Juniper pinion ecotype was doubled with this project. Through pre-construction vegetation assessments, plants in areas of disturbance were stockpiled and replanted, sensitive plant species were transferred from disturbed areas to open space, and more species from local nurseries were added. By restoring twice the volume of vegetation that was displaced by all areas of disturbance, the designers estimated that they had increased carbon sequestration on the site by 170,160 tons. These efforts also increased critical bird-breeding habitat for two endangered species, the Peregrine Falcon and the Gray Vireo, by about 7 acres. Common landscaped areas encompass more than 250 maintained acres spread over the more than 1,000 acres of our development, of which about 70 common area acres are irrigated. The maintained land's overall cost is in the range of $500,000 per year and is divided into five general areas according to the kind and intensity of the maintenance requirements (LAF, 2011).

Innovations/Lessons Learned:

- Public involvement and transparency are crucial to success. High Desert overcame considerable opposition from adjacent subdivision residents. As public incentive, High Desert used homes sales profit to support local educational scholarships to demonstrating broad sustainable intentions to the community.
- Uses only 20% of the city's annual water allowance in landscape areas, potentially saving as much as 28.7 million gallons annually.
- Base Line for Post Construction Evaluation: Although extensive analysis was performed for High Desert, hindsight recommends that all inventories and analysis be documented in a quantifiable manner, in-house. Strategies and processes for calculating data should be evaluated continuously to check for validity. The landscape architectural firm, Design Workshop, Inc. has since standardized these baseline inquiries to ensure proper evaluation of their work (LAF, 2011).

- All mulch used in public areas and open space come from decomposed granite harvested onsite or with recycled dam sediments from downstream.
- The equivalent of 15,230 trees are preserved each year by using decomposed-granite mulch instead of a traditional yearly wood chip mulch application.
- According to the developers, the amount of critical habitat vegetation of the Juniper pinion ecotype was doubled with this project. This was achievable partially through pre-construction vegetation assessments, stockpiling and replanting of plants in areas of disturbance, transferring sensitive plant species from disturbed areas to open space, and supplementing the native plantings with more species from local nurseries.
- Rain gardens are fed and water-wise demonstration gardens are irrigated with stormwater harvested from arroyos.
- A viewable "wildlife drinker" (a potable water-fed trickle pond) and planned corridor to the mountains enhances habitat and human connections.
- Boulders from disturbed areas of the site were incorporated into the open space landscapes as amenities instead of being hauled offsite.
- Educational/Interpretive signage, local art installations and demonstration gardens were installed throughout the development with the intent of enhancing communal stewardship. However, similar to Rancho Viejo, the interpretive signage has been modified to target more information about the community. The community uses volunteers from the homeowners to conduct landscape assessments of common area landscapes found throughout High Desert. Homeowners are asked to assess and rate the designated area's overall appearance, maintenance, and suitability. The assessment results are used by the Landscape Advisory Board as it evaluates the landscape maintenance contract when it comes up for renewal.
- Similar to the lesson learned at Rancho Viejo, the High Desert developers found that pioneering sustainable features is highly dependent upon relationships with reputable manufacturers and contractors. High Desert originally planned all irrigation zones to run on solar-powered moisture sensors but nearly lost all plants because of defective equipment and subsequent default on product warranty (LAF, 2011).

Daybreak Community in South Jordan, Utah

Master Planning: Daybreak is a 4,127-acre mixed-use, master-planned, sustainable community in located on surplus mining land in the semi-arid Salt Lake Valley in South Jordan, Utah. Day Break sits at an elevation of 4300 feet and typically has an average rainfall between 12-15 inches annually. Home construction began in 2004 and the community is expected to continue building for the next 18 to 20 years. All homes are required to be built as Energy-Star® rated homes. When completed, it will contain more than 20,000 residential units. The extensive parks, trail systems and open space integrates stormwater management, merges with natural systems, and includes a full range of sustainable features including native and drought-tolerant plants, habitat conservation, and the use of recycled materials (LAF, 2011). The development is part of the U.S. Green Building Council's pilot program known as LEED Neighborhood Development (ND), which is the first national system that evaluates developments based on the principles of smart growth, urbanism, and environmental design. Daybreak's designers even have ambitions that go beyond LEED-ND and beyond building the largest master-planned community in the state (Ulam, 2010).

Site Design: Daybreak incorporates many water-saving strategies such as mandating that turf grass does not exceed 50 percent of the lot landscaped areas, and that all plant beds must be drip-irrigated. Critics of the development have noted that despite the rules and water saving technologies, many of the plants selected for front yards are inappropriate for Utah's arid environment and not consistent with a high desert sustainable landscape. Native plant communities comprise 68% of common open space, and drought-tolerant plants cover at least 40% of every residential lot. Manicured turf is limited to recreation fields. As at Rancho Viejo, the prospective buyers requested an explanation for the more "wild" looking native landscapes and were concerned with their "unkempt" appearance. In many of the outlying open spaces, the design is more consistent with Utah's ecology. The open space areas preserve the native sagebrush and indigenous flowers of the high deserts. There are few trees that are indigenous to this high desert location, and as a result water-wise non-native trees have been introduced to provide shade during summer months (Ulam, 2010).

Water Management: The storm water system is well integrated with active and passive uses throughout Daybreak. The onsite stormwater management system includes 65-acre man-made Oquirrh Lake, 25 acres of constructed wetlands, stormwater canals, dry wells, infiltration basins, and roadside bioswales. On-surface stormwater management is integrated and serves to create habitat, supplement irrigation, and enhance recreation opportunities. Benefits from a well-integrated stormwater system include substantially decrease infrastructure costs and eliminates impact fees, substantially reduces demand on municipal infrastructure, increased land values through open space amenity creation, provide sustainable education opportunities, habitat, filters and cleans runoff and recharges groundwater. The landscape is designed to infiltrate 100% of their runoff up to 100 year storms from stormwater and snowmelt runoff. This was achieved primarily through surface conveyance and vegetated swales. This approach significantly reduced infrastructure costs.

Intercept swales are used to prevents runoff from entering Oquirrh Lake reservoir which is fed by a canal system that brings filtered non-potable water from 12 to 15 miles away, to reduce sedimentation and nutrient loading from fertilizers. Water from the Oquirrh Lake is then used to provide reserve irrigation to some of the water-wise landscaping in Daybreak's parks and open space.

Open Space: 25% of the land has been set aside for open space. The community has set aside up to 30 percent of the development for open space. The master plan calls for 53 parks and large community gardens where homeowners can grow their own flowers and vegetables.

A high percentage of common open space is native grasses and shrubs and the community has a goal of planting 100,000 trees on site. 100% of public common open space is irrigated with secondary water. Native plant communities comprise 68% of common open space, and drought-tolerant plants cover at least 40% of every residential lot. Manicured turf is limited to recreation fields. Open spaces including ball fields and village greens are part of a complex drainage system for the development. Instead of stormwater systems underneath the streets, the development features swales and drainage ditches to help irrigate the landscape and provide 100 stormwater retention for the entire site. Some of the ball fields are designed with rain gardens to capture runoff and filter it back into the aquifer. By using streets and waterways as a distribution system, Kennecott Land has saved millions of dollars on stormwater drainage costs. This secondary or reuse water for irrigation is used for establishment of plant communities. Once plants have established, irrigation is reduced dramatically.

Innovations:

- Irrigation - Instead of a spray head nozzle, the water is distributed through the underlying thatch layer by means of a system of tubes inserted about 12 to 15 inches apart. According to Kennecott Land, the system is about 10 percent more efficient than standard subsurface drip irrigation systems, which are typically located in the soil layer. A sophisticated emitter is used to monitor and control water usage to such a fine degree that there is virtually zero runoff onto curbs or into gutters. Houses with lot sizes larger than 5,000 square feet are required to install a smart control system that communicates with a central weather station that serves the entire development. The system gathers real-time data on wind, solar radiation and humidity. An evapotranspiration formula is sent from the system to the irrigation controllers instructing them when to turn irrigation water on and off. Saves about 1.5 million gallons of potable water each year by using an innovative drip irrigation design. Projected annual savings at build-out are 18.7 million gallons, saving about $54,000 annually (Ulam, 2010).
- ISO 14001 Environmental Certification – the developer, Kennecott Land is the first community developer in the United States to achieve the ISO 14001 Environmental Certification in 2005. Kennecott Land developed an Environmental Management System to help them with maintaining an environmentally responsible and sustainable approach to development.
- Every tree has its photograph taken and radio frequency microchips are inserted to provide a living database that catalogs the tree's age, health status and size. This has led to a reduction of tree mortality rates to only 4 to 5 percent by comparison to the industry average of 10 to 12 percent.
- Retains 100% of stormwater that falls on the site for up to a 100-year storm with no impacts on or connections to the municipal storm sewer system.
- Terraced demonstration gardens display the beauty of native species and teach residents about responsible landscape methods within the Great Basin ecology.
- Material excavated to create the lake was reused onsite as base for roads, saving on materials and hauling costs.
- Engineers estimate over $70 million in storm water infrastructure savings over the life of the Daybreak project due to the elimination of municipal impact fees and reduction in conventional conveyance infrastructure. This estimate

includes $30 million in residential impact fees, residential entitlements by owner, and reduced in-ground infrastructure.

- Using on-site nursery acclimation, species and age diversity and tree-by-tree computer-chip monitoring reduces tree mortality by 60% over typical rates, saving an estimated $2 million in replanting costs for the project goal of 100,000 trees planted (LAF, 2011).

Lessons Learned

- Better sediment control and management of builder contractors
- Get water into the landscape close to where it falls
- More use of vegetated swales and forebays
- Stronger educational programs for natural systems
- Need to incorporate City Public Works staff into natural systems planning

Other case studies of residential sustainable master-planned communities in the southwest provide excellent examples of sustainable water management strategies. The Landscape Architecture Foundation (LAF) Case Studies and reports such as "Growing Smarter at the Edge" provide in-depth information on the projects, challenges, innovations and lessons learned. Other sustainable community projects in arid environments for further study include Vistancia, DC Ranch, Rancho Suhuarita, Mesa Del Sol, Verrado, Hidden Springs and Otay Ranch.

All of these case studies, as well as Rancho Viejo's, illustrate that water management and innovative landscape designs with technically sound catchment and natural infrastructure systems are essential to a sustainable community environment. The Rancho Viejo de Santa Fe case study and literature review confirms that with current technologies we can greatly decrease water use, while simultaneously enhancing the natural character of our communities. In desert or arid climates such as Santa Fe, surface water can be successfully managed as a resource, using tools such as sustainable planning, site design and grading techniques, use of permeable surfaces, low water use and native plantings, natural and constructed rainwater catchment systems, water treatment plants supplying graywater for irrigation and a strong educational program for homeowners and community managers and landscape maintenance teams, resulting in a significant reduction in the use of potable water within residential communities. As increased cycles of drought coupled with population growth strain our limited water resources in arid environments, not only does it make sense to explore ways to get the most use of rainwater, it is also wise to design and create landscapes that need little or no supplemental water to thrive. Combined with sustainable planning, site design, water conservation and construction techniques, surface water management can be an effective strategy for protecting hillside and arroyo recharge areas, open space vegetation and habitat, reducing the use and cost of potable water and can result in aesthetically pleasing, healthier, cooler, and livable neighborhoods and communities.

The following charts provide summaries of the key findings from the case studies and highlight the similarities and unique qualities of the Rancho Viejo development (Figures III-1 and III-2).

Case Study Project Chart											
	Collaborative Planning Process with Public and Agencies	Preservation of Existing Open Space and Habitats	Native and Low Water Use Plantings	Protection of Historic Drainageways	Green Infrastructure	Graywater Reuse Systems for Open Space and On-lot Irrigation	Water Harvesting Systems (Rain Barrels, Cisterns, etc.)	Permeable Paving	Water Conservation Performance Tracking	Homeowner Educational Programs	
KEY CHARACTERISTICS OF PROJECT	**VILLAGE HOMES - DAVIS, CALIFORNIA**										**SUSTAINABLE DESIGN INNOVATIONS**
• Acreage: 60 - Acres • Population: 245 Residences • Opening: 1975, Build-out Completed: 1982 • Master Planned Community • Unique Agricultural Landscape with vineyards, Orchards, Vegetable Gardens • Energy Efficient Designs, Solar Energy	✓	✓	✓	✓	✓	✓	✓	✓		✓	• One of the first sustainable communities to combine natural and social ecology with community design. • Site designed to preserve land for Agriculture within the community • One of the first communities to include bioswales and green infrastructure • Participatory approach to planning with community, public agencies and designers • Creative natural drainage system consisting of a network of creek beds, swales, and pond areas that allow rainwater to be absorbed into the ground and percolated back into the water table, rather than carried away through storm drains. • 25% of land reserved for open space. Commons spaces are maintained jointly by families who share them. • Use of solar energy and energy conservation incorporated into all design elements – natural heating and cooling through passive and active systems. • Restricted use of turf areas to conserve water and hydro-zoning of irrigation. • Residents involved in the maintenance and management of community open spaces.
KEY CHARACTERISTICS OF PROJECT	**CIVANO - TUCSON, ARIZONA**										**SUSTAINABLE DESIGN INNOVATIONS**
• Acreage: 818 - Acres • Population: 6000 Units Expected • Opening: 1997 • Master Planned Community based on Sustainable Design Principles and New Urbanism • Energy and Resource Conserving Community	✓	✓	✓	✓	✓		✓	✓	✓	✓	• Keeps development costs down by gaining Federal and State tax exemptions and rebates for sustainable efficiency • The collaborative planning and development process included public/private partnerships with the City of Tucson and environmental and sustainable groups. • Civano Nursery located within the community continued offers homeowners and builders assistance with required landscape designs and plant materials. • Narrower streets with shade trees will help create livable neighborhoods and result in a cooler microclimate. • Compliance with sustainable goals are tracked through the City's Integrated Method of Performance and Cost Tracking for Sustainable Development (IMPACT) • 65% of trees on site were salvaged from construction and relocated on site • Grey Water Reuse Systems options for residents

Figure III-1 Case Study Project Chart

Case Study Project Chart

	Collaborative Planning Process with Public and Agencies	Preservation of Existing Open Space and Habitats	Native and Low Water Use Plantings	Protection of Historic Drainageways	Green Infrastructure	Graywater Reuse Systems for Open Space and On-lot Irrigation	Water Harvesting Systems (Rain Barrels, Cisterns, etc.)	Permeable Paving	Water Conservation Performance Tracking	Homeowner Educational Programs	
KEY CHARACTERISTICS OF PROJECT	**HIGH DESERT - ALBUQUERQUE, NEW MEXICO**										**SUSTAINABLE DESIGN INNOVATIONS**
• Acreage: 1067 - Acres • Population: 2630 Residential Units • Opening: 1993, Build-out: 2030 • Master Planned Residential Community • 270 Acres of Non-irrigated Open Space • Clustered Housing	✓	✓	✓	✓	✓		✓	✓	✓		• High Desert used a portion of their homes sales profit to support local educational scholarships to demonstrating broad sustainable intentions to the community. • Base-line for evaluating the sustainable performances in a quantifiable manner at High Desert was developed by Design Workshop, Inc. • Uses only 20% of the city's annual water allowance in landscape areas, potentially saving as much as 28.7 million gallons annually. • Preserves the equivalent of 15,230 trees a year, by using decomposed-granite mulch instead of a traditional yearly wood chip mulch application. • Amount of critical habitat vegetation of the Juniper pinion ecotype was doubled on site. Native plants were transplanted from construction areas. 50% of ecotype preserved. • Rain gardens are fed and water-wise demonstration gardens are irrigated with stormwater harvested from arroyos.
KEY CHARACTERISTICS OF PROJECT	**DAY BREAK - SOUTH JORDAN, UTAH**										**SUSTAINABLE DESIGN INNOVATIONS**
• Acreage: 4127 - Acres • Population: 20,000 Units Expected • Opening: 2004, Build-out: 2025 • Master Planned Community based on Sustainable Design Principles • Mixed-Use Development	✓	✓	✓		✓	✓	✓	✓		✓	• Retains 100% of storm water that falls on the site for up to a 100-year storm with no impacts on or connections to the municipal storm sewer system. • Irrigation includes Smart Control System and uses spray head nozzle to distribute water through the underlying thatch layer by means of a system of tubes for an extremely water-efficient system. Saves approximately 1.5 million gallons of potable water per year. • Kennecott Land developed an Environmental Management System to help them with maintaining an environmentally responsible and sustainable approach to development. • All homes required to be Energy Star Rated • Surface Stormwater management includes constructed wetlands, dry wells, infiltration basins, and bioswales. • On-site nursery to acclimate trees to site prior to planting • Radio Frequency micro-chips installed in trees to track health and reduce maintenance
KEY CHARACTERISTICS OF PROJECT	**RANCHO VIEJO - SANTA FE, NEW MEXICO**										**SUSTAINABLE DESIGN INNOVATIONS**
• Acreage: 2500 - Acres • Population: 1605 Units Expected • Opening: 1998, Build-out: Est. 2030 • Master Planned Community based on Smart-Growth and Sustainable Design Principles • Mixed-Use Development	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	• Expedited Entitlement process through collaborative community facilitation process with Santa Fe residents, government officials and land owners. • To preserve scenic rural landscapes, 9,000 acres of the original 20,000 acres with deeded to a public land trust to manage as scenic landscape and wildlife conservation area. • 50% of open space is conserved as aquifer recharge by limiting development to high flat plains and through cluster development. • Uses only 20% of water allowance. Potable water use was reduced by 12.4 million gallons as of 2010, by irrigating with treated effluent (grey water) and by using native plants, for a 81% water savings over the typical allocated county water use. Water use is monitored monthly by Ranchland Utility Company • Water catchment systems (cisterns and rain barrels) are installed at most homes and used to augment landscape water needs. • All new homes required to be Energy Star Rated

Figure III-2 Case Study Project Chart

IV. 2012 RE-EVALUATION STUDY SUMMARY OF FINDINGS

The 2012 re-evaluation study was developed using a process of interviewing community homeowners and management representatives, the landscape management company overseeing the maintenance of the landscape and irrigation, assessing the existing site conditions, homeowners and determining purposeful goals. This process was designed to build on the baseline research conducted in 2003 and to determine how the project had progressed since that time in achieving the established goals. This 2003 and 2012 study results were always assumed to be dynamic in nature and are anticipated to continue to evolve over time as goals are achieved and new challenges arise and technology allows for better solutions.

A. Interview Summary

The interview questions mainly focused on receiving feedback on the water management and conservation strategies implemented on site and the successes and challenges of the original landscape elements installed in the three villages constructed to date at Rancho Viejo. The lists of questions are included in Appendix C and feedback from homeowners is incorporated into the summary of findings.

The homeowners and HOA representatives interviewed seemed to be genuinely appreciative of the amount of preserved open space, habitat and natural areas at Rancho Viejo; the use of the native plantings in the landscapes that made for a unique feeling community; and were very supportive of the communities sustainable goals to conserve and reuse water within the home and landscape. However, all noted a lack of training on how to maintain their native landscapes and cistern systems. Homeowners throughout the community consistently commented on the poor quality work from certain contractors related to the roof construction, cisterns and underground infiltration systems. There was considerable frustration with Village 1 and Windmill Ridge homeowners who were over-using water in their landscapes, leaving too little for the newest communities to use. In contrast, there were also many homeowners, especially in the first two villages, who complained about the urban parks and streetscapes not being as green or mowed to a more manicured appearance.

The developers' representatives indicated that Rancho Viejo was a very successful community with advantages over other similar communities in the region. In particular, the sense of community and neighborhood nestled in a natural landscape, gray water reuse options, native and low water use landscapes, Energy Star homes, open space and trail systems were all mentioned as unique assets. Those interviewed consistently noted that the slow-down of the housing market and issues with poorly performing contractors had contributed to costly repairs, less rigorous management and maintenance of the irrigation, landscape and other sustainable components of the site. They did note that the new owners have a renewed interest in getting the community back on track, starting with the recent installation of streetscape trees and residential lot plantings at La Entrada, and are confident that the innovative strategies applied to the first village will continue to be improved on in future villages proposed.

B. Site Observation Summary of Findings

The following is a summary of the site conditions observed in 2012 and includes supplemental support information from the interviewees that address why some of the current conditions exist. Observations are organized in the same order as the original SWM Manuals' process of documentation.

1. Village Master Plan Grading and Drainage Strategies

1.1 Preliminary Grading Plan and Process

Grading appears to have been implemented as recommended in the SWM Manual except for mass grading[4], which was observed on the undeveloped lots of Windmill Ridge South and La Entrada.

Large areas of exposed soil and sparse vegetation on undeveloped lots were observed at the La Entrada development area. During windy conditions, dust particles were being blown throughout the new development area leaving silt deposits on paving and roofs. Even though erosion control measures were in place, they did not appear to be well maintained or as consistently used as was called for in the specifications or SWM Manual. Sediment buildup was evident in the adjacent culverts and evidence of erosion was observed on the steeper slope areas.

According to the original developer, mass grading was found to be far more economical for the newer villages than grading in smaller parcels to preserve

[4] Mass grading is a term used to describe the movement of earth by mechanical means to alter the topographic features of a site, including elevation and slope to prepare for the construction of facilities. Mass grading typically results in a flattened landscape or a terraced hill with uniform engineered 2:1 slopes.

existing trees and land forms. The developer felt the mass grading approach was more efficient when construction was occurring at a very fast paced, as new areas were being completely developed in less than 2 years and therefore erosion could be minimized. When the down turn in the economy began to affect the housing industry in 2008 it was evident that a mass grading approach was less successful. La Entrada was mass graded for 400+ lots just before the market down turn. This led to almost 247 lots that were mass graded, but never sold, leaving the soil exposed to erosion and only minimal plant restoration occurring naturally (Pino, 2012).

In the Windmill Ridge South (Area 4), there are 20 lots that were mass graded and remain to be built on. The siltation fencing is being used during construction according to the developer (Pino, 2012), and was observed to be mostly in place and more well-maintained than La Entrada. Evidence of silt buildup in the drainage structure and issues with blowing soil particles indicates erosion is still a concern. In May, 2012, the Rancho Viejo South Landscape Committee organized volunteers to help seed some bare areas of ground with the native blue grama grass to improve looks and help to control dust (L. Lefton, 2012). Some success was observed from this effort; however, blue grama is slow to spread and will require irrigation and potential several years to completely fill in.

1.2 Schematic Drainage Plans

The original strategy was to integrate the stormwater management detention areas within the development to maximize the open space park areas readily available to residences for passive recreation. The drainage areas were implemented according to the original guidelines, resulting in 50% (over 5,500 acres) of open space conserved for aquifer recharge by preserving the natural drainage system patterns. Windmill Ridge North and South in particular have attractive drainage areas throughout the community as linear or more open space parks that appear to be functioning well (Images 4.1, 4.2, 4.5). Little or no sediment was observed and the native plant materials are fully established and stabilizing the area from erosion.

Retaining the open space in a natural condition was preferred by the developer, but was found to be difficult to maintain in a manner that was aesthetically pleasing to the community. As a result some areas were planted with non-native grasses or native grasses are more heavily irrigated and mowed to appear as more traditional lawn areas. The developer also indicated that some of the man-made open spaces used for detaining runoff on-site could have been better directed towards their real end use in the community. The detention ponds installed at La Entrada, could have been developed as a more integrated part of the community as passive open space and not located where it is not easily viewed or accessed (Pino, 2012). Other open space drainage areas observed in La Entrada were not restored with either transitional or native landscapes, but instead were graveled over and only recently sparsely planted although the space was originally intended for passive recreation (Image 4.4).

Image 4.1 Windmill Ridge South Linear Park

Image 4.2 Windmill Ridge North Linear Park

Image 4.3 Windmill Ridge North Open Space

Image 4.4 La Entrada Linear Park

2. **Architecture - Roof Rainwater Harvesting Systems**

   2.1 Roof Design and Materials

   Starting in winter of 2002, all new roofs were designed to direct water to the canales[5] and/or downspouts, which were connected to the cisterns or underground infiltration systems. At the time of the original study, the roofing materials were still being tested to determine which ones would best provide clean runoff to the catchment systems. According to the developer, the original roof catchment systems cost about $8.000 per household and could save an estimated total of 325,000 gallons annually, which could pay for the installations in five to eight years through reduced water bills.

   The developer, HOA representatives and homeowners interviewed all indicated that problems are still occurring with older roofs in the communities, mainly due to poor building inspections and workmanship by the contractors. TPO (thermoplastic polyolefin) roofing materials when applied too thin eventually fail. There have also been issues with birds damaging the materials and roofing materials flaking off and clogging the roof drains.

   The system worked successfully with normal rain or snow fall, however, in 2006, the community experienced a 3-foot snow accumulation. Due to improper roof installation and the inability of the cistern systems to handle the large volume of runoff, the water did not properly drained from the roofs and in some cases infiltrated the siding and interiors of the structures. Many of the roofing contractors hired had gone out of business, leaving homeowners or the developers with costly repairs. Cost to the developers to repair the roofs and eliminate mold due to the leaks and poor roof inspections was reportedly close to three million dollars (Pino, 2012). To remedy this problem, the developer switched back to the spray polyurethane foam (SPF) material, which was thicker and had a more reliable sealing method. The faulty roofs were either replaced using the new foam roofing materials or repaired. The residential roofs now are all built with SPF roofs and only 110 homes have the TPO roofs (Pino, 2012).

[5] The term "canale" is used to describe a waterspout/channel used to direct rainwater through the face of the parapet and away from walls in Spanish Colonial architecture common to Santa Fe.

3. Lot Design

3.1 Surface Water Distribution

Natural Catchment Systems (bioswales, French drains, stone swales):

Most natural catchment and infiltration systems designed in residential planting beds and lawn areas appear to be installed as originally designed and functioning well (Images 4.5 to 4.7). Roof rainwater is either directed to the canales or downspout into these simple surface catchment systems. Very little erosion was observed, although some of the edging materials were improperly installed above and below ground and performing less successful (Image 4.16).

At the time of construction, there were several issues related to downspouts improperly located next to walkways and driveways. In winter months, melting snow overflow from the roof catchment systems poured over the paving surfaces causing ice buildup and unsafe conditions for homeowners. Since 2004, the downspouts have been relocated away from paths of travel and no new issues were observed in 2012.

The Rancho Viejo lead sales director confirmed that La Entrada homeowners were given the option to add downspouts to capture or direct water into the ground or catchment system, unlike the first Villages where downspouts were required as part of the architectural design. It was observed that homes constructed on steeply graded sites have installed downspouts draining the rainwater into adjacent plant beds rather than into storm drains, underground infiltration or catchment systems (Image 4.7).

Constructed Rainwater Storage Systems: Many of the homes designed with downspouts connected to cisterns or underground infiltration systems, were observed to now be draining rooftop runoff to rain barrels or graveled French drain or swale designs (Images 4.11, 4.12). Often these new systems have been made an integral part of the landscape. The systems observed appeared to be very effective in managing the runoff, directing it to bioswales, plant beds or stone swales for reuse or infiltration to aquifer with little or no erosion where properly installed. Homeowners have attached hoses and hand pumps to these systems to utilize them directly for irrigating their yards.

Underground Infiltration Systems: Homeowners with properly functioning infiltration systems indicated they felt they were a good solution for returning water to the aquifer, although the placement and screening of above ground cisterns and pumps remains a challenge for many. These systems were experimental when first installed in 2003. A lack of experience on the part of the installer, failure to test soils for ability to percolate as needed, poor communication with homeowners about the systems management and problems with improperly installed systems, led to flooding and failure within the first year of installation for many of the cistern and underground infiltration systems.

According to the HOA Manager in each of the built communities, a major problem with the cisterns or water infiltration systems is also a lack of maintenance by the homeowners. Homeowners are currently provided with a handbook when they purchase their home, but many indicated that the specific information on maintaining their systems were either confusing or not provided to buyers purchasing homes from previous owners (Rasinski, 2012).

Image 4.5 Rock Swale Passive Surface Water Catchment System







Image 4.6 Natural/Passive Water Catchment Systems – Canale, Downspout, Stone Swales


Image 4.7 La Entrada Downspout Drainage System

The downspouts on many of the townhouses, installed to capture rainwater and direct it to underground cisterns below the adjacent driveways, appear to be no longer functioning. According to the HOA manager, the homeowners, rather than go to the expense and inconvenience of tearing out the paving to repair the system, simply abandoned the systems. The downspouts were still in place during the 2012 site review, however, it was unclear where the water was being distributed below the paving surface, and the HOA manager was uncertain and no further issues related to the systems had arisen to his knowledge.

The developer and homeowners confirmed that nearly all the cisterns that were installed have now been disconnected, removed and/or replaced multiple times due to defective equipment and subsequent default on product warranty. Several homeowners indicated that the original infiltration systems installed were set at a higher grade than the water catchment system that piped it to the infiltrator. This improper installation caused flooding of the yard and required removal and reset of the system to the proper depth at the owners' cost. The original installers of the cistern and infiltration systems went out of business shortly after the systems were installed, however, at the time of installation there were very few local contractors with experience in installing these systems in residential lots.

New Biolac Waste Water Treatment Plant (WWTP): In 2003, the New Mexico Legislature changed a state law and the New Mexico Environment Department (NMED) issued new regulations for the use of residential gray water Graywater discharge of less than 250 gallons per day of private residential graywater originating from a residence for the resident's household flower gardening, composting or landscaping irrigation shall be allowed. These new rules made it possible and feasible for the general public to use their gray water for landscape irrigation.

The on-site waste water treatment project was an innovative solution in water conservation and reuse at Rancho Viejo. Treated effluent used to irrigate open space and parks and to control dust during construction. The total result of this strategy is intended to maintain the level of the aquifer for the next 100 years and significantly reduce the need to import outside water. This system provides 1A quality water to the site. The original developer's intent was for the recycled water to be used to irrigate the front and backyard landscapes of the new homes.

The sewage treatment plant is fully operating; however, the facility was located at the lowest point on site, which requires that all the treated water for use in the site irrigation systems must be pumped up hill. The original developer indicated that at the time of installation, the design requirements for a system that reclaims water from effluent wasn't entirely understood by the developer or the contractors installing and maintaining it. A minimum of 200 psi was determined to be the amount of water pressure needed for irrigation water to reach the furthest communities of Rancho Viejo.

This approach to the system design resulted in too high of pressure at the irrigation heads closest to the treatment center (Villages 1 and 2). Irrigation lines shook, heads leaked and in some locations the lines exploded on the low end. In addition, the current irrigation contractor repairing the system said the irrigation valves and overall system were poorly designed and inexpensive materials were used by the original installer. To address the problem, a new water regulator was installed to upgrade the system, which has improved performance, however, repair and/or replacement of valves is still frequently required (Pino, 2012) (Ross, 2012).


Image 4.8 Underground Cistern


Image 4.9 Cistern Pump Cover


Image 4.10 Downspout to Underground Cistern


Image 4.11 Rain Barrel Catchment System


Image 4.12 Rain Barrel Catchment System


Image 4.13 Modified Downspouts



Image 4.14 Paving and Area Drains



Image 4.15 Stone Erosion Control Techniques



Image 4.16 Edging Installation Issues

It was soon determined after installation that the treatment plant required significantly more effluent input to be able to return enough useable graywater back to the community for use in the irrigation system. The lack of runoff due to several years of drought limited the amount of available runoff to infiltrate back into the aquifer. As a result, there is now a shortage of recycled water for irrigating the landscapes in the first four Villages constructed at Rancho Viejo. According to the current Rancho Viejo General Manager, only 50% of the reuse water needed is currently available (Ross, 2012).

Currently, all the reuse water is being used by the first two communities, which is contributing to the overall shortage. The homeowners in these communities, however, still have the perception is that they still do not have enough treated water for irrigation. The developer indicated that once the communities began using the treated effluent for irrigating, they began to waste water more and were watering their landscapes to make them appear lusher rather than arid landscapes as appropriate for a sustainable community. Subsequently, there is currently no reuse water available for use by the newest village, La Entrada. This shortage led to a change in the landscape and irrigation design for La Entrada (Image 4.17). The front yards were installed with porous paving material rather than native grasses and no irrigation was installed by the developer (Pino, 2012).

3.2 Planting

Landscape Zones: As part of the early stages of the surface water management manuals development process, five landscape zones were established around each of the villages. The Landscape Vision Plan was developed in November 2002 by the author, to document these landscape zone requirements and to provide new homeowners with a tool to help them better understand the water management strategy and benefits, and the landscape character of the their new community and maintenance required for these systems to be successful. Landscape zones were also helpful in the design process in establishing the character of the transitional to more urban landscapes through plant selection.

The five community landscape zones include:

Undisturbed Open Space – large areas of preserved natural grassland and piñon-juniper plant communities. The trail systems within this area were located to avoid existing trees and arroyos or other sensitive habitats.

Image 4.17   La Entrada Lot Design

Transitional Open Space – landscapes that blend the undisturbed open with the outer edges of the developed landscapes. The landscape plantings have greater diversity of native grasses with fewer shrubs and tree species planted in informal patterns. Supplemental plantings include blue grama grass, Apache plume, chamisa, sage, three-leaf sumac and piñon pine. Restoration of disturbed areas in this transition zone included temporary irrigation systems or manual watering until vegetation was established.

Transitional Streetscapes – landscape areas near the major roadways bordering the villages such as medians, adjacent drainage swales and water quality ponds. Plantings in this semi-xeric zone are denser and include a mix of native and non-native drought tolerant materials such as blue grama grasses, wildflowers, Apache plume, chamisa, sage, three-leaf sumac and piñon pine. Water harvesting features include stone riffles, check dams and water quality ponds, which are used to direct surface water to plantings.

Village/Urban Streetscapes – landscapes within the village and urban streetscapes and located further away from the natural open space. Fast growing, drought tolerant street trees were selected to provide shade along streets and within the neighborhood core. Native tree and shrub species were planted near the edges of the development. Non-native grasses such as tall fescues were used for high use areas and require regular irrigation (Images 4.27, 4.28). Plantings along the edges of the core areas and open space areas where minimal foot traffic is anticipated or irrigation is not available include green ash, thornless honey locust, piñon pine, crabapples, butterflybush, blue mist shrub, Russian sage, chamisa, Apache plume, winterfat, and blue grama grass.

Village Parks, Plazas and Urban Open Space Landscapes – landscapes include highly visible public spaces such as plazas and active recreation parks. Plantings are more manicured in appearance although they consist of a variety of native and non-native plant materials including green ash, thornless honey locust, piñon pine, butterflybush, blue mist shrub, Russian sage, chamisa, potentilla, roses and many perennials options. Native grasses were used in some areas of the public spaces and parks where minimal foot traffic occurs or irrigation is not available. Non-native grasses such as tall fescues were used for high use areas and require regular irrigation and weekly mowing.

The landscapes of the estate lots, located along the periphery of the village development areas, typically are included with the transitional open space and streetscape zones. Townhomes and other standard village homes are included in the Village/Urban landscape zone.

All the residential lot plantings throughout the site appeared to be consistent with community landscape zones and the low-water use and native plant palette provided in the SWM Manual and Homeowners Covenants. The level of care given to the landscapes varies greatly with the complexity and type of garden installed. Most of the low water-use plants appear to very healthy and are large in size where well established. Homeowners interviewed said that they like the plant choices, although some indicated they disliked the look of the blue grama grasses for lawn areas. Native or low water-use plants for their gardens were also readily available from local nurseries. The homeowners' landscape covenants provide a list of the approved native and low-water use plants and non-native or invasive plants not allowed at Rancho Viejo. Any changes to the approved plant list by homeowners must be approved by the HOA landscape committee, which has helped ensure that the lot landscape plants are appropriate for the community and water resources available.

Due to a lack of reuse water available for irrigating the newest village at La Entrada, landscape plantings had been delayed in some areas for up to four years by the previous owners. In 2012, the new owners and developers have begun to install street tree plantings and are promoting a creative use of stone and decomposed granite as an alternative lawn material.

Landscape Maintenance:

In 2001, the native piñon pine and junipers on-site were infested with Bark Beetles. Where these trees had been transplanted into the transitional open space and streetscapes and village streetscapes and irrigated, only about 1% died and required replacement. In other non-irrigation open spaces on site, almost 100% of these trees died over the past 10 years. As a result of this, Windmill Ridge 3 and 4 were planted with Ash and Sycamore trees. During the 2012 interview, the current landscape contractor indicated that the Purple Robe Ash original specified, were now also being eliminated from the planting palette due to their apparent susceptibility to wind damage on-site. These trees are now being replaced, as needed, with Emerald Sunshine Elm, which are reportedly more tolerant of wind and drought conditions in New Mexico. The piñon pines are no longer drying from insect damage and are now surviving well on site, especially where located in irrigated areas.

Homeowner complaints to the HOA and Landscape Maintenance Contractors relate mostly to mowing and trimming of the native plants, which are being maintained in their natural form and native grasses are allowed to reseed themselves. This is a necessary process to allow the plants to fill in and spread to cover bare areas and subsequently reduce water loss through soil exposure. The major homeowner complaints related to landscape centered on the brown appearance of the dormant native grass and un-mowed blue grama grasses installed in the medians and open spaces.

In response to the complaints, the developer and general manager conducted a re-evaluation of the landscape plant selection in 2012. A review panel include a horticulturist and landscape contractors, were brought together to discuss the issues related to the native grasses and other native and low water use plants on site. The general consensus was that blue grama was a great native grass, and once established it can survive on just the natural rainfall. For a blue grama grass to look green through most of the seasons, it requires more water than a fescue lawn (Image 4.19). Homeowners who are coming from similar semi-arid or arid environments do not appear to have issues with the dormant appearance, whereas those homeowners from environments with more abundant rainfall do not find the appearance of the dormant or natural looking blue grama grasses or other native plants appealing (Ross, 2012).

3.3 Irrigation

Water reuse irrigation systems have been installed throughout the Rancho Viejo to irrigate the majority of the open space areas. Some systems using potable water were intended to be temporary, only to be used until native plants were established. Most of the more urban open spaces and parks are irrigated with treated effluent from the water treatment plant on site. The single family homes have the option of using treated effluent or potable water for irrigation. The townhomes located in Village 1, only have the option to use potable water due to the type of construction.

Image 4.19 Natural Lot Landscaping – Blue Grama, Village I North

Image 4.18 Estate Lot Landscaping

Image 4.20 Aggregate Lot Landscaping – Windmill Ridge South


Image 4.21 Lot and Streetscape Planting - Windmill Ridge South


Image 4.23 Lot and Streetscape Planting - Windmill Ridge North


Image 4.22 Lot and Streetscape Planting - Windmill Ridge South


Image 4.24 Lot and Streetscape Planting - Windmill Ridge South

Image 4.25 Townhome Streetscape Planting – Village 1 North

Image 4.26 Lot and Streetscape Planting – La Entrada

At La Entrada, SunCor planned to irrigate in the front and backyards in lieu of the rain barrel system. This would have required more reuse water, but it was soon realized that there was not enough water for this use in La Entrada. The developers soon realized that extra water would be needed to irrigate even the minimal landscaping. In response, they did not install any irrigation system or the landscaping. As there is not sufficient reuse water available for irrigation at La Entrada, in 2012 SunCor requested permission from the county; to increase their total water use to .25 acre feet average per household.

According to the developer's representative, "If you drive through the community over the past 2 to 3 years, the .16 looks like an under-landscaped site. The interior home water use is much better, water restricted devices and low flow systems are working well. Many of the convenience devices were eliminated to reduce the use of domestic water. The exterior use was artificially held back from water use and the landscape has suffered for it," (Ross, 2012).

Image 4.27 Windmill Ridge North Park – Irrigated Non-native Turf

Image 4.28 Village 1 Park – Irrigated Non-native Turf

Image 4.29 Windmill Ridge South Park – Non-irrigated Native Grass

During the 2012 interviews, the developer and the landscape maintenance contractor both indicated that the native plants were never transitioned off of the full irrigation cycle once they were established, so the effectiveness of reducing water usage by using low water-use plants was never fully realized. Using a temporary irrigation system to quickly establish hydro-seeded native grasses was found to be too costly by the developer, so no systems were installed in some of the large transitional open spaces.

The bare areas without irrigation eventually did revegetate naturally and are now almost fully restored and filled in without irrigation being introduced at the time of seeding. Those areas which were replanted with native grasses and were regularly irrigated appeared almost as thick in growth as a traditional non-native lawn and remained green longer into the winter season. Native grasses without irrigation quickly go dormant and brown during drought conditions. This was observed to be consistent throughout the entire community and is typical of the nature of blue grama grasses.

The current landscape contractor noted that the more well-established areas that were installed 5 to 10 years ago are very stable and can survive without irrigation, even if not properly weaned off the system. The grey water irrigation is shut off each fall and not turned on until April of the following year. Many of the homeowners indicated that they also shut down their own cistern irrigation systems at the start of the winter season.

In a dry state such as New Mexico, it makes sense to explore ways to get the maximum use of natural precipitation. It is also wise to design and create landscapes that need little or no supplemental water to thrive. Water conservation, as outlined by the Santa Fe County Ordinance, requires that native vegetation be irrigated only for the first three seasons. At Rancho Viejo, during the first years, the landscapes between the roadway curbs and the sidewalks and newly planted natural open space areas received deep watering regularly, which was gradually cut back during the second year. Newly planted or transplanted piñon trees require regular watering for around 3-5 years. After the initial growth period, irrigation was to be used only during long periods of drought.

By 2003, the residential water use was measured at .15 acre ft. per year compared to .25 acre ft. per year in Santa Fe County and .70 acre ft. per yr. in arid environments like Phoenix. The lower potable water use is mostly due to the successful implementation of the water conserving strategies.

Santa Fe County later contracted with the Ranchland Utility Company to monitor water use in the community and uses a stepped rate for water usage. In January 2003, average daily flow recorded by Ranchland for Rancho Viejo community development was recorded as 64,194 gallons per day (Ross, 2012).

3.4 Hardscape (Pervious Paving) Design

Pervious paving is mainly installed in residential landscapes or as mulching materials in roadway medians and shoulder areas. Significantly more porous paving is evident in the public streetscapes and open space areas, by comparison to the areas developed at beginning of the project. Porous paving materials have replaced areas that would have typically been installed with native grass plantings in roadway medians and planting zones between curbs and sidewalks (Images 4.30, 4.31).

Issues related to hardscape were mainly a result of failure of the infiltration/cistern systems, which caused paving areas on residential driveways and walks to fail, or wash out due to large rainstorm events. There also is an ongoing issue with the decomposed granite materials washing away on some pathways during heavy rain events, leading to higher maintenance requirements for trails and sloped areas paved with this porous paving material. Decomposed granite appears to be used less frequently on site than in 2003, mostly due to the dust and erosion problems with this material.

Image 4.30 Water Catchment Systems – Backyard Pervious Paving

3.5 Lot Landscape Maintenance

Management of the native grasses has been consistent with the maintenance specification provided by the design team. Seed head production is managed properly and the plants are allowed to grow two feet tall before cutting to allow the plants to reseed (Arvico, 2012).

Homeowners are provided with a handbook and other information on the irrigation systems, water harvesting systems, water conservation, etc. when they purchase a home at Rancho Viejo. However, maintenance of the landscapes is inconsistent as many of the homeowners do not know how to maintain a low-water use and/or native plant material landscape. In general, it was observed that once you turn the landscape maintenance over to the homeowners, the HOA's and developers have very little control in keeping the lots sustainable as designed. The developer felt the blue grama grasses may have been overused, however, the options for drought tolerant and native grass types are limited for the arid environment of Santa Fe, so no other replacement grass could be found that would succeed better or appear more aesthetic year round.

Inspections by the HOA managers are related mostly to the exterior aesthetics of the landscape and homeowners are notified when they need to provide more maintenance for their trees or front lawn areas. The HOA managers do not inspect home landscapes to ensure the covenants are being implemented unless there is a complaint. The maintenance plan calls for native plantings on lots to be trimmed back heavily then allowed to grow naturally and only get trimmed back heavily each year, however, the homeowners complain about how this appears. Homeowners who have moved to Santa Fe from more temperate climates often treat the native grasses as they would a traditional fescue or blue grass lawn, keeping them mowed short. Homeowners also regularly complain when the blue grama grasses in the medians are let to go to seed and when they go dormant and brown during the hotter summer months (Arvico, 2012). Achieving full coverage of soil is impeded without the natural reseeding process unless regular irrigation is present.

4. **Village Roadway**

4.1 Roadway Design Curb and Gutter Design

Curb and gutter design varies along the major streets from standard straight curbs to rolled curbs, depending on the grading and drainage requirements. Curb streets direct most of the surface runoff to standard storm drains connected to the infrastructure or to outfalls within adjacent stormwater management areas. Tertiary roadways are a mix of rolled curbs and no curbs, which allow surface water to migrate into the adjacent swales along both sides of the road. Street catchment systems were all designed and installed as outlined in the SWM Manual.

4.2 Streetscape Grading (Shoulder and Parkways)

The site designs for streetscapes and shoulders included carefully graded and landscaped swales, and innovative applications of bioswales and green streets (Images 4.31).

Planted Medians/Swales: In older areas of the community, plantings of native shrubs and trees have outgrown the median spaces, and are shading out the shorter perennials and native groundcovers originally installed. Plant removal has also been required where plants were blocking sight lines at roadway entrances and drives. Where irrigated, the common areas are watered with the treated graywater from on-site. Common areas also function as water harvesting areas for surface runoff from adjacent pervious surfaces such as walkways, drives and roadways.

Native Grass Swales: The swales located along steeply graded roadways were designed with stone riffles to slow water flows and reduce erosion and appear to be functioning well. Areas where native grasses (blue grama) have been long established are the most stable. Newer planting areas are still sparsely covered and subject to erosion and silt accumulation (Images 3.32).

Image 4.31 Rancho Viejo Residential Streetscape Examples

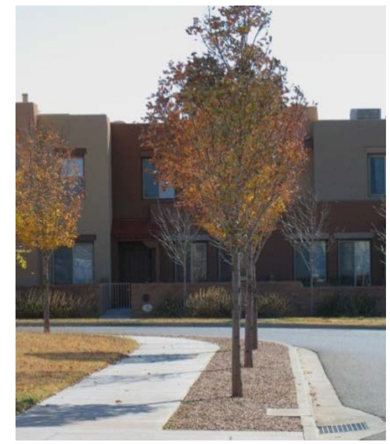

Image 4.32 Village 1 North – Grassed Swale

Image 4.33 Roadway Stone Armored Drainage Swales

The recommended channel lining of swales was not implemented along the extensive drainage channels that existing throughout the open space areas due to cost of installation and management (Images 4.33, 4.35).

Culverts Inlets and Outfalls: Along major roadways within the developments, a variety of techniques for stabilizing drainage structures are present. The stone drop structures or riffles installed within the drainageways have been very successful in slowing down the water flow and reducing erosion. However, siltation and overgrown plants and weeds are now clogging some of these structures. The goal of the developer and site designer was to create green infrastructure that appears as natural looking as possible and to avoid traditional large prefabricated systems within the neighborhood areas. Stone-faced headwalls, small boulder riffles and swale lining, native grasses, and structures resembling historic acequia systems (Image 4.33) with dimensional stone-lined channels are some of the strategies implemented at the culvert openings. However, some materials, although attractive, were not as effective in slowing runoff and preventing scoring or erosion as others (Image 4.34).

Areas with the least amount of stable armoring with stone or native grass plantings show considerable erosion and sediment blocking the structures. Most of these culvert systems are functioning, but all would benefit from being cleaned out and stabilized after heavy rainstorms. New Mexico soils are highly erodible and the severe downpours that occur in late summer are continually damaging these systems. Some erosion under adjacent paving is also evident. A longer term and cost effective solution is needed to stabilize the systems. Regular maintenance is needed to ensure they are functioning properly and remain clear, especially during the rainy season.

Image 4.34 Culvert Inlets and Outfalls

5. Open Space Design and Management

5.1 Soil Conservation

Some minor erosion problems are occurring in the drainageways installed in the more managed areas of the site along the roads and public spaces. Open spaces areas outside of the development area and along the walking paths have required more repair work due to erosion. A preventative management program has not continued since the original work was completed through 2004, due to cost. Severe rain storm often washed out the bank soils along arroyos passing through the site. The older stabilized areas of the drainageway showed little damage (Image 4.35), however, a newly installed control measure failed in 2010, causing some serious drainageway banks erosion, and rock and wood debris were pushed into the adjacent open space areas.

5.2 Planting of Open Space, Roadways and Adjacent Drainageways

The restoration of native landscapes surrounding a new community can be difficult, as these landscapes are constantly evolving with changes in rainfall, animal populations, microclimates, insects and diseases and human use. Knowledge of the local climate, soils, plant materials and orientation are critical to the success and survival of these environments.

Native grass restoration was provided by Tall Grass Restoration Company from 2003-2005. They provided the scientific method and materials for restoring life back into soil that has been severely depleted of organisms, organic matter and other elements which make soil a healthy stable growing medium. Highly visible open space areas were very successfully restored, allowing the native plant materials to re-establish and stabilize the highly erodible soils. After 2005, this service was no longer available from Tall Grass Restoration site. The developers had to modify their approach and used one of the current landscape contractors on-site to attempt to replicate some of the restoration processes. This was not successful and only those areas which were irrigated thrived (Pino, 2012).

Plantings were installed in most locations as originally designed, with the exception of the transplanting of some of the native piñon pine and junipers. In 2001, the native piñon pine and junipers on site were infested with Bark Beetles. Where these trees had been transplanted into the residential landscape and irrigated, only about 1% died and required replacement. In other non-irrigation open spaces on site, almost 100% of these trees died over the past 10 years. As a result of this, Windmill Ridge South (3 and 4) were planted with Ash and Sycamore, as the native trees had died and could not be preserved or transplanted by the time the construction for this development began.

In some drainage areas near open space zones, and where no temporary irrigation system was installed to establish the plant materials, large areas with poor plant coverage has occurred, exposing the soils to erosion. The natural/passive catchment systems designed for channels, ditches and swales areas in the streetscape and open space areas were all installed as originally designed but vary in their success based on the drainage area they are serving. Areas where there is more consistent vegetative cover or stone armoring the drainage area are functioning well and are attractive elements in the landscape. Where native grasses do not fully cover the drainage area services, sediment buildup within the upslope and erosion downslope of the culvert systems are apparent. The stone drop structures or riffles installed have been very successful in slowing down the water flow and reducing erosion in the more gently sloped swales, but were either not installed due to costs or have failed in the steeper slopes of the open space areas.

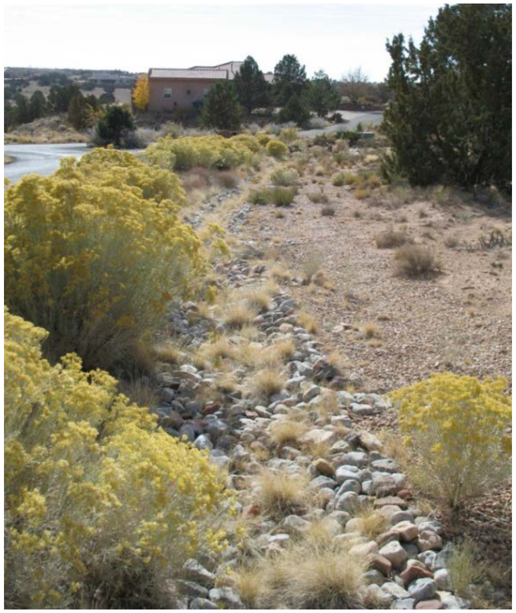

Image 4.35 Open Space Stone Armored Swale

V. ANALYSIS AND DISCUSSION

The sustainable development goal of water conservation was built into the overall development process along with clustered developments to preserve open space, making Rancho Viejo unique from many other similar case studies. The major factors affecting the success of Rancho Viejo's surface water management goals included changes in the primary developers, environmental factors, challenges with project contractors, education/public outreach and perception of homeowners of a sustainable arid landscape, and the effect a changing economy had on the original vision for surface water management and water conservation on-site.

A. Surface Water Management Goals Discussion

The Rancho Viejo Surface SWM Manual was intended to: expand upon the master-planning goals, to be a model for how to use sustainable planning and design strategies for using stormwater runoff as a resource, and to illustrate that landscape architects can effectively lead the design of sustainable surface water management systems. Through a collaborative approach, we can improve not only the visual quality of the site, but create habitat, stabilize soils, conserves water and meets the federal water quality and engineering requirements without prohibitively increasing land or maintenance costs.

At the beginning of the study in 2002, the development team and design consultants at Rancho Viejo recognized that they were experimenting with new methods to capture the multiple benefits of rainfall at every stage of its journey from rooftops to its return to the aquifer. A revisit to this project will help determine which of these strategies were successful and where new technology can improve the approaches taken.

The SWM Manual strategies were meant to be reviewed and updated to continually elevate and upgrade the quality of the conservation efforts as new technologies and innovative approaches emerge. However, the original developers interviewed indicated that the manual was not updated or distributed to new management teams since 2004. Although the manual is not fully used as intended, after conducting the interviews and site observation, it was apparent that most of the goals and strategies proposed for new development were still being implemented. This may be partially due in part to the full integration of the strategies into the original construction documents, specification, covenants, marketing materials and other support materials that have been used on a daily basis on site since the start of construction.

The Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary matrix charts the original goals, implementation status since 2002 and the success and challenges experienced over the past 10 years in the efforts to implement the proposed strategies. The following is a discussion on the lessons learned.

1. Village Master Plan Development and Management Strategies

(Figures V-1.1 to V1.3)

1.1 Handle Water at the Source

This key principal of sustainable surface water management was adopted during the Master Planning phase, was key to the success of the project's water conservation. Even with the challenges experienced with the catchment systems, overall the amount of potable water was reduced in homes and reuse water reduced in the landscape irrigation due to the supplemental water captured through this approach.

All of the case studies included strategies to achieve this basic principle of stormwater management in their project goals and site design. In this drought-plagued high desert, landscaping with native plants and a general focus on water retention is paramount, so homes are sited and built to take advantage of the precious rainfall. Rancho Viejo appears to have the most diverse options for residences to capture water on their lots, however the new community of Day Break has incorporated much larger scale systems such as the Oquirrh Lake, acres of constructed wetlands and infiltration basins by comparison to the other communities studied.

1.2 Reduce the Need for Mass Grading

In the literature review of *Innovative Ways to Conserve Water*, mass grading is identified as a key contributor to the degradation of native landscapes as it smoothes out the hydrologic roughness of the landscape, which causes more runoff and less infiltration and therefore, less moisture being stored in soil and subsequently a greater need for larger infrastructure systems. Low impact development strategies aim to retain/restore site hydrology, and bioretention-based stormwater systems restore hydrologic roughness to the site, capturing and holding water in a way that is more similar to native conditions (Venhuizen, 2006). By coordinating the grading with the site construction work and contractors, the number of times the surface must be reworked and soil erosion can be somewhat minimized.

Excessive reduction of vegetative cover through mass grading can start a cascade of negative effects that destroy existing ecosystems and degrade water quality. But sustainable practices of stewardship such as improving soil conditions can reverse the effects, preserving and restoring ecosystems so they function in ways that promote the continued existence of other species in the surrounding native landscape. This requires close coordination with the developer, project engineers, landscape architects and contractors.

Mass grading occurred on almost all of the other case studies at some point due to the speed in which the new homes were being put on the market. High Desert was able to avoid some mass grading by cutting roads into the hillsides. The advantages of mass grading to quickly market new homes must be carefully weighed against the impact of stripping a site of all its natural amenities and the cost to restore it and market it successfully in this condition.

1.3 Grade the Site to Allow for Water Harvesting (residential lots, parkways, open space and paving areas)

This strategy improved with each new village constructed at Rancho Viejo as the soils, drainageway design, architecture and site grading improved. The shortage of reuse water for irrigation and subsequent reduction of plantings reduced the amount of surface water to be harvested, but increased the need for well-designed swales and catchment systems to filter out sediment from pervious paving materials.

All of the case studies reviewed had implemented a mix of similar strategies for grading the site to accommodate water harvesting. Village Homes was one of the first communities ever to implement bioswales. Rancho Viejo and High Desert have integrated water harvesting in the grading throughout their sites due to the challenges with short intensive storms that produce large volumes of water that must be carefully managed on such erosive prone soils. Day Break is unique in that it has incorporated very large scale systems such as the Oquirrh Lake, acres of constructed wetlands and infiltration basins.

1.4 Install Green Infrastructure (i.e. through the use of natural meanders and stone check dams, creating visual amenities for the development instead of expensive eyesores that require screening).

Designing water catchment systems such as storm-water detention areas and swales can slow water flows, allowing it to filter into the soil and eventually into the aquifer, thereby reducing erosion and the water demand and cost of repair and maintaining existing and future drainage systems.

Drainageways and swales should always be roughly graded to slow water velocity and better capture what little moisture may be available. Soil imprinting is a method that harvests water from natural rainfall by creating indentations that hold water when it rains. Seed can be applied to either of these systems to stabilize the soils and slow water as well for further infiltration. In arid and semi-arid climates, however, the value of these practices needs to be weighed against locations where water is needed to irrigate the grasses in swales to stabilize them. This was less of an issue for Rancho Viejo and Day Break, which have the opportunity to utilize treated grey water to temporarily irrigate the grassed swales to stabilize them.

1.5 Retain and Design Large Open-space Areas Throughout the Community Development that Reflects the Historic Drainageways

The Day Break community is built on a previously mined, heavily disturbed site so the original natural drainage patterns really no longer exist. They did preserve over 68% of the land for common open spaces, much of which is used to capture stormwater for reuse. However, the other case study projects were able to protect much of their existing drainageways, but none to the extent of Rancho Viejo and High Desert.

Rancho Viejo and High Desert preserved the most open space, historic drainageways and arroyos that are characteristic high desert environment in New Mexico. Rancho Viejo is considered a model for other communities for its planning and preservation of open space and historic drainageways. Development occurred on the flat plateaus on site to preserve the major drainageway throughout the site and contributes to the 50% of open space was in alignment with the original vision, and conserved this land for aquifer recharge by preserving the natural drainage system patterns. Retaining the open space in a natural condition is preferred by the developers, but was found to be difficult to maintain. Some of the man-made open spaces within the developed areas could have been better directed towards their real end uses. For example, the detention ponds installed at La Entrada could have been developed as a more integrated part of the community as passive open space and not located where it is not easily viewed or accessed.

1.6 Design Stormwater Systems and Erosion Control Plans Based on Research of Existing Conditions and Land Use Restrictions (i.e. research of soil composition; slope of the site; depth to water table; proximity to bedrock, foundations, and wells; land consumption; land-use restrictions; high sediment input; and thermal impacts to downstream areas).

This was a common strategy for the case studies, as well as Rancho Viejo, but the depth to which the research goes varies with the complexity of the site. Rancho Viejo as well as High Desert are located on highly erodible soils, arid landscapes, limited water resources, and complex land restrictions, which required extensive research into these systems. Unique to Rancho Viejo were the archaeological studies, in-depth soil studies related to the water treatment plant and water injection system research.

1.7 Install and Maintain Construction and Sediment and Erosion Control Fencing and Control Contractor Access to Preserved Areas of the Site

This strategy was crucial to minimizing disturbance and preserving the natural habitats and drainage areas to be protected on site and one of the most difficult to manage throughout the project development. Santa Fe County and other public agency required erosion control systems to be in place to minimize on-site erosion and prevent off-site sedimentation. The specifications call for permanent or temporary stabilization to be installed within seven days in all swales, ditches, perimeter slopes and all slopes greater than 3:1; and within 14 days for all other disturbed or graded areas on the project site, following initial soil disturbance or re-disturbance. Requirements such as these are common across all of the other case studies reviewed, as NPDES compliance is required by all states and there is a lot of consistency across many of the State and local agency requirements for water conservation in the west.

Recommended strategies to trap sediment included: straw bales (native grass preferred), sandbags, or sediment traps; filters to limit sediment in runoff: vegetated berms, straw bales, sediment erosion fencing, inlets, or vegetative filter strips; routing devices to protect steep slopes by directing water to an infiltration area or discharge point: hay bale swales, terracing, grassed parallel swales or metal piping; culvert or chute outlet protectors to prevent high-velocity water damage: riprap, gabions, stilling basins/water-quality basins or protective aprons.

Controlling contractor access and disturbance of the site is an on-going process throughout the construction phase and requires regular visits to monitor contractor activity. This is a common challenge for all of the projects reviewed in the case studies. In the case studies, Civano and High Desert as well as Rancho Viejo, all incorporated strategies to remove trees and shrubs that were disturbed through the grading process, and relocated them to other areas on site. Rancho Viejo employed the strategy of assigning monetary penalties for damaging trees or other plant life, or other protected features can be effective tools, if enforceable and if the penalty is significant enough. Some success was achieved with construction of Windmill Ridge, and the developer and design team scheduled weekly or bi-weekly meetings with the contractor to discuss these issues and to help educate the contractors about why we were working to keep some areas undisturbed. This was only a successful approach when the developer was involved. When you can achieve buy-in from the team and sense of ownership of the project from all parties involved, success is more likely.

During the first phase of construction at Rancho Viejo, the contractors typically consisted of a group of different subcontractors who were contracted directly with the developer. This created some problems during the construction of the site as the subcontractors often disturbed or damaged each other’s work. For example, one issue that was apparent when the manual was written was that the silt fence and other erosion controls were being severely damaged and removed by other subs working in the area. To remedy this costly problem, the developer hired one lead managing contractor responsible for the overall site construction and for hiring subcontractors contracted directly to them for work on an as needed basis. Having a lead managing contractor eliminated the most issues with the maintenance of the erosion controls and other construction damage on site. The downturn in the housing industry and change in owner/developers and management team in 2011 may have contributed to this lack of oversight of contractors.

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary

1.0 Village Master Plan Development and Management Strategies			2012 Status of Implementation of Goals and Strategy Analysis		
GOAL 1.1 Handle Water at the Source	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Design grading, structures and catchment systems to capture surface water and rainwater at the source.	Implemented	Continue to integrate the design process for handling water at it's source into Engineering, Architecture and Site Design Construction Documents	Implemented	Capturing water at the source was found to be the most efficient way of reducing erosion from runoff and also the most energy efficient-way to acquire water for reuse. Reduction of infrastructure costs were realized in the villages constructed after 2002. Other Successes Included: • A reduction in traditional infrastructure was possible. By using green infrastructure systems, a reduction of traditional piping and storm sewer systems were eliminated, providing a cost saving to the developer. • The developers' willingness to test out a variety of systems from roofing materials and roof design, to cisterns, infiltration and other innovative systems was valuable in determining what systems worked best throughout the community where soils, aspect, grades all impacted the choices.	No Significant Issues. However, drainage plans were not updated to reflect changing conditions and water-harvesting plans were not created for all phases of development.
Prepare integrated grading, drainage and water-harvesting plans. Handle water at the source.	Partially Implemented	A drainage and water harvesting master plan must be prepared as part of the preliminary master plan for each village. Drainage plan should be updated and detailed in parallel with the master plan.	Partially Implemented		
Reduce infrastructure throughout the site by including natural drainageways, detention basins, rainwater catchment systems into the site and lot design.	Implemented	Continue to integrate the design process for handling water at it's source into Engineering, Architecture and Site Design Construction Documents	Implemented		
GOAL 1.2 Reduce the Need for Mass Grading	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Where mass grading cannot be avoided, prepare a Mass Grading Plan that preserves as much of the natural landscape as possible.	Implemented	Use the civil engineers Mass Grading Plan to establish staking limit and construction/erosion control fence edge.	Implemented	Successfully implemented in Windmill Ridge-North, and worked well when development was moving at a slower pace. This required coordinated scheduling or if unavoidable, mitigate potential wind erosion and sedimentation with appropriate controls such as tackifiers or crimped hay techniques. Other Successes Included: • With careful coordination, native piñon pines were relocated before grading and native vegetation • Integrated grading, drainage and water-harvesting plans were developed to establish construction disturbance boundaries near natural areas. • Windmill Ridge grading did include imprinting techniques to create a roughness that slowed runoff and allowed some of the surface water to infiltrate into the soil. • Stockpiling of topsoil to retain native seed source. • When mass grading was required, work was limited to dry seasons only.	What dictates the phasing of construction is the balancing of the on-site soil. In the first two villages, mass grading typically occurred over a four-week period and lot compaction occurs while the rough grading is done to keep the wind erosion to a minimum. Slower paced construction leads to more wind and water erosion. Mass grading did occur in Village 1 and La Entrada and some areas of Windmill Ridge South. This was a minor issue for Village 1, as the construction schedule was very quick. La Entrada and Windmill Ridge, however, were graded during the economic downturn and many of the lots still remain bare and subject to erosion. Other Challenges Included: • Mass grading was found to be far more economical for the newer Villages than grading in smaller parcels to preserve existing trees and land forms. • Hydrologic patterns were significantly changed by mass grading in Windmill Ridge South and La Entrada, causing more runoff, less infiltration. • Soils were more significantly compacted reducing their ability to absorb runoff and support vegetation without reworking soils. • Significant loss of native vegetative cover occurred followed by erosion and silting of drainageways for parcels not built within a 6 month period. Reduced vegetative cover affects soil health, because vegetation maintains soil structure, contributes to soil organic matter, and prevents erosion and sediment runoff. • Conflicts occurred when multiple contractors were working on site without a general contractor coordinating their work schedules. This lead to further disruption of stabilized grading areas and erosion. This issue was remedied through the selection of one general contractor to manage sub-contractors on site. • Climate – the infrequent, but severe storms in the region are significant challenges to stabilizing graded areas and establishing vegetative cover on slopes during the rainy season. Cost effective means of stabilizing extensive systems of large drainageways in highly erodible soils in the southwest needs to be further research.
Establish clearly recognized and highly visible construction and disturbance boundaries. Limit site disturbance, including earthwork and clearing of vegetation, to 40-feet beyond the building perimeter, 5-feet beyond primary roadway curbs and walkways, main utility branch trenches, and 25-feet beyond pervious paving areas, to limit compaction of soils.	Partially Implemented	Work with the civil engineer to minimize the area of disturbance and define limit of disturbance with fencing earlier in grading and site preparation process than previously done. Ensure limits are delineated accurately in the field with protection fencing. Rancho Viejo (RV) to monitor the status of the fencing on a regular basis. Confine the tree transplanting routes so contractor causes less compaction and damage to the existing habitats. Provide protection such as wood mulch or temporary gravel paving prior to the start of work. Work with RVs' land development superintendent to have these guidelines reviewed with the transplanting contractor.	Partially Implemented		
Groundwater Recharge: Wherever possible, create opportunities to allow water to filter into the ground rather than run off the surface and into storm drains.	Partially Implemented	The EPA recognizes recharge from detention/retention basins, however, there is no credit for recharge through these basins by the NM State Engineer as of December 2003. RV to continue to work with the new State Engineer to determine how this can be resolved and if Injection System can be constructed. Recharge areas such as swales, detention ponds, and other natural catchment areas will continue to be implemented.	Partially Implemented		
Stockpiling of topsoil: All topsoil is removed and stockpiled until final grading is complete and it can be reused. If topsoil is going to be stockpiled for over 30 days, it is seeded and placed into piles that meet the requirements for maintaining healthy soil microbes.	Not Implemented	RV wants to preserve the existing topsoil whenever possible. They may have to stockpile soils in the next phase of work for up to two years. The Landscape Architect (LA) recommended seeding the stockpiles with blue grama grass only. No annuals such as rye or barley should be used. Do not stockpile in areas to remain undisturbed.	Implemented		
Complete mass grading work only during the dry season.	Implemented	Mass grading is completed whenever the soil is dry. Amount of grading is also determined by the balance of cut and fill. Work to reduce the amount of mass grading in all future development phases.	Implemented		
GOAL 1.3 Grade Site to Allow for Water Harvesting	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Schematic Drainage Plan is prepared by Development Area.	Implemented	Schematic or Preliminary Grading Plans need to be coordinated with Engineer's Plan at an earlier stage than currently being done.	Implemented	Grading the site to allow for water harvesting on lots, parkways, open space and paving areas was successfully implemented in the first villages and worked best when adjusted lot by lot. Preliminary Grading and Drainage Plans were prepared for the first 2 village communities that established the drainage paths to open space areas for water harvesting.	• Contractor found it easier to grade multiple lots at a time. This required the regrading of many home lots once the houses were constructed to insure proper drainage would occur and where possible to benefit water harvesting techniques. • Significant variation in soils and ability to across the site does not allow for mass grading approaches according to the developer. • There continues to be issues with coordination between the Civil Engineers grading plans and establishing the water harvesting strategies early in the design process on and on a lot by lot basis.
Overall site is divided into small catchment areas.	Partially Implemented- WR - Unit III Only	Continue to review opportunities for this in all future phases. LA to assist RV and the civil engineer in creating naturally shaped basins that function as needed but also blend well into the natural contours and can be used as a visual amenity.	Partially Implemented- WR - Unit III Only		
Building pads are designed and installed to be above the adjacent walkways and streets to allow for positive drainage away from homes.	Implemented	Continue to implement this in all future phases as appropriate.	Implemented		

Figure V-1.1 Goals Matrix

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary						
1.0 Village Master Plan Development and Management Strategies			**2012 Status of Implementation of Goals and Strategy Analysis**			
GOAL 1.4 Install Green Infrastructure	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**	
Drainageways parallel to the road are designed and installed wide enough to allow for the centerline of flow to meander in steep areas to slow down water flow and potential erosion or undercutting of bank and allows water to filter into soils more readily.	**Not Implemented**	RV has directed the civil engineer to get this implemented wherever possible. RV requested more natural-looking solutions with meanders and varying roadway widths as well as tan stone materials, in the drainageway. Details are currently being developed as required. Decisions are based on the amount of open space next to the roadway and the adjacent grades.	**Partially Implemented**	• Installing green infrastructure with natural meanders and stone check dams created visual amenities for the development instead of expensive eyesores that require screening. • Swales with natural meanders and stone check dams were successfully installed in the main areas of the community where enough space was available. • Simple stone riffles and haybales were installed in steeply graded swales to slow water and help with filtering debris and reducing potential for erosion and silting.	• In many of the estate development areas and open space drainage areas, the drainageways are so extensive that it was not cost effective to address all these systems. • The visual quality of some of the systems installed degraded considerably with time and a lack of regular maintenance. • Stone armoring can be expensive and is prone to catching debris and silting up. • Storm event severely damage check dams in the major drainageways over time, requiring less stable haybale structures to be removed. • Native grasses are typically seeded in swales within the more urban spaces, however, only limited seeding or sodding has been installed in the last phases of work to stabilize disturbed soils in the open spaces due to costs. Although some erosion does occur, the grasses in the open spaces do eventually fill in the bare areas but it can take 3-5 years for this to occur during drought years.	
Where appropriate, channels, seed or sod ditches and swales with native grasses to stabilize soils and allow water to infiltrate into the subsoil.	**Implemented**	Success in establishing seeded drainageways is sometimes achieved by grading the swale side slopes at 1 to 2 percent, mainly in open spaces. Drought was a barrier to successful germination in many locations in 2001 and 2002. LA to work with contractor to determine what mix or soil conditions may be required to improve our success with this installation. Field verify that check dams and other soil erosion methods are installed prior to seeding. Soil amendment options are being tested by Tall Grass Restoration, for better seed coverage and established during all times and especially during drought, in areas of high visibility and highly erodible areas.	**Implemented**			
GOAL 1.5 Retain and Design Large Open-space Areas that Preserve or Reflect Historic Drainage Patterns	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**	
Master Plans and Site Design must preserve at least 50 percent of the land for parks and open space, for preservation of habitat, view corridors, native landscapes, arroyos and drainageways. Site development on existing plateaus away from existing major drainageways/arroyos. Wherever possible, preserve large contiguous open space areas to retain habitat corridors and historic views across the site.	**Implemented**	No Additional Recommendations. Planning process and site design fully addressed this recommendation.	**Implemented**	This strategy was a key component of the sustainable master-planning process and was identified as a key selling point for homebuyers. The open space areas protect the major view corridors and give Rancho Viejo its unique sense of place. Successes Included: • Development occurred on the flat plateaus on site to preserve the major drainageway throughout the site and contributes to the 50% of open space achieved at Rancho Viejo. • Preserved contiguous habitat and historic views across the site.	Developers found that maintaining native grasses in some of the transitional areas was not successful due to the homeowners' unfamiliarity with the look of a natural landscape, indicating that more education of new buyers is needed. The scale of the open space made it difficult to maintain, especially in the care of the drainageways. Armoring of outfalls into the natural drainageways did occur and in many cases heavy silting and erosion were observed. The cost to stabilize such an extensive natural drainage system was too prohibitive for the developer so only spot repairs in open space areas occur where potential damage to adjacent trails, walkway, roads, or detention basin facilities could or has occurred.	
GOAL 1.6 Design the Stormwater Systems and Erosion Control Plans Based on Existing Soils, Grades, Drainage Patterns and Land-use Restrictions	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**	
Create Drainage Plans and Erosion Control Plans based on in-depth research of soil composition; slope of the site; depth to water table; proximity to bedrock, foundations, and wells; land consumption; land-use restrictions; high sediment input; and thermal impacts to downstream areas.	**Implemented**	No Additional Recommendations. Planning process and site design fully addressed this recommendation.	**Implemented**	• Erosion-prone areas were protected through development of an erosion control plan that was put in place before and during construction. • Collaborative design and research with the developer, project engineers, architects, and contractors helped to successfully achieve this goal for the major areas of the site. • Street catchment systems were all designed and installed as outlined in the manual. The stone drop structures or riffles installed have been very successful in slowing down the water flow and reducing erosion. Channel lining was not implemented as it was determined to be too costly due to the extensive drainage channels throughout the site.	• The unknown factor of weather and actual runoff patterns can only be tested with time. These systems need to be adjusted to accommodate natural patterns that form after the land is disturbed. • Oversight of contractors to ensure proposed drainage patterns and systems were installed as designed.	

Figure V-1.2 Goals Matrix

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary

1.0 Village Master Plan Development and Management Strategies			2012 Status of Implementation of Goals and Strategy Analysis		
GOAL 1.7 **Install and Maintain Construction and Sediment/Erosion Control Fencing to Minimize Disturbance**	2002 Status	2003 Recommendations to Improve Site Sustainability	2012 Status	Successes	Challenges
Prevent loss of soil during construction by SWM runoff and/or wind erosion through the use of strategies such as:				• Designated on-site parking and drive locations and stockpile locations was successful in some areas of the development and did help to avoid soil compaction. However, on smaller sites where space was more limited, getting contractors to adhere to this was less successful. • The siltation fencing is still being used during construction and is still remaining in places where lots are still under construction in Windmill Ridge. • New details were developed for haybale swales and other temporary systems were put into place to slow storm water runoff. The most success occurred with stone riffles, which can be long term solutions and are often more stable during heavy rainstorms.	• Native grasses are typically seeded in disturbed areas within the developed community areas, however, no plantings have been installed in the last phases of work to stabilize disturbed soils in the open spaces due to costs. • At La Entrada, there has been a failure to maintain the silt fencing to the level required. This may be a result of less manpower being available for oversight due to the recent drop in housing sales and cutback in staffing. • Soil stabilizer products are often difficult and costly to maintain on large development sites and must be reapplied to be effective when construction is delayed. It can, however, significantly reduce dust and silting of drains and roofing on adjacent homes. • Haybales were installed on the steeper slopes and drainageways to slow runoff. The haybales eventually disintegrate and were not visible in most areas of the site. However, where used in open space drainage areas with heavier water flows, they were held in place with rebar. The rebars are now fully exposed where the haybales have disintegrated and may be a safety hazard in some locations and should be removed. • Balancing cut and fill is important due to the tremendous costs involved. However, this factor often drives how much of the land is disturbed and how grades will be established and drainage patterns. Master grading plans must include cut and fill studies and be adjusted regularly through the project to ensure protection of native landscapes to be preserved.
Soil stabilizer/tackifiers applied and reapplied on a timely basis.	**Implemented**	Coordinate and plan for stabilizers in advance of grading based on time of year, size of area disturbed and locations. On vacant lands use crimping with hay first, then if needed use a tackifier. Evaluate on a yearly basis to determine best means of management and impacts of solutions on future development.	**Implemented in Some Locations**		
Sediment erosion fencing installed as specified on engineers plans.	**Not Implemented**	RVs' land development superintendent will supervise and monitor all future fencing installations on a regular basis. Civil engineer is creating the new details to meet NPDES requirements.	**Implemented in Most Locations - Except La Entrada**		
Grassed swales are located at the top of steep slopes adjacent to residential walls and designed to slow water and drive it into the subsurface.	**Implemented in Some Locations**	Location and design need to be reviewed on site for appropriateness. LA to create a section detailing proposed swale design at top of slope. LA to review the civil grading plans to determine where this is an appropriate detail and provide recommendations for avoiding potential concentrated runoff and subsequent soil erosion. Coordinate new detail with the civil engineer at the development plan stage.	**Implemented in Steepest Locations**		
Construction is phased to minimize water and wind erosion.	**Implemented**	In all new phases of development, work to minimize the limit of disturbance as part of the planning process. The potential schedule for construction should also be reviewed as part of the planning process. Main challenge is preserving open space when trying to balance cut and fill on site.	**Implemented**		
Natural vegetation maintained or new plantings installed to stabilize disturbed soils.	**Implemented - But Limited by the County Drought Planting Restrictions**	Mostly new plantings are planned. When Santa Fe County planting and watering restriction are in effect it is difficult to get plantings installed and quickly established. Natural vegetation is preserved based on the level of disturbance. In all new phases of development, work to minimize the limit of disturbance as part of the planning process. The potential schedule for construction should also be reviewed as part of the planning process.	**Implemented - But Limited by the County Drought Planting Restrictions**		
Temporary hay or native grass (preferred) bales are installed in swales to slow storm water Stone or hay bale weirs/check dams are installed in appropriate drainageway locations (recommended every 50 feet) to slow storm water movement and potential damage to newly seeded areas.	**Implemented**	This effort was constrained by drought, however, it was effective in reducing loss of soils when there is no seed cover by slowing the water down at critical areas and driving it into the ground. RV plans to implement this as part of meeting the new NPDES requirements. Hay bales have been used in some locations. They are cost-effective and can be used in other locations as an inexpensive solution. Haybales breakdown in one to two seasons, based on rainfall received. New details from the civil engineer will address and delineate locations for this. The design team needs to continue to review best option for future improvements. RV to review to ensure the details implemented as specified. Location and design need to be more closely considered and reviewed on site.	**Implemented**		

Figure V-1.3 Goals Matrix

2. Residential Architecture (Rooftop Catchment Systems) Strategies (Figure V-2.1)

The surface water management goals for the overall Residential Architectural Catchment system included:

2.1 Design Architecture to Improve Rainwater Capture and Reuse

Perhaps the oldest stormwater catchment and treatment device, cisterns have been used to collect rainfall and runoff for many different uses since the Bronze Age (2000 to 1200 B.C.). Now cisterns harvest rainwater from rooftops and temporarily store it for landscape irrigation. As old as the devices are, incorporating cisterns into modern landscapes can be a challenge (Kinkade-Levario, 2007).

Rainwater harvesting was a key component of Rancho Viejo's conservation program. In conjunction with Santa Fe's Rain Capture Inc., Rancho Viejo began installing fully automated rainwater harvesting systems (cisterns) with every new home. These 600- and 1,200-gallon underground systems are designed to capture and use much of the water that lands on the roof, draining the runoff into French drains or downspouts that empty into an above or below ground cistern. A standard system provides a significant portion of the water needed for landscaping; upgrades are available that allow almost any home to capture 100 percent of the water needed for landscaping and evaporative coolers, thus reducing total household demand for potable water by up to 40 percent. These systems are expected to pay for themselves within five to eight years. There were, however, few contractors who truly understood the systems when they were first installed in 2003, and issues with placement, existing soils, maintenance and the quality of the systems were key barriers to success.

Using metal roofing for water catchment systems was originally recommended, as it is the cleanest system. Roofing materials such as asphalt, composition shingles, clay tiles and concrete tiles were avoided, which are rougher and more porous and consequently tend to collect dirt and harbor mildew, ultimately adding to filtering requirements. Roofs made of asphalt or roofs with lead-containing materials contaminate the rainwater collected and render it undesirable for reuse. Due to cost, spray foam systems were selected by the developer.

The foam roofing materials posed quite a few problems with improper installation, bird damage, flaking of foam due to UV exposure, which led to a re-evaluation of the materials and methods of installation. Most roofs on site have now been repaired or in the process of repair or replaced. This was a costly problem for both the homeowners and developer.

For communities to successfully implement a roof catchment system, the research needs to occur prior to the final design of the architecture. There are numerous resources available now to aid in the design of roof catchment systems. In the publication, *Design for Water*, the author provides in-depth descriptions of systems and illustrates many different options to consider and describes the need for carefully determining the best system to meet the users intended water demands, budgets, level of maintenance and whether a passive or more complex active system is desirable (Kinkade-Levario, 2007). Regular inspections of contractors work, thoroughly testing product on site prior to applying to homes and ensuring the contractor is experienced in using these specialized materials are recommended for all future roof construction.

2.2 Design Effective Rooftop Catchment and Disperse Systems (gutters, downspouts and canales) to Effectively Manage Heavy Rains and Freezing Conditions

Placing downspouts about every 20 feet along the gutter, instead of the more common 40-feet or longer, ensures that heavy rains will not likely overflow the gutter and instead will flow to catchments. Designs appear to work best when sized to provide a minimum of 1 square inch of cross-section area for every 100 square feet of roof that they serve as large-dimension gutters and downspouts have a much larger carrying capacity to collect every drop of rainfall. First flush systems on downspouts were recommended but not installed. These systems are particularly useful when downspouts connect to cistern systems, to filter out debris that can clog most catchment and infiltration systems.

More coordination between the landscape architect, architect and builder and thorough reviews by knowledgeable inspectors may have avoided issues with canale locations conflicting with pedestrian walks and driveways, and improper installation of roof and in-ground catchment systems. More attention to the on lot soil conditions and grading should have occurred before and during construction.

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary

2.0 Architecture (Roof Catchment Systems) Strategies			2012 Status of Implementation of GOALs and Strategy Analysis		
GOAL 2.1 **Design Rooftops to Improve Rainwater Capture and Reuse**	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Roofs of all newly constructed buildings are designed to maximize water catchment for reuse and avoid undesirable trapping of water.	**Some Housing Products**	LA and RV to review new architecture to look for ways to maximize water catchment systems in the future. Consider the efficiency of water catchment, maintenance and cost implications of the spray foam in comparison to metal roofing in future designs of all residential, commercial and office buildings.	**Implemented since 2003 with Modifications**	• Redesigned roofs utilizing SPF materials were successful in providing clean water and efficient roof design for water catchment systems where installed. Only certain models of homes were modified to maximize water harvesting capabilities in the beginning of the development, but this was expanded to include all roof designs for the later villages developed. • Simple roof construction improved the efficiency of the catchment systems. The simpler the roof configuration, the easier it is to run gutters and downspouts. Simple roofs also tend to collect less debris and therefore require less maintenance and lower maintenance costs may be realized.	• Spray foam roofing materials used were not as effective in collecting water as metal roofing proposed, but were found to be more cost effective and appropriate to style of homes in the community. • Problems with installation of foam roofing occurred. Foam roofing installed too thin, flaking of materials from UV exposure, bird damage and leaking were the result of poor performance by contractors and some products selected. Faulty roof have been or are in the process of being repaired and replaced with a more reliable product and by contractor.
All new pitched roofs are designed with unpainted metal roofing consisting of smooth, non-porous systems (reduces filtering needs) or metal coated with zinc and aluminum.	**On Commercial and Support Buildings Only**	Light- to medium-colored metal roofing is currently the standard on support buildings; the majority of the rooftops are a spray foam material manufactured by BASF, with an acrylic or silicone coating that dries into a hard plastic that is inert, but can flake off. Further research into tested roof foam products is required. Look for more opportunities to utilize the appropriate metal roofing to maximize the quality and quantity of water collected.	**On Commercial and Support Buildings Only**		
Roof design is coordinated with the canale or downspout locations to avoid interference with walkways, drives, patio, utility and yard wall locations.	**Implemented In Most New Locations**	Prior to construction, RV and LA to review architectural drawings as they relate to the actual site conditions.	**Implemented**		
GOAL 2.2 **Design Effective Rainwater Dispersement systems to Effectively Safely Manage Heavy Rains and Freezing Conditions**	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Where canales are used, appropriate surface drainage systems are installed to mitigate erosion and footing damage (e.g. splash block, French drains, and cistern barrels).	**Implemented In Most New Locations**	Review drawings and existing conditions to confirm that canales are located away from areas where potential icing from run off or freezing will create safety issues. Ideally they should be located on the south side of the structures. Canales are only being used on the fronts of the building. French drains have been found to be ineffective in WR where there is a higher clay content and water cannot effectively drain away from the structure footings. In those situations, large cobble splash block areas have been installed.. Continue to monitor and look for better materials and approaches as technology improves.	**Implemented In Most New Locations**	• The Downspout designs were effectively implemented in the Windmill Ridge villages, although some modifications were required after testing. In La Entrada, homeowners have the options of open canale systems which direct water into rain barrels or French drain or other surface conveyance means. • Through testing, the appropriate size of the downspouts and gutters were selected that could handle the severe storm events that occur annually. This required a time frame that included both the summer rainstorms and winter freezing rain and snow-melt conditions to fully test the systems. • Cleanout systems were added that allow homeowners to more easily maintain their systems.	• Continual coordination is needed on locating these systems appropriately and effectively around the homes. • Encased downspouts encased in the architecture for aesthetic reasons caused significant problems with internal leaking and maintenance and were eventually replaced with standard exterior systems. • Downspouts connected to underground cistern systems and underground cisterns and infiltration systems created major challenges on site due to improper installation and difficulty maintaining. Most were either abandoned or required costly replacement or modifications for homeowners to use effectively. • Homeowners lack of understanding the catchment systems and their maintenance. • Often during construction on site, soil particles are blown onto roofs and contribute to the clogging of the drains. This resulted in no leaf strainers or other filters being installed in the roof catchment systems.
Downspouts are connected directly to cistern systems with 5-inch Schedule 40 PVC pipe (Not plastic sewer pipe).	**Not Implemented**	Testing of products will occur in some areas in the Village of Rancho Viejo. Continue to monitor and upgrade as better products become more available and/or more affordable.	**Implemented in Locations with Underground Cisterns Only**		
Design downspouts to prevent avoid buildup and properly sized to handle large volumes of water:	**Not Implemented**	Downspouts should be sized to provide 1 square inch of cross-section area for every 100 square inches of roof that they serve. Minimum installed size of downspouts is 5 inches. (5 inch x 5 inch downspout can safely handle 2500 square feet of roof area).	**Implemented in some locations in newer development areas**		
First-flush systems installed on roof where gutter is connected to downspouts.	**Not Implemented**	Investigate potential first-flush systems that may be needed should a cistern system be installed.	**Not Implemented**		
Locate downspouts a maximum of 40 feet on center (20 feet is best) along the gutter to ensure handling of heavy rains and conveyance to the catchment systems.	**Implemented in Some Locations**	Locations of downspouts are currently based on the relationship to the site design (i.e., walkway, drive, and patio locations).	**Implemented in Some Locations**		
Changes in downspout direction are minimized to reduce clogging of pipes.	**Implemented in Most Locations**	There are a few locations where downspouts have been re-routed to avoid draining onto paving areas. Monitor on a regular basis especially during winter and rainy season to see if there are potential problems. Upgrade/resolve problem areas and redesign as needed for future homes.	**Implemented**		
Leaf strainers and cover screens over gutters are used where they are connected to downspouts.	**Not Implemented**	No screens have been installed anywhere on site. Monitor on a regular basis to determine if there is a need.	**Not Implemented**		
Gutters, downspouts and pipes are cleaned out regularly.	**Implemented**	Cleanouts are being provided on most downspout systems. Homeowners are responsible for maintaining as part of the warranty. The covenants need to be reviewed to make sure that this responsibility is clear to the homeowners.	**Implemented**		

Figure V-2.1 Goals Matrix

3. Lot Design Strategies (Figures V-3.1 to V-3.3)

The surface water management goals for the overall Residential Lot Design included:

3.1 Install Rainwater Storage and Distribution Systems

At Rancho Viejo, a variety of rainwater storage systems were recommended to be installed and tested, with final selection based on the soil, site grading, and other limiting factors of the lots. Each system requires an understanding of the specific locations soil and drainage conditions to function properly, however, the developer and contractors were unable to address each lot separately due to tight construction schedules and costs. If this had been implemented as planned, the storage systems would most likely have been more successful, assuming they were properly installed. The potential for considerable variation in the lots soils, drainage, exposure and grading indicates that a standard approach to the location and type of system and install location still needs to be evaluated for effectiveness for each home before installation.

All of the projects reviewed in the case studies incorporated some form of catchment system, and many indicated they had issues with the installation of the underground cisterns. Determining what is the best cistern and infiltration system for arid environment with varying soil types, finding experienced, reputable contractors and reliable manufacturers is still a challenge for most communities. If manufactured infiltration and catchment systems such as cisterns are implemented, ensure they are installed maintained by a qualified and experienced contractor or are easy enough to maintain by the homeowner. Annual training and reminders to the homeowners is required in either case, to ensure the systems function properly over time or costly repairs and replacements may be needed. High Desert and Day Break also struggled with the issue of underperforming contractors and issues with their cistern systems. Similar to the lesson learned at Rancho Viejo, the community developers found that pioneering sustainable features is highly dependent upon relationships with reputable manufacturers and contractors.

3.2 Create Landscape Catchment/Collection Areas

The typical means of providing rainwater catchment areas is through the use of pervious or permeable surfaces, swales and planting areas. The amount of water harvested depends on the size, surface texture and slope of the catchment area. Paved areas such as concrete asphalt or brick paving provide high water yields. Bare soil surfaces provide harvests of medium yield. Planted areas, such as grass or groundcover areas, offer the lowest yields because the plants hold the water longer allowing it to infiltrate into the soil.

Swales and Landscapes: Green streets, bioswales and bio-detention ponds can absorb water and channel or hold excess run-off, cleansing pollutants in the process. Evergreens and conifers were found to intercept 35 percent of water hitting them (EPA, 2012). The original landscape concept at Rancho Viejo was to utilize the swales and French drains in the lawn areas and planting beds as water collection systems. Blue grama lawns were installed in the first village and Windmill Ridge North. However, due to the heavy rainfalls experienced in during late summer, erosion was observed on lots with significant grade changes. This resulted in the introduction of more bioswales or stoned drainageways especially between lots to direct runoff from canales and surface water to stabilized catchment areas or structures such as underground cisterns. The limited availability of reuse water for Windmill Ridge South and La Entrada led to the use of more aggregate surface materials with sparse plantings. There is still a cost savings and ease of maintenance for lots that are mostly pervious materials, however, it can create, if not designed well a rather stark look to the neighborhoods, especially in late fall and winter. The aggregates also can reflect significant amounts of heat, and would be best if installed under the shade of trees or structure to avoid contributing to increased energy cost for air conditioning of homes.

Reduction of Impermeable Paving Surfaces: The terms permeable, pervious and porous are all used to describe surfaces designed to allow percolation or infiltration of stormwater through the surface into the soil below where the water is naturally filtered and pollutants are removed. In contrast, traditional pavement is an impervious surface that sheds rainfall and associated surface pollutants forcing the water to run off paved surfaces directly into nearby storm drains and then into streams and lakes. The pervious paving options are typically porous and allow water to go directly through them. Permeable surfaces often consist of pavers separated by joints filled with small stone where the majority of runoff water filters through, however, there are new pavers on the market that allow runoff to filter through specially design asphalt and concrete paving.

The use of pervious pavement is a sustainable approach to landscape design and has been found to:

1. Reduce storm water runoff. (Even when pervious pavement structure is saturated, its rough surface texture continues to slow surface flow of stormwater);
2. Replenish groundwater;
3. Reduce flooding which may over-load combined sewer sewage treatment plants;
4. Require less land set aside and cost for development of retention basins and traditional infrastructure;
5. Reduce pollutants in run-off;
6. Reduce irrigation of area plantings based on the seepage of rain into the sub soil surfaces;
7. Reduce thermal pollution
8. Lessen evaporative emissions from parked cars
9. Reduce glare and automobile hydroplaning (skidding) accidents;
10. Reduce pavement ice buildup.

Pervious paving surfaces at Rancho Viejo are limited mostly to residential lots and some community parking lots, parks, and the community garden. A wide variety of materials were used throughout the community including crushed stone, decomposed granite, gravel, and other types of aggregate paving. The most commonly used permeable paving consists of dry-laid flagstone paving or concrete pavers. All of these materials blend well with the natural landscape and were found to be a low maintenance solution for most homeowners.

Issues related to paving areas at Rancho Viejo were mainly a result of failure of the infiltration/cistern systems, which caused paving areas on residential driveways and walks to fail, or wash out due to large rainstorm events. There also is an ongoing issue with the decomposed granite materials washing away on some pathways during heavy rain events, leading to higher maintenance requirements for trails and sloped areas paved with this porous paving material. Decomposed granite appears to be used less on site than in 2003 because of the dust and erosion problems. In the High Desert Case Study, some roadways were originally designed using the finished grade only, to allow for water infiltration. The amount of dust created by these roadways quickly became a concern for residents.

In more northern climate communities such as Day Break, pervious pavement can be compromised by plowing that dislodges pavers and sanding which clogs and disrupts the pavements filtration process. Additional concern for heavy clay soils, often associated with northern climates, can limit the usefulness of pervious pavement. Clay soils are impervious and limit expected water quality improvements. The use of a graveled water storage areas built on top of clay soils is often not an acceptable solution because storage capacity is quickly overcome. This was experienced in Windmill Ridge North during the first year of testing. Coupling drainage of graveled storage with additional stormwater management practices is possible but the expense of their design and development may be cost prohibitive. Other issues that may be necessary to address include problems for wheelchairs and other disabled individuals, effects of parking lot sweepings, and resistance to damage from snowplowing and de-icing operations.

3.3 Utilize Mulching Materials to Reduce Water Loss in Plant Beds and Exposed Soil Surfaces

The main advantage of using mulching materials in arid environments is to insulates and protect soils from drying effects caused by evaporation of water from soil exposed to hot sun and winds. Mulched soils are cooler than non-mulched soils and have less fluctuation in soil temperature. Optimum soil temperatures and less moisture evaporation from the soil surface enables plants to grow evenly and can reduce the amount of potable or reuse water required. Mulches also break the force of rain and irrigation water thereby preventing erosion, soil compaction and crusting. Some mulches do aid in water being absorbed into the underlying soils faster, however, careful selection and testing of the appropriate mulches for low water use plants is required.

Rancho Viejo tested several materials for mulching with the goal of using locally available sustainable materials. The pecan shell mulching was a bi-product of the local agriculture industry and appeared at first to be a good solution, however, the materials were scattered in high winds and animals and birds were attracted to the mulch. High Desert was innovative in its use of decomposed-granite mulch harvested on site, or recycled sediment from the dam instead of using the more traditional wood mulches. It is estimated that this approach saved an equivalent of 15,230 trees by this process.

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary					
3.0 Residential Lot Design Strategies			**2012 Status of Implementation of Goals and Strategy Analysis**		
GOAL 3.1 Install Rainwater Storage and Distribution Systems	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
3.1.1 Manufactured Water Distribution Systems					
Underground infiltration systems are used to store and infiltrate storm water into underground chambers.	**Implemented in Some Locations**	Infiltration systems were designed by Ingenuity, Inc. and installed in Village I and Windmill Ridge (WR) Unit I Model Homes. These systems have not worked well in WR due to high clay content in some locations. This created a water lens that prevented water from filtering into the subsoil. This system should only be used when no other system is possible and soils are appropriate.	**No Longer Being Installed**	• The simple cistern systems and rain barrels installed are now functioning well. There is a great variety of systems in place and available within a range of prices for homeowners to choose from. • Although cisterns systems are no longer a standard feature for homes, homeowners still have the option of installing these systems as well as infiltration systems. • Homeowners regularly utilize the cisterns for supplementing their irrigation systems, especially during winter months when irrigation systems have been shut down.	• Downspouts connected to underground cistern systems and underground cisterns and infiltration systems created major challenges on site due to improper installation and difficulty maintaining. Most were either abandoned or required costly replacement or modifications for homeowners to use effectively. • Homeowners lack of understanding the catchment systems and their maintenance. • The simpler rain barrel catchment systems installed were easier to manage and more cost effective, however, these systems do not have a large enough capacity to actually supply enough water to irrigate most lot landscapes and can only be used for supplemental watering.
3.1.2 Cistern System Design					
Cistern option available for all housing product types.	**Not Implemented**	Cisterns systems were not currently installed on-site when this survey was completed, however, RV planned to test 1-3 cistern system options in the Village I area, but only 1 system ended up being tested. In March 2003, Rancho Viejo elected to build all of their new homes with rainwater-harvesting systems. The rainwater systems were intended to cut down on the additional demand that landscaping of new home construction would put on the area's water resources. Currently the plan is to only catch the water off of the back side of the buildings roofs. The remainder of the roof water will be released through canales or downspouts.	**Implemented in 2003- Still an Option**		
GOAL 3.2 Create Water Catchment Areas (Pervious Paving, Planting Areas, Swales, etc.)	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Lawns and walkways are sloped towards ground storage and/or plant beds.	**Implemented**	Implemented where possible. LA is coordinating with RV to review and/or assist with the residential lot grading plans to work to improve on the on-lot drainage patterns. Prototypical plans were used to guide contractors.	**Implemented**	• A wide variety of permeable, pervious and impervious paving was installed on lots throughout the site. Windmill Ridge South and La Entrada, in particular, have exceptionally large areas of non-planted surfaces compared to the earlier constructed areas. The areas aid in the return of water to the aquifer and as a water resource for landscape plants. Some designs were exceptionally creative in designing the collection areas to either blend naturally with the landscape or to become features of the landscapes.	• Improperly installed edging, filter fabric, stone mulch materials, etc. are creating areas of erosion and visually unattractive landscapes in some of the landscapes in all the communities, including public open spaces maintained by the HOA's. The catchment and collection areas reviewed included a high percentage of design materials improperly installed, such as edging that was installed above the adjacent grade rather than flush with finish grade. This can lead to runoff pooling in behind the edging, flooding out low-water use plantings. Installing mulch materials to less than 3 inches in depth encourages weed growth and creates higher maintenance landscapes. Local community programs that provide design assistance or maintenance guidelines should be considered.
Sodded or seeded swales or concave depressions are installed to catch and detain low-intensity storm-water run off and are planted with grass or other plants. As an alternative, stone swales with a variety of stone sizes are used in limited quantities in yard areas where establishing lawn is not feasible at the time of installation.	**Implemented Seeding Only Except at Model Homes**	Regrading of the swales is needed to maximize the water-harvesting capabilities. Most swales are seeded with native grasses but many have been filled with stone. Some problems are occurring in specific areas where the grasses are not establishing fast enough to control erosion. LA to work with RV and arrange for soil tests to be taken at select locations throughout the site to determine why some grasses are quick to establish and others are not. Investigate slope, aspect, time of year, soil conditions, rainfall or temporary irrigation available, and seed mixes. Where stone catchment areas are to be installed, LA to assist RV with developing examples of visually attractive stone mixes and swale forms that function properly.	**Implemented Seeding Only Except at Model Homes**		
Storm water dissipation systems (stone drainageways, riffles, etc.) are installed to slow concentrated water, reduce erosion and allow water to filtrate into the soils.	**Implemented**	Stone materials should be selected with a mix of stone sizes to more closely resemble a dry stream bed and to be more aesthetically acceptable to homeowners. Sides of stoned drainage systems should be gently graded. Dissipaters and riffles should be combined with the appropriate sediment erosion control systems so as not to fill with sediment and be rendered ineffective.	**Implemented**		
If stone materials are installed in place of lawns, the sites are graded to prevent washing of stone on to walkways and silting of stone is prevented through the use of systems listed above.	**Implemented in Some Locations**	Need to improve this process. Some erosion is occurring and stone is migrating across walks. LA is now assisting RV and the civil engineer in reviewing the grading for lot design to reduce these problem areas.	**Implemented in Some Locations**		
Pervious (gravel, crushed stone, open-jointed) paving is used wherever possible to allow rainwater to infiltrate into ground water or planting beds.	**Implemented**	Implemented in some on-lot yards. Paved drives can lead to drainage problems to the front of the conservation lots in particular. The Estate and conservation lot homeowners choose the surface they want and typically asphalt is selected due to the length of the driveways and steeper grades. Aggregate paving typically erodes. Grates in the stone or impervious surfaces were an option to direct runoff to swales from drives.	**Implemented in Some Locations**		

Figure V-3.1 Goals Matrix

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary

3.0 Residential Lot Design Strategies				2012 Status of Implementation of Goals and Strategy Analysis		
GOAL 3.3 Utilize Mulching Materials to Reduce Water Loss in Plant Beds and Exposed Soil Areas.	2002 Status	2003 Recommendations to Improve Site Sustainability	2012 Status	Successes	Challenges
Gravel or crushed stone mulch is installed in drainage swales along yard walls and alley drives.	Implemented	Standard practice on all areas of the site.	Implemented by Homeowners	• Mulching materials are heavily used throughout the community to enhance the effectiveness of the water-harvesting systems by reducing soil exposure to sun and subsequent water loss when maintained at a minimum three inch depth.	• Somewhat less successful was the use of wood chips and pecan shells for mulching materials. Both faded to a grey tone that homeowners did not find aesthetically pleasing but migrated in heavy rains across paving and landscape areas. Pecan shell mulching, although a good re-use of a natural and local available material, created issues with wildlife disrupting the mulch beds for remnants of nuts, and wind dispersing the shells across paving areas. These materials are used very sparsely now within the communities.
Splash blocks, French drains or other systems are used to prevent erosion under downspouts or canales.	Implemented in Some Locations	Needs improvement. Currently installed by just dumping a pile of stones under the downspouts or canales in an area approximately 2-feet-wide by 3-feet-long.LA has created a new detail for the splash block area of 4-inch cobble, to be tan in color. Area should be approximately 2-feet-wide by 3-feet-long and to an 8-inch to 12-inch depth. RV to review installation on-site to ensure that contractors have met the specifications.	Implemented		
Mulching materials and water-harvesting techniques are used to prevent water loss through evaporation.	Implemented	With local water restrictions in place, seeding of parkway has not occurred. Trees need more shading of root systems to reduce evaporation of water. LA has developed a new detail that incorporates a hay bale uphill from the rootballs to drive the water into the ground. Incorporate mulch over the rootball area to reduce moisture evaporation, especially when seeding of the parkway is delayed due to drought.	Implemented by Homeowners		

4.0 Village Roadways and Open Space Strategies			2012 Status of Implementation of Goals and Strategy Analysis		
GOAL 4.1 Design Roadways and Paving Surfaces to Aid Infiltration of Stormwater and Runoff into Soils or Landscape	2002 Status	2003 Recommendations to Improve Site Sustainability	2012 Status	Successes	Challenges
Curb cuts are installed to allow for collection water off of paved areas in parking lots and roadways to direct water to plantings.	Implemented in Some Locations	The appropriate solution needs to be chosen by location, adjacent grade, etc. The alternate is a drop structure and pipe, but this can increase infrastructure costs and can only occur where adjacent grades allow it to function properly. LA to work directly with the civil engineer and RV to identify the appropriate locations for curbs to maximize water-harvesting capabilities and to reduce storm water piped to the detention ponds or county storm water systems, as the regulations permit.	Implemented	• Rolled curbs were installed wherever possible, mostly in areas where slopes did not exceed 5 percent. Steeper graded roadways are curbed to handle the larger, faster flowing volumes of roadway runoff. • Parking areas were minimized in the overall site design and where needed were incorporated into the roadway as parallel parking. Standard parking lots near office and commercial buildings consist of gravel paving to facilitate water infiltration.	• The rolled curbs in some areas were not successful as it created adjacent swales that were too deep and became roadway safety hazards in icy or rainy conditions. Rolled curbs, according to the developer made surface water management more difficult. • Although low flow crossings at the roadway were recommended, these were not implemented. At Rancho Viejo, due to the highly erodible soil, excessive silting occurred where these were installed in the early phases and issues with water collecting in these low areas and freezing in winter creating driving hazards for residents.
Use of impervious paving is minimized and designed to capture storm water for groundwater recharge and/or reuse on site.	Not Implemented	Parking areas are minimized to keep down the amount of impervious paving on-site. Gravel is a problem as it migrates onto other paving areas causing potential hazards to pedestrians and is messy in appearance. Currently asphalt is the most cost-effective for RV. LA has also created an updated detail and spec for this system that could be applied to future commercial and office developments on-site.	Implemented in Some Locations		
Rolled or flat curbs are designed and installed to allow storm water to drain uniformly along roadways into stabilized shoulders and drainageways.	Implemented in Some Locations	This hasn't been very successful in some areas, as it often resulted in deep swales that were roadway safety hazards. Surface water more difficult to manage is more difficult with rolled curbs as designed. LA to work with RV and the civil engineer to develop new curb diagrams and guidelines/criteria for curb selection that best handle the storm water in a cost-effective but sustainable manner. LA or civil engineer to determine the appropriate curb detail at the development stage, based on the criteria outlined for curb selection.	Implemented in Some Locations		
Parking lot paving is pitched to drain to depressed islands designed to collect water off of paved areas through curb cuts and direct the storm water to plantings beds or lawn areas.	Not Implemented	There are very few parking lots associated with the residential lots except for those adjacent to the park or open space areas. Currently the civil engineer has designed these to drain into the street. LA's details need to be included on the engineers' drawings if they are going to be built to achieve this strategy. Redesign of these areas to be worked out with the engineer to drain into open space/planting areas. LA and RV to coordinate these designs with the civil engineer and to confirm that streetscape designs are meeting NPDES requirements for water quality.	Implemented in Some Locations		
Driveways are gravel-lined to a width of 18-inches to direct water always from walkways and drives and into holding areas or roadway.	Implemented in Some Locations	This currently is only feasible on the estate lots. May want to look into this more closely as there have been problems in the past with erosion on these longer drives. Some concerns with migrating stone and appearance in other areas of the development. RV and LA to review to determine where this is appropriate in future developments.	Implemented in Some Locations		

Figure V-3.2 Goals Matrix

4. Village Roadway and Open Spaces Strategies (Figures V-3.2 to V-4.1)

The surface water management goals and strategies documented for the community's open spaces along roadways and preserved open spaces surrounding the community included:

4.1 Design Roadway and Public Walkways to Aid Infiltration of Stormwater and Runoff into Soils or Landscape Plantings

It is often difficult to achieve graded slopes that mimic existing landforms and existing gradients in the narrow open space areas along roadways, and it requires the landscape architect to work very closely with the civil engineers on a project. To create meanders in drainageways parallel to roadways, these systems need to be designed wide enough to accommodate a more natural solution, minimize swale side slopes, and still be able to adjust to various roadway and right-of-way variations. The meanders in lower flowing drainage channels can help slow down flows and assist soil infiltration.

Village Homes and Civano incorporated narrow roadways, which reduced the amount of pervious surfaces and aided the directing of runoff into adjacent planting areas or swales. However, Village Homes' roadways were found to be too narrow for emergency vehicle use. Meanders were introduced to mimic the natural flow patterns at Rancho Viejo in the first two villages, and were successful where there was careful oversight by the landscape architect. Rolled curbs and curb cuts were successful in moving water to the drainageways, but issues related to directing water more uniformly to the adjacent landscape were challenges at both Rancho Viejo and High Desert, leaving some areas of native plantings very dry and others too wet.

4.2 Install Temporary Soil Erosion Control Measures to Maintain or Improve Stormwater Quality

Measurements to protect the quality of stormwater generally has been successful, especially in irrigated areas, however improvements are needed in the transitional and open space areas where a lack of effective erosion control methods is resulting in damage to the smaller drainageways as well as the arroyo's and native landscape. Many of the culverts draining stormwater from roadways or bioswales into the open space areas are silted or blocked with debris. Erosion around the outfalls can also eventually lead to the collapse of the adjacent trail or roadways, if no maintenance occurs. Regular maintenance is especially important especially in these outfall areas.

Strategies include extending the culvert drain pipe beyond drives and roadway crossings by a minimum of 24 inches to allow for gentle transitions of grades and safe pedestrian and vehicular conditions. Drainageway pipes should drop directly into existing arroyos or detention ponds without proper armoring and maintenance. Water quality ponds, plunge pools, or riprap or gabion dissipaters are utilized to limit damage, as required by NPDES.

In the other case studies, management of the drainageways has also been a challenge. Almost all have been challenged with issues of silting and debris collection and plantings overgrowing the systems. Regular maintenance programs to keep these systems clear are required to prevent erosion and flooding. The results can create habitat and aid infiltration of stormwater back into the aquifer.

4.3 Stake Areas to be Protected and Allow for Field Decisions on the Preservation and Protection of Specific Site Features or Trees

Utilizing a construction schedule that describes the relationship between the implementation and maintenance of controls and the various stages of earth disturbance and construction would greatly benefit the process of sustainably developing the site. This, however, needs buy-in from the developer to ensure success. Schedule should include: schedule for clearing and grubbing for those areas necessary for installation of perimeter controls (limit of disturbance fencing); schedule for installing perimeter controls; Schedule for clearing and grubbing of all remaining areas; road grading and grading for remainder of the site; utility installation and storm drains to be used or blocked during construction; final grading; landscaping; or stabilization; and removal of controls (relate to the completion of all work requiring heavy equipment or vehicles).

4.4 Design Grassed or Bio-Swales Planted with Native Species to Maintain Low Intensity Runoff Even in Heavy Storms

To improve the success of quickly stabilizing green swales and runoff areas, collaboration with soil engineers and landscape contractors can result in a modified soil mix or installation method, such as imprinting, that will improve the quick and successful establishment of vegetative cover to reduce erosion.

Native plants are preferred for use in swale design as they often can provide year-round vegetative cover without need for supplemental irrigation or fertilization. Furthermore, native species usually provide high habitat value for indigenous birds and other animals. Exotic species can also be appropriate, though some can become invasive if allowed to proliferate.

Bioswales is another term for the swales/drainage courses at Rancho Viejo that are designed with gently sloped sides (less than six percent) and filled with vegetation, compost or riprap. Depending upon the geometry of land available, the bioswales may have a meandering or almost straight channel alignment. These systems are linear or meandering, with length and width dimensions ideally much greater than the more typical 2:1 applied to bioretention cells for high pollutant runoff areas like parking lots. This was fairly innovative concept at Rancho Viejo, when they were first installed. Village Homes was the first community to incorporate bioswales, but at a much smaller scale. Since that community was developed, there has been extensive research into these systems and the science and techniques have been refined but the basic system is the same. Seattle in particular has developed innovative strategies for incorporating these systems into urban areas. All of the other case studies indicated these had been successfully incorporated.

Pretreatment Detention Basins: These systems were designed to trap coarse sediments to prevent premature clogging of the filtration systems. Ideally pretreatment devices should be located throughout the development area and at the source of the major surface water collection points. Plant materials in these areas can often increase the amount of pollutants absorbed or settled out of the water column and also provide biological, chemical and physical processes for breaking down the pollutants.

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary					
4.0 Village Roadways and Open Space Strategies			**2012 Status of Implementation of Goals and Strategy Analysis**		
GOAL 4.2 Install Temporary Soil Erosion Control Measures to Improve Stormwater Quality	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Sediment erosion control fencing installed prior to any other on-site activities. Install and maintain in a manner that prevents wind and surface-water erosion where soil has been disturbed and landscape is not yet established.	**Not Implemented**	Detailed on both the engineering and LA drawings but not being implemented or monitored/enforced consistently. Install and maintain in compliance with the drawings, specs and public regulations. Installed after mass grading. Need to review installation and monitor status on a more regular basis by the RV Land Development Superintendent.	**Implemented**	• Designated on-site parking and drive locations and stockpile locations was successful in some areas of the development and did help to avoid soil compaction. However, on smaller sites where space was more limited, getting contractors to adhere to this was less successful. • The siltation fencing is still being used during construction and is still remaining in places where lots are still under construction in Windmill Ridge. • Haybales and other temporary systems were put into place to slow storm water runoff. The most success occurred with stone riffles.	• Native grasses are typically seeded in disturbed areas within the developed community areas, however, no plantings have been installed in the last phases of work to stabilize disturbed soils in the open spaces due to costs. • At La Entrada, there has been a failure to maintain the silt fencing to the level required. This may be a result of less manpower being available for oversight due to the recent drop in housing sales and cutback in staffing. • Haybales were installed on the steeper slopes and drainageways to slow runoff. The haybales eventually disintegrate and were not visible in most areas of the site. However, where used in open space drainage areas with heavier water flows, they were held in place with rebar. The rebars are now fully exposed where the haybales have disintegrated and may be a safety hazard in some locations and should be removed.
Culverts are graded to limit hazardous conditions for vehicles but capable of managing major storm events.	**Implemented**	Storm drain pipes and surface drains are now used to alleviate this problem. The use of squash pipes also reduces the depth of the drainageways. Curbs and gutter locations need to be properly located to make this work. LA to work with RV and the civil engineer to designate where certain curb and gutter types should be used early on in the design process.	**Implemented in Some Locations**		
Cleanout of concrete and other construction materials is not permitted to occur on-site or to enter the drainage systems.	**Implemented in Some Locations**	This has been monitored on a regular basis on site. RV to continue to improve monitoring and compliance.	**Implemented in Some Locations**		
GOAL 4.3 Stake Final Areas to be Protected In Field	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Schedule site walk with the designer, general contractor and client to stake areas to be protected and allow for field decisions on the preservation and protection of specific site features or trees.	**Implemented in Some Locations**	This is being implemented only on the most sensitive sites, mainly at the request of the Landscape Architect. Through regular meetings with the contractor, this process improved in 2003.	**Implemented in Some Locations**	• Areas to be protected were identified on site plans, and methods for site protection from construction activity were specified in the construction documents. Strategies included the use of snow fence or bright plastic mesh fencing used to remind construction workers to keep clear, and temporary signage. • Regular meetings during heavy construction periods were beneficial and helped to protect open space areas. However, when the project team changed these meetings became less frequent and reviews on site for protection of open space occur randomly.	• Keeping protective fencing effectively in place at least until all heavy machinery and vehicles (including delivery vans) are off site. • Keeping best practices in place for protecting open space and existing trees is difficult to maintain during the life of a 20-30 year project, especially when there is a change in contractors, developer management and design team, as well as slow downs in construction.
GOAL 4.4 Design Grassed Swales for Low Intensity Runoff Areas	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
4.4.1 Swales					
Design grassed or bio-swales planted with native species to maintain low intensity runoff even in heavy storms.	**Implemented in Some Locations**	A lack of irrigation and extended drought conditions impeded the establishment of native grasses plantings in swales. Supplemental stone armoring was required to slow flows along the steeper roadway grades. Planting of shrubs in swales has not occurred unless it occurs naturally.	**Implemented in Most Locations**	• Grading the side slopes of the swales at only 1 or 2 percent increased the success for the establishment of native grasses for erosion control. Drought, however, was a barrier to successful germination in some of the installed locations. • The appropriate location of rolled, straight and curb cuts are now determined by the amount of surface water to be handled and the adjacent landscapes. The soils at Rancho Viejo are highly erodible in some areas, especially where no existing groundcover exists and along steep roadway grades occur. • Measurements to protect the quality of stormwater in general has been successful, especially in irrigated areas, however improvements are needed in the transitional and open space areas where a lack of effective erosion control methods is resulting in damage to the smaller drainageways as well as the arroyo's and native landscape.	• Regrading was required for some of the swales after installation to maximize their water-harvesting capabilities. The design of the swales needs to have some flexibility until home landscaping is installed. The amount of impervious surfaces and design of on-lot grading and water harvesting systems can reduce or increase the amount of flow that the public drainageways need to accommodate. Unless planned for, these changes can be costly and often only are addressed when flooding or erosion occurs in the swales. • Creating meanders in the swales was only possible where there was enough width to create the swale without increasing the steepness of the adjacent slopes, which subsequently created safety issues for vehicles and pedestrians and increased soil erosion.
Parkways between the sidewalk and curbs are designed as shallow swales to capture surface-flowing storm water and retain it in areas where it can best be used by plants. Steeper sloped parkways are designed with riffles and other permanent or temporary structures to slow surface waters and drive them into the soil for use by plants.	**Implemented**	Installed as needed in all phases of development so far. RV and LA to continue to investigate better ways to capture and retain water in the medians and reduce erosion especially during times when the County restricts any planting of grasses.	**Implemented**		
Roads are designed to drain to landscape planting areas or large-scale detention ponds whenever possible to replenish the aquifer and slowly release water into the drainageways.	**Implemented**	Review site to confirm the construction meets NPDES requirements.	**Implemented**		
Top and toe of slopes are eased/gently transitioned into the adjacent grades. Swales have gently sloping bermed sides and are contoured to hold and infiltrate water for use by plants and lawn areas.	**Not Implemented**	Grading at these locations needs to be improved in the field. LA to work with the civil engineer to review grading plans early in the process so these changes can be implemented in the field. Gentle side slopes on swales are not currently being constructed as detailed. Better cross sections and specifications need to be created, as well as increased field inspections to ensure swales are constructed properly. LA to create a new gently sloping swale detail and incorporate the detail into the CD packages for the landscape and/or the civil drawings.	**Implemented in Some Locations**		
New slope banks are contour-graded to mimic existing flowing landforms and gradients present on site.	**Not Implemented**	Work with the civil engineer to ensure that the critical slope and erosion control information and details are located on the engineers drawings to minimize slope grades and potential subsequent erosion.LA to work with the civil engineer and RV to review grading plans to create as natural a slope forms as possible on-site, for aesthetics and improved erosion and water-management control.	**Not Implemented**		
Design and install grassed drainageways parallel to the roadways that are wide enough to allow for the centerline of flow to be meandered in steep areas to slow down water flow and potential erosion or undercutting of bank and allows water to filter into soils more readily.	**Not Implemented**	RV has directed the civil engineer to see that this gets implemented wherever possible. They would like to see more natural-looking solutions with meanders and varying roadway widths as well as tan stone materials, in the drainageway. Details are currently being developed when required. Decisions are based on the amount of open space next to the roadway and the adjacent grades.	**Implemented in Some Locations**		

Figure V-4.1 Goals Matrix

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary					
4.0 Village Roadways and Open Space Strategies			**2012 Status of Implementation of Goals and Strategy Analysis**		
GOAL 4.4 **Design Grassed Swales for Low Intensity Runoff Areas**	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
4.4.2 Stormwater Velocity Dissapator Strategies					
Stone and hay bale trench interceptor and spreader swales: Shallow ditches are constructed parallel to the slope contours allowing storm water to spill evenly along the entire length and down the slope. By dispersing the flow, it slows the run off enough to allow it to infiltrate into the subgrade if the grade does not exceed 3:1 in slope.	**Installed in Some Locations**	Implemented in open space areas south of Richard Avenue in Windmill Ridge. The design team (RV, LA and the civil engineer) to review new development areas to determine where these systems would be the best solution and the most cost-effective.	**Installed in Some Locations**	See Section 4.4.1 Comments	• Many of the culverts draining stormwater from roadways or bioswales into the open space areas are silted or blocked with debris. Erosion around the outfalls may also eventually lead to the collapse of the adjacent trail or roadways, if no maintenance occurs. Regular maintenance does not appear to be occurring in these less visible areas. • Maintenance and cleanout of the culverts is the responsibility of the local HOA. Landscape Maintenance crews typically only visit the overall site only 1 time per month for trash and debris removal.
Ladder swales: A series of swales are constructed from a drainage ditch along the driveways extending from the main ditch. These are similar to rungs on a ladder and are designed to collect or spread water to slow the flow rate and allow storm water to filter into the subsoil.	**Not Implemented**	Currently they do not appear to be installed on site. Ladder swales would be more likely to be installed in open space areas. RV and LA to evaluate on a site by site basis. These structures should be installed as part of the site grading and early in the process to maximize the effectiveness of the swales.	**Not Implemented**		
French drains or dry wells: Cylindrical holes are constructed and filled with gravel to catch and infiltrate storm water.	**Implemented**	Installed under canales in some homes. These systems have not been effective in WR due to existing heavy clay soils. Implement only where soils allow for necessary drainage away from structure footing and into the subsurface areas. Contractors to install these structures only on future sites where soil types are appropriate for this type of drainage system and where cost reduction is a priority.	**Implemented**		
Piped or open culverts are provided where storm water must cross concrete walks in community parks and open space areas. Grades are eased along edge of concrete and swales sodded.	**Implemented in Some Locations**	Location and design need to be more closely considered and reviewed on site to accommodate as-built conditions. Concrete work needs to be carried at least 6 inches below the finished grade of the swale to avoid exposure and undercutting of the down-turned drainageway edge. LA will review grading plans and identify potential culvert locations in parks and open spaces on plans for bidding. LA will detail the concrete turndown at open culverts and piped conditions to resolve the current problems with the installations. RV will review in field during the construction to ensure culverts are properly constructed and concrete finished to the quality desired.	**Implemented**		
4.4.3 Culverts and Outfalls					
Culvert drain pipe is extended beyond drives and roadway crossings by a minimum of 24 inches to allow for gentle transitions of grades and safe pedestrian and vehicular conditions.	**Implemented**	Work with the civil engineer to see that this detail is included in construction documents, and implemented where needed in future development areas.	**Implemented in Some Locations**		
Structural elements are integrated naturally into the landscape creating visual amenities as well as potential wildlife habitat and storm water management capabilities.	**Implemented**	LA and RV need to work more closely with the contracts to ensure that the culvert treatment is consistent with the drawings and intent. LA to review detail with RV (land development superintendent) prior to start of construction. Schedule meeting with contractor to explain intent and design.	**Implemented**		
Culverts at trails are designed with shoulders of a minimum of 2 feet and outfalls designed with wing walls and graded to prevent undercutting of walkways and drainageways. Soils are compacted and stabilized as needed to avoid collapse or undercutting of soils around the culverts or outfalls in all locations. Disturbed areas are immediately seeded to protect the area from erosion and structural failure.	**Not Implemented**	The civil engineer submittal drawings show this detail, however, drawings used by the contractors do not always include this information. Future changes to be addressed on the erosion and sedimentation control construction/permit documents and implementation monitored by the civil engineer.	**Not Implemented**		
4.4.3 Culverts and Outfalls					
Drainageway pipes are designed not to drop directly into existing arroyos or detention ponds without proper armoring and maintenance. Water quality ponds, plunge pools, or riprap or gabion dissipaters are utilized to limit damage.	**Not Implemented**	NPDES - Requires all piped storm water to be directed to a detention pond and not into arroyos or piped into open space areas. Currently the outfalls that feed into the arroyos and open spaces exist on-site causing serious erosion problems and sediment deposition downstream. Those that do feed into and from the detention ponds are not being properly armored to stabilize the banks or flow areas. These have been detailed in the civil engineer drawings but are not being properly implemented due to costs. RV needs to conduct pre-construction meeting and timely review of installation of outfalls construction and stabilization methods. Consider having the civil engineer review his installations and provide recommendations for future improvements of documents and installation techniques.	**Not Implemented**		
All culverts and outfalls are cleaned out on a weekly basis.	**Varies with Maint. Contract**	Part of the HOA maintenance contract and varies by Village. Typically cleaned out monthly at a minimum. HOA's indicate that their maintenance budget cannot support cleanout of the SWM detention ponds more than once a year or after very large storm events.	**Varies with Maint. Contract**		

Figure V-4.2 Goals Matrix

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary

4.0 Village Roadways and Open Space Strategies			2012 Status of Implementation of Goals and Strategy Analysis		
GOAL 4.4 Design Grassed Swales for Low Intensity Runoff Areas	2002 Status	2003 Recommendations to Improve Site Sustainability	2012 Status	Successes	Challenges
4.4.2 Stormwater Velocity Dissapator Strategies					
Stone and hay bale trench interceptor and spreader swales: Shallow ditches are constructed parallel to the slope contours allowing storm water to spill evenly along the entire length and down the slope. By dispersing the flow, it slows the run off enough to allow it to infiltrate into the subgrade if the grade does not exceed 3:1 in slope.	Installed in Some Locations	Implemented in open space areas south of Richard Avenue in Windmill Ridge. The design team (RV, LA and the civil engineer) to review new development areas to determine where these systems would be the best solution and the most cost-effective.	Installed in Some Locations	See Section 4.4.1 Comments	• Many of the culverts draining stormwater from roadways or bioswales into the open space areas are silted or blocked with debris. Erosion around the outfalls may also eventually lead to the collapse of the adjacent trail or roadways, if no maintenance occurs. Regular maintenance does not appear to be occurring in these less visible areas. • Maintenance and cleanout of the culverts is the responsibility of the local HOA. Landscape Maintenance crews typically only visit the overall site only 1 time per month for trash and debris removal.
Ladder swales: A series of swales are constructed from a drainage ditch along the driveways extending from the main ditch. These are similar to rungs on a ladder and are designed to collect or spread water to slow the flow rate and allow storm water to filter into the subsoil.	Not Implemented	Currently they do not appear to be installed on site. Ladder swales would be more likely to be installed in open space areas. RV and LA to evaluate on a site by site basis. These structures should be installed as part of the site grading and early in the process to maximize the effectiveness of the swales.	Not Implemented		
French drains or dry wells: Cylindrical holes are constructed and filled with gravel to catch and infiltrate storm water.	Implemented	Installed under canales in some homes. These systems have not been effective in WR due to existing heavy clay soils. Implement only where soils allow for necessary drainage away from structure footing and into the subsurface areas. Contractors to install these structures only on future sites where soil types are appropriate for this type of drainage system and where cost reduction is a priority.	Implemented		
Piped or open culverts are provided where storm water must cross concrete walks in community parks and open space areas. Grades are eased along edge of concrete and swales sodded.	Implemented in Some Locations	Location and design need to be more closely considered and reviewed on site to accommodate as-built conditions. Concrete work needs to be carried at least 6 inches below the finished grade of the swale to avoid exposure and undercutting of the down-turned drainageway edge. LA will review grading plans and identify potential culvert locations in parks and open spaces on plans for bidding. LA will detail the concrete turndown at open culverts and piped conditions to resolve the current problems with the installations. RV will review in field during the construction to ensure culverts are properly constructed and concrete finished to the quality desired.	Implemented		
4.4.3 Culverts and Outfalls					
Culvert drain pipe is extended beyond drives and roadway crossings by a minimum of 24 inches to allow for gentle transitions of grades and safe pedestrian and vehicular conditions.	Implemented	Work with the civil engineer to see that this detail is included in construction documents, and implemented where needed in future development areas.	Implemented in Some Locations		
Structural elements are integrated naturally into the landscape creating visual amenities as well as potential wildlife habitat and storm water management capabilities.	Implemented	LA and RV need to work more closely with the contracts to ensure that the culvert treatment is consistent with the drawings and intent. LA to review detail with RV (land development superintendent) prior to start of construction. Schedule meeting with contractor to explain intent and design.	Implemented		
Culverts at trails are designed with shoulders of a minimum of 2 feet and outfalls designed with wing walls and graded to prevent undercutting of walkways and drainageways. Soils are compacted and stabilized as needed to avoid collapse or undercutting of soils around the culverts or outfalls in all locations. Disturbed areas are immediately seeded to protect the area from erosion and structural failure.	Not Implemented	The civil engineer submittal drawings show this detail, however, drawings used by the contractors do not always include this information. Future changes to be addressed on the erosion and sedimentation control construction/permit documents and implementation monitored by the civil engineer.	Not Implemented		
4.4.3 Culverts and Outfalls					
Drainageway pipes are designed not to drop directly into existing arroyos or detention ponds without proper armoring and maintenance. Water quality ponds, plunge pools, or riprap or gabion dissipaters are utilized to limit damage.	Not Implemented	NPDES - Requires all piped storm water to be directed to a detention pond and not into arroyos or piped into open space areas. Currently the outfalls that feed into the arroyos and open spaces exist on-site causing serious erosion problems and sediment deposition downstream. Those that do feed into and from the detention ponds are not being properly armored to stabilize the banks or flow areas. These have been detailed in the civil engineer drawings but are not being properly implemented due to costs. RV needs to conduct pre-construction meeting and timely review of installation of outfalls construction and stabilization methods. Consider having the civil engineer review his installations and provide recommendations for future improvements of documents and installation techniques.	Not Implemented		
All culverts and outfalls are cleaned out on a weekly basis.	Varies with Maint. Contract	Part of the HOA maintenance contract and varies by Village. Typically cleaned out monthly at a minimum. HOA's indicate that their maintenance budget cannot support cleanout of the SWM detention ponds more than once a year or after very large storm events.	Varies with Maint. Contract		

Figure V-4.3 Goals Matrix

5. **General Planting Design Strategies** (Figures V-5.1 to V-5.4)

The surface water management goals for the overall Site Planting Design included:

5.1 Maximize Permeability and Opportunities for Infiltration by Increasing Vegetative Cover, Mulching Properly And Reducing Impervious Paving Surfaces

Keeping stormwater on the surface instead of letting it soak into the ground depletes the groundwater supplies upon which the community relies on. The green streets strategies to maximize permeability and infiltration of surface water includes narrower residential streets, use of pervious paving for trails and low vehicular use areas and alleys, reduce soil compaction and clearing of vegetated areas to retain the inherent infiltration capacity, plan for denser development to minimize impervious surfaces, use curb cuts or rolled curbs to direct water to adjacent planted swales or open space areas (Metro, 2002). (See Section V-4.1 discussions).

5.2 Design New landscapes and Restoration Plantings with Native Plant Materials and Low-Water Use, Drought-tolerant Plants to Reduce Water Use by More than 50 Percent

Rancho Viejo's (RV) was unique in its master-planning and development strategies for water conservation and reuse to be addressed at the community, village, neighborhood and home lots scales. They were the most successful community of those researched in achieving a reduction of potable water use at the time of this study. To achieve their goals of reducing water use by more than 50 percent, native and low water use plant materials were critical. There are only a limited number of tree species that are native to New Mexico and suitable and available in sizes needed for street and shade tree plantings. Each new project site has factors that will impact the design and health of the non-native plant materials. It often takes years to determine which plant species and cultivars will provide the healthiest and most sustainable plantings. The restoration of native landscapes surrounding a new community can be difficult, as these landscapes as they are constantly evolving with changes in rainfall, animal populations, microclimates, and insects and diseases, for example. Knowledge of the local climate, soils, plant materials and orientation are critical to success. It was estimated that only 6-10% of the landscape survived without irrigation. About 75% of the native landscape appears to survive with irrigation to establish it, but the grasses die off again once they are weaned off of the temporary irrigation system (Ross, 2012). Selecting plants that are adapted to a cycle of wet and dry conditions may be a more effective approach for future plantings.

Along with habitat loss, exotic invasive species are a major cause of loss of biodiversity and species. Increasing the use of native plants in landscape design, reduced the risk from invasive species and helped bolster the wild native plant populations. Native grass restoration at Rancho Viejo was provided by Tall Grass Restoration Company from 2003-2005. They provided the scientific method and materials for restoring life back into soil that has been severely depleted of organisms, organic matter and other elements which make soil a healthy stable growing medium. Healthy soils typically include Mycorrhizal fungi, which populate the area around a plant's roots and form very thin filaments, adding to the length and efficiency of a plant's roots. Plants with mycorrhizal fungi can survive better in their non-native environments and typical have a stronger immune system, making them resistant to soil-borne pathogens. Studies show however that the mycorrhizal plant-fungus relationship is complex, which may have led to the failure of landscape contractor, who was less experienced in the use of mycorrhizal inoculation. One particular inoculum is not necessarily always the best choice for a particular plant species. Ideally before applying inocula on a large scale projects, land managers should conduct trial experiments to determine the desirable and non-desirable plant species responses to inocula, though given the typical development time constraints, this might be difficult to achieve. Over the long-term, land managers and researchers may ultimately be able to determine the best mixture of mycorrhizal fungi species to use for inoculum in systems that have a wide range of environmental conditions.

It is important to always consider the long term. Understanding the dynamics of the living systems in which you work will lead to better people and wildlife places. Improve plant diversity to improve wildlife diversity. The overall approach should favor green land management techniques rather than landscape maintenance techniques. Maintenance is often by rote, whereas management is the understanding that healthy plants are best able to resist pests and diseases. Understanding the existing soils biology and building upon it is critical to the success of maintaining a healthy native landscape.

5.3 Preserve Existing Vegetation Whenever Possible

Preserving native vegetation on site can reduce the amount of plant material that needs to be purchased, installed and maintained, and reducing the extra cost of erosion control and restoration seeding of disturbed areas. However, the native vegetation is not always easy to maintain to the satisfaction of some homeowners, who prefer a manicured landscape in highly visible areas.

The original design assumed that vegetation in open space areas would stabilize these areas naturally without intervention. Drought conditions over the past few years reduced the success of the native plantings and recovery in natural areas. In the RV North community, there are areas in the non-irrigated open space and linear parks where the blue grama grasses have died out. The native grasses spread and infill best when allowed to go to seed, however, the homeowners complain when this occurs as it creates a less manicured appearance. This was a common homeowner perception issue with all of the case studies. Rancho Viejo and the other communities all attempted to incorporate some form of education to new homebuyers and homeowners, but with mixed results. Until the perception of native and water conserving landscape changes for homeowners through the U.S., there will most likely always be a challenge with acceptance of a less manicured landscape.

5.4 Slope Stabilization

This goal strives to ensure that channels, ditches and swales are graded to minimize erosion. Even shallow slopes can be eroded when exposed to high volumes of water due to extended runoff from major storms. Installing fast-growing, self-rooting native groundcovers with deep and fibrous root system for erosion control or hydroseeded with a combination of quickly established grasses and desirable long-term groundcover varieties can provide a more stable drainageway system.

The detention basins are natural water harvesting systems, and can be used as amenities and passive recreation areas within the communities. However, in La Entrada the detention basin was located behind the community. As it is not visible to most of the community, it is rarely used and poorly maintained. There was no supplement water system when the detention basin was planted after grading. Some reseeding occurred but natural scarring had already occurred and the extra seeding was not successful without supplemental irrigation. The system for capturing stormwater in the detention basins is working well. There is recharge and evaporation, but the negative impacts of stormwater runoff are being controlled. Where basins are located in common areas, the water is used more effectively, regular maintenance is budgeted for occurs due to the visibility of the basins within the community. The catchment basins at Day Break are so extensive that they have become more recreation amenities and key selling points for homeowners. In dryer climates such as Rancho Viejo and High Desert the drainage swales and detention basin can also be rich visual environments and habitats that reflect the native landscape, but require careful design and budgeted regular maintenance to ensure they function properly and are stable, due to the character of the soils and rain patterns.

5.5 Landscape Irrigation and Maintenance

Rancho Viejo's master plan calls for clustering the greatest housing densities on flatter grasslands, which helps foster efficient irrigation. The treated reuse water and rainwater catchment systems are key resources for all on-lot irrigation. The sustainable use and water conservation practices adopted by the homeowners and community have resulted in potable water use averaging below the County's annual water-use requirements.

Rancho Viejo is unique in its ability to also irrigate the extensive common open spaces with seasonally stored treated effluent irrigation systems. This ensured that these landscapes could be established quickly and be stable enough for heavy use by homeowners without using potable water systems. This saves the development an average of $1,962,500 per year in annual water costs by using secondary (grey water) irrigation system in all public spaces (Goodwin & Yang, 2011). Drip-line irrigation installed is a simple method for delivering a constant amount of water directly to the roots of plantings, conserving water usage by about 60%. Other water-efficient irrigation systems incorporated use low-pressure spray heads. The amount of pressure can be adjusted to plant needs in that zone. Although some water is lost in evaporation and air circulation, these low-pressure heads can also save close to 60% of the amount of water used. Day Break's testing of innovative Smart Control System and underground tube irrigation system and electronic tracking of the health of the trees will significantly improve the ability of communities to develop sustainable low water use and healthy landscapes in the future.

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary					
5.0 General Plantings Design Strategies			**2012 Status of Implementation of Goals and Strategy Analysis**		
GOAL 5.1 **Maximize Permeability by Increasing Vegetative Cover and Reducing Impervious Surfaces**	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Maximize permeability by scarifying soils to mitigate construction compaction and to allow seeding to establish and increase its ability to absorb water prior to planting.	**Not Implemented**	Soils are roughed on the surface to allow for seeding to become established but this may not be effective enough. Care must be taken not to increase potential soil erosion and loss from this effort. LA to work with Tall Grass Restoration to test soils and find a better solution to get the seeded grass areas to establish more consistently. Suggested alternatives include improved soil amendments and soil imprinting.	**Implemented in Only a Few Locations**	• A wide variety of permeable, pervious and impervious paving was installed on lots throughout the site. Windmill Ridge South and La Entrada, in particular, have exceptionally large areas of non-planted surfaces compared to the earlier constructed areas. The areas aid in the return of water to the aquifer and as a water resource for landscape plants. Some designs were exceptionally creative in designing the collection areas to either blend naturally with the landscape or to become features of the landscapes.	• Improperly installed edging, filter fabric, stone mulch materials, etc. are creating areas of erosion and visually unattractive landscapes in some of the landscapes in all the communities, including public open spaces maintained by the HOA's. The catchment and collection areas reviewed included a high percentage of design materials improperly installed, such as edging that was installed above the adjacent grade rather than flush with finish grade. This can lead to runoff pooling in behind the edging, flooding out low-water use plantings. Installing mulch materials to less than 3 inches in depth encourages weed growth and creates higher maintenance landscapes. Local community programs that provide design assistance or maintenance guidelines should be considered.
Temporary covers (seeding or 6-month biodegradable erosion control blankets) are installed on bare areas during dormant season as construction proceeds.	**Implemented in Some Locations**	This has only been effective in keeping the slopes from eroding but seeded grasses have not established well in many locations. Crimped straw with a tackifier is an alternative to consider. Incorporate these areas into the soil test to determine why some seeded areas are successful and others are not.	**Implemented in Some Locations**		
GOAL 5.2 **Use of Native and Low Water-Use Plant Materials**	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Design new landscapes and restoration plantings with native plant materials and other drought-tolerant plants to reduce water use by more than 50 percent.	**Implemented**	RV's desire is to stabilize the disturbed areas with native vegetation and to reduce the amount of disturbance as a whole. New details from the civil engineer will address and delineate locations for this. The design team needs to continue to review best option for future improvements. RV to review site on a regular basis to ensure the details implemented as specified.	**Implemented**	• Highly visible open space areas were very successfully restored, allowing the native plant materials to re-establish and stabilize the highly erodible soils. After 2005, this service was no longer available from Tall Grass Restoration site. The developers had to modify their approach and used one of the current landscape contractors on-site to attempt to replicate some of the restoration processes. This was not successful and only those areas which were irrigated thrived (Pino, 2012). • Planting of open space, roadways and adjacent drainageways: Plantings were installed in most locations as originally designed using mostly native plant materials. Native shrubs in particular, were successfully established in these areas. Piñon pine and junipers have also established well. Where these trees had been transplanted into the residential landscape and irrigated, only about 1% died and were subsequently replaced. In other non-irrigation open spaces on site, almost 100% of these trees died over the past 10 years. As a result, these trees were no longer planted in the Windmill Ridge South or La Entrada Landscapes.	• Water-wise tree species were substituted, however, some of the tree species tested on site, were not successful, mostly due to their ability to withstand strong winds, compacted or poor draining soils and extended periods of drought with limited irrigation. • Using a temporary irrigation system on disturbed areas that were hydroseeded with native grasses was found to be too costly by the developer. The areas that remained bare due to a lack of irrigation eventually did revegetate naturally and now are almost fully restored without irrigation being introduced at the time of seeding. Those areas which were replanted with native plants and were regularly irrigated were very successful and appear almost to be as thick as a traditional lawn.
Channels, ditches and swales are seeded or sodded with native grasses where appropriate.	**Implemented When Seeding is Allowed by County**	Seeded native grasses should be used and are used on site currently. Sod is too expensive to use on a site this size. LA to look into alternate solutions for establishing grasses during drought restrictions. See History of Seeding summary in Appendix D of the 2003 Surface Water Management Manual	**Implemented When Seeding is Allowed by County**		
Native and low water-use plant materials are used throughout the site. Plant materials are selected for their deep rooting characteristics, which promote deeper saturation, rooting and greater ability to withstand drought. Plants with similar water requirements are grouped together and irrigated by need for water (very low, low, medium, and high water use).	**Implemented**	Currently occurring on a regular basis as part of LA's landscape construction documents. Continue to improve plant selection and installation based on on-site performance.	**Implemented**		
Plant materials are designed and installed to shade drainageways and swales in order to reduce water loss through evaporation.	**Implemented**	Continue to consistently consider the location of the plant materials in designs to assist with cooling of the structures and parking lots in order to reduce the energy consumed to cool these site elements.	**Implemented**		
Use locally grown plant material to reduce energy consumption through transportation (fuel consumption and pollution) and improves the plants' chances for acclimation to the site conditions.	**Implemented in Some Locations**	Many of the native plants are purchased within a 100-mile radius. Most of the non-native plants and some trees are coming from out-of-state based on availability. Limiting the sources may reduce our opportunities to purchase the plants requested at a competitive price. In addition, many of our contractors purchase their plants from re-wholesalers when the time frames for completion are short. Most plants from re-wholesalers come from out-of-state.	**Implemented in Some Locations**		
Install soil additives or amendments during plant bed soil preparation to improve water retention and availability to plant materials.	**Implemented**	Organic Technology Additives are currently specified to help with water availability to plants. LA to discuss with the landscape contractor how they are installing the products and determine if the installation methods should be modified to improve performance.	**Implemented**		
Alternative lawn materials are available to homeowners that do not increase maintenance, contribute to conserving water and reduce reflective heat build-up.	**Implemented**	Gravel option is now available but is not preferred by the homeowners. This solutions is a good alternative when water restrictions will not allow seeding of the lots. Extended exposure to storm water run off can severely erode topsoil and create unsightly landscapes. The stone mulch, even when temporary, helps stabilize the soils and reduce evaporation. Look for a stone material that is more tan or rose in color, not grey. LA to assist with finding potential stone sources.	**Implemented**		

Figure V-5.1 Goals Matrix

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary

5.0 General Plantings Design Strategies			2012 Status of Implementation of Goals and Strategy Analysis		
GOAL 5.5 Landscape Irrigation and Maintenance	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Drip Irrigation systems are installed for tree, shrub and perennial plantings.	**Implemented**	This is a county and city requirement for water conservation.	**Implemented**	See Previous Page Comments	See Previous Page Comments
All plantings are on zoned irrigation systems to allow for reduction or shutting off of specific zones where plants have become established and only require irrigation during severe drought situations.	**Implemented**	Village I has been cutting back on water to plants as specified. Most of the landscape areas, except the park, will be taken off the automatic watering system this year. Windmill Ridge should begin reducing water to its older landscapes this year. May need to monitor more closely to insure that the plant irrigation is being reduced to wean the plants off of the water system entirely within a three- to five-year period.	**Implemented**		
Homeowners are provided with irrigation system maintenance guidelines for efficient water-conserving techniques and water sensors.	**Implemented**	Homeowners Association (HOA) and the landscape contractor provide a manual and briefly train the homeowners on how to use the irrigation system and to be water wise.	**Implemented**		
Water audits are conducted on at least two (2) of each residential product and all commercial or office irrigation systems each year.	**Not Implemented**	LA recommended a contractor to perform water audits (completed). It is recommended that two (2) water audits be conducted for randomly selected homes in each residential product type, each year to determine the effectiveness of the systems and to identify areas in which we can improve the system in the future. Homes selected will have lawn areas that are currently irrigated with spray heads.	**Not Implemented**		
5.5.2 Landscape Maintenance					
All areas of the site are inspected frequently and any problems or failures of mulch, diseased or unhealthy plant materials removed or issue corrected immediately, especially during the rainy season.	**Implemented**	Monitoring needs to be more regular. Currently we are responding only to major weather events. RV to monitor more closely in future (Land Development Superintendent).	**Implemented**	• Homeowners are provided with a handbook and other information on the irrigation systems, water harvesting systems, water conservation, and required plant lists when they purchase a home at Rancho Viejo. • Landscape Maintenance Contractors vary by HOA, however, all seem to be doing a good job maintaining the native landscapes within the budget and schedule set by the HOA. Additional budgets should be set aside for cleanout of culverts and drainageways to keep them free of debris and silt, especially in preparation before rainy seasons.	• Maintenance of the home landscapes is inconsistent. Interviews indicated that many homeowners do not know how to maintain a low-water use and native plant material landscape. In general, once landscape maintenance is turned over to the homeowners, the HOA's and developers have very little control in keeping the lots sustainable as designed. The developers created 2-3 zones of responsibility for the front yards and this has become problematic. The 3 major zones include: areas cared for by the resident, areas maintained by the HOA maintains which are typically landscapes between the street and lawn areas, and areas with shared responsibility. The divisions of responsibility created confusion on the part of the homeowner and landscape maintenance contractors. In some locations, homeowners have painted stripe lines in the front yards where the landscape is only cared for up to the line. Care of the streetscape is the responsibility of the HOA, but appears to be inconsistent throughout the overall community. Each HOA has a different landscape maintenance contractor. The guidelines developed for each community are not being followed in all cases. According to the developer's site manager, consistency between the associations is difficult to achieve (Ross 2012).
Inform the Homeowners Association representative and hire landscape contractors experienced in maintaining communities that are striving to reduce their water use and protect the surface-water management systems in an efficient and cost-effective manner.	**Implemented in Some Locations**	Some training of the HOA representative has occurred to date, including an introduction to the landscape vision and landscape maintenance requirements. Continue to work to improve the performance of the landscape maintenance contractors and HOA representative. Encourage educational programs for homeowners to better understand how to maintain their landscapes, cisterns and grey water sustainably and appropriately.	**Implemented**		
Sodded or seeded swales or concave depressions are installed to detain low-intensity storm-water run off and are planted with grass or other plants. As an alternative, stone swales with a variety of stone sizes are used in limited quantities in yard areas where establishing lawn is not feasible at the time of installation.	**Implemented Seeding Only Except at Model Homes**	Regrading of the swales is needed to maximize the water-harvesting capabilities. Most swales are seeded with native grasses but many have been filled with stone. Some problems are occurring in specific areas where the grasses are not getting established fast enough to control erosion. LA to work with RV and arrange for soil tests to be taken at select locations throughout the site to determine why some grasses are quick to establish and others are not. Investigate slope, aspect, time of year, soil conditions, rainfall or temporary irrigation available, and seed mixes. Where stone catchment areas are to be installed, LA to assist RV with developing examples of visually attractive stone mixes and swale forms that function properly.	**Implemented Seeding Only Except at Model Homes**		
Swales are designed to have an overflow and spillway at a point along the depression.	**Some Locations**	LA to work with RV to identify the best drainage paths on residential lots and to identify the useable spaces to retain and meet homeowners' needs. (In progress — refer to prototypical plans in this section).			
Homeowner covenants clearly identify what planting is required of the homeowners and when it must be completed, to reduce potential erosion from wind and water.	**Implemented in Some Locations**	This issue mainly has to do with how long a time frame the homeowners have to either establish lawn or finish off the treatment of their lots to reduce topsoil erosion and unsightly landscapes. RV needs to review and evaluate the covenant documents to be certain they are clear and complete. RV to establish a means in which to ensure that these requirements are enforced. See appendix for copy of current homeowner covenants.	**Implemented in Some Locations**		
Hay bales buried down-slope of trees to trap water for use by plants.	**Not Implemented**	Currently implemented in open space lot areas. LA has developed a detail for grassed swale and hay bale riffle outside of the weep holes of the yard walls. See Section 4.2.1 Comments on open-space design. LA has also created an additional detail and criteria for installing hay bale boomerangs upslope of tree plantings to better drive water into the ground and make it available to the plant materials, especially when the slopes cannot be planted due to drought restrictions imposed by the County of Santa Fe.			

Figure V-5.2 Goals Matrix

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary

5.0 General Plantings Design Strategies			2012 Status of Implementation of Goals and Strategy Analysis		
GOAL 5.3 Preserve Existing Vegetation Whenever Possible	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Natural vegetated areas are protected or left in place as long as possible to reduce erosion, preserve wildlife habitats and enhance property values.	**Implemented**	RV's desire is to stabilize the disturbed areas with native vegetation and to reduce the amount of disturbance as a whole. New details from the civil engineer will address and delineate locations for this. The design team needs to continue to review best option for future improvements. RV to review site on a regular basis to ensure the details implemented as specified.	**Implemented**	• Through careful site planning and conservation plans, over 50 percent of the site and the natural vegetation was preserved.	• Areas graded to where the public-use areas are transitioning to native landscape created some challenges and extensive site supervision to try and protect the native vegetation from disturbance. • Due to the drought conditions, where existing vegetation was removed, the native vegetation was very slow to re-establish and in some areas has never come back. This has resulted in highly eroded natural drainageways in many areas, where water from impervious surfaces flow out into the native landscape without any structures in place to slow or filter water resources.
When clearing and grubbing of plants is required, grubbing of tree roots is held back until grading is to proceed, as the roots can provide substantial erosion control.	**Implemented in Some Locations**	Needs Improvement. See Section 1.1 comments	**Implemented in Some Locations**		
GOAL 5.4 Slope Stabilization	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Where appropriate, channels, ditches and swales have been graded to minimize erosion and are seeded or sodded with native grasses to stabilize soils and allow water to infiltrate into the subsoil.	**Implemented**	Success in establishing seeded drainageways is sometimes achieved by grading the swale side slopes at 1 to 2 percent, mainly in open spaces. Drought was a barrier to successful germination in many locations in 2001 and 2002. LA to work with contractor to determine what mix or soil conditions may be required to improve our success with this installation. Field verify that check dams and other soil erosion methods are installed prior to seeding. Soil amendment options are being tested by Tall Grass Restoration, for better seed coverage and established during all times and especially during drought, in areas of high visibility and highly erodible areas.	**Implemented**	• Many of the slopes on site are now stabilized by well-established native grasses. The more stabilized areas appear to receive either runoff from irrigation systems or are irrigated.	• Some minor erosion problems are occurring in the drainageways located within more managed areas of the site, and along the roads and public spaces. Open space areas outside of the developed area and along the walking paths have required extra repair work due to erosion. A preventative management program has not continued since the original work was completed through 2004, due to cost. • In the spring of 2012, a severe rain storm washed out the soils near a major arroyo passing through the site. The older stabilized areas of the drainageway showed little damage, however, a newer control measure installed in 2010, failed, causing some serious drainageway banks erosion, and rock and wood debris were pushed into the adjacent open space areas (Ross 2012).
Trees, shrubs and grasses or other vegetation is retained wherever possible.	**Implemented in Some Locations**	Needs Improvement. See Section 1.1 comments	**Implemented in Some Locations**		
GOAL 5.5 Landscape Irrigation and Maintenance	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
5.5.1 Landscape Irrigation					
Irrigation: Where irrigation is used, sensors are used to monitor the effectiveness of the systems.	**Not Implemented**	Permanent irrigation systems are currently being used in select open space areas such as the plazas and shared park areas. LA is providing production information and costs and will identify the cost benefits of putting in such systems, including maintenance, and evaluating potential locations. Consider rain shut-off devices and irrigation meters for future systems as well as rain sensors. Train personnel to monitor soil moisture levels and water only at level required. Evaluate total loss of potable water due to infrastructure leaks. Train personnel to recognize signs of potential leaks and to repair immediately.	**Implemented in Some Locations**	• Established landscapes are easily maintained and require only routine pruning, mowing and general landscape maintenance. • Santa Fe County limited the water use to .25 ac. ft. per dwelling per year. Rancho Viejo's target was .15 ac. ft. in 2003. Water Audits have not been conducted since the 2004. However, in 2012, Santa Fe County confirmed that the community had reached .16 acre feet of water/year.	• The irrigation is designed to be turned on only as needed or to establish new landscapes and was installed according to the specifications. However, no as-built indicating the installed location of mainlines and laterals lines exist and no record of where other key irrigation equipment is installed. Repairs are therefore difficult to conduct in a timely and cost efficient manner.
Create target efficiency budgets for each major water zone based on the outdoor landscape area use.	**Not Implemented**	Not currently implemented. Need to discuss this further with RV to develop a means of achieving the audits once the targets are set.	**Generally Implemented**		
Water sensors installed as part of the irrigation system.	**Not Implemented**	LA to look into new reliable sensor systems that may be applied in a variety of site situations; on-lots, open space (permanently irrigated areas).	**Not Implemented**		
Water Audits: Design and budget as part of the development process along with specifications for installation of the sensors.	**Not Implemented**	This has not occurred to date, but RV has indicated that this is a desirable step to take.	**Not Being Conducted any Longer**		
Temporary or permanent irrigation systems are used to establish seeded lawn areas.	**Implemented**	Temporary irrigation systems have not been found to be cost effective. Continue to utilize permanent systems, but evaluate temporary systems in the future to determine if new technology has resulted in a more cost-effective temporary system. Currently too expensive due to size of site. May be possible in the future depending on changes in technology. Re-evaluate every 2 years to determine if cost-effective solutions are readily available.	**Implemented**		

Figure V-5.3 Goals Matrix

Rancho Viejo Surface-Water Management Goals - Successes and Challenges Summary

5.0 General Plantings Design Strategies			2012 Status of Implementation of Goals and Strategy Analysis		
GOAL 5.5 Landscape Irrigation and Maintenance	**2002 Status**	**2003 Recommendations to Improve Site Sustainability**	**2012 Status**	**Successes**	**Challenges**
Drip Irrigation systems are installed for tree, shrub and perennial plantings.	Implemented	This is a county and city requirement for water conservation.	Implemented	See Previous Page Comments	See Previous Page Comments
All plantings are on zoned irrigation systems to allow for reduction or shutting off of specific zones where plants have become established and only require irrigation during severe drought situations.	Implemented	Village I has been cutting back on water to plants as specified. Most of the landscape areas, except the park, will be taken off the automatic watering system this year. Windmill Ridge should begin reducing water to its older landscapes this year. May need to monitor more closely to insure that the plant irrigation is being reduced to wean the plants off of the water system entirely within a three- to five-year period.	Implemented		
Homeowners are provided with irrigation system maintenance guidelines for efficient water-conserving techniques and water sensors.	Implemented	Homeowners Association (HOA) and the landscape contractor provide a manual and briefly train the homeowners on how to use the irrigation system and to be water wise.	Implemented		
Water audits are conducted on at least two (2) of each residential product and all commercial or office irrigation systems each year.	Not Implemented	LA recommended a contractor to perform water audits (completed). It is recommended that two (2) water audits be conducted for randomly selected homes in each residential product type, each year to determine the effectiveness of the systems and to identify areas in which we can improve the system in the future. Homes selected will have lawn areas that are currently irrigated with spray heads.	Not Implemented		
5.5.2 Landscape Maintenance					
All areas of the site are inspected frequently and any problems or failures of mulch, diseased or unhealthy plant materials removed or issue corrected immediately, especially during the rainy season.	Implemented	Monitoring needs to be more regular. Currently we are responding only to major weather events. RV to monitor more closely in future (Land Development Superintendent).	Implemented	• Homeowners are provided with a handbook and other information on the irrigation systems, water harvesting systems, water conservation, and required plant lists when they purchase a home at Rancho Viejo. • Landscape Maintenance Contractors vary by HOA, however, all seem to be doing a good job maintaining the native landscapes within the budget and schedule set by the HOA. Additional budgets should be set aside for cleanout of culverts and drainageways to keep them free of debris and silt, especially in preparation before rainy seasons.	• Maintenance of the home landscapes is inconsistent. Interviews indicated that many homeowners do not know how to maintain a low-water use and native plant material landscape. In general, once landscape maintenance is turned over to the homeowners, the HOA's and developers have very little control in keeping the lots sustainable as designed. The developers created 2-3 zones of responsibility for the front yards and this has become problematic. The 3 major zones include: areas cared for by the resident, areas maintained by the HOA maintains which are typically landscapes between the street and lawn areas, and areas with shared responsibility. The divisions of responsibility created confusion on the part of the homeowner and landscape maintenance contractors. In some locations, homeowners have painted stripe lines in the front yards where the landscape is only cared for up to the line. Care of the streetscape is the responsibility of the HOA, but appears to be inconsistent throughout the overall community. Each HOA has a different landscape maintenance contractor. The guidelines developed for each community are not being followed in all cases. According to the developer's site manager, consistency between the associations is difficult to achieve (Ross 2012).
Inform the Homeowners Association representative and hire landscape contractors experienced in maintaining communities that are striving to reduce their water use and protect the surface-water management systems in an efficient and cost-effective manner.	Implemented in Some Locations	Some training of the HOA representative has occurred to date, including an introduction to the landscape vision and landscape maintenance requirements. Continue to work to improve the performance of the landscape maintenance contractors and HOA representative. Encourage educational programs for homeowners to better understand how to maintain their landscapes, cisterns and grey water sustainably and appropriately.	Implemented		
Sodded or seeded swales or concave depressions are installed to detain low-intensity storm-water run off and are planted with grass or other plants. As an alternative, stone swales with a variety of stone sizes are used in limited quantities in yard areas where establishing lawn is not feasible at the time of installation.	Implemented Seeding Only Except at Model Homes	Regrading of the swales is needed to maximize the water-harvesting capabilities. Most swales are seeded with native grasses but many have been filled with stone. Some problems are occurring in specific areas where the grasses are not getting established fast enough to control erosion. LA to work with RV and arrange for soil tests to be taken at select locations throughout the site to determine why some grasses are quick to establish and others are not. Investigate slope, aspect, time of year, soil conditions, rainfall or temporary irrigation available, and seed mixes. Where stone catchment areas are to be installed, LA to assist RV with developing examples of visually attractive stone mixes and swale forms that function properly.	Implemented Seeding Only Except at Model Homes		
Swales are designed to have an overflow and spillway at a point along the depression.	Some Locations	LA to work with RV to identify the best drainage paths on residential lots and to identify the useable spaces to retain and meet homeowners' needs. (In progress — refer to prototypical plans in this section).			
Homeowner covenants clearly identify what planting is required of the homeowners and when it must be completed, to reduce potential erosion from wind and water.	Implemented in Some Locations	This issue mainly has to do with how long a time frame the homeowners have to either establish lawn or finish off the treatment of their lots to reduce topsoil erosion and unsightly landscapes. RV needs to review and evaluate the covenant documents to be certain they are clear and complete. RV to establish a means in which to ensure that these requirements are enforced. See appendix for copy of current homeowner covenants.	Implemented in Some Locations		
Hay bales buried down-slope of trees to trap water for use by plants.	Not Implemented	Currently implemented in open space lot areas. LA has developed a detail for grassed swale and hay bale riffle outside of the weep holes of the yard walls. See Section 4.2.1 Comments on open-space design. LA has also created an additional detail and criteria for installing hay bale boomerangs upslope of tree plantings to better drive water into the ground and make it available to the plant materials, especially when the slopes cannot be planted due to drought restrictions imposed by the County of Santa Fe.			

Figure V-5.4 Goals Matrix

B. Other Influencing Factors

Impact of Climate and Soils: Precipitation patterns since 2003 have had a significant impact on the development design and the success of the community's landscapes and the innovative surface water management strategies tested at Rancho Viejo. New Mexico's soils typically lack the organic matter necessary to provide sufficient plant nutrients and water retention. Native plants tend to need less organic matter than adapted plants, but most plants benefit from the addition of some organic matter, such as compost, into the soil. Compost helps sandy soils retain water and helps clay-dominated soils drain faster. When water mixes with compost in soil, the resultant carbonic acid dissolves the 18 essential elements typically found in compost so that plant roots can more easily take up these nutrients. Compost also aerates the soil so that plant roots can maintain their optimal moisture content. In these improved conditions, the insects, microorganisms and mycelium found in healthy soil can thrive, so plants can establish themselves quickly in the landscape (NMOSE, 2009).

Economic Downturn Impacts: In 2010, the economic downturn was to a point where the housing market in Santa Fe was almost completely dried up, according to Ike Pino, former manager and president of Rancho Viejo, LLC. The bank, which held the loan on the property, called for a letter of credit (estimated at $180 million). Pinnacle West, sold all the remaining project areas on site and divested itself of the development market. In December, 2010, the first part of the project called Rancho Viejo Village 1 (north and south) was sold by Pinnacle West to a small group of the original Santa Fe landowners and principals of Scottsdale, Arizona-based investors who formed a company called Univest-Rancho Viejo LLC. Univest established separate Developer, Homebuilder and Wastewater Treatment business operations in the community (Pino, 2012). The remaining development and the home-building business, architectural plans and infrastructure were purchased by the same family partnership that first subdivided the area in the 1990's.

Public Agency Requirements: The construction costs have increased to meet new regulatory requirements, and more inspections, making it difficult to absorb the costs of the sustainable strategies in this current economy. The current General Manager of Rancho Viejo indicated that the cost and benefits are no longer balancing and are instead encumbering the process with extra costs which cannot be passed on to homeowners in this economic market. The original developer installed techniques for efficiency, but when residences are completed there is a significant drop off of the maintenance of the system due to cost and time required (Ross, 2012).

National Pollutant Discharge Elimination System Program (NPDES): Requirements developed as part of the Clean Water Act of 1972 continue to be adhered to by the developer and community of Rancho Viejo. See the SWM Manual (Appendix F) for more detailed information on these requirements. Alternative water management systems help with the approval process, NPDES and other State regulations. These systems can also support the developers marketing and economic goals by creating desirable and habitat friendly landscapes and an enhanced community image. The systems can achieve stormwater goals often within the customary open space requirements resulting in lower water-use costs for homeowners and lower or comparable infrastructure costs for the developer.

Homeowner Satisfaction and Perception: At Rancho Viejo, the sustainable approach to water conservation when combined with the concepts of good neighborhood design, sense of community, healthy environment which exists within a unique native landscape environment, trails and open space amenities, etc., have been found to be effective in attracting and sustaining homeowners.

Communicating the value of the home's and the community's sustainable features to the homebuyers is still a part of the marketing strategy. According to Patrick Thomas, the Rancho Viejo Qualifying Broker, the sustainable approach is important for some homebuyers, but isn't typically a top reason for buying a home in the community. Many of the concepts of surface water management are foreign to home buyers. Cisterns, rain barrels, graywater reuse, for example, can be difficult systems for some homebuyers to understand how to maintain them, even when provided with handbooks and guidelines. The community homeowners, in general, believe the sustainable community is a positive approach. "Most people who have bought homes in the community understand and recognize that the sustainable landscape and low water and energy use systems are hallmarks and virtues of the community and they are proud of it" (Ross, 2012). There is, however, room for improvement in their understanding that reclaimed water is still a limited resource. Homeowners have a tendency to use more irrigation once they know that it is reclaimed water and not potable water. Better education and limit on use of the treated water is necessary to allow for enough water for all the communities to use this equally.

Educating the Team: Building a sustainable water management program requires education of a broad audience. Contractors may need additional training about sustainable construction techniques and materials, and environmental regulation. Builders and developers also need to understand the rationale for changing some of the practices tested on site that improve water conservation or maintenance. New innovations in materials and that construction methodology should be reviewed as each new phase of development occurs.

A renewed educational program, in particular, is recommended for homeowners and site management team to help them understand the maintenance of their landscape and water conserving features. Communicating the value of the water conserving systems to the homeowners helps minimize the gap between expectations and delivery, which is critical for sales and satisfied homeowners. Marketing programs should communicate green benefits as part of a larger quality-of-life and lifestyle of the community not just as the primary selling point. Potential homebuyers would also benefit from information that helps them to understand the unique nature and commitment needed to live in a sustainable community, especially in an arid environment, prior to a home purchase.

In "Making Green Communities Work," Steve Kellenberg outlines the educational components needed and provides a valuable guide to the process of educating the team. The components include:

- **Master Developer –** *Some level of passion for green building by the development organization for a project is needed for a project to be successful.*
- **Builder -** *The design team, purchasing and field supervision in particular need to buy into the process and coordinate closely through a lead general contractor.*
- **Sub-contractors** – *Builder subs need to be informed about why they are changing stand practice or products.*
- **Public Agencies** – *Involving city staff and public works, and other key agencies involved with the zoning or regulatory requirements or field inspections should be made a part of the vision and design development process whenever possible.*
- **End-User Residents and Workers** – *The new homeowners need to be trained on how to operate the sustainable living environment once it is completed.*
- **Interpretation** – *Interpretive centers, educational exhibits, nature trail systems and stewardship programs can make the community aware of the preserved natural features of the site such as arroyos, wetlands and preserved native plant species and wildlife corridor elements* (Kellenberg, 2004).

Recycling, waste management, irrigation practices, landscaping, and use of water and energy saving devices requires an ongoing education/public outreach program funded and maintained by the Home Owners Association (HOA). There are a few references within the governing documents for each community at Rancho Viejo that address the landscape and water usage, including the community covenants, homeowners' handbook documents, which are provided to all new homeowners. In addition, informal education programs that are sponsored by the HOA to answer questions on home maintenance and management of the irrigation system, plantings, etc. Other tools were created originally for the home sales in Village 1 and Windmill Ridge North, including the Landscape Vision, Rain Water Harvesting, and Water Conservation pamphlets, but due to costs are no longer distributed.

Interpretive signage was originally installed along nature trails, specialty brochures on water conservation and other informational signage have been used throughout the community with very positive results (Images 5.1, 5.2). However, most of the educational signage is no longer in place, according to the developer (Ross, 2012). (Appendix D)

Image 5.1: Example Rancho Viejo Educational Materials

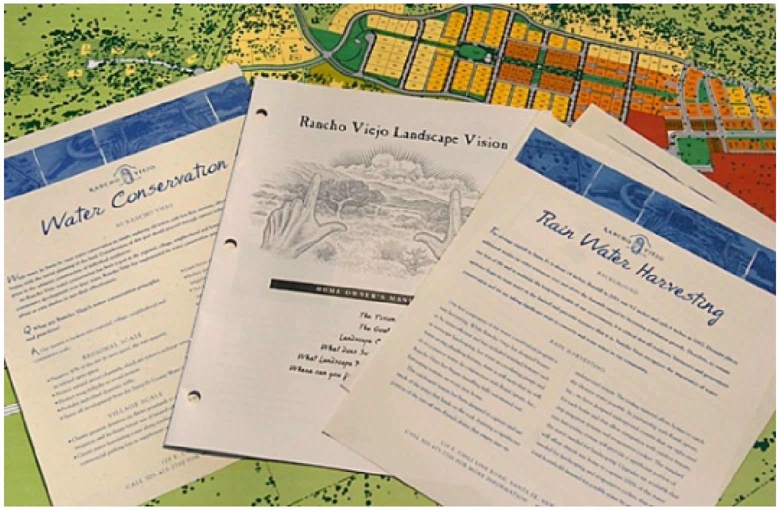

Image 5.2 Example Rancho Viejo Water Management Pamphlets

C. Applying LEED Strategies

The study included a review of the guideline "LEED Strategies for New Construction (NC)" and the "LEED Neighborhood Development (ND)" guideline. The applicable components from LEED that were reviewed for compliance were:

1. Sustainable Sites - erosion and sedimentation control and stormwater management;
2. Water Efficiency - water efficient landscaping and water use reduction;
3. Materials and Resources – use of local/regional materials and resource reuse; and
4. Innovation and Design Process –which addresses special innovation in design.

The LEED strategies for community development closely parallel many of the key design components implemented at Rancho Viejo. Water efficient landscaping, reduction of impervious surfaces, water harvesting and reuse, green infrastructure to filter contaminants from runoff, bioswales, bioretention basins, and vegetated filter strips, vegetated swales and detention basins, are examples of the strategies listed in LEED that are implemented at Rancho Viejo (USGBC, 2005).

LEED certification was considered by the master developer (SunCor); however, the project never went through the certification process. It was anticipated by the developers and project planners that the project would most likely have achieved the Silver Certification. The corporate leadership at the time, however, decided that it was too costly to go through the certification process (Pino, 2003). Although the master developer decided not to apply for LEED certification due to costs, the overall project site has achieved Energy Gold Star ratings and the houses are certified under Build America, which is based on LEED.

D. Summary of Innovations

There have been many innovations at the Rancho Viejo community that significantly contributed to the success of the surface water management program and sustainability goals.

- The developers of Rancho Viejo placed a great emphasis on the goal of maintaining natural and urban open spaces, as it considers the preservation of substantial amounts of open space as a means to not only contain sprawl, which is an inefficient use of land and services, but to preserve the natural landscape.
- Zoning was based upon an analysis of developable areas, the built-out capacity and the lands that need protection; resulting in village-style clustering and allowing for large swaths of land to remain open (Porter, 2003).
- High density development occurs on the flat grassland meadows that require the least site disturbance and grading to accommodate development (Porter, Kolkmeyer, Moore, 2012).
- 50% of open space was conserved for aquifer recharge by pairing development with land types and through cluster development. Within these open spaces are parks, village centers and walking trails.
- Phased development to reduce initial costs and debt, along with being flexible to market needs and demands (Porter et al., 2012).
- Within each village, pedestrian-oriented central gathering spaces were designed with minimal paving areas. These gathering spaces in many cases also function as stormwater management areas.
- Groundwater recharge, reuse of treated effluent, harvesting surface-water runoff, and the use of domestic cisterns or rain barrels for most homes were successful strategies for managing water reuse on site.

- Energy conservation through solar orientation. 70% of the homes in the first two villages have an energy-efficient orientation and the last two villages built are being constructed to the U.S. Department of Energy's 'Build America' energy standards (Porter et al., 2004).
- The Biolac Waste Water Treatment Plant (WWTP) project at Rancho Viejo is an innovative solution in water conservation and reuse. This system includes the reuse of treated effluent for irrigation of common areas and parks and the use of water saving devices and systems in each residence.
- The success in reducing water use at Rancho Viejo led to the county passing a water conservation ordinance that gave Rancho Viejo credit for the reductions and allowed more dwellings to be constructed. This same ordinance is available to all developers in Santa Fe County and provides a motivation for others to follow Rancho Viejo's example and further reduce water use in the county.
- Potable water use was reduced by 12.4 million gallons as of 2010 (enough to supply 262 typical single-family households per year) by irrigating with treated effluent (grey water) and by using native plants, for a 81% water savings over the typical allocated county water use. This saves an average of $196,250 per year in annual water costs as of 2010. (LAF, 2011). City and County Water Right Purchases: Around 2003 the City and County of Santa Fe had no water agreement. Typically the allocation required .25 acre feet of water/year to be assumed / assessed per home. The cost was $30,000/acre feet for the Water Right Purchase. The developer collected data on all homes built and were able to submit data that showed that they averaged .20 acre feet/year. They requested that the County change from an allotment of 4 houses /acre feet to allowing 5 houses/acre feet. The agencies accepted this change for both the previously constructed units and new ones proposed. This gave the developer basically a bonus of 168 lots they could develop in Windmill Ridge 3 with no cost for the Water Right Purchase. In early 2012, the County of Santa Fe confirmed that the potable water use for the entire community was now below .16 acre feet of water/year.
- Drip-line irrigation is used to provide a constant amount of water directly to the roots of plantings, potentially conserving water usage by 60%.
- Grouping plants in irrigation zones that have similar water requirements (hydrozoning) and installation of rain or water meters has contributed to a reduction of water use.
- Water-capture systems (cisterns and rain barrels) are used to augment landscape water needs.

This case study of Rancho Viejo de Santa Fe captures many of the successes and challenges of the water conservation strategies implemented. The Santa Fe watershed may soon face climate changes that may require even more creative strategies to address water management to create a more resilient watershed.

VI. CONCLUSION

Sustainability was just becoming a popular concept nationally when Rancho Viejo was first conceived in 1996, although the concept of surface water-harvesting and water conservation has a very old history and illustrates how industrialized societies can learn to be more sustainable by studying ancient cultures. Until recently, rainwater management had traditionally been considered only a concern for developers and design teams, especially with the ever increasing development rates and conversion of open space to impervious surfaces. Today, stormwater management design is being transformed from what was once just a regulated requirement to being viewed as a valuable resource and tool for creating successful sustainable landscapes, especially in arid environments (Thompson & Sorvig, 2008).

There are now many new examples, national and international, of sustainable communities where innovative designers and developers have recognized and embraced the opportunity to use rainwater and runoff as a valuable resource and captured. These communities have often directed the water resources in a natural and artful manner that enhances the aesthetics and sustainability of the development, surrounding community and watershed. However, only a small percentage of these sustainable communities have been studied in depth to measure the success of achieving the sustainable water management goals established by the developers and planners. The four case studies of master-planned communities in this report were found to have established very similar water management goals and, had the same or relatively similar challenges and successes as those of Rancho Viejo.

The case study of Rancho Viejo is focused specifically on the evaluation of the policies and strategies to conserve water and improve water quality and supply issues as defined in the project developers' water management goals. The challenge was to fit a large new community into a sensitive landscape in a manner that preserves the intrinsic values of the landscape, protects wildlife habitat, provides for affordability, conserves water and does so in a political environment where people are extremely protective of their community heritage, dislike change and do not trust corporate outsiders.

Through this study process, Rancho Viejo was found to have succeeded in the majority of its water management goals as well as other sustainable design strategies, but still has room for improvement and innovation as it develops the future villages. The new technologies being test at Day Break and other new sustainable communities, also emphasizes the need for continual research and evaluation of water and dispersal systems.

One of the distinctive qualities and achievements of Rancho Viejo's was the more informal and naturalistic open space surrounding the community, which protects habitat and foster a sense of place and neighborhoods. It also shows how important the designed and natural landscape is to creating a strong community identity and resident satisfaction. Rancho Viejo is also exceptional in its' achievement of reducing potable water usage to 40% below County requirements, establishing an on-site waste water treatment plant for supplying reuse water for irrigation and preserving 50% of open space and historic drainageways for aquifer recharge and habitat preservation.

Rancho Viejo was unique in its integrated and collaborative approach to the planning and approval process contributions to the development process for future green communities in the County. The project teams' contribution to changing the way the Santa Fe Community College District was developed is considered a model for new sustainable development locally and can be learned from nationally. Many benefits can be realized with such a collaborative planning process, especially when natural rainfall is considered a precious resource and is managed to sustain the project, the surrounding community, district and watershed. The results of arid-land water-harvesting, in particular, can be startling.

Other benefits of sustainable stormwater management include:

- reduction of development costs
- reduction of landscape maintenance cost
- increased sales performance
- reduced impact on environments and habitats
- replenishment of the aquifer
- compliance with environmental regulations
- improved water and stream quality
- flood prevention
- reduced infrastructure costs
- reduced land area of traditional stormwater management techniques
- increased property values through natural landscaping, open space, wetlands and waterways

This case study shows that a collaborative planning process, implementation of innovative technical strategies in sustainable site design and construction, and a strong homeowner educational program can result in an expedited approval process; a significant reduction in potable water use; reduced infrastructure costs; and protected water recharge areas, open space vegetation and habitats. These systems can also support the developers marketing and economic goals by creating desirable and habitat friendly landscapes and an enhanced community image.

However, despite these benefits, sustainable communities represent only a fraction of recent development in the United States. This is because applying sustainable principles can often be more difficult than implementing the traditional development practices. There are numerous sustainable community frameworks available that give form and direction to the environmental, social and economic activities of a community. In the absence of a national framework to reference, the landscape of sustainable community frameworks vary considerably. The LEED designation system has had a rapid market adoption and yet still does not fully represent all of the sustainable landscape strategies. This often makes it difficult to evaluate projects using a consistent baseline.

There are also many examples of where the opportunity for creative water reuse has been missed or designs have only been focused on the disposal of surface water from a site. Potential barriers to success that can challenge a design team achieving their goals in a sustainable water management approach often include:

- Lack of vision and understanding of the cost benefits of a surface water conservation and management plan by the developer or project team
- Lack of coordination or collaboration between the developer team, designers and public agencies
- Landscape ordinance that conflict with the proposed water quality approaches
- Economic pressures
- Systems have diminishing effectiveness over time if not properly maintained
- Resistance from public agencies and state engineers who are unfamiliar with alternative water conserving, water harvesting, water treatment and reuse systems.
- New methods conflict with understanding of traditional engineering or construction methods
- New landscape management and maintenance must be learned for these water-conserving landscapes and re-use systems by the landscape contractors, homeowners, HOA, management groups and municipalities who must assume the responsibilities for managing the systems once the developer has left the site (Wenk, 2003).
- Challenges of water rights issues in the west limiting water capture and reuse

Challenges that influenced the level of success at Rancho Viejo included maintenance of the cisterns, capacity of the onsite water treatment plant, education of the homebuyers, changes caused by long periods of drought, and the slowing of housing market and economic downturn, which eventually led to a change in master developer. Economic pressures are challenges for all communities struggling with high development costs and reduced water resources. Economic pressures can impact water conserving strategies and often result in greater tension and greater suppression of many viable efforts towards innovation in sustainable water management and other creative techniques, while relatively fruitful times experienced only a few years ago provided an accommodative environment to pursue many initiatives. The two issues of water conservation and economic conservation are inextricably linked and can frustrate the goals of either of these elements when taken alone.

Despite the challenges at Rancho Viejo, most of the strategies proposed in the Surface Water Management Manual have been successfully implemented and managed. With the experience they have gained from documenting and testing their vision and goals out on the first three village communities, there is a great opportunities for the next villages planned at Rancho Viejo to increase innovation and effectiveness of their sustainable water management strategies.

In the "2012 Climate Change and Santa Fe Watershed Report," it states that water will become even scarcer in the near future as temperature are expected to increase and more severe drought is anticipated in New Mexico (Lewis, MacClune, & Tyler, 2012). The vulnerability of groundwater supply is poorly understood because the mechanisms and timing of recharge are difficult to quantify. Climate change projections suggest that water management need to be at the forefront of innovative design strategies to reduce water demands through expanded water harvesting techniques, promoting aquifer recharge by developing green infrastructure and programs for groundwater storage and recovery and increasing water storage capacity for captured rainwater.

More intense precipitation events are also projected, which suggests better erosion control and management of existing drainageways may be needed due to anticipated increases in peak storm flows, greater magnitude and frequency of flooding, higher erosion rates, more sediment transported by storm flows (Lewis et al., 2012).

All of Rancho's Viejo water management strategies such as their collaborative planning process, protection of open space and habitat, protection of the watershed and aquifer, sustainable water conservation and site design strategies are transferable to other projects. Rancho Viejo's success demonstrates that developers and designers should continue to seize the opportunity to integrate the sustainable management of surface water resources early on in the planning process to the end of construction to fully benefit from long-term ecological and economic benefits of green development.

The move toward greener communities presents enormous opportunities for planners, architects, landscape architect, developers and investors who understand the ways in which environmentally responsible development can be achieved and result in economic, social and environmental benefits. In the book, *Developing Sustainable Planned Communities*, the authors highlight the benefits of sustainable development, noting that sustainable development is good business and opens up opportunities to access land, capital and creative cutting edge designs and access to a fast growing market (Franco et al., 2007). Integrating creative techniques for conservation of water and reuse of surface water runoff into the planning and site design for residential communities is the primary strategy being explored in this study.

Sustainable site design and management strategies related to water conservation, still needs to be tested in a variety of environments and political and economic climates. Rancho Viejo can serve as a living model of successful sustainable community design in arid environments and an ongoing laboratory for research and replication. It is imperative that we continue this progress by evaluating the long term success and challenges of the implemented systems in real communities. By showcasing projects representing different geographic regions, sizes, types, and stages of development, we can demonstrate the feasibility of creating sustainable, water-conserving communities virtually anywhere economical, ecological and socially responsible and beneficial purposes.

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VIII. APPENDICES

APPENDIX A: List of Images

APPENDIX B: 2002 - 2012 Climatological Summaries

APPENDIX C: Interviews

APPENDIX D: Rancho Viejo Landscape Vision

APPENDIX E: NRCS Custom Soil Resource Report - Santa Fe County and Environs

APPENDIX F: 2003 Surface Water Management Manual

APPENDIX A: LIST OF IMAGES

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APPENDIX B: 2003 - 2012 CLIMATOLOGICAL SUMMARIES

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

MONTHLY CLIMATOLOGICAL SUMMARY

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station:**GHCND:USC00298085, SANTA FE 2, NM US - 2003** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature (°F)											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2003 Month	Mean Max.	Mean Min.	Mean	Heating Degree Days	Cooling Degree Days	Highest	Lowest	Number Of Days				Total	Greatest Observed	Snow, Sleet		Number Of Days		
								Max>=90°	Max<=32°	Min<=32°	Min<=0°			Total Fall	Max Depth	>=.10	>=.50	>=1.0
5	77.5	41.7	59.7	176.2	38.2	93	26	2	0	4	0	0.28	0.16	0.0	0	1	0	0
6	84.0	48.0	66.0	28.4	61.7	90	36	2	0	0	0	0.32	0.19	0.0	0	1	0	0
7	93.0	58.5	75.7	0.0	335.5	99	53	26	0	0	0	0.16	0.07	0.0	0	0	0	0
8	86.5	55.8	71.2	4.0	184.3	95	46	13	0	0	0	1.56	0.74	0.0	0	4	1	0
9	78.4	46.6	62.6	87.1	15.5	86	37	0	0	0	0	0.76	0.35	0.0	0	3	0	0
10	71.2	39.0	55.0	304.7	0.0	83	18	0	0	4	0	1.09	0.54	0.0	0	4	1	0
11	53.6	25.2	39.4	739.6	0.0	69	9	0	1	25	0	0.73	0.46	3.0	0	2	0	0
12	45.3	17.1	31.1	1013.0	0.0	58	-3	0	2	30	1	0.26	0.15	1.0	0	2	0	0
Summary	73.7	41.5	57.6	2353.0	635.2	99	-3	43	3	63	1	5.16	0.74	4.0	0	17	2	0

Station:**GHCND:USC00298085, SANTA FE 2, NM US - 2004** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature (°F)											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2004 Month	**Mean Max.**	**Mean Min.**	**Mean**	**Heating Degree Days**	**Cooling Degree Days**	**Highest**	**Lowest**	**Number Of Days**				**Total**	**Greatest Observed**	**Snow, Sleet**		**Number Of Days**		
								Max>=90°	Max<=32°	Min<=32°	Min<=0°			Total Fall	Max Depth	>=.10	>=.50	>=1.0
1	45.0	20.1	32.5	1004.0	0.0	55	1	0	2	30	0	0.23	0.17	2.7	2	1	0	0
2	43.2	17.6	30.4	1002.8	0.0	59	-1	0	3	28	1	0.46	0.25	4.8	2	1	0	0
3	61.9	30.2	46.0	583.7	0.0	77	18	0	0	20	0	0.57	0.35	0.0	0	1	0	0
4	61.3	32.5	46.9	538.2	0.0	75	24	0	0	17	0	1.90	0.67	0.0	0	5	2	0
5	78.1	41.4	59.7	163.8	5.6	86	24	0	0	3	0	0.00	0.00	0.0	0	0	0	0
6	85.1	50.0	67.5	24.8	101.3	93	38	7	0	0	0	0.60	0.41	0.0	0	1	0	0
7	86.7	54.0	70.3	7.0	167.9	93	47	10	0	0	0	2.05	1.09	0.0	0	6	1	1
8	81.7	51.3	66.6	18.9	66.8	88	42	0	0	0	0	1.22	0.38	0.0	0	4	0	0
9	77.0	46.6	61.9	124.4	33.7	89	36	0	0	0	0	1.62	1.03	0.0	0	3	1	1
10	63.5	36.1	49.8	452.7	0.0	72	26	0	0	10	0	2.19	0.69	0.0	0	4	2	0
11	49.3	25.2	37.2	830.5	0.0	69	-4	0	2	26	1	1.14	0.84	9.5	8	2	1	0
12	43.3	18.3	30.7	1058.4	0.0	58	-5	0	3	30	1	0.59	0.47	1.6	0	1	0	0
Summary	64.7	35.3	50.0	5809.2	375.3	93	-5	17	10	164	3	12.57	1.09	18.6	8	29	7	2

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MONTHLY CLIMATOLOGICAL SUMMARY

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Asheville, North Carolina 28801

Station:**GHCND:USC00298085, SANTA FE 2, NM US - 2005** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature (°F)											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2005 Month	**Mean Max.**	**Mean Min.**	**Mean**	**Heating Degree Days**	**Cooling Degree Days**	**Highest**	**Lowest**	**Number Of Days** Max>=90°	Max<=32°	Min<=32°	Min<=0°	**Total**	**Greatest Observed**	**Snow, Sleet** Total Fall	Max Depth	**Number Of Days** >=.10	>=.50	>=1.0
1	47.1	25.7	36.3	884.9	0.0	62	15	0	1	27	0	1.93	0.59	4.0	2	5	2	0
2	45.9	25.9	36.0	783.7	0.0	55	10	0	0	22	0	1.79	0.45	5.0	2	8	0	0
3	50.0	24.8	37.6	795.2	0.0	68	2	0	3	28	0	1.94	0.56	24.5	20	4	1	0
4	63.5	33.1	48.4	499.0	0.0	71	16	0	0	10	0	0.88	0.43	0.0	0	2	0	0
5	73.8	41.2	57.2	234.5	16.2	92	27	4	0	2	0	0.45	0.25	0.0	0	3	0	0
6	83.5	49.1	66.4	50.8	92.0	94	38	4	0	0	0	0.47	0.22	0.0	0	2	0	0
7	90.0	54.9	72.5	0.0	217.6	94	46	18	0	0	0	0.47	0.25	0.0	0	2	0	0
8	83.1	53.4	68.2	7.7	110.7	91	44	5	0	0	0	1.62	0.83	0.0	0	3	1	0
9	80.2	48.7	64.4	57.6	43.0	87	38	0	0	0	0	2.69	1.56	0.0	0	5	1	1
10	65.3	36.9	51.1	431.3	0.0	78	25	0	0	8	0	1.36	0.54	0.0	0	4	1	0
11	57.9	24.8	41.4	706.0	0.0	73	9	0	1	24	0	0.22	0.22	0.0	0	1	0	0
12	46.6	18.0	32.2	1013.0	0.0	59	-6	0	1	30	1	0.05	0.05	1.0	0	0	0	0
Summary	65.6	36.4	51.0	5463.7	479.5	94	-6	31	6	151	1	13.87	1.56	34.5	20	39	6	1

Station:**GHCND:USC00298085, SANTA FE 2, NM US - 2006** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature (°F)											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2006 Month	**Mean Max.**	**Mean Min.**	**Mean**	**Heating Degree Days**	**Cooling Degree Days**	**Highest**	**Lowest**	**Number Of Days** Max>=90°	Max<=32°	Min<=32°	Min<=0°	**Total**	**Greatest Observed**	**Snow, Sleet** Total Fall	Max Depth	**Number Of Days** >=.10	>=.50	>=1.0
1	48.2	18.0	33.1	987.8	0.0	58	3	0	0	30	0	0.00	0.00	0.0	0	0	0	0
2	51.8	17.8	34.7	844.7	0.0	70	1	0	1	28	0	0.00	0.00	0.0	0	0	0	0
3	54.9	27.7	41.4	732.6	0.0	67	1	0	1	21	0	0.35	0.24	4.0	3	1	0	0
4	69.1	34.9	52.0	387.7	0.0	80	22	0	0	10	0	0.29	0.27	0.0	0	1	0	0
5	78.8	44.1	61.5	131.6	23.2	90	35	1	0	0	0	0.29	0.10	0.0	0	1	0	0
6	87.1	52.3	69.6	14.4	157.0	96	42	12	0	0	0	0.76	0.26	0.0	0	3	0	0
7	85.1	57.0	71.1	0.5	190.3	94	50	10	0	0	0	3.65	1.28	0.0	0	8	3	1
8	79.2	54.9	67.1	11.7	76.3	88	43	0	0	0	0	4.05	1.04	0.0	0	10	3	1
9	72.1	42.1	57.0	235.4	0.0	80	30	0	0	3	0	1.94	0.62	0.0	0	5	1	0
10	64.9	35.4	50.2	457.7	0.0	80	21	0	0	14	0	1.56	0.72	0.0	0	3	1	0
11	56.8	23.4	40.1	745.9	0.0	73	-8	0	1	30	1	0.24	0.19	3.5	2	1	0	0
12	41.9	17.1	29.5	1098.9	0.0	53	6	0	5	30	0	2.10	0.85	50.0	41	5	2	0
Summary	65.8	35.4	50.6	5648.9	446.8	96	-8	23	8	166	1	15.23	1.28	57.5	41	38	10	2

U.S. Department of Commerce
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Station:**GHCND:USC00298085, SANTA FE 2, NM US - 2007** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature (°F)											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2007 Month	Mean Max.	Mean Min.	Mean	Heating Degree Days	Cooling Degree Days	Highest	Lowest	Number Of Days				Total	Greatest Observed	Snow, Sleet		Number Of Days		
								Max>=90°	Max<=32°	Min<=32°	Min<=0°			Total Fall	Max Depth	>=.10	>=.50	>=1.0
1	37.0	14.7	25.9	1209.2	0.0	49	-4	0	8	30	2	0.54	0.17	10.5	40	3	0	0
2	47.1	19.6	33.3	886.0	0.0	57	-5	0	3	28	2	0.45	0.29	5.5	7	2	0	0
3	59.7	26.6	43.2	652.9	0.0	76	6	0	0	23	0	0.85	0.43	0.0	0	3	0	0
4	63.0	33.1	48.0	490.1	0.0	75	22	0	0	15	0	1.01	0.45	0.0	0	2	0	0
5	72.1	41.2	56.7	257.2	0.0	83	26	0	0	2	0	1.07	0.59	0.0	0	3	1	0
6	84.2	49.8	66.9	43.2	103.1	95	31	8	0	1	0	1.26	0.46	0.0	0	5	0	0
7	87.6	54.1	70.9	0.4	185.0	98	49	13	0	0	0	2.94	0.90	0.0	0	8	2	0
8	87.8	55.2	71.6	0.0	204.7	96	50	13	0	0	0	0.82	0.30	0.0	0	3	0	0
9	80.2	49.6	64.9	43.7	41.6	89	40	0	0	0	0	1.43	0.47	0.0	0	3	0	0
10	70.2	36.5	53.4	346.7	0.0	81	15	0	0	8	0	0.65	0.17	0.0	0	4	0	0
11	57.9	24.8	41.4	706.1	0.0	72	10	0	1	27	0	0.20	0.20	3.5	2	1	0	0
12	40.8	18.3	29.5	1096.6	0.0	62	-9	0	6	27	1	1.74	0.55	7.5	3	4	1	0
Summary	65.6	35.3	50.5	5732.1	534.4	98	-9	34	18	161	5	12.96	0.90	27.0	40	41	4	0

Station:**GHCND:USC00298085, SANTA FE 2, NM US - 2008** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature (°F)											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2008 Month	Mean Max.	Mean Min.	Mean	Heating Degree Days	Cooling Degree Days	Highest	Lowest	Number Of Days				Total	Greatest Observed	Snow, Sleet		Number Of Days		
								Max>=90°	Max<=32°	Min<=32°	Min<=0°			Total Fall	Max Depth	>=.10	>=.50	>=1.0
1	38.1	13.8	26.1	1207.6	0.0	53	-6	0	5	30	1	1.05	0.42	4.5	3	3	0	0
2	47.5	22.3	34.9	871.9	0.0	63	8	0	1	28	0	0.90	0.33	7.0	3	4	0	0
3	56.3	23.0	39.7	782.3	0.0	69	7	0	1	30	0	0.39	0.35	5.5	4	1	0	0
4	64.2	28.4	46.4	558.7	0.0	76	17	0	0	25	0	0.29	0.15	1.5	0	1	0	0
5	72.1	40.1	56.1	286.7	11.7	86	23	0	0	3	0	0.84	0.33	0.0	0	3	0	0
6	86.5	49.3	67.8	33.1	120.2	94	33	11	0	0	0	0.04	0.04	0.0	0	0	0	0
7	84.2	55.0	69.6	4.0	149.9	93	49	4	0	0	0	2.65	0.84	0.0	0	5	2	0
8	84.2	54.5	69.4	10.8	148.9	93	45	5	0	0	0	3.29	1.53	0.0	0	6	1	1
9	77.5	46.8	62.1	87.1	3.2	86	40	0	0	0	0	0.39	0.18	0.0	0	2	0	0
10	68.4	35.4	51.8	379.6	0.0	82	18	0	0	8	0	2.23	1.26	0.0	0	4	2	1
11	55.9	24.8	40.5	735.5	0.0	73	14	0	0	26	0	0.63	0.51	2.0	1	2	1	0
12	42.1	20.1	31.1	1049.8	0.0	58	-2	0	3	31	1	2.30	0.81	22.8	9	6	1	0
Summary	64.8	34.5	49.6	6007.1	433.9	94	-6	20	10	181	2	15.00	1.53	43.3	9	37	7	2

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

MONTHLY CLIMATOLOGICAL SUMMARY

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station:**GHCND:USC00298085, SANTA FE 2, NM US - 2009** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature (°F)											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2009 Month	Mean Max.	Mean Min.	Mean	Heating Degree Days	Cooling Degree Days	Highest	Lowest	Number Of Days				Total	Greatest Observed	Snow, Sleet		Number Of Days		
								Max>=90°	Max<=32°	Min<=32°	Min<=0°			Total Fall	Max Depth	>=.10	>=.50	>=1.0
1	46.2	19.9	33.1	986.9	0.0	56	12	0	0	31	0	0.12	0.10	2.8	2	1	0	0
2	52.9	21.7	37.4	773.1	0.0	67	11	0	0	27	0	0.14	0.13	0.2	0	1	0	0
3	57.4	27.0	42.1	707.4	0.0	71	14	0	1	25	0	0.60	0.34	5.5	0	2	0	0
4	63.1	31.1	47.1	534.8	0.0	78	13	0	0	19	0	0.60	0.33	4.0	1	2	0	0
5	75.9	44.2	60.1	155.2	4.3	86	37	0	0	0	0	0.63	0.20	0.0	0	2	0	0
7	87.1	55.6	71.2	3.4	201.1	96	47	14	0	0	0	2.28	0.94	0.0	0	5	1	0
8	85.3	52.3	68.9	14.2	134.6	93	45	6	0	0	0	1.02	0.25	0.0	0	4	0	0
9	75.6	44.2	59.9	159.7	9.4	86	29	0	0	2	0	2.07	0.67	0.0	0	5	2	0
10	62.6	33.8	48.2	519.7	0.0	75	13	0	0	15	0	1.77	0.54	2.3	2	5	1	0
11	56.8	24.4	40.6	729.5	0.0	71	7	0	0	24	0	0.34	0.18	1.0	1	2	0	0
12	37.2	13.8	25.5	1222.2	0.0	51	0	0	8	31	1	0.60	0.35	8.2	4	3	0	0
Summary	63.6	33.5	48.6	5806.1	349.4	96	0	20	9	174	1	10.17	0.94	24.0	4	32	4	0

Station:**GHCND:USC00298085, SANTA FE 2, NM US - 2010** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature (°F)											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2010 Month	Mean Max.	Mean Min.	Mean	Heating Degree Days	Cooling Degree Days	Highest	Lowest	Number Of Days				Total	Greatest Observed	Snow, Sleet		Number Of Days		
								Max>=90°	Max<=32°	Min<=32°	Min<=0°			Total Fall	Max Depth	>=.10	>=.50	>=1.0
1	41.0	15.3	28.0	1142.8	0.0	52	1	0	4	31	0	1.42	0.73	13.8	6	4	1	0
2	40.8	20.3	30.6	960.3	0.0	51	5	0	2	28	0	1.13	0.49	11.5	6	4	0	0
3	52.9	24.6	38.7	760.5	0.0	75	14	0	0	28	0	1.99	0.44	16.0	6	8	0	0
4	63.7	32.4	48.0	507.6	0.0	73	16	0	0	16	0	0.26	0.15	1.0	0	1	0	0
5	72.7	39.6	56.1	286.4	13.9	84	19	0	0	8	0	0.16	0.08	0.0	0	0	0	0
6	85.6	51.4	68.5	18.7	125.6	95	42	8	0	0	0	1.59	0.53	0.0	0	4	1	0
7	83.7	56.3	70.0	5.2	160.7	95	47	7	0	0	0	4.29	1.20	0.0	0	7	4	1
8	83.5	52.9	68.2	7.2	108.9	89	42	0	0	0	0	1.52	0.68	0.0	0	4	1	0
9	82.0	47.5	64.8	40.3	34.6	87	39	0	0	0	0	1.31	1.09	0.0	0	2	1	1
10	67.5	37.4	52.5	386.1	0.0	82	17	0	0	6	0	0.49	0.16	0.0	0	3	0	0
11	51.6	21.6	36.5	852.1	0.0	68	2	0	0	28	0	0.02	0.01	0.0	0	0	0	0
12	46.8	21.4	34.2	956.5	0.0	57	1	0	3	27	0	1.11	0.55	12.0	0	4	1	0
Summary	64.3	35.1	49.7	5923.7	443.7	95	1	15	9	172	0	15.29	1.20	54.3	6	41	9	2

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

MONTHLY CLIMATOLOGICAL SUMMARY

National Climatic Data Center
Federal Building
151 Patton Avenue
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Station:**GHCND:USC00298085, SANTA FE 2, NM US - 2011** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2011 Month	Mean Max.	Mean Min.	Mean	Heating Degree Days	Cooling Degree Days	Highest	Lowest	Number Of Max>=90°	Max<=32°	Min<=32°	Min<=0°	Total	Greatest Observed	Snow, Sleet Total Fall	Max Depth	Number Of Days >=.10	>=.50	>=1.0
1	42.4	14.4	28.4	1133.3	0.0	57	-4	0	4	31	2	0.09	0.09			0	0	0
2	44.2	13.5	28.8	1010.5	0.0	63	-24	0	5	27	5	0.13	0.05	4.5		0	0	0
3	60.8	29.1	45.0	619.9	0.0	71	13	0	0	23	0	0.11	0.10	1.0		1	0	0
4	65.8	34.2	50.0	446.8	0.0	77	21	0	0	11	0	0.29	0.22	0.0		1	0	0
5	71.8	36.5	54.1	339.3	3.6	87	20	0	0	10	0	0.08	0.08			0	0	0
6	87.4	50.7	69.1	12.8	137.2	95	41	7	0	0	0	0.08	0.08			0	0	0
7	88.5	58.6	73.6	0.0	269.5	94	52	15	0	0	0	1.43	0.68	0.0		4	1	0
8	88.0	56.5	72.1	0.0	225.5	94	49	10	0	0	0	3.89	1.83	0.0		4	2	2
9	76.6	46.2	61.3	128.3	21.2	89	38	0	0	0	0	0.56	0.20			3	0	0
10	65.8	35.1	50.4	450.4	0.0	78	24	0	0	11	0	1.94	0.87			5	1	0
11	52.2	25.3	38.8	785.7	0.0	65	14	0	0	27	0	0.52	0.28	0.0		2	0	0
12	38.1	14.2	26.1	1202.6	0.0	54	-2	0	6	31	1	1.17	0.32	6.6		5	0	0
Summary	65.1	34.5	49.8	6129.6	657.0	95	-24	32	15	171	8	10.29	1.83	12.1		25	4	2

Station:**GHCND:USC00298085, SANTA FE 2, NM US -2012** Elev. 6755 ft. above sea level Lat. 35.619°, Lon. -105.975°

Date	Temperature											Precipitation (in.)						
Elem->	MMXT	MMNT	MNTM	HTDD	CLDD	EMXT	EMNT	DT90	DX32	DT32	DT00	TPCP	EMXP	TSNW	MXSD	DP01	DP05	DP10
2012 Month	Mean Max.	Mean Min.	Mean	Heating Degree Days	Cooling Degree Days	Highest	Lowest	Number Of Max>=90°	Max<=32°	Min<=32°	Min<=0°	Total	Greatest Observed	Snow, Sleet Total Fall	Max Depth	Number Of Days >=.10	>=.50	>=1.0
1	46.4	20.1	33.3	983.0	0.0	55	7	0	0	31	0	0.44	0.40	2.6	2	1	0	0
2	46.4	20.7	33.6	875.9	0.0	58	11	0	0	29	0	0.24	0.08	9.5		0	0	0
3	60.3	26.1	43.2	675.0	0.0	77	7	0	0	26	0	0.17	0.13	2.5		1	0	0
Summary	51.0	22.3	36.7	2533.9	0.0	77	7	0	0	86	0	0.85	0.40	14.6	2	2	0	0

APPENDIX C: INTERVIEWS

C-1 INTERVIEWEES

Name	Title/Role	Organization
Isaac Pino	Current Director of the City of Santa Fe Department of Public Works and the Community Services Department. Former President and General Manager of Rancho Viejo, LLC	City of Santa Fe
Rexford Ross	General Manager of Rancho Viejo	Univest Rancho Viejo, LLC in its entirety and also representing La Entrada
David Rasinski	RV North HOA Manager*	HOAMCO
John Tubbs	RV South HOA Manager*	HOAMCO
Patrick Thomas	Qualifying Broker / Sales Manager	Univest Rancho Viejo, LLC (Formerly with SunCor Rancho Viejo, LLC)
Ray Berg	High Desert Community Association Landscape Committee	Homeowner, Landscape Committee Director
Esai Arvico, Tom Ogee	Landscape Contractor - Maintenance Site Supervisor for Rancho Viejo Windmill Ridge	Heads Up Landscaping
Susan Buchroeder	Homeowner RV South, Community Association Interim Landscape Committee Director**	Homeowner
Bruno Keller	Homeowner in RV North	Homeowner, Landscape Committee President**
Susy Moesch	Homeowner RV North Windmill Ridge	Homeowner, Community Board Member
Anne Lefton	Homeowner in RV South/Windmill Ridge	Homeowner

* HOA Managers are responsible for common areas, parks and the areas between the street and the sidewalk in front of the homes; and managing the landscape contractors (mostly irrigation), act as contact for the village's landscape committees (landscape repair and management) and addresses water related issues. .

** The Landscape Committee members are mainly involved with the beautification and enhancement of the landscape in their specific community within Rancho Viejo.

C-2 INTERVIEW QUESTIONAIRES

Rancho Viejo de Santa Fe HOA - Example Interview Questions for the Representatives of the HOA's (RV North, RV South, La Entrada), Developers Representatives, Marketing Team and Homeowners.

The questions addressed in this study mainly focus on determining the major factors affecting the success of a sustainably designed surface water management system in a master planned residential community; how does site design help create water resource for residential landscapes; what are the challenges and successes of water catchment and re-use systems at Rancho Viejo to successfully supplying a community with enough water to sustain an attractive, low water-use and native landscape; and what other new and progressive strategies are being explored to improve the success of surface water management in residential communities in arid environments.

All interviewees were provided with the definition of Sustainable Practices: "Sustainable practices refer to the goals set by RV to 1) reduce development costs by reducing the impact on natural resources such as water and soils by utilizing low water use and native plants that require less water and maintenance and through limiting disturbance of open space areas to reduce costs for erosion damage and restoring damaged native landscapes, 2) capture and reuse of storm water runoff on site and work towards returning stormwater to the aquifer to receive water credits, improve water quality and reduce amount of stormwater infrastructure needed, 3) establish a process to strategically improve the surface water management (SWM) system in each new phase of development. 4) Improve the site's environment and wildlife and plant habitats (through preservation and restoration of native landscape) and 5) increase sales performance by creating a community that appeals to those homebuyers who want to live in an interesting community set in a stable prairie environment."

The following are examples of the interview questions posed to the representatives of the community interviewed in 2012.

A. Developers and HOA Managers

1. Please briefly describe your role in the landscape management and oversight of the community and any of the communities sustainable* design components such as the water-catchment systems (i.e. rain barrels, cisterns), low water-use and native landscape plantings, irrigation system, drainageway designs, erosion control, etc.

Guidelines and Covenants:

2. Are you familiar with the Rancho Viejo Surface Water Management Manual and guideline for sustainable practices?
3. Are there other guidelines for homeowners or the community that is provided upon moving to the Rancho Viejo South community (i.e. Landscape Covenant, HOA Maintenance Covenant, RV Surface Water Management Manual)? Are the same covenants used for all the communities developed at Rancho Viejo?
4. How are the requirements of the Covenants related to plantings and surface water management, monitored on site to ensure they are properly being implemented?

Sustainable Design Systems:

5. In general, do you feel that the sustainable components such as the water catchment systems, native and low water use landscape plantings, have been successful?
   Please describe any challenges, if any, with the catchment systems and reclaimed water system used to irrigate the landscape.
6. Were there any other water saving techniques used in the residential homes? (e.g. Gray water, plumbing fixture and fitting efficiency methods). Were they successful in reducing potable water use?
   Is there data that can be found on monthly or annual potable water consumption rates?
7. Was a target water efficiency budgets set for your community?
   If yes, what was the target amount?
   Do you know if this target is achieved annually?
8. Is there a maintenance program implemented by the HOA to ensure the downspouts, cisterns or rain barrel catchment systems and underground

infiltration systems are regularly maintained to ensure they function properly?

9. Have there been other challenges for the homeowner's and community in installing and maintaining these systems?
10. How do you feel the costs for maintaining the more sustainable/green design systems compares to a more traditional or non-sustainable community?
11. Is there any data that has been collected that indicates that there has been a savings or increase in water-use for the individual homeowners and the community, by using sustainable design elements, such as the cisterns and rain barrels systems, or other water reuse systems in place?

Native and Low Water Use Plantings:

12. Is the use of the low water use and native plantings a requirement of the homeowners' Covenants? Are there any restrictions on what the homeowner's can plant?
13. Does your community continue to use a primarily native and low water-use plantings for any new plantings on site?
14. Have the low water use landscape plantings in the open space areas and residential yards helped to reduce the amount of irrigation needed? If yes, is there any data that can be shared on that?
15. Have the low water-use and native plantings posed any challenges? Are there any areas that appear to be degraded?
16. Alternative Lawn Materials: Did many homeowners choose not to have lawn areas and instead installed pavers, gravel/crushed stone, or other mulch material options?
    If no, why do you think this was not a popular choice?
    If yes, were there any issues with the gravel mulch appearance, maintenance, etc.?
17. Have there been any challenges with the landscape maintenance by the community, homeowners and contracted landscape maintenance companies? If yes, please describe the issues and if they have been resolved to date.

Marketing:

18. How much information about the community's philosophy on water conservation and commitment to a sustainable community is shared with potential homebuyers?
19. Has the more sustainable approach to the design of the community attracted more buyers? If not, do you know why it may not have been successful?

Additional Questions for the Developers / Owner's Representatives:

20. Have the economic pressures on the building industry influenced the efforts towards site design innovation at Rancho Viejo? If so, please describe.
21. What have been the specific challenges to incorporating the sustainable components such as the water catchment systems and drainageways?
22. What are the government regulatory officials and agencies reviewing the project for compliance?
23. Who established the targeted water-use and where is it documented that this is a target for the community?
24. What have been the challenges with the overall site/landscape design?

B. Homeowners

Low Water-use Landscaping:

1. Are you aware of any requirements or guidelines from Rancho Viejo on the types of plants that may be installed in the front, side or back yards?
2. Was there any difficulty in finding the native plants or in their rate of survival?
3. Does your home have any grass (native or non-native) lawn areas (i.e. Blue grama, Buffalo Grass, Bluegrass Mix, etc.).
   If yes, what type is it and have there been any issues with the care of the lawn? If no, what materials are installed in your yard, (i.e. decomposed granite, native earth, gravel or other stone paving, or other mulch)? Are they easy to maintain?
4. Please provide general feedback on:
   - What do you think of the aesthetics of the paving material?
   - the ease of maintenance of a lower water-use landscape
   - the aesthetics of the native and low water-use landscape
   - what has worked well and what has been a challenge in maintaining your landscape (i.e. drainage, drought, soil conditions, difficulty in obtaining native plants, aesthetics concerns, etc.).

Irrigation Systems:

5. What type of irrigation system (if any), do you have for your home landscape?
   - Does the system use potable water or reuse/treated water?
   - Is your system on a timer and/or how often do you typically water in a month?
   - If your water is supplied through the RV treated water system, is there enough water available to you to maintain your landscape? If not, how much are you able to use and does this cause any challenges to maintaining healthy plantings?

Water Reuse or Catchment Systems:

6. What water reuse or catchment systems, if any, do they have in place for use in their landscapes? (i.e. rain barrels, cisterns, water gardens, roof catchment systems etc.)
   - Are there swales in your yard for handling water as well? How well are they working?
   - How easy is it to maintain your water harvesting system systems?
   - Do you feel there is a need for any training for its use or do you have someone else maintain it?

Open Space and Public Spaces:

7. What is their overall impression of the aesthetics of a native landscape, streetscape, trails and open space or transitional landscaping?
   - Are there any areas that you feel should be maintained differently by the community associations?

Water Conserving Landscape Design:

8. In general, do you feel that the sustainable components such as the water catchment systems, native and low water use landscape plantings, have been successful?
   - Do you feel the low water use landscape plantings in the open space areas and residential yards helped to reduce the amount of irrigation water needed?

Educational Tools:

9. Are they familiar with or have you seen any pamphlets on the Landscape Vision, Rain Water Harvesting, and Water Conservation related specifically at Rancho Viejo?
10. Are there any interpretive signs installed along the trails or used elsewhere around the site?
11. Are there any opportunities provided by your community or Rancho Viejo as a whole to learn more about how to maintain their water catchment or native landscapes? If not, what would you find valuable to learn more about related to your home landscape or the community landscape and water conservation strategies?

C. Landscape Contractor

Landscape and Irrigation Maintenance:

1. Please generally describe the scope of your work at Rancho Viejo.
2. In general, what have been the challenges with maintaining a community the size and complexity of Rancho Viejo?
3. Are there areas of the community that are doing very well or better than others? If so, why do you think that is?
4. Are there some areas that are doing more poorly? If so, why do you think that is? Do you have recommendations on how they can be improved in the future or what we could have done differently with the design to make them more successful?
5. Are there specific challenges with managing the low-water use and native landscape plantings within the development? (i.e. sources of plant materials, landscape design elements, special plant maintenance requirements, wind, soils, water shortage, etc.).
6. What plants seem to be the easiest to maintain?
7. What plants seem to create the most challenges for maintenance or management?
8. Are you responsible for any of the restoration or management of the natural open space surrounding RV? If so, what are the challenges and successes?
9. How often does your company or on-site crews interact with homeowners? Are you involved in any education/training programs at Rancho Viejo to help homeowners understand how to maintain their own plantings or to understand why the open spaces areas are managed in a certain way?
10. Is there any new technology, plant materials, or approaches to managing a low water use community and green street design such as Rancho Viejo, which you would recommend they consider implementing?

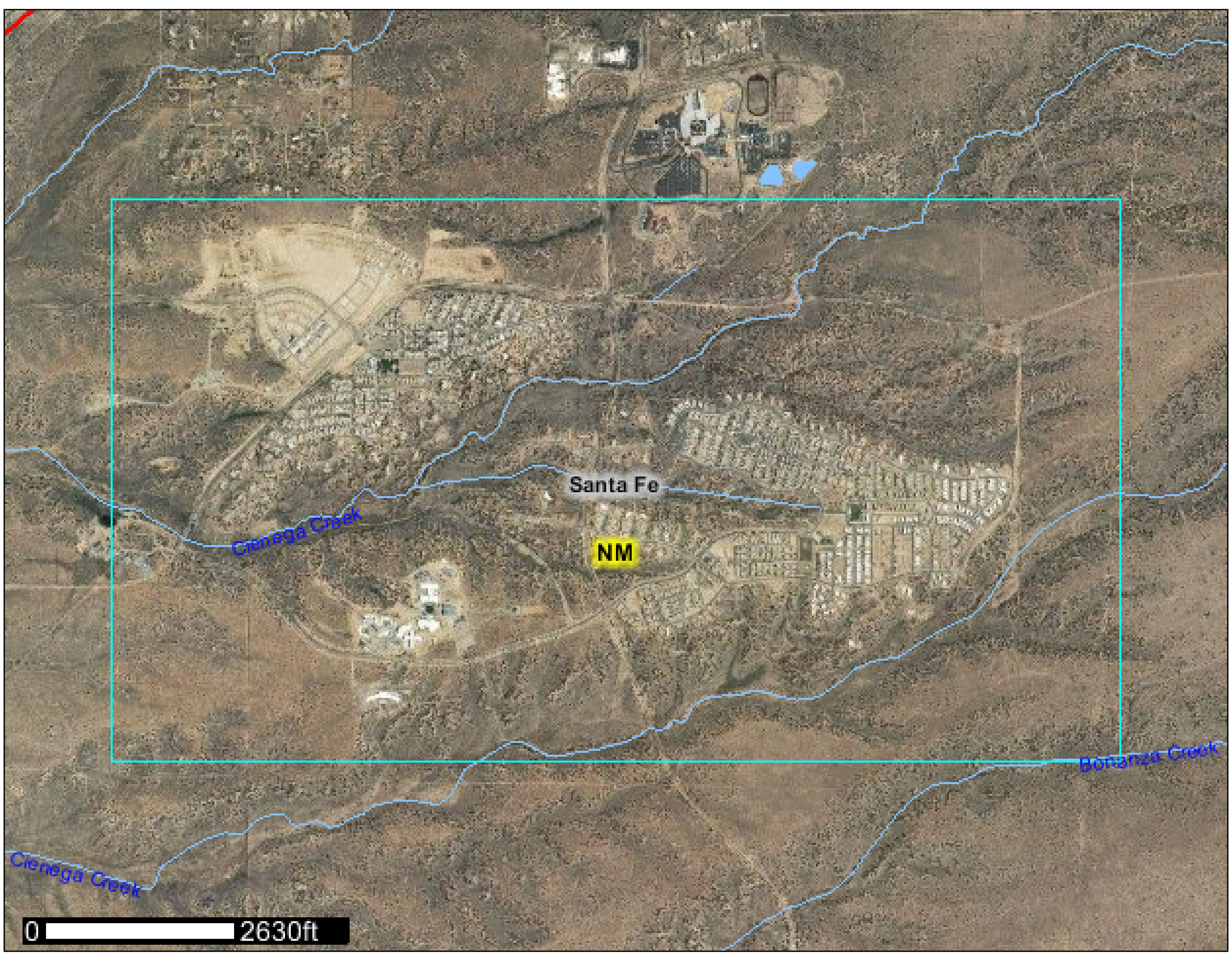
APPENDIX E: NRCS CUSTOM SOIL RESOURCE REPORT SANTA FE COUNTY AND ENVIRONS

United States Department of Agriculture

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Santa Fe Area, New Mexico, Santa Fe County and Part of Rio Arriba County; and Santa Fe County Area, New Mexico



July 27, 2012

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

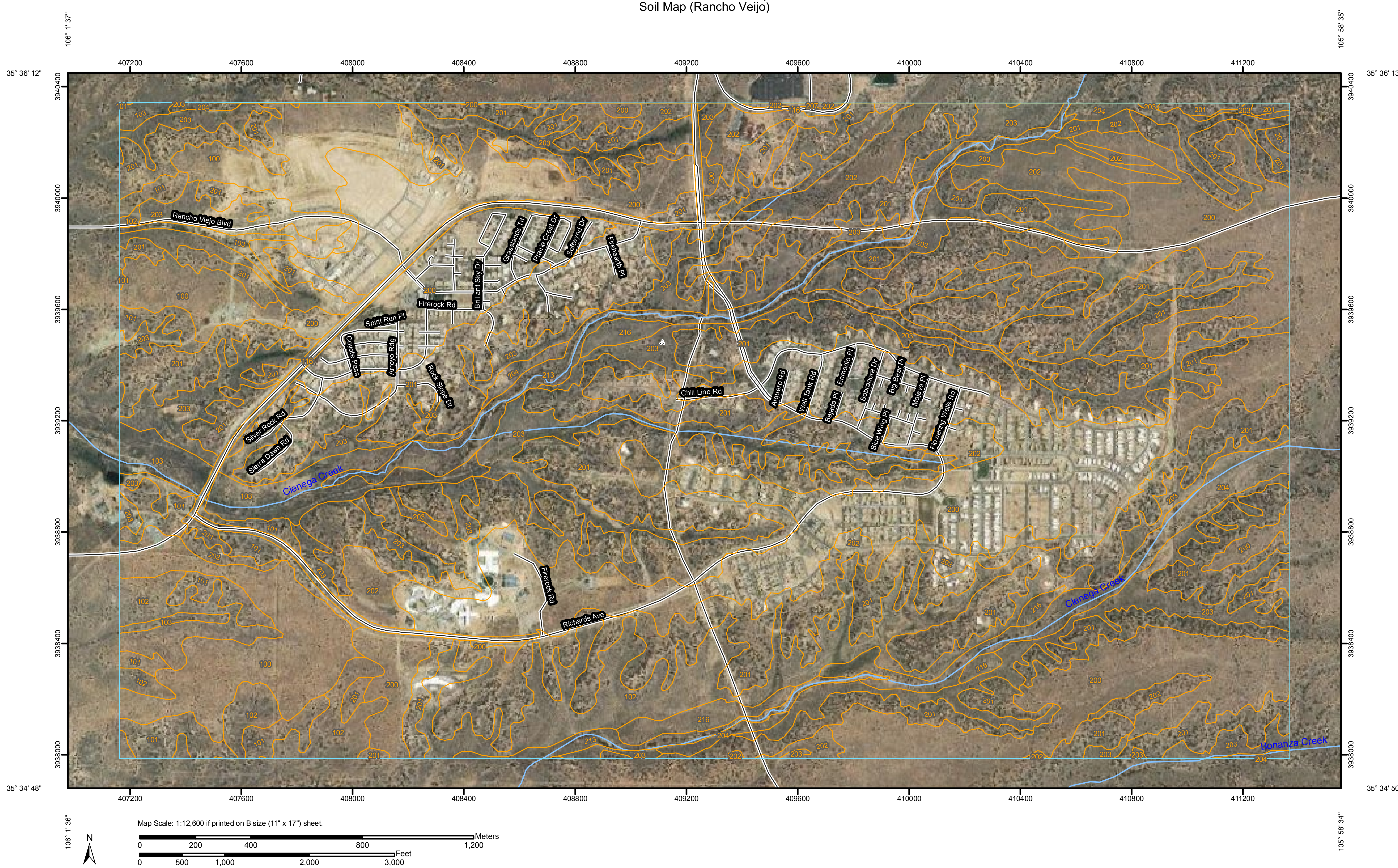
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map (Rancho Veijo)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

- Gully
- Short Steep Slope
- Other

Political Features

- Cities

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:12,600 if printed on B size (11" × 17") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Santa Fe Area, New Mexico, Santa Fe County and Part of Rio Arriba County
Survey Area Data: Not available

Soil Survey Area: Santa Fe County Area, New Mexico
Survey Area Data: Version 6, May 13, 2009

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend (Rancho Veijo)

Santa Fe Area, New Mexico, Santa Fe County and Part of Rio Arriba County (NM686)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
No soil data available for this soil survey area.			
Subtotals for Soil Survey Area		**—**	**—**
Totals for Area of Interest		**2,449.5**	**100.0%**

Santa Fe County Area, New Mexico (NM687)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
100	Panky loam, 1 to 4 percent slopes	137.1	5.6%
101	Zozobra-Jaconita complex, 5 to 25 percent slopes	56.2	2.3%
102	Khapo sandy loam, 3 to 8 percent slopes	148.3	6.1%
103	Zepol silt loam, 0 to 2 percent slopes, flooded	50.9	2.1%
116	Arents-Urban land-Orthents complex, 1 to 60 percent slopes	29.6	1.2%
200	Predawn loam, 1 to 4 percent slopes	587.0	24.0%
201	Tanoan-Encantado complex, 5 to 25 percent slopes	809.9	33.1%
202	Alire loam, 2 to 6 percent slopes	116.0	4.7%
203	Buckhorse-Altazano complex, 2 to 8 percent slopes, flooded	378.4	15.4%
204	Altazano loamy sand, 0 to 2 percent slopes, flooded	56.6	2.3%
207	Urban land	0.1	0.0%
213	Levante-Riverwash complex, 1 to 3 percent slopes, flooded	59.2	2.4%
216	Dondiego loam, 1 to 3 percent slopes	20.4	0.8%
Subtotals for Soil Survey Area		**2,449.5**	**100.0%**
Totals for Area of Interest		**2,449.5**	**100.0%**

Map Unit Descriptions (Rancho Veijo)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Santa Fe County Area, New Mexico

100—Panky loam, 1 to 4 percent slopes

Map Unit Setting

Elevation: 5,900 to 6,700 feet
Mean annual precipitation: 10 to 13 inches
Mean annual air temperature: 50 to 52 degrees F
Frost-free period: 150 to 170 days

Map Unit Composition

Panky and similar soils: 90 percent

Description of Panky

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Summit
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granite, gneiss, schist, loess, and volcanic ash

Properties and qualities

Slope: 1 to 4 percent
Depth to restrictive feature: 1 to 5 inches to abrupt textural change
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 45 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Very slightly saline to slightly saline (4.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 13.0
Available water capacity: Very low (about 0.5 inches)

Interpretive groups

Land capability (nonirrigated): 6c
Ecological site: Loamy (R035XA112NM)

Typical profile

0 to 3 inches: Loam
3 to 8 inches: Clay loam
8 to 11 inches: Clay loam
11 to 17 inches: Loam
17 to 36 inches: Loam
36 to 53 inches: Loam
53 to 66 inches: Loam
66 to 88 inches: Loam
88 to 115 inches: Loam

101—Zozobra-Jaconita complex, 5 to 25 percent slopes

Map Unit Setting

Elevation: 5,400 to 6,900 feet
Mean annual precipitation: 10 to 13 inches
Mean annual air temperature: 50 to 52 degrees F
Frost-free period: 150 to 170 days

Map Unit Composition

Zozobra and similar soils: 45 percent
Jaconita and similar soils: 40 percent

Description of Zozobra

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Shoulder
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Alluvium derived from granite, gneiss, schist, and loess

Properties and qualities

Slope: 5 to 12 percent
Depth to restrictive feature: 20 to 35 inches to strongly contrasting textural stratification
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 50 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water capacity: Low (about 3.1 inches)

Interpretive groups

Land capability (nonirrigated): 6c
Ecological site: Gravelly (R035XG114NM)

Typical profile

0 to 3 inches: Gravelly sandy loam
3 to 7 inches: Loam
7 to 15 inches: Loam
15 to 24 inches: Sandy loam
24 to 28 inches: Gravelly loamy sand
28 to 35 inches: Gravelly loamy coarse sand
35 to 46 inches: Loamy coarse sand
46 to 54 inches: Gravelly coarse sand
54 to 67 inches: Very gravelly loamy coarse sand
67 to 88 inches: Gravelly coarse sand

Description of Jaconita

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granite, gneiss, and schist

Properties and qualities

Slope: 10 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Very low (about 1.7 inches)

Interpretive groups

Land capability (nonirrigated): 6e
Ecological site: Gravelly (R035XG114NM)

Typical profile

0 to 2 inches: Very gravelly coarse sandy loam
2 to 6 inches: Very gravelly coarse sandy loam
6 to 14 inches: Extremely gravelly loamy coarse sand
14 to 45 inches: Very gravelly coarse sand
45 to 56 inches: Very gravelly loamy coarse sand
56 to 78 inches: Gravelly coarse sand
78 to 92 inches: Very gravelly coarse sand
92 to 104 inches: Loamy fine sand
104 to 118 inches: Fine sand

102—Khapo sandy loam, 3 to 8 percent slopes

Map Unit Setting

Elevation: 5,400 to 6,700 feet
Mean annual precipitation: 10 to 13 inches
Mean annual air temperature: 50 to 52 degrees F
Frost-free period: 150 to 170 days

Map Unit Composition

Khapo and similar soils: 85 percent

Description of Khapo

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Toeslope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Slope alluvium derived from granite, gneiss, schist, loess, and volcanic ash; slope alluvium derived from granite, gneiss, schist, loess, and volcanic ash

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 13.0
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability (nonirrigated): 6c
Ecological site: Loamy (R035XA112NM)

Typical profile

0 to 2 inches: Sandy loam
2 to 5 inches: Sandy loam
5 to 11 inches: Sandy clay loam
11 to 29 inches: Fine sandy loam
29 to 43 inches: Fine sandy loam
43 to 72 inches: Fine sandy loam
72 to 89 inches: Sandy loam
89 to 120 inches: Loam

103—Zepol silt loam, 0 to 2 percent slopes, flooded

Map Unit Setting

Elevation: 5,800 to 7,000 feet
Mean annual precipitation: 10 to 13 inches
Mean annual air temperature: 50 to 52 degrees F
Frost-free period: 150 to 170 days

Map Unit Composition

Zepol and similar soils: 85 percent

Description of Zepol

Setting

Landform: Flood plains on eroded fan remnants
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from loess, volcanic ash, pumice, basalt lapilli, granite, and schist

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water capacity: High (about 10.8 inches)

Interpretive groups

Land capability (nonirrigated): 6c
Ecological site: Loamy (R035XA112NM)

Typical profile

0 to 3 inches: Silt loam
3 to 6 inches: Silt loam
6 to 12 inches: Silt loam
12 to 22 inches: Silty clay loam
22 to 27 inches: Silt loam
27 to 35 inches: Silt loam
35 to 46 inches: Silt loam
46 to 75 inches: Silt loam
75 to 89 inches: Silt loam
89 to 114 inches: Loam

116—Arents-Urban land-Orthents complex, 1 to 60 percent slopes

Map Unit Setting

Elevation: 5,400 to 7,600 feet
Mean annual precipitation: 9 to 15 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 140 to 170 days

Map Unit Composition

Arents and similar soils: 50 percent
Urban land: 25 percent
Orthents and similar soils: 20 percent

Description of Arents

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope, toeslope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Roadfill material derived from granite, gneiss, schist, sandstone, or siltstone

Properties and qualities

Slope: 1 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 13.0
Available water capacity: Moderate (about 6.2 inches)

Interpretive groups

Land capability (nonirrigated): 8

Typical profile

0 to 4 inches: Gravelly loam
4 to 26 inches: Gravelly loam
26 to 46 inches: Gravelly loam
46 to 63 inches: Loam
63 to 90 inches: Loam

Description of Urban Land

Setting

Landform: Eroded fan remnants
Down-slope shape: Linear
Across-slope shape: Linear

Properties and qualities

Slope: 1 to 15 percent
Depth to restrictive feature: 0 inches to strongly contrasting textural stratification

Interpretive groups

Land capability (nonirrigated): 8

Description of Orthents

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Toeslope, backslope
Down-slope shape: Linear
Across-slope shape: Concave

Parent material: Roadcut material derived from granite, gneiss, schist, loess, sandstone, or siltstone

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Very high (19.98 to 99.62 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 3 percent
Maximum salinity: Nonsaline (0.0 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water capacity: Very low (about 1.6 inches)

Interpretive groups

Land capability (nonirrigated): 8e

Typical profile

0 to 7 inches: Very gravelly coarse sand
7 to 15 inches: Very gravelly coarse sand
15 to 80 inches: Stratified gravelly coarse sand to very gravelly coarse sand

200—Predawn loam, 1 to 4 percent slopes

Map Unit Setting

Elevation: 6,100 to 7,300 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Predawn and similar soils: 90 percent

Description of Predawn

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Summit
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granite, gneiss, schist, loess, and volcanic ash

Properties and qualities

Slope: 1 to 4 percent
Depth to restrictive feature: 2 to 6 inches to abrupt textural change
Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 50 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 13.0
Available water capacity: Very low (about 0.6 inches)

Interpretive groups

Land capability (nonirrigated): 4c
Ecological site: Loamy (R035XA112NM)

Typical profile

0 to 2 inches: Loam
2 to 4 inches: Loam
4 to 9 inches: Clay loam
9 to 14 inches: Clay loam
14 to 19 inches: Clay loam
19 to 27 inches: Loam
27 to 36 inches: Loam
36 to 52 inches: Gravelly sandy loam
52 to 77 inches: Very gravelly coarse sand
77 to 86 inches: Gravelly loamy sand

201—Tanoan-Encantado complex, 5 to 25 percent slopes

Map Unit Setting

Elevation: 5,500 to 7,500 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Tanoan and similar soils: 45 percent
Encantado and similar soils: 40 percent

Description of Tanoan

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Shoulder
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Alluvium derived from granite, gneiss, schist, and loess over residuum weathered from basaltic tuff or granitic sandstone

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water capacity: Low (about 5.1 inches)

Interpretive groups

Land capability (nonirrigated): 4c
Ecological site: Juniperus monosperma-Pinus edulis/Fallugia paradoxa/Bouteloua hirsuta-Bouteloua gracilis (F036XA136NM)

Typical profile

0 to 3 inches: Gravelly sandy loam
3 to 7 inches: Loam
7 to 24 inches: Loam
24 to 32 inches: Sandy loam
32 to 57 inches: Loam
57 to 70 inches: Gravelly loamy coarse sand
70 to 84 inches: Gravelly coarse sandy loam

Description of Encantado

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and slope alluvium derived from granite, gneiss, and schist over residuum weathered from granitic fanglomerate and sandstone

Properties and qualities

Slope: 10 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water capacity: Very low (about 2.5 inches)

Interpretive groups

Land capability (nonirrigated): 4s
Ecological site: Juniperus monosperma-Pinus edulis/Fallugia paradoxa/Bouteloua hirsuta-Bouteloua gracilis (F036XA136NM)

Typical profile

0 to 3 inches: Very gravelly sandy loam
3 to 9 inches: Very gravelly loam
9 to 22 inches: Very gravelly coarse sandy loam
22 to 33 inches: Gravelly loamy coarse sand

33 to 45 inches: Very gravelly loamy coarse sand
45 to 54 inches: Very gravelly loamy coarse sand
54 to 63 inches: Gravelly loamy sand
63 to 85 inches: Very gravelly loamy sand

202—Alire loam, 2 to 6 percent slopes

Map Unit Setting

Elevation: 6,100 to 7,400 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Alire and similar soils: 90 percent

Description of Alire

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Summit
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived granite, gneiss, schist, loess, and volcanic ash

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 13.0
Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability (nonirrigated): 4c
Ecological site: Loamy (R035XA112NM)

Typical profile

0 to 2 inches: Loam
2 to 8 inches: Clay loam
8 to 15 inches: Clay loam
15 to 28 inches: Clay loam
28 to 45 inches: Loam
45 to 57 inches: Gravelly loam

57 to 71 inches: Gravelly sandy loam
71 to 105 inches: Gravelly sandy loam

203—Buckhorse-Altazano complex, 2 to 8 percent slopes, flooded

Map Unit Setting

Elevation: 5,700 to 7,500 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Buckhorse and similar soils: 55 percent
Altazano and similar soils: 35 percent

Description of Buckhorse

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Toeslope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from granite, gneiss, schist, granitic sandstone, fanglomerate, and mudstone

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water capacity: Moderate (about 6.3 inches)

Interpretive groups

Land capability (nonirrigated): 4c
Ecological site: Loamy (R035XA112NM)

Typical profile

0 to 4 inches: Coarse sandy loam
4 to 11 inches: Coarse sandy loam
11 to 22 inches: Loam
22 to 37 inches: Loam
37 to 49 inches: Fine sandy loam
49 to 61 inches: Sandy loam
61 to 83 inches: Gravelly coarse sand

Description of Altazano

Setting

Landform: Inset fans on eroded fan remnants
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Slope alluvium derived from granite, gneiss, schist, granitic sandstone, fanglomerate, and mudstone

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water capacity: Low (about 5.7 inches)

Interpretive groups

Land capability (nonirrigated): 4w
Ecological site: Gravelly (R035XG114NM)

Typical profile

0 to 2 inches: Gravelly sandy loam
2 to 8 inches: Gravelly coarse sandy loam
8 to 19 inches: Very gravelly loamy coarse sand
19 to 29 inches: Gravelly sandy loam
29 to 46 inches: Loam
46 to 65 inches: Loam
65 to 74 inches: Gravelly coarse sandy loam
74 to 90 inches: Gravelly loamy coarse sand

204—Altazano loamy sand, 0 to 2 percent slopes, flooded

Map Unit Setting

Elevation: 6,100 to 7,400 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Altazano and similar soils: 85 percent

Description of Altazano

Setting

Landform: Flood plains on valley floors
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granite, gneiss, schist, granitic sandstone, fanglomerate, and mudstone

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: 22 to 30 inches to abrupt textural change; 22 to 30 inches to strongly contrasting textural stratification
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline (0.0 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Very low (about 2.2 inches)

Interpretive groups

Land capability (nonirrigated): 4c
Ecological site: Gravelly (R035XG114NM)

Typical profile

0 to 3 inches: Loamy sand
3 to 8 inches: Fine sandy loam
8 to 12 inches: Loamy sand
12 to 18 inches: Stratified sandy loam to loam
18 to 26 inches: Gravelly loamy coarse sand
26 to 29 inches: Loam
29 to 36 inches: Loam
36 to 58 inches: Loam
58 to 76 inches: Gravelly coarse sandy loam
76 to 92 inches: Gravelly coarse sand

207—Urban land

Map Unit Setting

Elevation: 5,500 to 7,400 feet
Mean annual precipitation: 9 to 15 inches
Mean annual air temperature: 47 to 52 degrees F
Frost-free period: 140 to 170 days

Map Unit Composition

Urban land: 85 percent

Description of Urban Land

Setting

Landform: Stream terraces, eroded fan remnants
Down-slope shape: Linear
Across-slope shape: Linear

Interpretive groups

Land capability (nonirrigated): 8

213—Levante-Riverwash complex, 1 to 3 percent slopes, flooded

Map Unit Setting

Elevation: 5,600 to 7,700 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition

Levante and similar soils: 55 percent
Riverwash: 35 percent

Description of Levante

Setting

Landform: Flood plains on valley floors
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granite, gneiss, schist, and granitic sandstone

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.0 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Very low (about 2.8 inches)

Interpretive groups

Land capability (nonirrigated): 4c
Ecological site: Sandy (R035XA113NM)

Typical profile

0 to 4 inches: Loamy sand
4 to 17 inches: Coarse sand
17 to 32 inches: Gravelly coarse sand

32 to 45 inches: Stratified gravelly loamy coarse sand to gravelly coarse sand
45 to 58 inches: Gravelly loamy coarse sand
58 to 86 inches: Very gravelly coarse sand
86 to 122 inches: Very gravelly coarse sand

Description of Riverwash

Setting
Landform: Channels on flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from mixed

Properties and qualities
Slope: 0 to 1 percent
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Frequency of flooding: Frequent
Calcium carbonate, maximum content: 3 percent
Gypsum, maximum content: 3 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water capacity: Very low (about 3.0 inches)

Interpretive groups
Land capability (nonirrigated): 8

Typical profile
0 to 10 inches: Gravelly coarse sand
10 to 50 inches: Very gravelly coarse sand
50 to 65 inches: Gravelly sandy clay loam
65 to 85 inches: Gravelly coarse sand

216—Dondiego loam, 1 to 3 percent slopes

Map Unit Setting
Elevation: 6,100 to 7,400 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 140 to 160 days

Map Unit Composition
Dondiego and similar soils: 85 percent

Description of Dondiego

Setting
Landform: Stream terraces on valley floors
Landform position (three-dimensional): Tread
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Alluvium derived from granite, gneiss, schist, and loess

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Very rare
Frequency of ponding: None
Calcium carbonate, maximum content: 3 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability (nonirrigated): 4c
Ecological site: Loamy (R035XA112NM)

Typical profile

0 to 2 inches: Loam
2 to 9 inches: Loam
9 to 22 inches: Loam
22 to 28 inches: Loam
28 to 36 inches: Sandy loam
36 to 48 inches: Loam
48 to 59 inches: Loam
59 to 69 inches: Gravelly sandy loam
69 to 85 inches: Gravelly loamy coarse sand
85 to 102 inches: Stratified gravelly loamy coarse sand to sandy loam

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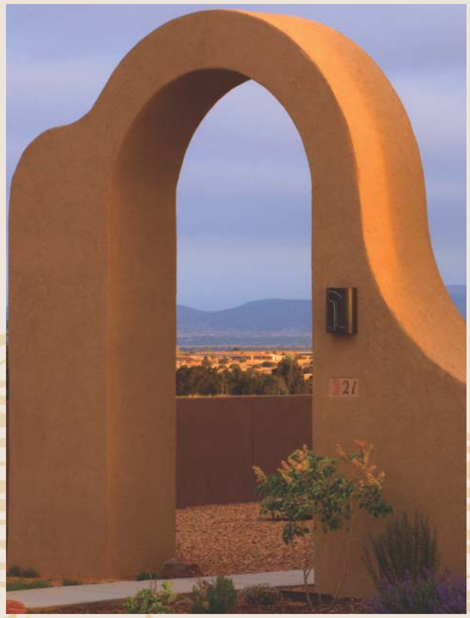
APPENDIX F: 2003 SURFACE WATER MANAGEMENT MANUAL



Rancho Viejo's
Surface Water Management Manual

July 2003

RANCHO VIEJO

Rancho Viejo's Development Philosophy

Rancho Viejo is a distinct community that allows for the harmonious, long-term growth of Santa Fe through planning, patient development and respect for the land and its resources. Designed for the people who live and work in Santa Fe, Rancho Viejo is an accessible community that provides for their enduring economic, educational and recreational well-being, while nurturing the cultural heritage of the region.

Table of Contents

A. INTRODUCTION

The Purpose

Rancho Viejo has identified seven storm-water management goals. The purpose of this manual is to document those goals and identify the strategies and techniques to implement them. The manual contains a summary of the lessons learned from testing storm-water drainage and water-harvesting systems, erosion control methods and associated landscape design techniques over the five years that Rancho Viejo has been under development.

Rancho Viejo's Goals for the Design of Sustainable Surface-Water Management Systems

- Maximize the usable land on residential lots.
- Reduce the impact on natural resources, mainly water and soils.
- Capture the sites' potential energy and resources through the collection and reuse of site storm-water runoff.
- Create storm-water management systems that are sustainable, functional and when visible to the public, aesthetically pleasing.
- Meet new NPDES requirements for water management.
- Work towards returning storm-water to the aquifer and receiving water credits for achieving this.
- Establish a process to strategically improve the surface-water management system in each phase of development.

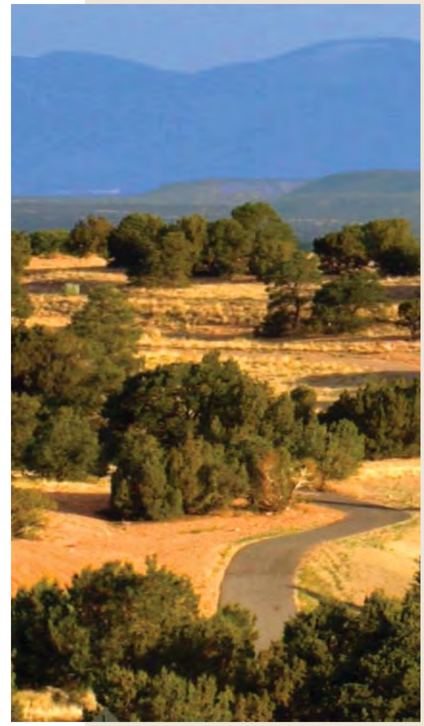
The Surface-Water Management Manual is a tool to implement the goals through:

- documenting the lessons learned
- documenting the current construction techniques that have been proven and adopted by Rancho Viejo
- integrating site design, engineering and landscape architecture, construction management and construction and
- assisting with prioritizing, budgeting and scheduling of new or improved approaches to surface-water management.

The approach for the surface-water management system at Rancho Viejo is to go beyond minimizing site destruction and strive to re-establish the natural processes necessary to sustain ecologic, social and cultural systems. Sustainability is an international term. Probably the most widely accepted definition of sustainable development is development that meets the needs of the present (today's population) without compromising the ability of future generations to meet their own needs (Brundtland 1987).

A. INTRODUCTION

What is Sustainability at Rancho Viejo?



Sustainable design is considered a tool to achieve sustainable development and is often defined as a design approach that allows the ongoing processes that sustain all life (natural systems) to maintain themselves over time and continue to function along with development (Franklin 1999).

At Rancho Viejo, sustainability is reflected in both design and construction. Rancho Viejo is striving to preserve the resources, ecosystem and natural beauty of the property while minimizing water use, pollution, consumption of natural resources and degradation of the environment over a long period of time and restore or preserve the natural environment so it is self-sustaining.

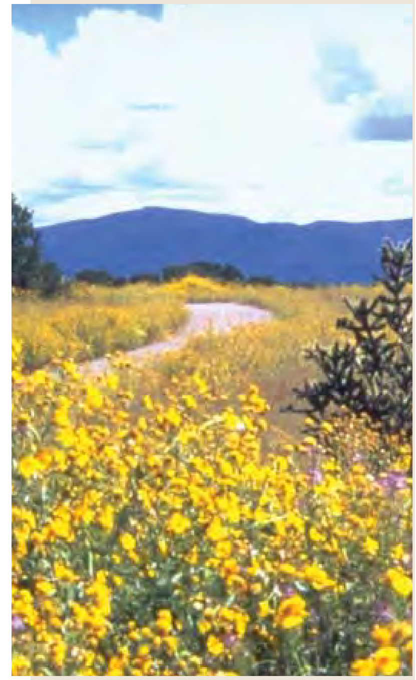
NPDES Requirements

Since the creation of the Clean Water Act in 1972, the National Pollutant Discharge Elimination Systems (NPDES) program has been a major force in the nation's efforts to protect and restore the quality of our rivers, lakes, and coastal waters. According to the program, any construction activity that includes clearing, grading, or excavation resulting in land disturbance of 5 acres or greater must be conducted in accordance with NPDES General permit No. CAS000002, for Discharges of Storm Water Runoff Associated with Construction Activity (referred to as the Construction Site General Permit). Sites less than 5 acres are also required to obtain a permit if the project is part of a "larger common plan of development" that will exceed 5 acres. In March 2003, a Phase 2 rule for small construction activity took effect, requiring permits for all construction sites 1 acre or larger. The best management practices outlined in the strategy section of this document are designed to meet the requirements of the NPDES.

The requirements state that more stringent guidelines can be used but not less. Rancho Viejo recognizes that it is much more cost effective to mitigate non-source pollution now then to try and retrofit the site after the fact. The NPDES requirements as they relate to Rancho Viejo are explained in further detail in Appendix D of this document.

A. INTRODUCTION

Rancho Viejo's Water Plan Components



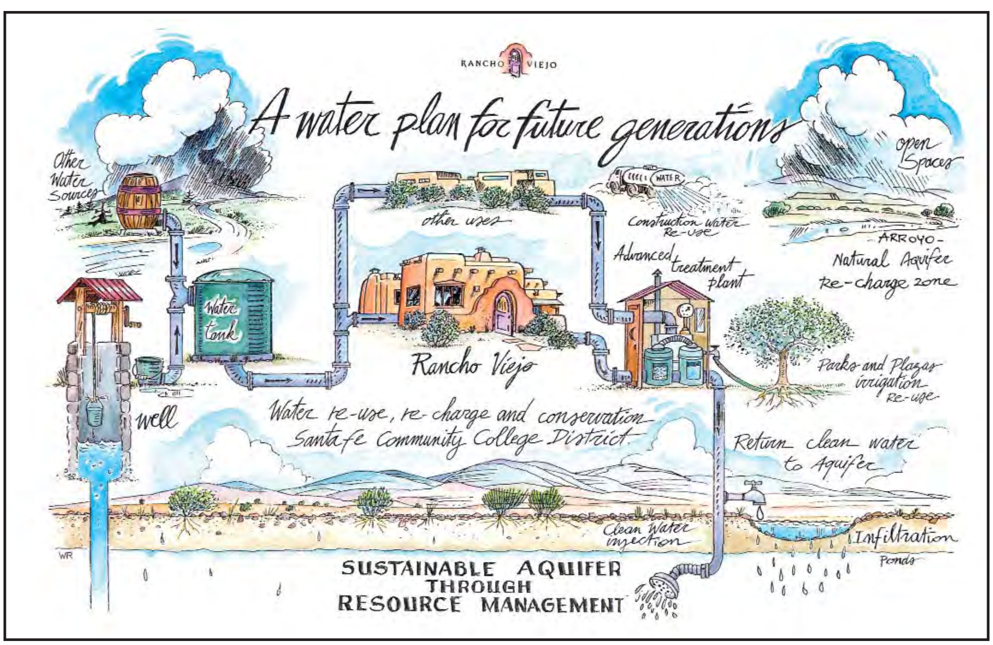
Rancho Viejo's is working to reduce its overall water requirements and usage. The Rancho Viejo Water Plan takes a holistic approach to water conservation that challenges the water implications of development and operations at every scale of the community development process.

The Surface-Water Management Manual is only one of the five documents that make up Rancho Viejo's Water Plan. The other four plans in the family of documents include:

The Water Master Plan

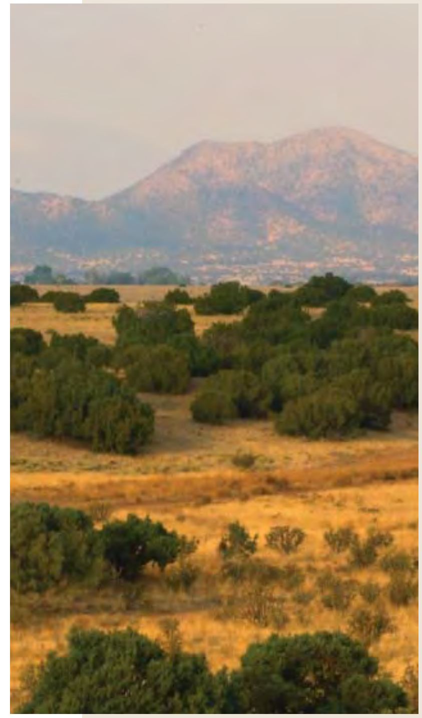
Rancho Viejo's holistic approach to water management is diagrammed in a sketch titled "A Water Plan for Future Generations." When all components of the system are in place, Rancho Viejo will use groundwater, treat wastewater to a high quality level and recharge the effluent into the aquifer. Treated effluent will be used to irrigate open space and parks and to control dust during construction. The surface-water management and domestic conservation plans will reduce water consumption. The total result will maintain the level of the aquifer for the next 100 years and significantly reduce the need to import outside water.

The Rancho Viejo Land Use Plan provides the foundation for the holistic water plan. The natural arroyos that cross the property are protected in their natural condition. They are the primary aquifer recharge areas and arroyo vegetation provides natural filters that control erosion and waterborne contaminants. Concentrated village development is located on level open meadows, which concentrates the footprint of development on the land, limits areas to be irrigated and reduces grading and vegetation removal, soil erosion and expensive drainage improvements.



A. INTRODUCTION

Rancho Viejo's Water Plan Components



The Landscape Vision Plan

The philosophy at Rancho Viejo is to work with nature and natural systems to conserve water and create landscapes of beauty. The Rancho Viejo Landscape Vision describes this philosophy and introduces the native plants and planting and maintenance standards required to implement the vision. It is an educational document dedicated to focusing the collective energies of the developer, designers, contractors and homeowners in creating a water-conserving native landscape that has exceptional beauty.

The Common Area Landscape and Irrigation Plan

The common area irrigation strategy is based on providing the appropriate level of landscaping and irrigation for the unique use of each type of open space. The amount of water used for irrigation is not consistent and quantities are adjusted based on seasonal rainfall. Water for new landscaping is reduced incrementally over a three-year period to allow native plants to acclimate to natural rainfall.

The Domestic Conservation Plan

Wise use of water within individual homes includes water-conserving fixtures and appliances, passive harvesting of rainwater for irrigation, and cisterns to capture water for irrigation systems and swamp coolers. Rancho Viejo started providing underground cisterns as a standard feature for new homes in March 2003.

A. INTRODUCTION

Rancho Viejo's Landscape Vision

The vision for the open space and built landscape of the Rancho Viejo community is one that embraces the surrounding natural landscape as the foundation for design. Rancho Viejo's vision is to synthesize key principles of ecological planning and sustainable design. A significant effort has been made to reduce Rancho Viejo's footprint on the land and environment.

A. INTRODUCTION

Rancho Viejo's Landscape Vision

The Goals
There are three goals from the Rancho Viejo Landscape Vision Document that the drainage plan implements:

- To limit disturbance of open space areas, maintaining the character of the land and preserving native plants
- To create an aesthetically pleasing and sustainable landscape,
- To use water resources efficiently and sustainably, by reducing the use of potable water for common area irrigation, utilizing the landscape and streetscape grading as a means of capturing and reusing storm water.

Rancho Viejo's Landscape Zones
Rancho Viejo's landscape approach is to create a seamless transition from the surrounding undisturbed native landscapes to the more urban environments of the village areas.

This transition takes place through a series of five planting zones, which preserve and integrate native vegetation and materials throughout the entire community. This conserves water, protects soils from erosion and potential degradation of water quality, and aids the infiltration of storm water into the subsoils and eventually the aquifer. The Surface-Water Management Plan checklist identifies how to manage water in each of these zones.

- Undisturbed Open Space (Aquifer Recharge Zone)
- Transitional Open-Space Landscapes
- Transitional Street Landscapes
- Village/Urban Streetscapes
- Village Parks, Plazas and Open-Space Landscapes

B. THE APPROACH

Documentation

The purpose of the manual, as described in the introduction is to document the lessons learned from five years of testing and to create a working document that will be systematically improved, with each new phase of development. This document will allow the team to be pro-active, improving and streamlining the process of designing, engineering and constructing a drainage system that also serves as a community amenity. This document will be systematically improved with each new phase of development.

To document these efforts, the Landscape Architect led a series of bi-weekly work sessions, from November through December 2002, to review lessons learned, agree on standards for each stage of drainage, from when water hits the roof to where it leaves the site, and to identify the next steps in improving the drainage system. Key leaders and staff at Rancho Viejo, the design team and participants from Rancho Viejo included vice presidents Bob Taunton (general manager), Ike Pino (land development manager) and Dan Russell (housing manager).

Additional meetings were also held with County staff and State of New Mexico Environment Department staff members. Meetings with representatives from the State of New Mexico Environment department included Fred Kalish, Sandy Spon, and Bret Lucas, who provided valuable information on the potential changes to the State Water Plan and support for our efforts. Staff from the Clif Walbridge Engineering firm, the project civil engineer addressed specific issues of grading, drain system design, and erosion control. Fred Wirth of Tall Grass Restoration assisted in evaluating native grass restoration efforts.

Review and Update

This manual is a living document and the intent is to improve on it as Rancho Viejo continues to test sustainable surface-water management techniques. Consequently, this manual will be reviewed at the conclusion of each development phase, to document lessons learned in new construction techniques and changes in local, state and federal agency requirements. The checklists also provide recommendations for future changes in design and implementation.

C. BENEFITS

Rancho Viejo's Water Management Philosophy

Natural rainfall is a precious resource and should be managed to sustain the project and the surrounding community and district. Surface-water management is the opportunity to manage the rainfall runoff for beneficial purposes including reduction of development costs, increased sales performance, improved environments and habitats, and a return of water to the aquifer.

C. BENEFITS

Reduced Development Costs

Rancho Viejo has tried to accomplish some very tangible results for some very practical reasons. One key reason is the potential for reducing cost and increasing sustainability, while it fulfills one of their management strategies.

Drainage costs can be reduced and water can be used for irrigation or aquifer recharge by incorporating the three principles of surface-water management (capture water close to where it falls; reuse as close to the source as possible and in the best manner; and avoid creating concentrated runoff and subsequent erosion)

Reduced cost benefits:

- Less development money will be spent repairing erosion damage and restoring damaged landscapes
- Thriving native landscapes require less water. Lower potable water use decreases water bills.
- Native plant materials, if properly installed and once established require less maintenance - including little or no pruning/mowing, watering or fertilizer to remain attractive, thereby decreasing overall maintenance costs for the developer and eventually for the homeowners' association.
- More effective use and infiltration of storm and irrigation water leaves more potable water for other critical uses and reduces water bills. The less surface water to pipe, the more pipe sizes can be reduced and potentially detention basins may be reduced in size, decreasing development expenses.
- Water quality is improved and protected as required by NPDES.
- The water requirements for Rancho Viejo (according to the Ground Water Report produced as part of the *Community College District - Rancho Viejo Approach to the Aquifer Management,* dated June 13, 2000, by Balleau Groundwater, Inc.) is estimated to be 0.25 acre feet per year per unit (AFY/unit). Rancho Viejo expects that conservation and re-use may reduce unit requirements to less than 0.15 AFY, thereby potentially increasing the number of lots that RV will be allowed to develop and sell.

C. BENEFITS

Increased Sales Performance

The local community's recognition of responsible development can potentially result in increased sales. Buyers will also be contributing to the success of the community by adopting the sustainable community philosophy in the management of their homes and utilities. Greater diversity of habitat and plant materials contributes to greater diversity of wildlife. The appeal of living in an interesting community setting of a stable prairie environment will be an important element in attracting potential buyers to the site and adding to Rancho Viejo's fame.

Improvement of the Environment and Habitats

Over half of Rancho Viejo's 11,000 acres will be parks and open space. The rest of the land will remain untouched in order that the rich habitats for plants and animals may continue to thrive. The arroyos will remain in their natural state with only vegetation enhancement in limited locations, to increase the wildlife habitat and stabilize the highly erodible soils.

Some benefits to the environment:

- Erosion damage will be prevented or repaired.
- Flooding downstream will be reduced.
- Improved water quality will be realized.
- Habitats remain connected instead of fragmented, increasing their wildlife value and the potential wildlife diversity.
- Native landscapes especially in sensitive areas can be preserved. Preserving native landscapes will stabilize soils, preserve habitats and the natural balance of the prairie and provide an attractive visual quality.
- By increasing plant corridors, stabilizing drainageways and managing the additional surface-water runoff in a sustainable manner, more birds, butterflies and other wildlife will be able to find the food, shelter and nesting areas required for their survival in and around the community.

C. BENEFITS

Improvement of the Environment and Habitats

- Timely installation and maintenance of required erosion control systems will minimize topsoil loss, downstream silting and erosion damage and high repair costs.
- When collected, rainwater percolates into the soil and eventually into the aquifer, forcing salts down and away from the root zone area. This allows for greater root growth and water uptake, which increases the drought tolerance of plants. Subsequently the appearance of the landscape is richer and more inviting to the homeowner and visitor.
- Through effective water harvesting and surface-water management techniques, urban runoff and associated pollution and sediment migration will be reduced.
- By grading the site to detain surface water and increasing vegetative cover, water will be trapped and driven into the ground closer to the point of origin. Drainage water will be diverted to highly permeable areas (where water penetrates the soil quickly), and water will percolate to the water table.
- Flooding downstream can be reduced.

C. BENEFITS

Return of Water to the Aquifer

As noted above, a large percentage of the Rancho Viejo land will remain undeveloped. The arroyos will remain in their natural state with only vegetation enhancement in limited locations, to increase the wildlife habitat and stabilize the highly erodible soils. Both of these design approaches will contribute to the absorption of storm water.

The overall strategy is to gain as much value as possible form the dual use and reuse of water as it passes through Rancho Viejo homes, yards, parks, open space and treatment systems. The highly treated water is then returned to the underlying aquifer to maintain the level of the aquifer in perpetuity.

Benefits include increased water filtration into the ground and eventually into the aquifer by locating storm water detention areas and swales over highly permeable soils, rather than allowing water to be lost through evaporation.

D.

SURFACE-WATER MANAGEMENT PRINCIPLES AND STRATEGIES

Practices and Principles

The Principles of Sustainable Surface-Water Management

The checklists and guidelines in Section E of this manual are based on a set of widely accepted practices and principles of sustainable surface-water management.

Capture water as close to where it falls as is practical.

Reuse water as close to the source as possible and in the best manner.

Avoid creating concentrated runoff and subsequent erosion and sediment transportation.

Standard Best Management Practices (BMPs)

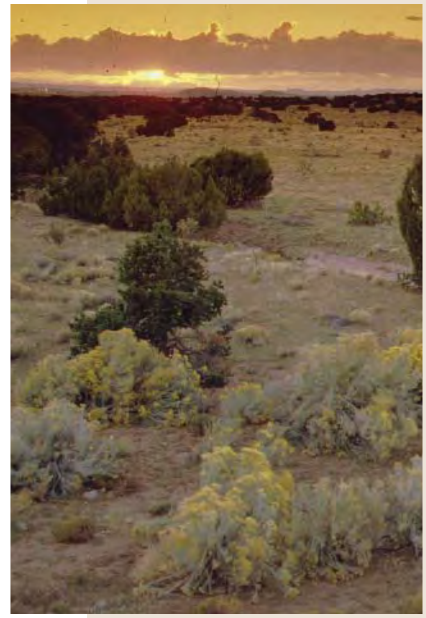
The strategies described in this section are recommended for all construction on site by Rancho Viejo, including erosion and sediment control, material and equipment storage practices, and waste disposal practices. The checklist and guidelines provide standards and details for how to accomplish these practices.

The BMPs strive to:

- preserve vegetation and cover soils
- control runoff during construction
- install and maintain sediment controls
- keep waste material out of storm drains and surface waters
- keep business and work areas clean and maintain catch basins
- cover containers and materials
- prepare for and clean up spills
- dispose of wastes properly
- minimize wastes
- recycle wastes
- preserve and enhance surface waters and adjacent vegetation
- educate employees and homeowners

D. SURFACE-WATER MANAGEMENT PRINCIPLES AND STRATEGIES

Strategies



Summary of Recommended Strategies

The strategies outlined below describe the best management practices proposed for handling water from where it hits the ground or roof to where it exits the site through the open-space areas. These strategies parallel the major components of the checklist provided in Section E.

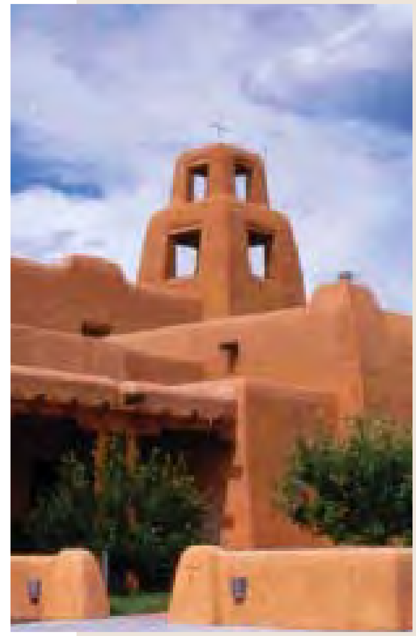
General Drainage-System Design

The goals of the drainage system design is to:

- Handle water at the source as the most efficient way of reducing urban runoff and also the most energy efficient-way to acquire water.
- Reduce the need for mass grading wherever possible through coordinated scheduling or if unavoidable, mitigate potential wind erosion and sedimentation with appropriate controls such as tackifiers or crimped hay techniques.
- Grade site to allow for water harvesting on lots, parkways, open space and paving areas.
- Install non-traditional drainage swales with natural meanders and stone check dams to slow the water runoff and drive it into the ground, creating visual amenities for the development instead of expensive eyesores that require screening.
- Design large open-space areas around and within the community developments that reflect the historic drainageways.
- Design storm-water systems based on research on soil composition; slope of the site; depth to water table; proximity to bedrock, foundations, and wells; land consumption; land-use restrictions; high sediment input; and thermal impacts to downstream areas.
- Design water catchment systems such as storm-water detention areas and swales, to slow water flows, allowing it to filter into the soil and eventually into the aquifer, thereby reducing erosion and the water demand and cost of repair and maintaining existing and future drainage systems.
- Identify erosion-prone areas and create an Erosion Control Plan for implementation before and during construction
- Install and maintain construction fencing, sediment control fencing and control contractor access to site to minimize disturbance of the natural landscape to be preserved.
- Limit on-site stockpiling and parking. Designate on-site parking and drive locations and stockpile locations and enforce adherence by contractors to avoid soil compaction, oil and gas leaking and contamination of soils.
- Grade sites to a maximum of 3:1 slopes. Santa Fe County does allow 2:1 slopes . However, grading at 2:1 slopes will uncover the existing utility lines at Rancho Viejo in many locations. Assume in the open space areas that 2:1 slopes (to reduce impact on the adjacent landscape) can be implemented. All other places, including rear lots, should be graded to a maximum of 3:1 slope.

D. SURFACE-WATER MANAGEMENT PRINCIPLES AND STRATEGIES

Strategies



Architectural Design

- Strategically design architecture (rooftop catchment systems, cisterns, etc.), to improve the surface storm-water capture and reuse potential.
- Design roofs to allow for collection of water into a catchment system for reuse. The simpler the roof configuration, the easier it is to run gutters and downspouts. Simple roofs also tend to collect less debris and therefore require less maintenance and lower maintenance costs may be realized.
- Use metal roofing for water catchment systems as it is the cleanest system. The smoother and less porous the collection surface, the less filtering of water is required. Avoid asphalt, composition shingles, clay tiles and concrete tiles, which are rougher and more porous and consequently tend to collect dirt and harbor mildew, ultimately adding to filtering requirements. Roofs made of asphalt or roofs with lead-containing materials contaminate the rainwater collected and render it undesirable for reuse.
- Design gutters, downspouts and canales to be away from walkways, patios, driveways, and areas where water will be trapped against the building or other structural footings, where potential icing from the runoff or freezing at open downspouts will create dangerous conditions.
- Place downspouts about every 20 feet along the gutter, instead of the more common 40 feet or longer. This ensures that heavy rains will not likely overflow the gutter and instead will flow to catchments.
- Size downspouts and gutters appropriately. Size to provide 1 square inch of cross-section area for every 100 square feet of roof that they serve. (For example, a 5-inch x 5-inch downspout can safely handle about 2500 square feet of roof area.) Large-dimension gutters and downspouts have a much larger carrying capacity to collect every drop of rainfall.

Lot Design

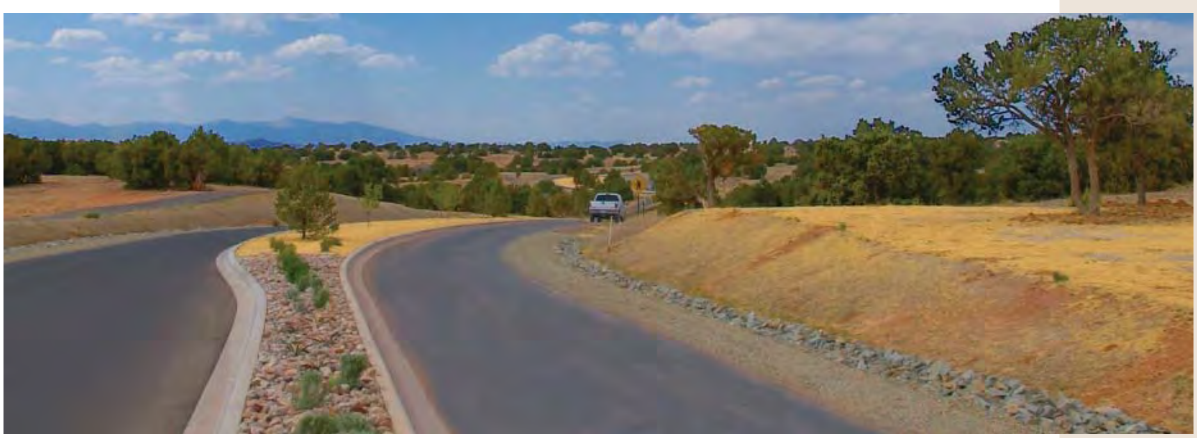
- Create landscape catchment/collection areas. Paved areas such as concrete asphalt or brick paving provide high water yields. Bare soil surfaces provide harvests of medium yield. Planted areas, such as grass or groundcover areas, offer the lowest yields because the plants hold the water longer allowing it to infiltrate into the soil. The amount of water harvested depends on the size, surface texture and slope of the catchment area.
- Utilize mulching materials to enhance the effectiveness of the water-harvesting systems. The mulch reduces soil exposure to sun and subsequent water loss when maintained at a minimum three inch depth.
- Design grading to facilitate water being absorbed into the soil or to be directed to plant beds.
- Grade sites to drain away from building or structure footings at a minimum of 1 percent.

D. SURFACE-WATER MANAGEMENT PRINCIPLES AND STRATEGIES

Strategies

Village Roadway and Open Space

- Design roadway grading and paving plans to allow water to be absorbed into the soil or to be directed to plant beds from roadway, sidewalks and other paved surfaces.
- Install temporary soil erosion control measures to maintain or improve storm-water quality:
  - Barriers to trap sediment: straw bales (native grass preferred), sandbags, or sediment traps
  - Filters to limit sediment in runoff: vegetated berms, straw bales, sediment erosion fencing, inlets, or vegetative filter strips
  - Routing devices to protect steep slopes by directing water to an infiltration area or discharge point: hay bale swales, terracing, grassed parallel swales or metal piping.
  - Culvert or chute outlet protectors to prevent high-velocity water damage: riprap, gabions, stilling basins/water-quality basins or protective aprons.
- Install sediment erosion control systems before and during construction per Santa Fe County and other public agency requirements, to minimize on-site erosion and prevent off-site sedimentation.
- Install permanent or temporary stabilization within seven days in all swales, ditches, perimeter slopes and all slopes greater than 3:1; and within 14 days for all other disturbed or graded areas on the project site, following initial soil disturbance or re-disturbance.
- Design the utility corridor to the minimum width required. Use construction techniques such as pipe trenchers to limit disturbance.
- Design construction and final easement a maximum width of 35 feet.
- Schedule site walk with the designer, general contractor and client to stake areas to be protected and allow for field decisions on the preservation and protection of specific site features or trees.



D. SURFACE-WATER MANAGEMENT PRINCIPLES AND STRATEGIES

Strategies

- Erect fencing before any other work begins, including site clearing for roadway construction. Mark protected areas on all drawings, specify site protection in contracts and physically keep construction activity out of protected areas using snow fence or bright plastic mesh fencing used to remind construction workers to keep clear. Fencing should remain in place at least until all heavy machinery and vehicles (including delivery vans) are off site.
- Eliminate long straight utility swaths. Where easements are extra wide to allow for future expansion, clear easement only in the area of actual use. Follow the topography and natural features to avoid uninterrupted lines longer than 1,000 linear feet.
- Keep opening into natural vegetation stands for utility corridors as narrow as possible. Target a 10-foot width.
- Design utility corridors to function as multi-functional spaces, combined public road/trail/bike path and maintenance roads.
- Design access roads to be grassed to reduce runoff and erosion. Except for the road itself, shrubs or small trees should be allowed to remain.
- Design parking lots with depressed islands with pitched pavement and curb cuts for collecting water off of paved areas and directing it to plantings.
- Prepare a construction schedule that describes the relationship between the implementation and maintenance of controls and the various stages of earth disturbance and construction. Schedule will include:
  - Schedule for clearing and grubbing for those areas necessary for installation of perimeter controls (limit of disturbance fencing).
  - Schedule for installing perimeter controls
  - Schedule for clearing and grubbing of all remaining areas
  - Road grading and grading for remainder of the site
  - Utility installation and storm drains to be used or blocked during construction
  - Final grading; landscaping; or stabilization
  - Removal of controls (relate to the completion of all work requiring heavy equipment or vehicles).
- Design storm-water management areas with pretreatment devices such as water quality ponds to trap coarse sediments to prevent premature clogging of the system. These systems can be attached to the detention basin, but ideally they should be located throughout the development area at the source of the surface-water collection. If an area remains moist long enough to support wetland plantings, plant materials can increase the amount of pollutants absorbed or settled out of the water column and also provide biological, chemical and physical processes for breaking down the pollutants.
- Design grassed swales for areas with low intensity of runoff even in heavy storms.

D. SURFACE-WATER MANAGEMENT PRINCIPLES AND STRATEGIES

Strategies

General Planting Design

- Maximize permeability and opportunities for infiltration by increasing vegetative cover, mulching properly and reducing impervious paving surfaces.
- Design new landscapes and restoration plantings with native plant materials and other drought-tolerant plants to reduce water use by more than 50 percent.
- Preserve existing vegetation on site to reduce the amount of plant material that needs to be purchased, installed and maintained, as well as reducing the additional cost of erosion control and restoration seeding of disturbed areas.
- Install fast-growing, self-rooting native groundcovers with deep and fibrous root systems for erosion control or hydroseed with a combination of quickly established grasses and desirable long-term groundcover varieties. Even shallow slopes can be eroded when exposed to high volumes of water due to extended runoff from major storms.
- Native plants are preferred for use in swale design. Proper selection of native species for swales can provide year-round vegetative cover without need for supplemental irrigation or fertilization. Furthermore, native species usually provide high habitat value for indigenous birds and other animals. Exotic species can also be appropriate, though some can become invasive if allowed to proliferate. Local landscape ordinances often provide lists of acceptable and non-acceptable plants and grasses.

Site Maintenance

- Conduct a complete water balance analysis by noting the location of plants to be irrigated, the monthly rainfall in the area and the available options for concentrating rainfall directly to the plants on the lots. By computing expected rainfall and vegetation water needs, storage needs can be determined and the storage system can be sized appropriately.
- Install and maintain erosion control systems in a timely manner to minimize topsoil loss, downstream silting and erosion damage and high repair costs.
- Keep the site well maintained by contractors experienced with maintaining native landscapes. Once established, native plant materials, if properly installed, require very little maintenance and are relatively easy to maintain with little or no pruning, watering or fertilizer to remain attractive.
- Install water sensors and employ water audits to monitor water use. Monitor maintenance of the irrigation systems and schedules for reducing water distribution to native plants that have become established.

E. SURFACE-WATER MANAGEMENT CHECKLISTS AND DETAILS

Checklist and Detail introduction

Rancho Viejo has experimented with methods to capture the multiple benefits of rainfall at every stage of its journey from rooftops until it enters the aquifer. The lessons learned and standard construction details are documented in the following checklists and details. They will guide the design of all grading and drainage improvements at Rancho Viejo. This section is not to be used as a field manual. The appropriate information from the manual will be detailed in the construction document package for each development phase and construction project.

The checklist is structured for easy review, reference and update. It begins by introducing the surface-water management goals for Rancho Viejo. Each section describes the recommended approach to master planning, architecture, lot design, or roadway and open space design, as they relate to surface-water management.

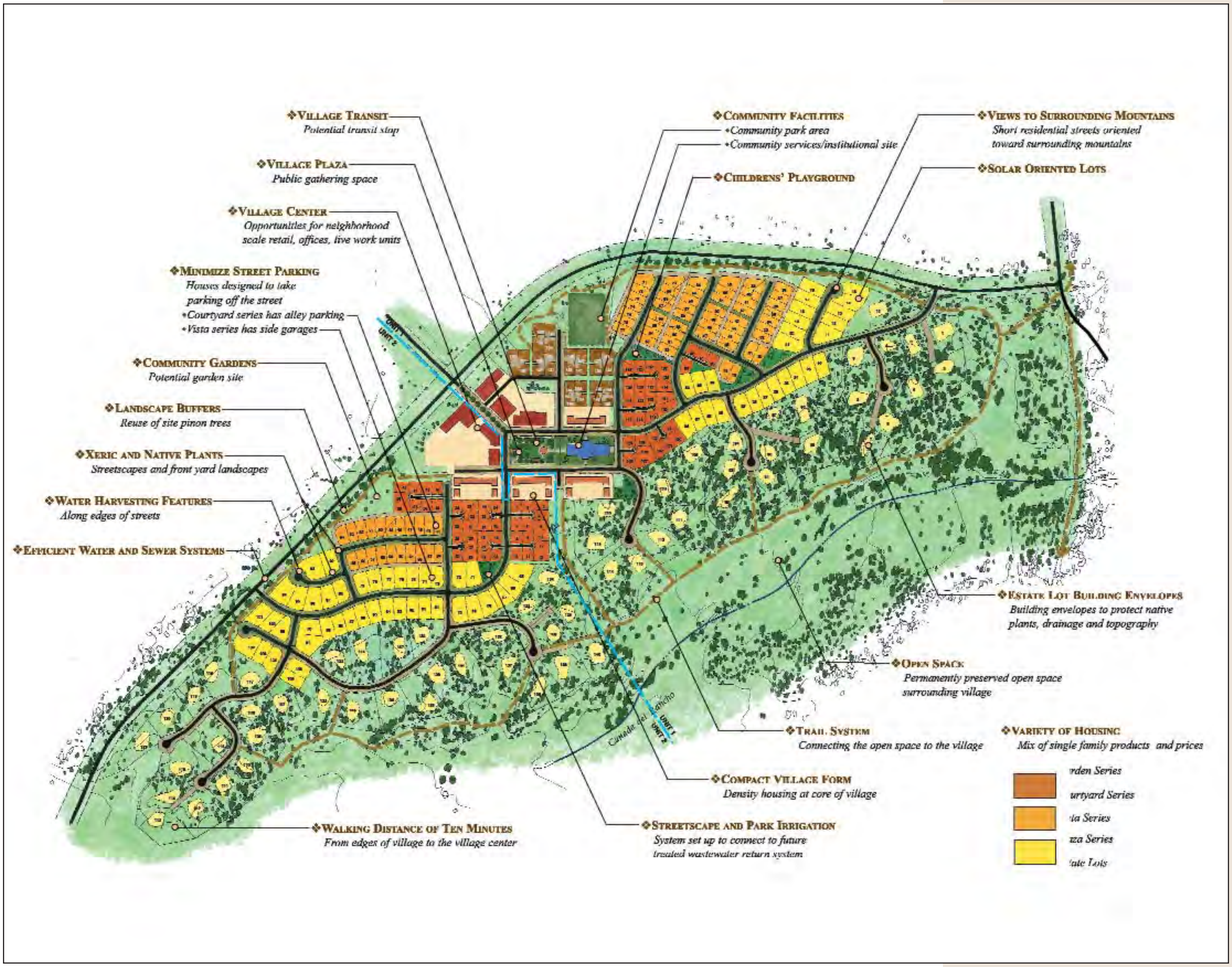
The checklists identify the strategies for moving towards a sustainable community based on the goals and vision of Rancho Viejo, the State of New Mexico's guidelines, requirements of the NPDES (and other EPA regulations), the LEEDs standards, and other green building guidelines accepted in the industry.

The checklist identifies the current status of these efforts indicating if they have been designed or implemented. A remarks column reflects the comments recorded from our work sessions and subsequent discussions with Rancho Viejo on specific implementation management issues from Clif Walbridge, the project civil engineer, to address specific issues of grading, drainage system design and from Fred Wirth of Tall Grass Restoration for assistance in evaluating our native grass restoration. The last column summarizes the recommendations for future changes to research, design and implement to move the effort forward.

Each section contains example details, photos and plans that illustrate the current thinking in what is working well or new details for implementation of a sustainable surface-water management system at Rancho Viejo. This document, however, is meant to be reviewed and updated annually, as we continue to evaluate and upgrade the quality of the work and as new technologies and research becomes available.

E. SURFACE-WATER MANAGEMENT CHECKLIST AND DETAILS

1. Village Master Plan



SUSTAINABLE LANDSCAPE STRATEGY PLAN
THE VILLAGE AT RANCHO VIEJO

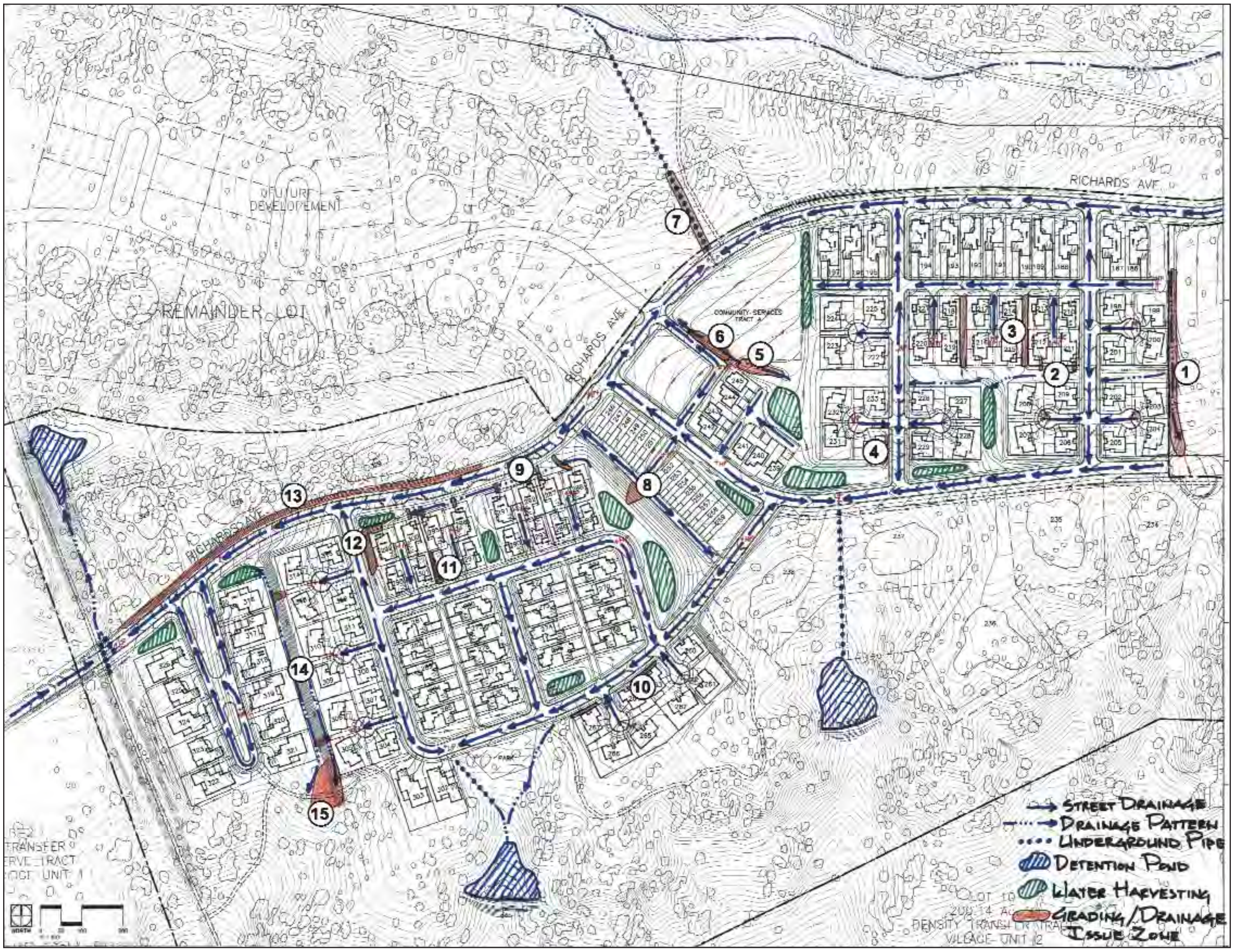
Note: This checklist below represents the status of the Rancho Viejo Community surface-water management design, implementation and maintenance strategies and practices as of December 2002. Future Changes to Implement represent the strategies that are being planned or implemented as of July 2003.

SYMBOLS KEY

MP	Master Plan	**WR**	Windmill Ridge	**RV**	Rancho Viejo
SD	Schematic Design	**Y**	Yes	**SWM**	Surface-Water Management
DD	Design Development	**N**	No	**HOA**	Homeowners Association
CD	Construction Docume	**DW**	Design Workshop, Inc.	**NPDES**	National Pollutant Discharge Elimination Systems

SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
1.0 Village Master Plan		**Designed**			**Implemented**	**RV Comments**	**Future Changes to Implement**
1.1 Preliminary Grading Plan		**Plans**	**Details**	**Specs**			
	Prepare a Mass Grading Plan that preserves as much of the natural landscape as possible.	Y	N/A	N/A	Y	The Engineers' mass grading plan is used for the staking limits. What dictates the phasing of construction is the balancing of the on-site soil. Typically mass grading occurs over a four-week period. Lot compaction occurs while the rough grading is done. (This helps keep the wind erosion to a minimum). Slower paced construction may lead to more wind and water erosion.	Use the civil engineers Mass Grading Plan to do the staking. This staking limit will also become the fence edge. See Section 4.2.1 for specific recommendations for managing wind and water erosion.
	Prepare integrated grading, drainage and water-harvesting plans.	Y	Y	Y	Y Partially	No comments.	A drainage and water harvesting master plan must be prepared as part of the preliminary master plan for each village. Drainage plan should be updated and detailed in parallel with the master plan.
	Establish clearly recognized and highly visible construction and disturbance boundaries.	MP	N/A	N/A	Y Partially	Documenting and installing construction boundaries still needs to be coordinated with civil engineer's plans, but installation of the fencing is occurring in the field. Some fencing is installed prior to and some after the mass grading. Using fencing to mark the edge of the grading/disturbance area has been successful so far, when it has been installed and maintained properly. Harvesting of trees, however, has gone beyond the fenced zone and is causing considerable damage.	Define the disturbance limits with fencing earlier in the grading and site preparation process than it has previously occurred. Work with the civil engineer to minimize the area of disturbance and to clearly define the limits and see that they are delineated accurately in the field with protection fencing. RV to monitor the status of the fencing on a regular basis. Confine the tree transplanting routes so the contractor causes less compaction and damage to the existing habitats. Provide protection such as wood mulch or temporary gravel paving prior to the start of work. Work with RVs' land development superintendent to have these guidelines reviewed with the transplanting contractor.
	Limit site disturbance, including earthwork and clearing of vegetation, to 40-feet beyond the building perimeter, 5-feet beyond primary roadway curbs and walkways, main utility branch trenches, and 25-feet beyond pervious paving areas, to limit compaction of soils.	MP	N/A	N/A	N	Disturbance of the site has not been tightly identified by specific distances or monitored to ensure the agreed-upon limit of disturbance is being held.	The limit of disturbance will be more closely addressed in the WR - Unit III Development. DW to work closely with RV and the civil engineer to establish a grading plan that will minimize disturbance and therefore minimize loss of vegetation and topsoil loss, thereby reducing erosion and sediment buildup in surface-water run off.
	Groundwater Recharge: Wherever possible, create opportunities to allow water to filter into the ground rather than run off the surface and into storm drains.	N/A	N/A	N/A	N	The EPA recognizes recharge from detention/retention basins, however, there is no credit for recharge through these basins by the NM State Engineer as of December 2003. RV is planning on working with the new State Engineer to determine how this can be resolved.	DW to meet with representatives of the State Engineer's office to discuss the new Draft Infiltration Plan.
	Stockpiling of topsoil: All topsoil is removed and stockpiled until final grading is complete and it can be reused. If topsoil is going to be stockpiled for over 30 days, it is seeded and placed into piles that meet the requirements for maintaining healthy soil microbes.	N	N	N	N	RV is interested in preserving the topsoil whenever possible. They may have to stockpile soils in the next phase of work for up to two years.	DW recommends seeding the stockpiles with blue grama grass only. No annuals such as rye or barley should be used.
1.2 Schematic Drainage Plan		**Plans**	**Details**	**Specs**			
	Schematic Drainage Plan is prepared by Development Area.	SD	Y	Y on Dwgs	Y		Needs to be coordinated with Engineer's Plan at an earlier stage.
	Overall site is divided into small catchment areas.	SD	Y	N	Y- WR - Unit III Only	In Process - WR is now being reviewed for this.	Continue to review opportunities for this in all future phases. DW to assist RV and the civil engineer in creating naturally shaped basins that function as needed but also blend well into the natural contours and can be used as a visual amenity.
	Building pads are designed and installed to be above the adjacent walkways and streets to allow for positive drainage away from homes.	SD	N/A	N/A	Y	Implemented in WR.	Continue to implement this in all future phases as appropriate.

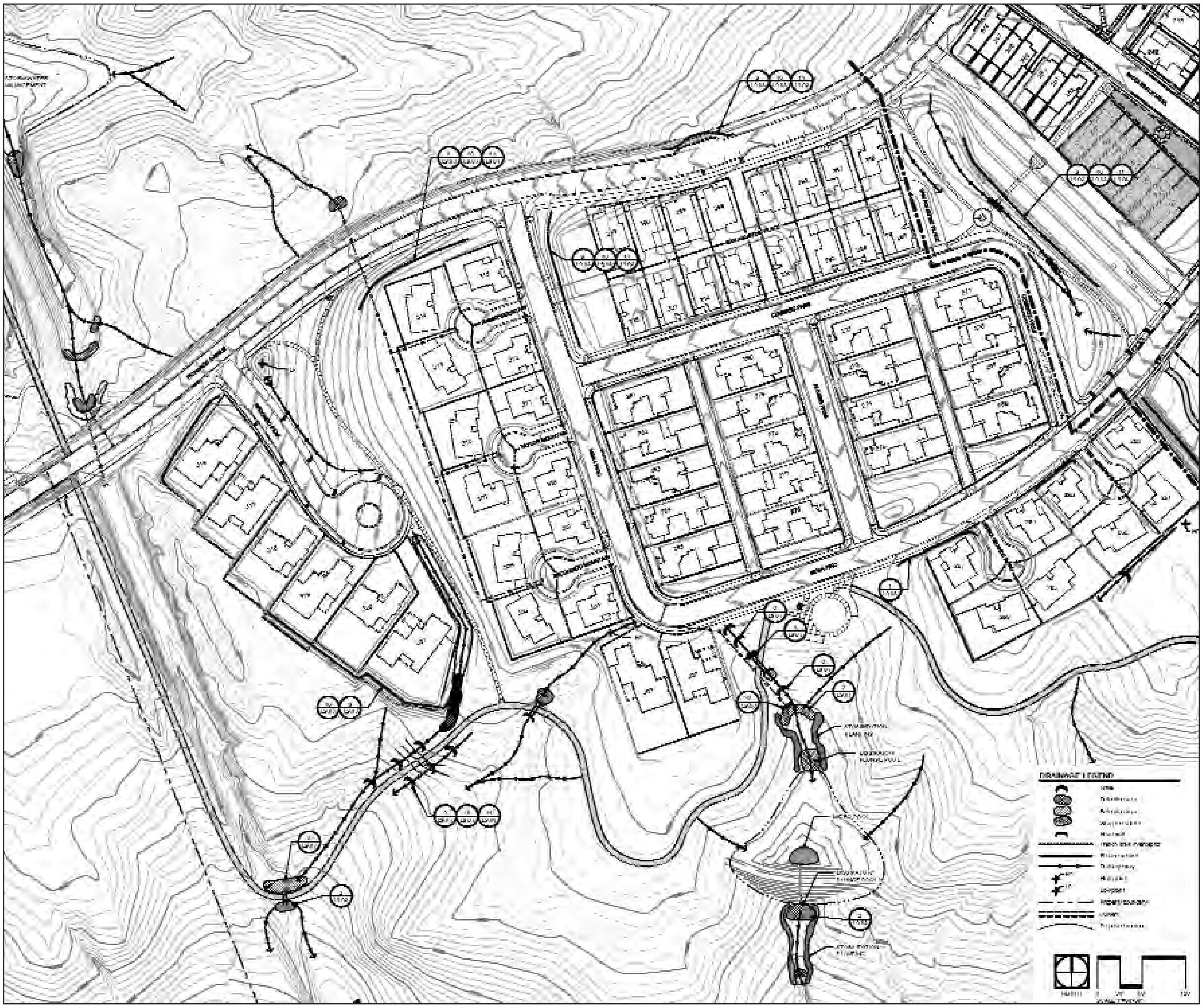
1. Village Master Plan



PRELIMINARY GRADING AND DRAINAGE PLAN
WINDMILL RIDGE UNIT 2

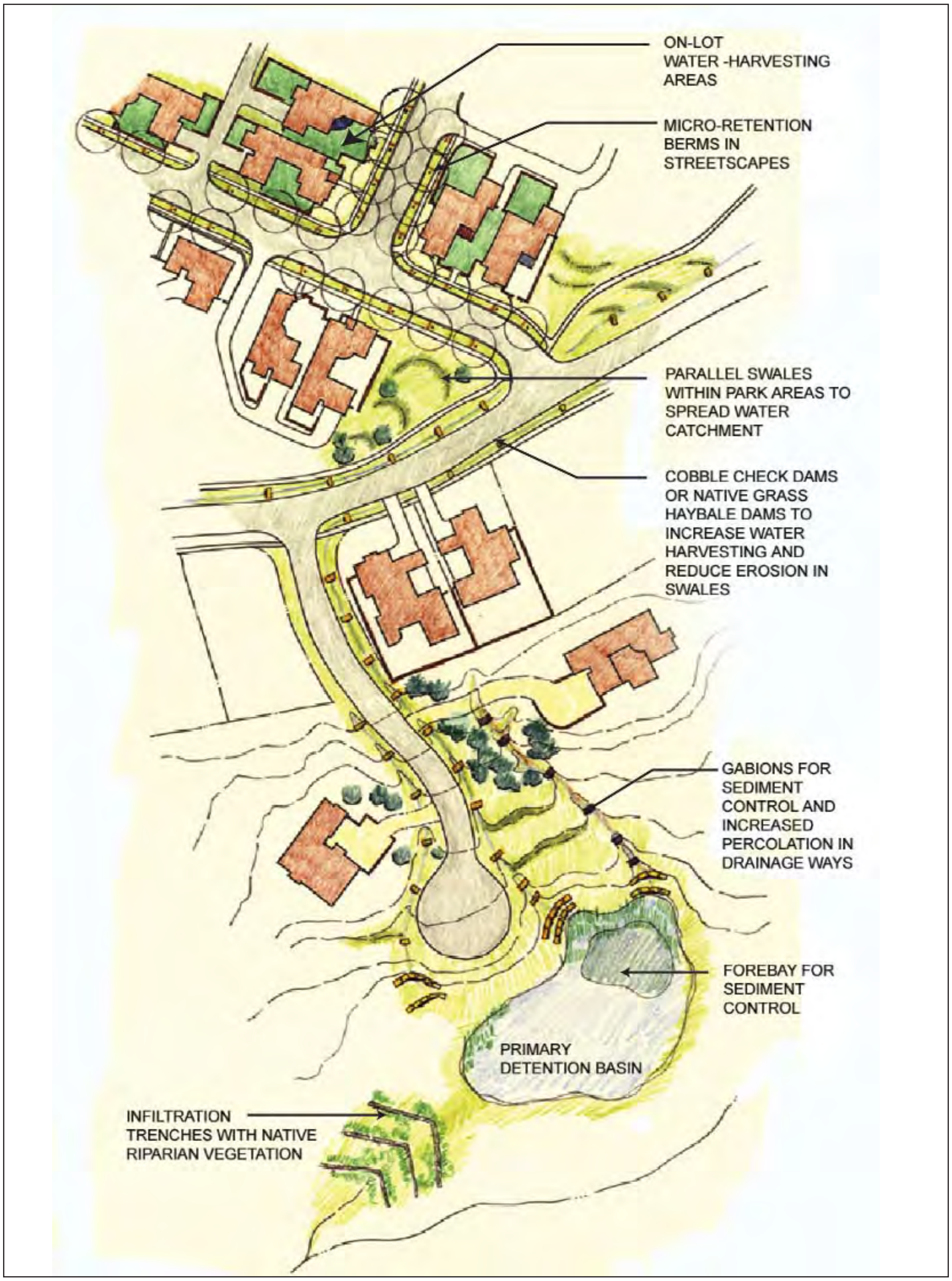
E. SURFACE-WATER MANAGEMENT CHECKLISTS AND DETAILS

1. Village Master Plan



PRELIMINARY GRADING AND DRAINAGE PLAN
WINDMILL RIDGE UNIT II

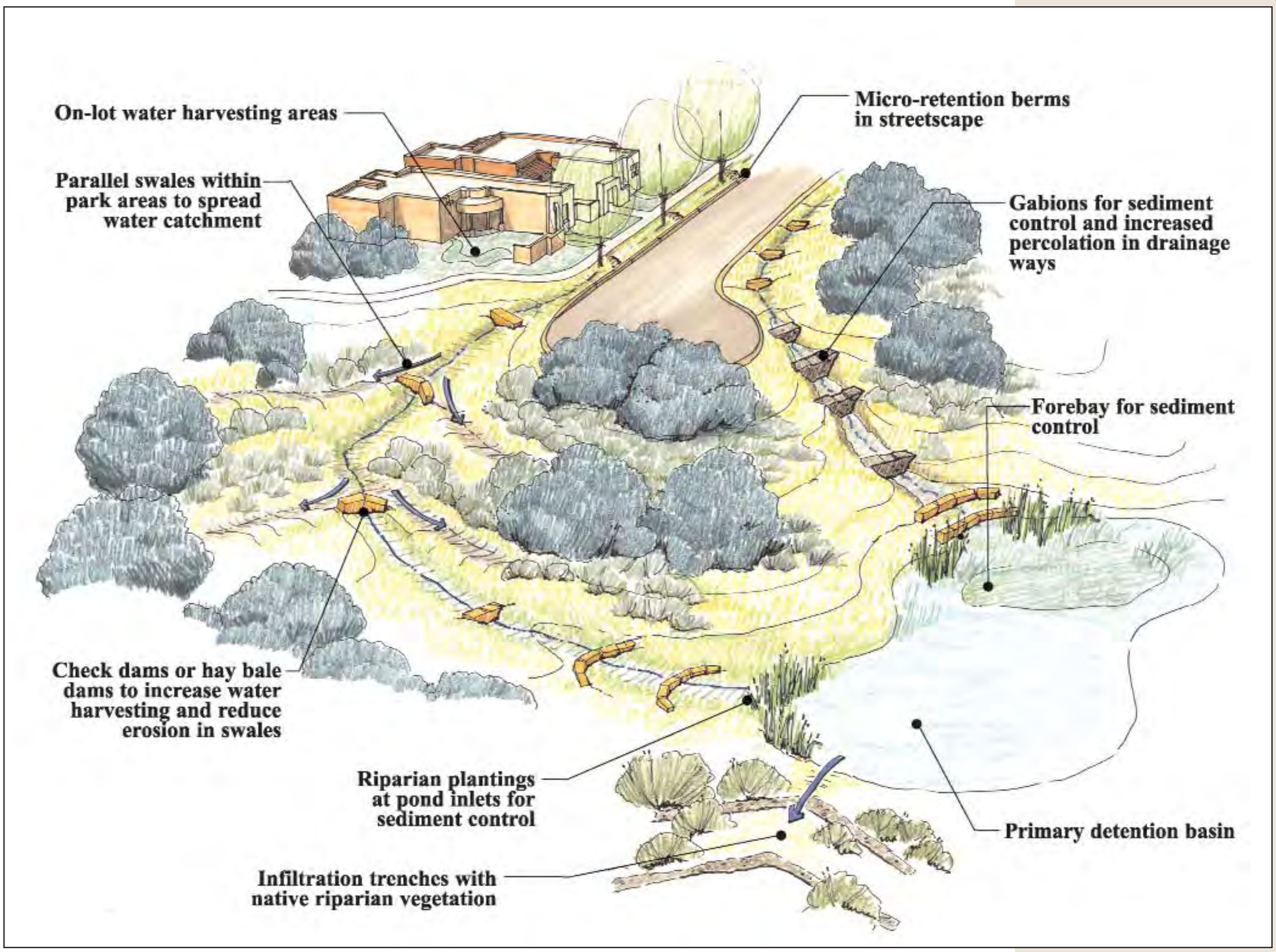
1. Village Master Plan



CONCEPTUAL STORM-WATER MANAGEMENT STRATEGIES

E. SURFACE-WATER MANAGEMENT CHECKLISTS AND DETAILS

2. Architecture



CONCEPT FOR WATER-HARVESTING FROM ROOFTOPS TO OPEN SPACES

E. SURFACE-WATER MANAGEMENT CHECKLIST AND DETAILS

SYMBOLS KEY

MP	Master Plan	**WR**	Windmill Ridge	**RV**	Rancho Viejo
SD	Schematic Design	**Y**	Yes	**SWM**	Surface-Water Management
DD	Design Development	**N**	No	**HOA**	Homeowners Association
CD	Construction Docume	**DW**	Design Workshop, Inc.	**NPDES**	National Pollutant Discharge Elimination Systems

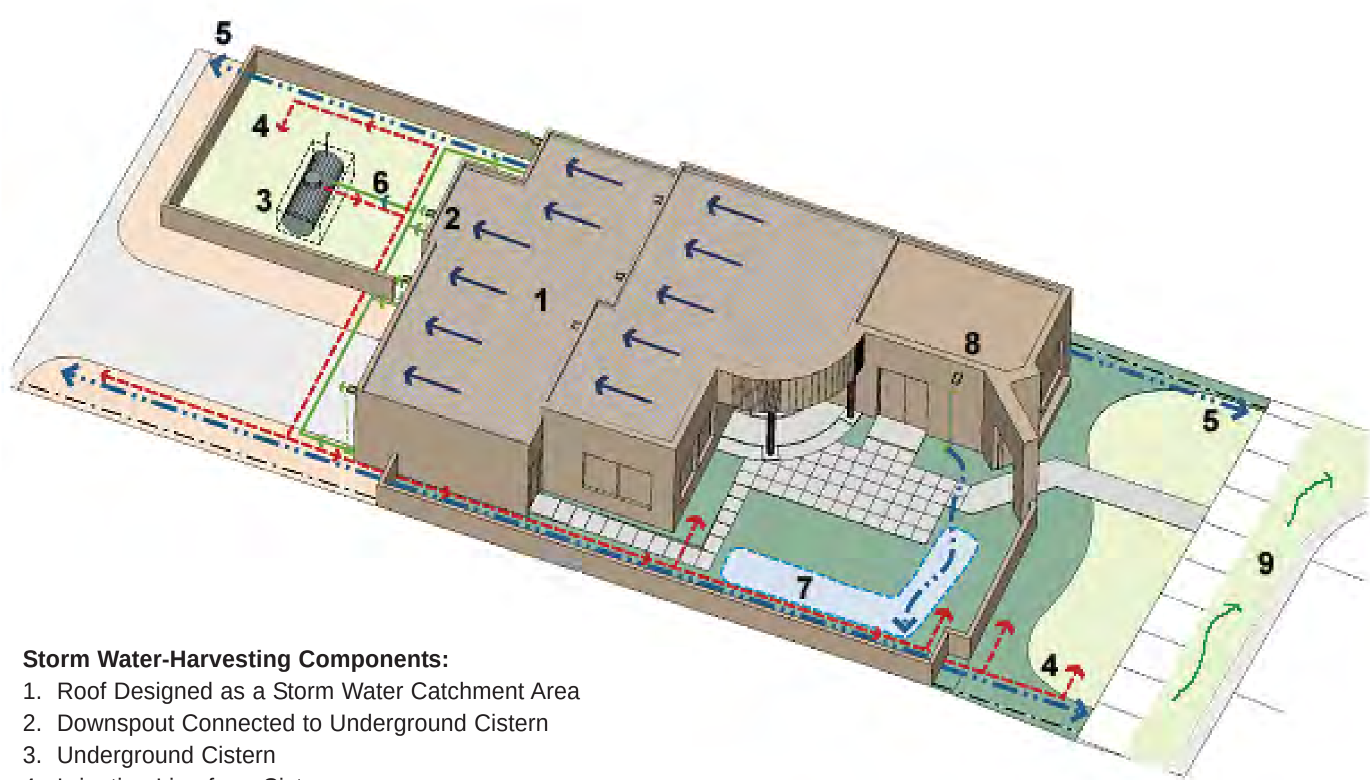
SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
2.0 Architecture		**Designed**			**Implemented**	**RV Comments**	**Future Changes to Implement**
2.1 Roof Designs		**Plans**	**Details**	**Specs**			
2.1.1 Roof Designs							
	Roofs of all new buildings constructed are designed to maximize water catchment for reuse.	**SD**	**Y**	**N**	**Some Housing Products**	Vista series models are currently the only roofs constructed to maximize water-harvesting capabilities. RV is expecting an update of all roof designs to allow for catchment on at least half (backyard) of the roof surface. Spray Foam roofing materials are currently used on all residential roofs, which is not as effective in collecting water as metal roofing.	DW and RV to review new architecture to look for ways to maximize water catchment systems in the future. RV to provide drawings to DW in January 2003 for review. See Comments in Section 2.1.2 for new roof material recommendations.
	Roofs of all new building constructed are designed to avoid undesirable trapping of water and subsequent leaks.	**CD**	**Y**	**Y**	**Y**	Effective roof systems are currently being designed on all new building constructed by the architect.	DW or cistern contractor to review the roof designs and coordinate with potential cistern design and provide recommendations for future modifications to roofing to improve water catchment capabilities.
	Roof design is coordinated with the canale or downspout locations to avoid interference with walkways, drives, patio, utility and yard wall locations.	**SD**	**Y**	**Y**	**Y - In Most New Locations**	Needs better coordination, but it has gotten much better in the WR development area.	Prior to construction, RV and DW to review architectural drawings as they relate to the actual site conditions.
2.1.2 Construction Materials							
	All new pitched roofs are designed with unpainted metal roofing consisting of smooth, non-porous systems (reduces filtering needs) or metal coated with zinc and aluminum.	**CD**	**Y**	**Y**	**On Commercial and Support Buildings Only**	Light- to medium-colored metal roofing is currently the standard on support buildings; the majority of the rooftops are a spray foam material manufactured by BASF, with an acrylic or silicone coating that dries into a hard plastic that is inert, which after time, can flake off but can be filtered out.	Need to continue researching the potential impact the foam roofing has on the filtration system of the cisterns over time. Some problems due to the high UV rays that may cause the spray foam surface to produce fine flakes. The manufacturer and other cistern consultants have indicated that the proposed filters on the cistern system will catch any sediment from the roof material. RV to continue to review other comparable products available in the future. Need to consider the efficiency of water catchment, maintenance and cost implications of the spray foam in comparison to metal roofing in future designs of all residential, commercial or office buildings. Look for more opportunities to utilize the appropriate metal roofing to maximize the quality and quantity of water collected from the roof systems.
2.1.3 Maintenance							
	Downspouts and canales are sealed and checked regularly for leaks.	**N/A**	**Y**	**Y**	**Y**	Information located on architectural drawings. This has not been a problem in the WR development area and RV believes the problems have been resolved.	None
2.2 Roof Drains (Distribution Systems)		**Plans**	**Details**	**Specs**			
2.2.1 Canale Design							
	Canales that serve an aesthetic purpose only are designed as false canales that only handle overflow or first flushes. These canales are designed in tandem with a downspout system that is enclosed in the wall or surface-mounted.	**SD**	**Y**	**Y**	**Y - In Most New Locations**	Coordination of installation locations has improved considerably in the WR development area but may still have room for improvement. RV's review of the existing canale design indicates that this is not currently a problem.	Review drawings and existing conditions to confirm that canales are located away from areas where potential icing from run off or freezing will create safety issues. Ideally they should be located on the south side of the structures. Continue to review alternate canale and downspout design as material technologies improve.
	Where functioning canales are installed, they are designed of sturdy materials to handle heavy rains and the weight of ice.	**CD**	**Y**	**Y**	**Y**	Canales are being better designed in WR. So far few problems have occurred but new systems recently installed need to be monitored through the winter of 2003.	Continue to monitor and look for better materials and approaches as technology improves.
	Where canales are used, appropriate surface drainage systems are installed to mitigate erosion and footing damage (e.g., splash block, french drains, and cistern barrels).	**CD**	**Y**	**Y**	**Y**	Canales are only being used on the fronts of the building. French drains have been found to be ineffective in WR where there is a higher clay content and water cannot effectively drain away from the structure footings. In those situations, large cobble splash block areas have been installed.	Continue to monitor and look for better materials and approaches as technology improves.

E. SURFACE-WATER MANAGEMENT CHECKLIST AND DETAILS

SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
2.0. Architecture - continued		Designed			Implemented	RV Comments	Future Changes to Implement
2.2 Roof Drains		Plans	Details	Specs			
2.2.2 Downspout Design							
	Gutter design: 6-inch, half-round, seamless aluminum gutters attached to 5-inch downspouts installed on all new building construction.	N	N	N	N	Not currently used on site. The roofs drain directly into the downspouts. Downspouts, as noted below, are specified at 3-inch x 4-inch.	If gutters are needed they should meet this standard. Work with RV to price the upgraded gutter system (5-inch x 5-inch) and consider for all new home construction. Work for consistency of materials and sizes on all new construction.
	Roof is properly sealed around the downspout to prevent leakage, especially with encased downspout systems.	Y	Y	Y	Y	No longer considered an issue anymore on-site by RV, as problems appear to have been resolved.	None
	Open and directly connected downspouts: Downspouts are connected to the surface of the structure and directly to cistern systems with 5-inch Schedule 40 PVC pipe (Not plastic sewer pipe).	SD	Y	Y	N	Current designs will be implemented in WR Unit 3 and in test areas in the Village of Rancho Viejo.	Continue to monitor and upgrade as better products become more available and/or more affordable.
	Encased and directly connected downspouts: Water is directed into metal downspouts connected directly into underground infiltration or catchment systems for reuse.	Y	Y	Y	Some Places	Encased downspouts were only used in the Village I area. A variety of downspouts are being used on site and are selected mostly for aesthetic as well as functional purposes. RV has indicated that all new construction will be designed with the downspouts integral to the architecture.	Continue to review alternate materials that will enhance the quality of the water and ability to capture rain-water for reuse on-site.
	Open downspout system: Water is directed into metal downspouts that open at the surface of the ground and release run off into surface-water management systems.	Y	Y	Y	Some Places	These are now planned to be used only on the front sides of the residences. On the back sides, the canales will direct water into the catchment systems.	Wherever possible, design all roofs to trap water into effective catchment systems.
	Downspouts are located away from walkways, patios, driveways, areas where water could be trapped against the building or other structural footings.	SD	Y	Y	Some Places	The downspouts still need better coordination by RV on-site.	Need to ensure this is implemented in all future buildings.
	Downspouts are designed to avoid debris buildup and handle large volumes of water:						
	First-flush systems installed on roof where gutter is connected to downspouts.	N	N	N	N	First-flush systems have not been installed, only holes in the canales and gutters have been provided for this purpose.	Investigate potential first-flush systems that may be needed should a cistern system be installed.
	Wherever possible, downspouts are located every 40 feet (20 feet on center is best) along the gutter to ensure handling of heavy rains and conveyance to the catchment systems.	Y	Y	N	Some Places	Locations are currently based on the relationship to the site design (i.e., walkway, drive, and patio locations).	DW to assist with evaluation of the new roof catchment system plans to ensure that they can effectively handle the storm water. Implement wherever possible. Design roofs to accommodate this option.
	Changes in downspout direction are minimized to reduce clogging of pipes.	Y	N	Y	Most Places	In most cases this is being addressed. There appear to be some problems at locations where downspouts have been re-routed to avoid draining onto paving areas.	Monitor on a regular basis especially during winter and rainy season to see if there are potential problems. Upgrade/resolve problem areas.
	Horizontal pipe runs do not exceed 45 degrees.	Y	N	Y	Most Places	Structures still need to be more carefully reviewed for those that do not meet the recommended design criteria, as long-term maintenance problem may occur if not redesigned.	Monitor on a regular basis. Upgrade/resolve problem areas.
	Downspouts are sized to provide 1 square inch of cross-section area for every 100 square inches of roof that they serve. Minimum installed size of downspouts is 5 inches. (5 inch x 5 inch downspout can safely handle 2500 square feet of roof area).	N	N	N	N	Currently the downspouts are specified at 3-inch x 4-inch vertical components with a top section of approximately 6-inch width x 8-inch height before the downspout connects to the verticals. In some locations, however, the downspouts have been measured at a 2 1/2-inch x 3-inch size, which does not perform as well as the recommended 5-inch downspouts. For downspouts connected to canales, a 3-inch x 4-inch hole is cut into the bottom of the canale and caulked. The installations seem to be somewhat inconsistent.	Implement the 5-inch downspouts in future construction.
	Downspouts are oversized where needed, to allow debris to be flushed.	N	N	N	Y	Only installed after a need is determined. Currently no oversized downspouts are installed on site.	Monitor on a regular basis. Upgrade/resolve problem areas.
	Leaf strainers and cover screens over gutters are used where they are connected to downspouts.	N	N	N	N	No screens have been installed anywhere on site.	Monitor on a regular basis to determine if there is a need. Often during construction on site, soil particles are blown onto roofs and contribute to the clogging of the drains. Upgrade/resolve problem areas.
	Gap provided between the downspout and where it exits the building and enters the underground system.	CD	Y	Y	Y	Implemented where required, but may possibly be needed in other locations.	Work to eliminate this type of downspout in the future and connect directly to catchment systems such as cisterns, as an integral part of the housing product.
	Cleanouts are provided at the base of downspouts.	N	N	N	N	Currently not provided on any of the downspouts.	If downspouts are connected directly into cisterns or underground catchment systems, this may not be critical. However, if they are not, they should all be equipped with this feature.
2.2.3 Maintenance							
	Gutters, downspouts and pipes are cleaned out regularly.	N/A	N/A	Y	Y	Cleanouts are being provided on most downspout systems. Homeowners are responsible for maintaining as part of the warranty.	The covenants need to be reviewed to make sure that this responsibility is clear to the homeowners.

E. SURFACE-WATER MANAGEMENT CHECKLISTS AND DETAILS

2. Architecture

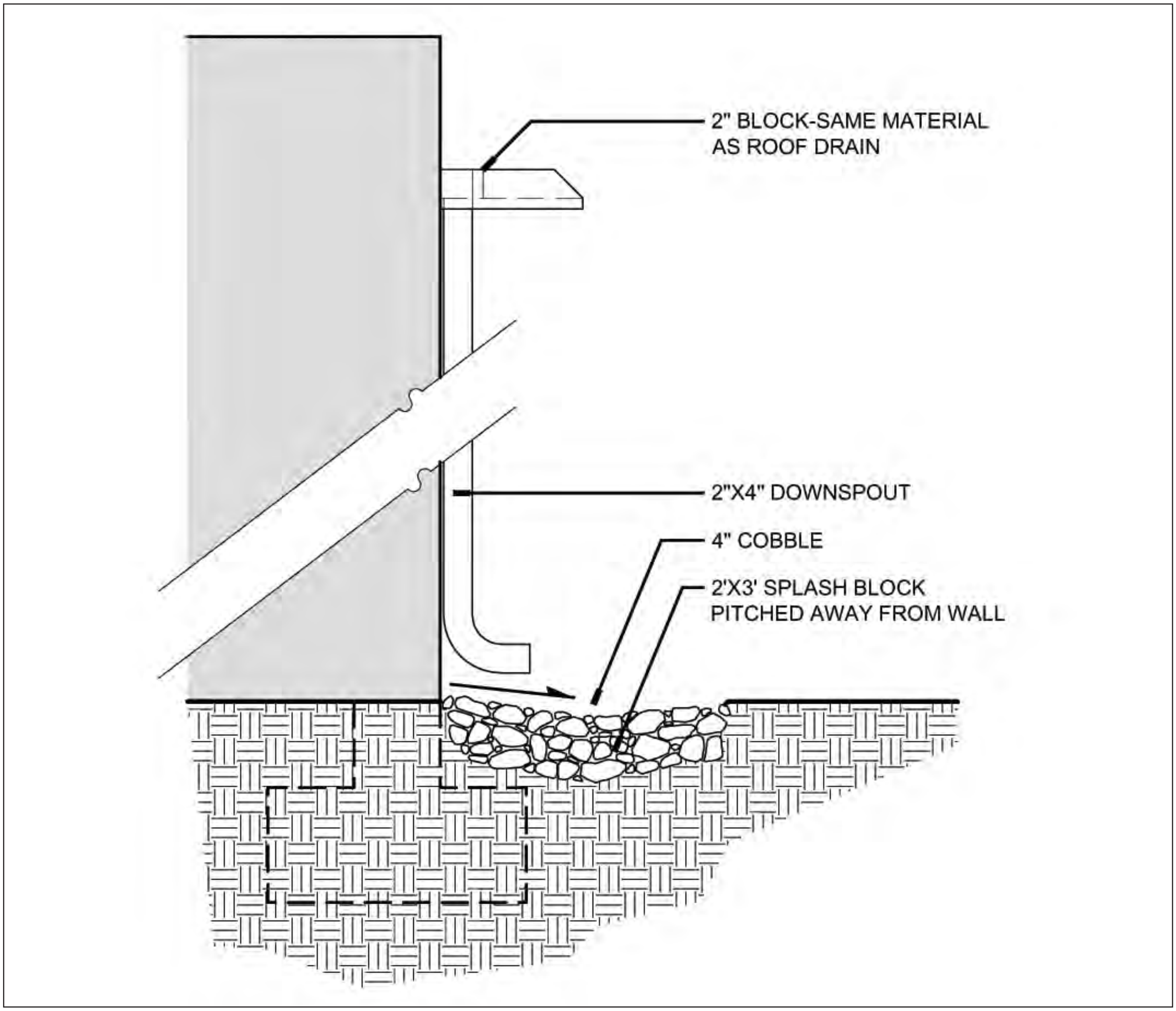


Storm Water-Harvesting Components:

1. Roof Designed as a Storm Water Catchment Area
2. Downspout Connected to Underground Cistern
3. Underground Cistern
4. Irrigation Line from Cistern
5. Lot Drainage Path
6. Roof Drain Pipe Connection to Cistern
7. Yard Water-Harvesting Swale or Catchment System
8. Open Downspout to Swale
9. Parkway Swaled for Water Harvesting

WATER-HARVESTING SYSTEM FOR ON-LOT COURTYARD SERIES
WINDMILL RIDGE UNIT 1

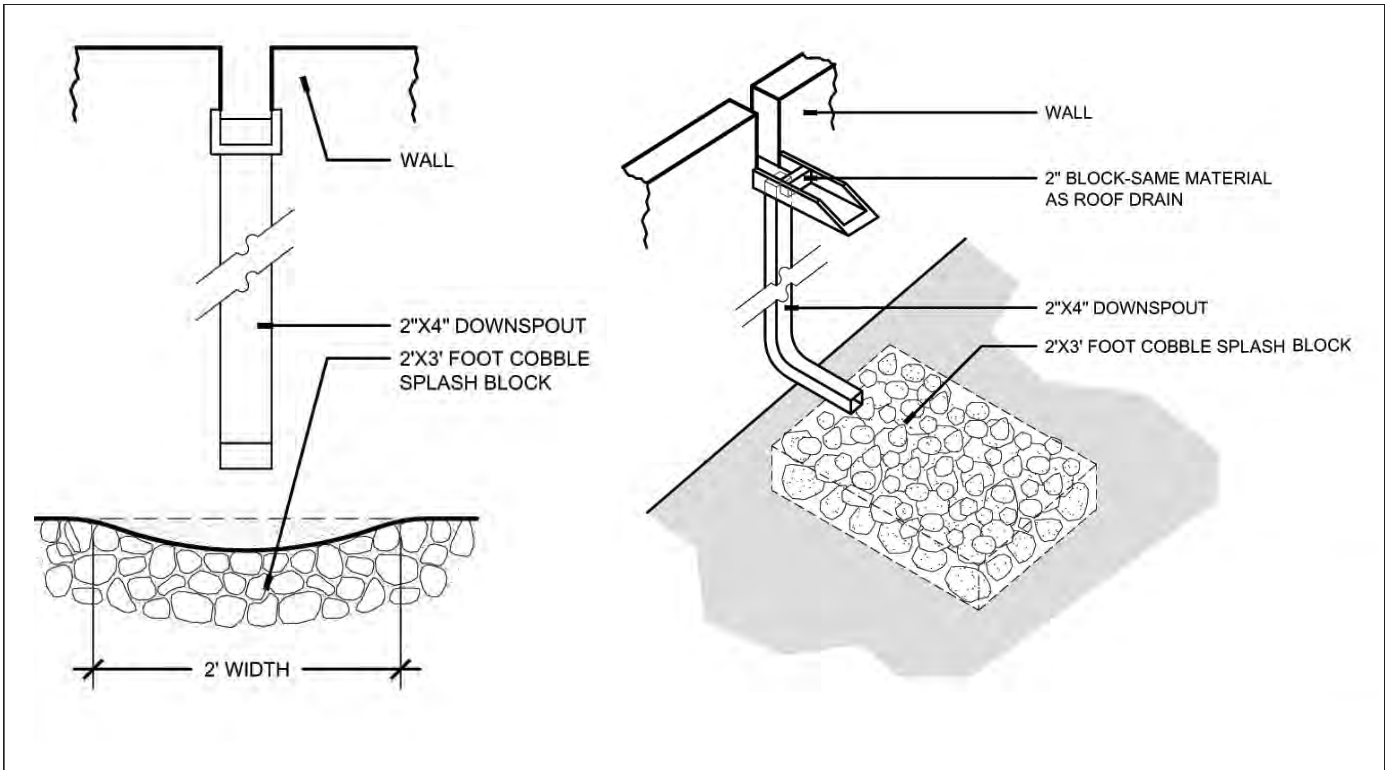
2. Architecture

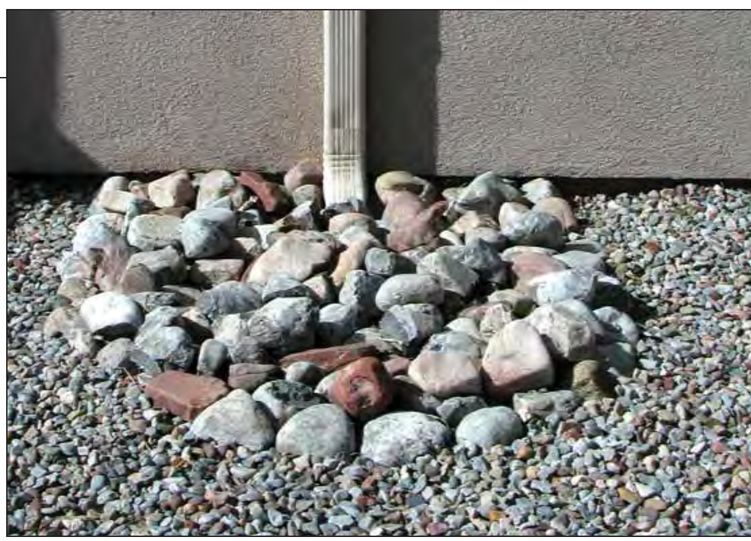


DOWNSPOUT TO COBBLE SPLASH-BLOCK CROSS SECTION
WINDMILL RIDGE SECTION

2. Architecture

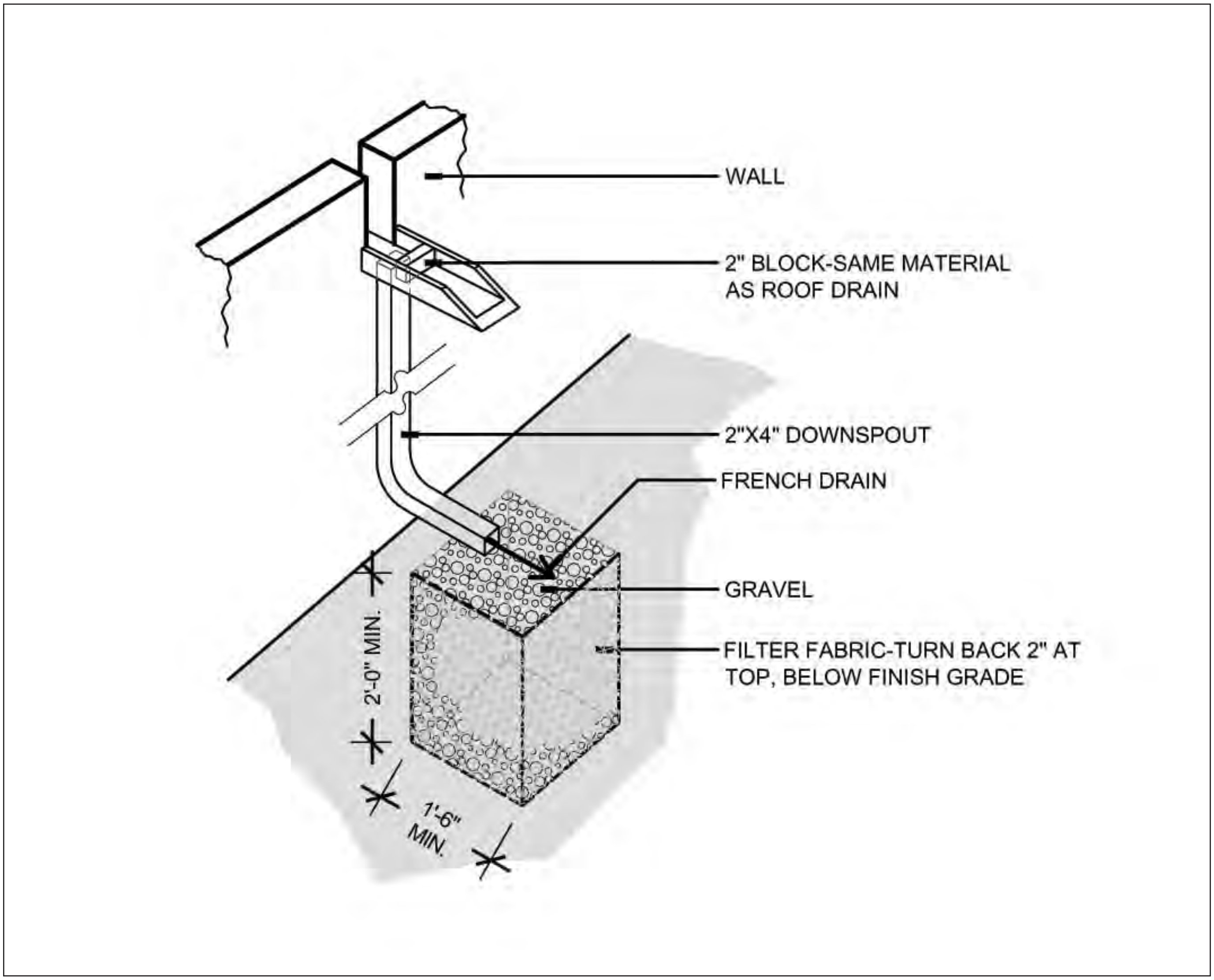
DOWNSPOUT TO COBBLE SPLASH BLOCK
WINDMILL RIDGE - UNIT 1





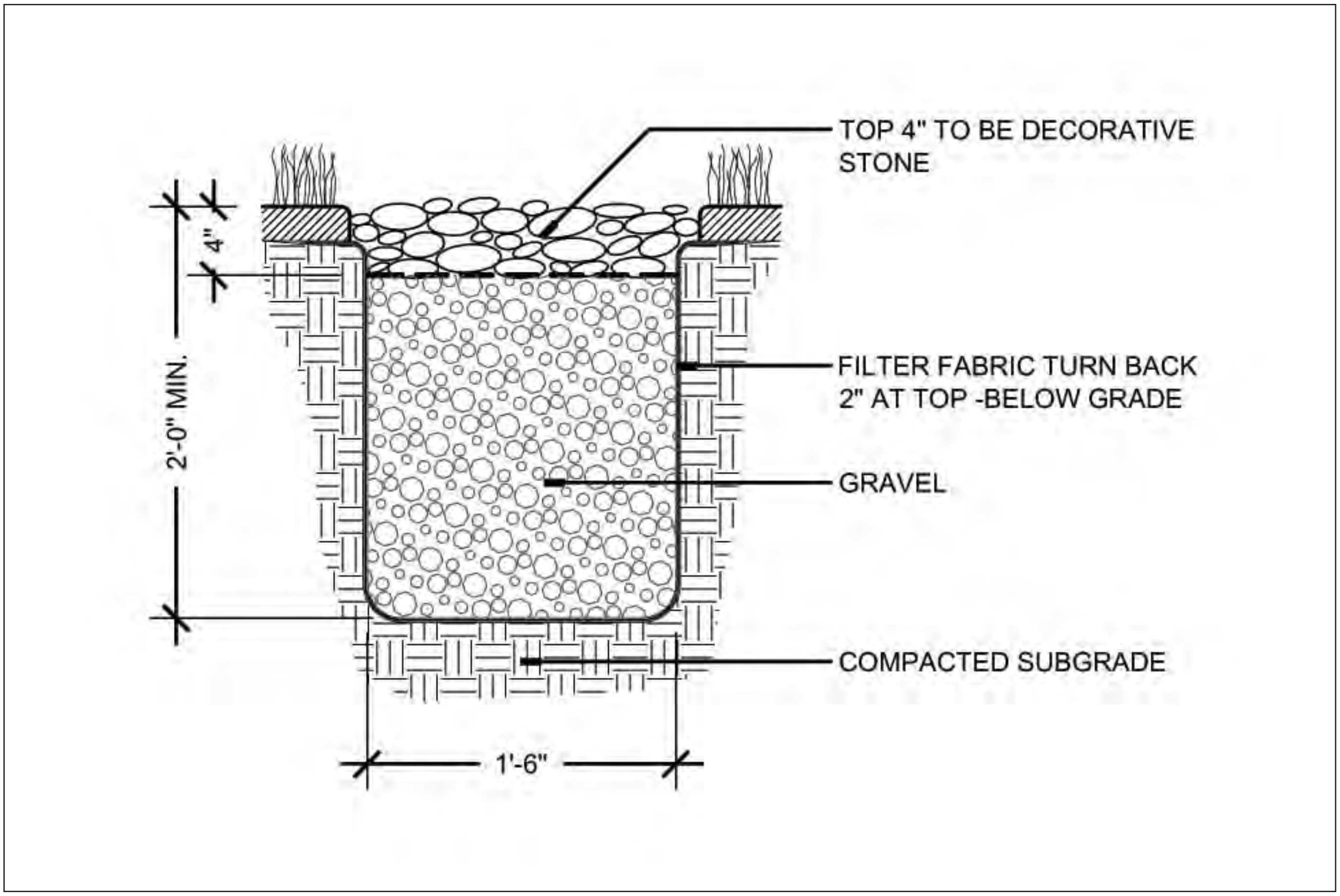
CLOSED DOWNSPOUT TO COBBLE SPLASH BLOCK

2. Architecture



CLOSED DOWNSPOUT TO GRAVEL SUMP
WINDMILL RIDGE

2. Architecture



GRAVEL SUMP DETAIL (FOR WELL-DRAINED SOILS ONLY)
THE VILLAGE AT RANCHO VIEJO

E. SURFACE-WATER MANAGEMENT CHECKLISTS AND DETAILS

3. Lot Design

SYMBOLS KEY

MP	Master Plan	**WR**	Windmill Ridge	**RV**	Rancho Viejo
SD	Schematic Design	**Y**	Yes	**SWM**	Surface-Water Management
DD	Design Development	**N**	No	**HOA**	Homeowners Association
CD	Construction Docume	**DW**	Design Workshop, Inc.	**NPDES**	National Pollutant Discharge Elimination Systems

SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
3.0 Lot Design		**Designed**			**Implemented**	**RV Comments**	**Future Changes to Implement**
3.1 Water Distribution Systems		**Plans**	**Details**	**Specs**			
3.1.1 Natural Catchment System Design							
	Sodded or seeded swales or concave depressions are installed to detain low-intensity storm-water run off and are planted with grass or other plants. As an alternative, stone swales with a variety of stone sizes are used in limited quantities in yard areas where establishing lawn is not feasible at the time of installation.	CD	Y	N	Y - Seeding Only Except at Model Homes	Regrading of the swales is needed to maximize the water-harvesting capabilities. Most swales are seeded with native grasses but many have been filled with stone. Some problems are occurring in specific areas where the grasses are not getting established fast enough to control erosion.	DW to develop specs and details to clearly describe the design of an effective water-harvesting swale (in progress). DW to work with RV and arrange for soil tests to be taken at select locations throughout the site to determine why some grasses are quick to establish and others are not. Investigate slope, aspect, time of year, soil conditions, rainfall or temporary irrigation available, and seed mixes. Where stone catchment areas are to be installed, DW to assist RV with developing examples of visually attractive stone mixes and swale forms that function properly. Some examples can be viewed at the current model homes in WR Unit 1.
	Swales have gently sloping bermed sides and are contoured to hold and infiltrate water for use by plants and lawn areas.	CD	Y	N	N	Gentle side slopes on swales are not currently being constructed even though they are detailed to be. Better cross sections and specifications need to be created, as well as increased field inspections to ensure swales are constructed properly.	DW to create a new gently sloping swale detail and incorporate the detail into the CD packages for the landscape and/or the civil drawings as appropriate.
	Swales are designed to have an overflow and spillway at a point along the depression.	CD	Y	N	Some Locations	Need to review on an individual basis on site. Field verify swales are installed as detailed.	DW to work with RV to identify the best drainage paths on residential lots and to identify the useable spaces to retain and meet homeowners' needs. (In progress — refer to prototypical plans in this section).
	Hay bales buried down-slope of trees to trap water for use by plants.	CD	Y	N	N	Implemented in open space areas of lots.	DW has developed a detail for grassed swale and hay bale riffle outside of the weep holes of the yard walls. See Section 4.2.1 Comments on open-space design. DW has also created an additional detail and criteria for installing hay bale boomerangs upslope of tree plantings to better drive water into the ground and make it available to the plant materials, especially when the slopes cannot be planted due to drought restrictions imposed by the County of Santa Fe.
3.1.2 Natural Water Distribution Design - Ground Storage Systems							
	Sites are graded to drain away from building or structure footings at a minimum of 1 percent (minimum of 2 percent preferred in lawn or plant beds).	Y	N	N	Most Locations	The site is graded with a 4-inch drop of grade from the homes' exterior stucco finish to the finished grade at the building perimeter. Grading and drainage are designed to slope away from the home and surrounding walls. This slope must be maintained to keep storm water from standing next to the structures and impacting the integrity of the footings. RV provides the homeowners with written and verbal cautions about changing the finished grading on site. This will ensure that storm water is not allowed to accumulate or stand next to the building or yard wall foundations.	DW to coordinate with RV to determine if there is an opportunity to review residential lot grading plans (if they exist) to confirm that water-harvesting capabilities are maximized and structures are protected (in progress).
	Sites are graded to prevent storm water from draining from open-space areas or individual residential lots onto other lots.	CD	Y	Y	Y	Improved grading in the WR area. Pads are no longer set below the adjacent grades without proper drainageways.	DW to coordinate with RV to determine if there is an opportunity to review or assist with lot grading plans to improve on the drainageway systems (in progress - refer to prototypical plans in this section of the manual).
	Lawns and walkways are sloped towards ground storage and/or plant beds.	CD	Y	Y	Y	Implemented where possible.	DW is coordinating with RV to review and/or assist with the residential lot grading plans to work to improve on the on-lot drainage patterns (in progress - refer to prototypical plans in this section).
	Natural Water Distribution Systems						
	Where appropriate, channels, ditches and swales are seeded or sodded with native grasses to stabilize soils and allow water to infiltrate into the subsoil.	CD	Y	Y	Y	Success in establishing seeded drainageways is sometimes achieved by grading the swale side slopes at 1 to 2 percent, mainly in open spaces. Drought was a barrier to successful germination in many locations in 2001 and 2002.	DW to work with contractor to determine what mix or soil conditions may be required to improve our success with this installation. Field verify that check dams and other soil erosion methods are installed prior to seeding. Soil amendment options are being tested by Tall Grass Restoration, for better seed coverage and established during all times and especially during drought, in areas of high visibility and highly erodible areas.

SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
3.0 Lot Design - continued		Designed			Implemented	RV Comments	Future Changes to Implement
3.1 Water Distribution Systems		Plans	Details	Specs			
3.1.2 Natural Water Distribution Design - Ground Storage Systems - continued							
	Storm water dissipation systems (stone drainageways, riffles, etc.) are installed to slow concentrated water, reduce erosion and allow water to filtrate into the soils.	CD	Y	Y	Y	Stone materials should be selected with a mix of stone	DW has identified potential sources for tan or rose-colored stone (avoid grey stones) that is locally available. DW is currently working with RV to evaluate pricing to determine if stockpiling of stone resources is more cost-effective and allows for higher consistency in color and size of stone. See Appendix H for stone product information and recommendations.
	Use of impervious paving is minimized and designed to capture storm water for groundwater recharge and/or reuse on site.	N	N	N	N	Parking areas are minimized to keep down the amount of impervious paving on-site. Gravel is a problem as it migrates onto other paving areas causing potential hazards to pedestrians and is messy in appearance. Currently asphalt is the most cost-effective.	DW is researching alternate paving materials such as the compacted crushed stone surface used at the G. R. Peters Gallery, which has a catchment system below (completed). DW has also created an updated detail and spec for this system that could be applied to future commercial and office developments on-site.
3.1.3 Manufactured Water Distribution Systems							
	Underground infiltration systems are used to store and infiltrate storm water into underground chambers.	SD	Y	Y	Y (In Select Locations)	Designed by Ingenuity, Inc. Used in Village I and WR Unit I Model Homes. Have not worked well in WR due to high clay content. This creates a water lens that prevents water from filtering into the subsoil. This system should only be used when no other system is possible and soils are appropriate.	None
3.1.4 Cistern System Design							
	Cistern option available for all housing product types.	SD	Y	N	N	Cisterns systems were not currently installed on-site when this survey was completed, however, RV is in the process of testing out 1-3 cistern systems in the Village I area.	In February 2003, Rancho Viejo announced that as of March 2003, Rancho Viejo will be building all of their new homes with rainwater-harvesting systems. The rainwater systems are intended to cut down on the additional demand that landscaping of new home construction would put on the area's water resources. Currently the plan is to only catch the water off of the back side of the buildings. The remainder of the roof water will be released through canales or downspouts.
	Cistern Design:						
	All pipe sections connected with watertight and cemented joints.	SD	Y	N	N	New architectural details will meet these requirements.	None
	Pipe systems and connections installed at an average of .25-inches per foot and a minimum slope of 5-inches per 100-feet of run.	SD	Y	N	N	New architectural details will meet these requirements.	None
	Roof washer - Filtering systems are installed for water to be used for purposes other than irrigation.	N	N	N	N	Filters have not been used to date as there are no cisterns fully constructed on site as of May 2003.	Implement in future as cisterns are installed if the system selected requires one.
	First-flush systems are installed on roofs of new construction.	N	N	N	N	See Section 2.2.2 comments.	Arrange for systems to be installed if research indicates they are needed to protect the cistern water quality to a higher level.
3.1.5 Maintenance and Monitoring							
	Water audits are conducted on at least two (2) of each residential product and all commercial or office irrigation systems each year.	N/A	N/A	N	N	This is needed for both lots that have seeded lawns and planting beds and those that have graveled yards with some shrub plantings.	DW recommended a contractor to perform water audits (completed). It is recommended that two (2) water audits be conducted for randomly selected homes in each residential product type, each year to determine the effectiveness of the systems and to identify areas in which we can improve the system in the future. Homes selected will have lawn areas that are currently irrigated with spray heads.
	Schedule cleanouts of underground infiltration systems for the first year after installation and every three years following the first year.	N/A	N/A	Y	N	Cleanout is covered in the Landscape Maintenance Guidelines. This will eventually be the responsibility of the homeowners.	Update the covenants and information provided to the homeowners to make sure they understand this requirement as the systems are implemented.

SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
3.0 Lot Design - continued		Designed			Implemented	RV Comments	Future Changes to Implement
3.2 Lot Design Strategies: Planting, Irrigation and Hardscape		Plans	Details	Specs			
3.2.1 Planting Design							
	Native and low water-use plant materials are used throughout the site. Plant materials are selected for their deep rooting characteristics, which promote deeper saturation, rooting and greater ability to withstand drought.	CD	Y	Y	Y	Currently occurring on a regular basis as part of DW's landscape construction documents.	Continue to improve plant selection and installation based on on-site performance.
	Plants with similar water requirements are grouped together and irrigated by need for water (very low, low, medium, and high water use).	CD	Y	Y	Y	Currently occurring on a regular basis as part of DW's landscape construction documents.	Continue to consistently consider the location of the plant materials in designs to assist with cooling of the structures and parking lots in order to reduce the energy consumed to cool these site elements.
	Plant materials are designed and installed to shade drainageways and swales in order to reduce water loss through evaporation.	CD	Y	Y	Y	May be included in the lot landscape designs now prepared by DW.	This should be consistently considered in the design work.
	Plant material is grown locally to reduce energy consumption through transportation (fuel consumption and pollution) and improves the plants' chances for acclimation to the site conditions.	N	N/A	N	Y to Some Degree	Many of the native plants are purchased within a 100-mile radius. Most of the non-native plants and some trees are coming from out-of-state based on availability. Limiting the sources may reduce our opportunities to purchase the plants requested at a competitive price. In addition, many of our contractors purchase their plants from re-wholesalers when the time frames for completion are short. Most plants from re-wholesalers come from out-of-state.	DW to review the plant sources of the contractor awarded the work and work with them to find sources closer to the project site and still within the project budget.
	Soil additives or amendments are installed during plant bed soil preparation to improve water retention and availability to plant materials.	CD	Y	Y	Y	Organic Technology Additives are currently specified to help with water availability to plants.	DW to discuss with the landscape contractor how they are installing the products and determine if the installation methods should be modified to improve performance.
	Mulching materials and water-harvesting techniques are used to prevent water loss through evaporation.	CD	Y	Y	Y	With water restrictions seeding of parkway has not occurred. Trees need more shading of root systems to reduce evaporation of water.	DW has developed a new detail that incorporates a hay bale uphill from the rootballs to drive the water into the ground. Incorporate mulch over the rootball area to reduce moisture evaporation, especially when seeding of the parkway is delayed due to drought.
	Metal edging: Openings are left in the plant bed's metal edging to allow excess water from heavy rains to move out of plant beds and freely into the detention areas.	N	N	N/A	N	Problem occurs where the edging is located under open canales or in drainageways.	DW has developed a modified detail that specifies how to address problem areas such as these through cutting out sections of the edging or where it can be eliminated without creating maintenance problems.
	Alternative lawn materials are available to homeowners that do not increase maintenance, contribute to conserving water and reduce reflective heat build-up.	SD	Y	Y	Y	Gravel option is now available but is not preferred by the homeowners. This solutions is a good alternative when water restrictions will not allow seeding of the lots. Extended exposure to storm water run off can severely erode topsoil and create unsightly landscapes. The stone mulch, even when temporary, helps stabilize the soils and reduce evaporation.	Look for a stone material that is more tan or rose in color, not grey. DW to assist with finding potential stone sources. See Section 3.1.2.
	Homeowner covenants clearly identify what planting is required of the homeowners and when it must be completed, to reduce potential erosion from wind and water.	N/A	N/A	N/A	Y to Some Degree	This issue mainly has to do with how long a time frame the homeowners have to either establish lawn or finish off the treatment of their lots to reduce topsoil erosion and unsightly landscapes.	RV needs to review and evaluate the covenant documents to be certain they are clear and complete. RV to establish a means in which to ensure that these requirements are enforced. See appendix for copy of current homeowner covenants.
3.2.2 Irrigation Design							
	Water sensors installed as part of the irrigation system.	N	N	N	N	RV has indicated that this is a desirable step to take.	DW to look into new reliable sensor systems that may be applied in a variety of site situations; on-lots, open space (permanently irrigated areas).
	Temporary or permanent irrigation systems are used to establish seeded lawn areas.	CD	Y	N	Y	Temporary irrigation systems have not been found to be cost effective.	Continue to utilize permanent systems, but evaluate temporary systems in the future to determine if new technology has resulted in a more cost-effective temporary system.
	Drip Irrigation systems are installed for tree, shrub and perennial plantings.	CD	Y	Y	Y	This is a county and city requirement for water conservation.	None
	Where bubblers are used, basins are installed level to the finish grade and extend beyond the edge of the canopy to retain water around the tree rootballs where it is most needed.	CD	Y	Y	Y	Basins extend only around 3- to -4 feet to the edge of canopy of large trees. For transplanted piñons, basins are extended to canopy edge.	Modify the planting details to extend basins beyond the canopy and indicate on plans where these details are to be implemented.
	All plantings are on zoned irrigation systems to allow for reduction or shutting off of specific zones where plants have become established and only require irrigation during severe drought situations.	CD	Y	Y	Y	Village I has been cutting back on water to plants as specified. Most of the landscape areas, except the park, will be taken off the automatic watering system this year. Windmill Ridge should begin reducing water to its older landscapes this year.	May need to monitor more closely to insure that the plant irrigation is being reduced to wean the plants off of the water system entirely within a three- to five-year period.
	Homeowners are provided with irrigation system maintenance guidelines for efficient water-conserving techniques and water sensors.	N/A	N/A	Y	Y	Homeowners Association (HOA) and the landscape contractor provide a manual and briefly train the homeowners on how to use the irrigation system and to be water wise.	

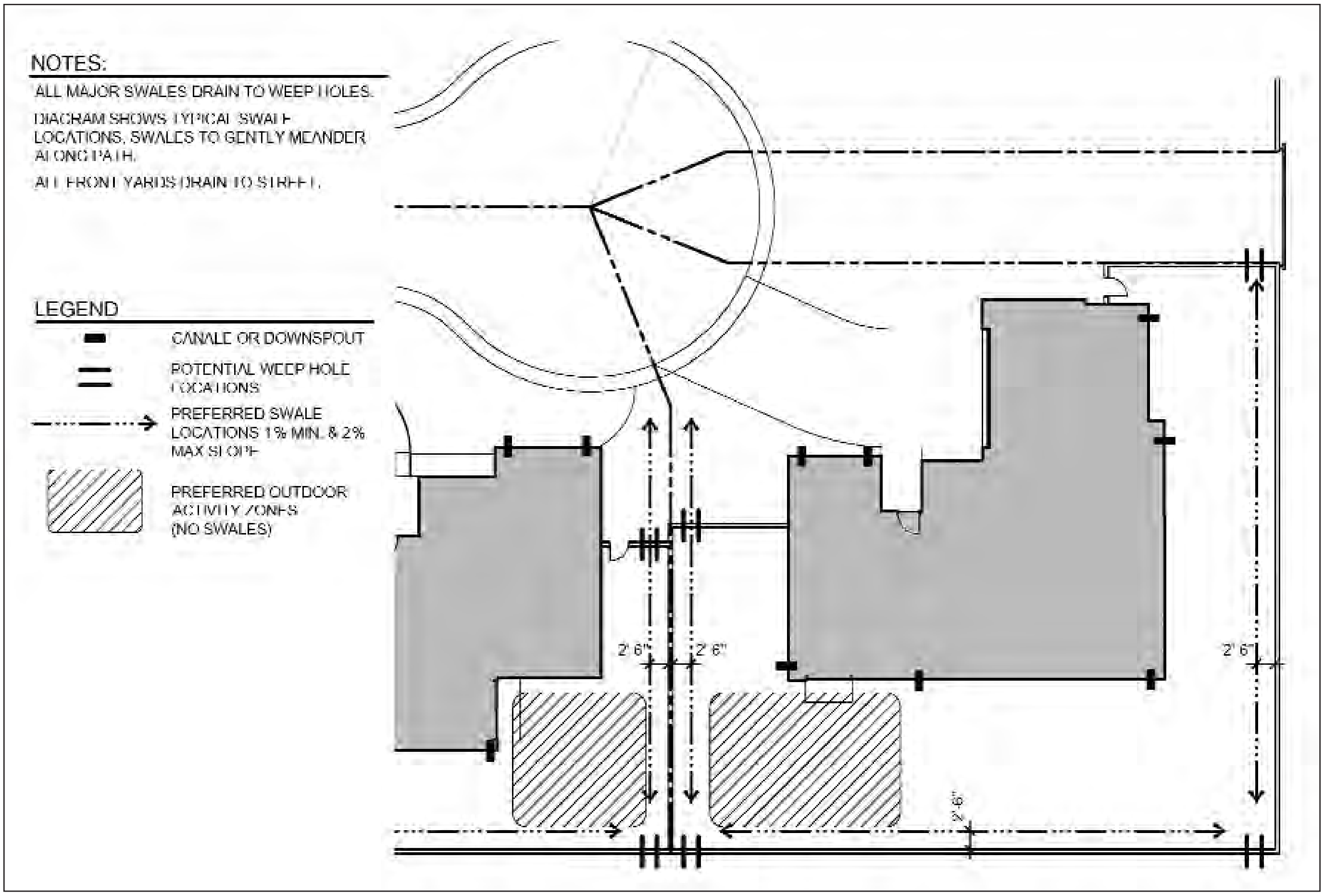
E. SURFACE-WATER MANAGEMENT CHECKLIST AND DETAILS

SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
3.0 Lot Design - continued		Designed			Implemented	RV Comments	Future Changes to Implement
3.2 Lot Design Strategies: Planting, Irrigation and Hardscape - cont.		Plans	Details	Specs			
3.2.3 Hardscape Design							
	Water Audits: Design and budget as part of the development process along with specifications for installation of the sensors.	N	N	N	N	This has not occurred to date, but RV has indicated that this is a desirable step to take. See Section 3.1.5 for additional comments.	See Section 1.1 for comments and recommendations
	Pervious (gravel, crushed stone, open-jointed) paving is used wherever possible to allow rainwater to infiltrate into ground water or planting beds.	CD	Y	Y	Y	Implemented in some on-lot yards. Paved drives can lead to drainage problems to the front of the conservation lots in particular. Estate lots: It is up to the homeowners to use asphalt or any other surface they want.	Grates may also be an appropriate solution to consider and make available as an option to the estate and conservation lot owners.
	Curb cuts are installed to allow for collection water off of paved areas in parking lots and roadways to direct water to plantings.	N	Y	N	Y - In Some Locations	Choose the appropriate solution by location, adjacent grade, etc. The alternate is a drop structure and pipe, but this can only occur where certain adjacent grades allow it to function properly.	DW to work directly with the civil engineer and RV to identify the appropriate locations for curbs to maximize water-harvesting capabilities and to reduce storm water piped to the detention ponds or county storm water systems, as the regulations permit.
	Concrete or stone patios and walkways are installed to provide positive drainage away from all structures.	Y	Y	Y	Y	Positive drainage away from structures is specified in general on the civil engineering. However, implementation on individual sites varies greatly.	DW to work with RV to prepare typical drainage patterns for lots that address this issue. Monitor installations closely and remedy problems as needed to meet this requirement.
	Weep holes in walls have been installed at appropriate locations and spacing to allow for water movement off lot when water must drain into open spaces.	Y	Y	Y	Y	Weep holes are properly installed based on the finished grade at the time. Homeowners often change the grades on their lots which leads to drainage problems on and off the lots. Unit 2 WR walls were built prior to the construction of the home. A decorative drain block will be installed and the yard will be graded to the weep holes in future construction.	Need to review covenants and other documents to make sure that the owner signs off on the grading approach for their entire lot. Weep holes in walls to be placed 6-inches above the finished grade on the lot side of the wall. On the on-lot side, the homeowner can change the grade so the best option is to punch in the weep holes using an open block after the finish grade on the interior is complete.
3.3 Lot Sediment and Erosion Control		Plans	Details	Specs			
3.3.1 Soil Protection							
	Prevent loss of soil during construction by SWM run off and/or wind erosion through the use of:						
	Soil stabilizer/tackifiers applied and reapplied on a timely basis.	N	N	N	Y	Implemented in some locations (Tract G). Timely application still needs to be coordinated.	Coordinate and plan for stabilizers in advance of grading based on time of year, size of area disturbed and locations.
	Construction is phased to minimize water and wind erosion.	Civil	Y	Y	Y	This still needs to be improved on. Problems lie in balancing cut and fill on site. As we move into the next phases there may be more opportunities for this.	In all new phases of development, work to minimize the limit of disturbance as part of the planning process. The potential schedule for construction should also be reviewed as part of the planning process.
	Natural vegetation maintained or new plantings installed to stabilize disturbed soils.	CD	Y	Y	Y - But Limited by the County Drought Planting Restrictions	Mostly new plantings are planned. There are problems with getting plantings installed or good establishment when Santa Fe County planting and watering restriction are in effect. Natural vegetation is preserved based on the level of disturbance.	In all new phases of development, work to minimize the limit of disturbance as part of the planning process. The potential schedule for construction should also be reviewed as part of the planning process.
	Temporary hay or native grass (preferred) bales are installed in swales to slow storm water movement and potential damage to newly seeded areas (temporary system).	Y	Y	N	Y	This effort has been constrained by drought, however, it can also be effective in reducing loss of soils when there is no seed cover by slowing the water down at critical areas and driving it into the ground or making it available to plant materials. RV plans to implement this as part of meeting the new NPDES requirements.	Confirm this is being implemented as part of the NPDES requirements.

E. SURFACE-WATER MANAGEMENT CHECKLIST AND DETAILS

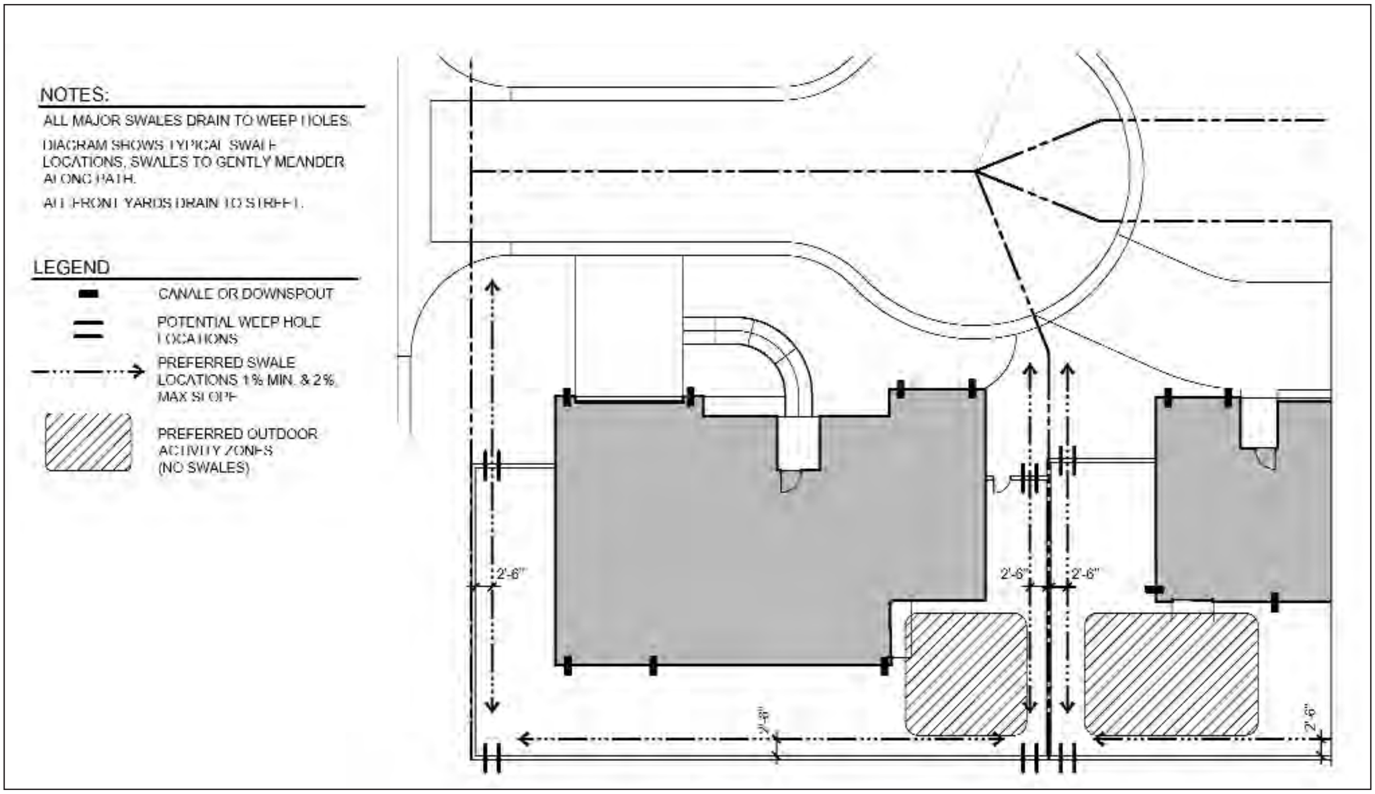
SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
3.0 Lot Design - continued		**Designed**			**Implemented**	**RV Comments**	**Future Changes to Implement**
3.3 Lot Sediment and Erosion Control - continued		**Plans**	**Details**	**Specs**			
3.3.1 Soil Protection - continued							
	Sediment erosion control fencing installed in a manner that prevents wind and surface-water erosion where soil has been disturbed and landscape is not yet established.	**CD**	**Y**	**Y**	**N**	Detailed on both the engineering and DW drawings but not being implemented or monitored/enforced consistently.	Install and maintain in compliance with the drawings, specs and public regulations.
	Splash blocks, french drains or other systems are used to prevent erosion under downspouts or canales.	**CD**	**Y**	**Y**	**Y - In Some Locations**	This may not be needed in WR as we are moving towards catchment systems on the buildings. May be used as a temporary measure (front and sides of most homes) until cisterns are installed to handle all rooftop run off. See Section 3.1.2 Comments. Currently installed by just dumping a pile of stones under the downspouts or canales in an area approximately 2-feet-wide by 3-feet-long. This is visually unattractive and does not work as well as if it were properly installed as specified in an excavated area beneath the downspout or canale.	DW has created a new detail for the splash block area of 4-inch cobble, to be tan in color. Area should be approximately 2-feet-wide by 3-feet-long and to an 8-inch to 12-inch depth. RV to review installation on-site to ensure that contractors have met the specifications.
	Driveways are gravel-lined to a width of 18-inches to direct water always from walkways and drives and into holding areas or roadway.	**N**	**N**	**N**	**N**	This currently is only feasible on the estate lots. May want to look into this more closely as there have been problems in the past with erosion on these longer drives. Some concerns with migrating stone and appearance in other areas of the development.	RV and DW to review to determine where this is appropriate in future developments.
	Culverts are graded to limit hazardous conditions for vehicles but capable of managing major storm events.	**Y**	**Y**	**Y**	**Y**	Storm drain pipes and surface drains are now used to alleviate this problem. The use of squash pipes also reduces the depth of the drainageways.	Curbs and gutter locations need to be properly located to make this work. DW to work with RV and the civil engineer to designate where certain curb and gutter types should be used early on in the design process.
	Cleanout of concrete and other construction materials is not permitted to occur on-site or to enter the drainage systems.	**Y**	**N**	**Y**	**Y - Sometimes**	This has been monitored on a regular basis on site.	RV to continue to improve monitoring and compliance.
	Erosion control materials are provided outside of the yard walls weep holes to prevent erosion and damage to the adjacent arroyos and drainageways.	**CD**	**Y**	**Y**	**N**	Not currently implemented.	DW has created a new detail indicating the use of hay bales to mitigate erosion on slopes from weep-hole run off.
	If stone materials are installed in place of lawns, the sites are graded to prevent washing of stone on to walkways and silting of stone is prevented through the use of systems listed above.	**N**	**N**	**N**	**Y - Sometimes**	Need to improve this process. Some erosion is occurring and stone is migrating across walks.	DW is now assisting RV and the civil engineer in reviewing the grading for lot design to reduce these problem areas.
3.3.2 Maintenance							
	Erosion Control Fencing is inspected and maintained regularly.	**CD**	**Y**	**Y**	**N**	This is currently being addressed. RV to monitor installations more closely.	RV is intending to implement this now to meet NPDES requirements for 2003 and beyond. Erosion and sedimentation control to be clearly mapped out on the civil engineers drawings as well as the bid documents, enabling these to be part of bid contract.
	Yard drains, french drains, and splash block areas are cleaned out on a regular basis.	**CD**	**Y**	**Y**	**Unknown - Not Currently Monitored**	Responsibility of the homeowners, but needs to also be covered in covenants if it is going to be enforced by the HOA.	The HOA needs to be monitoring the drainage on the lots to be sure that the homeowners are not modifying the grades without taking responsibility for any negative results.

3. Lot Design



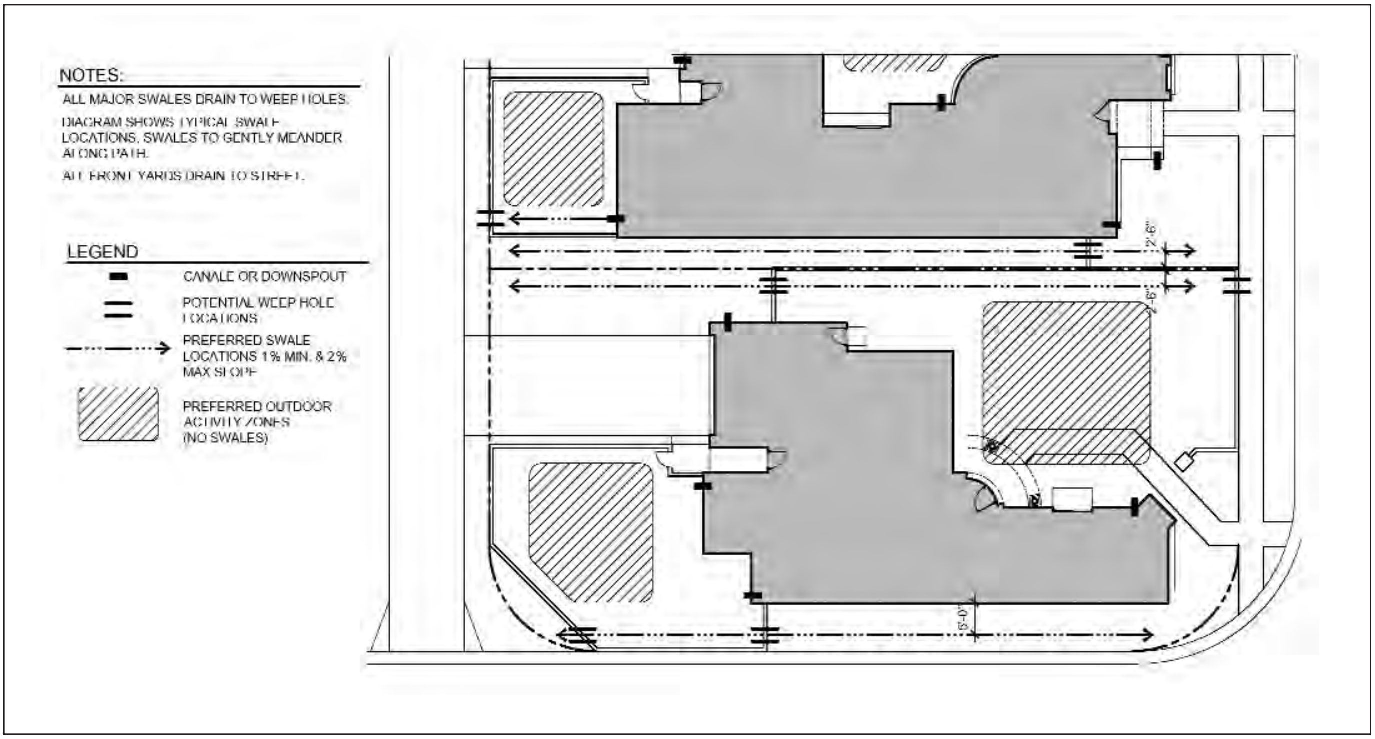
GARDEN LOT SCHEMATIC DRAINAGE PATTERN 1
WINDMILL RIDGE UNIT II

3. Lot Design



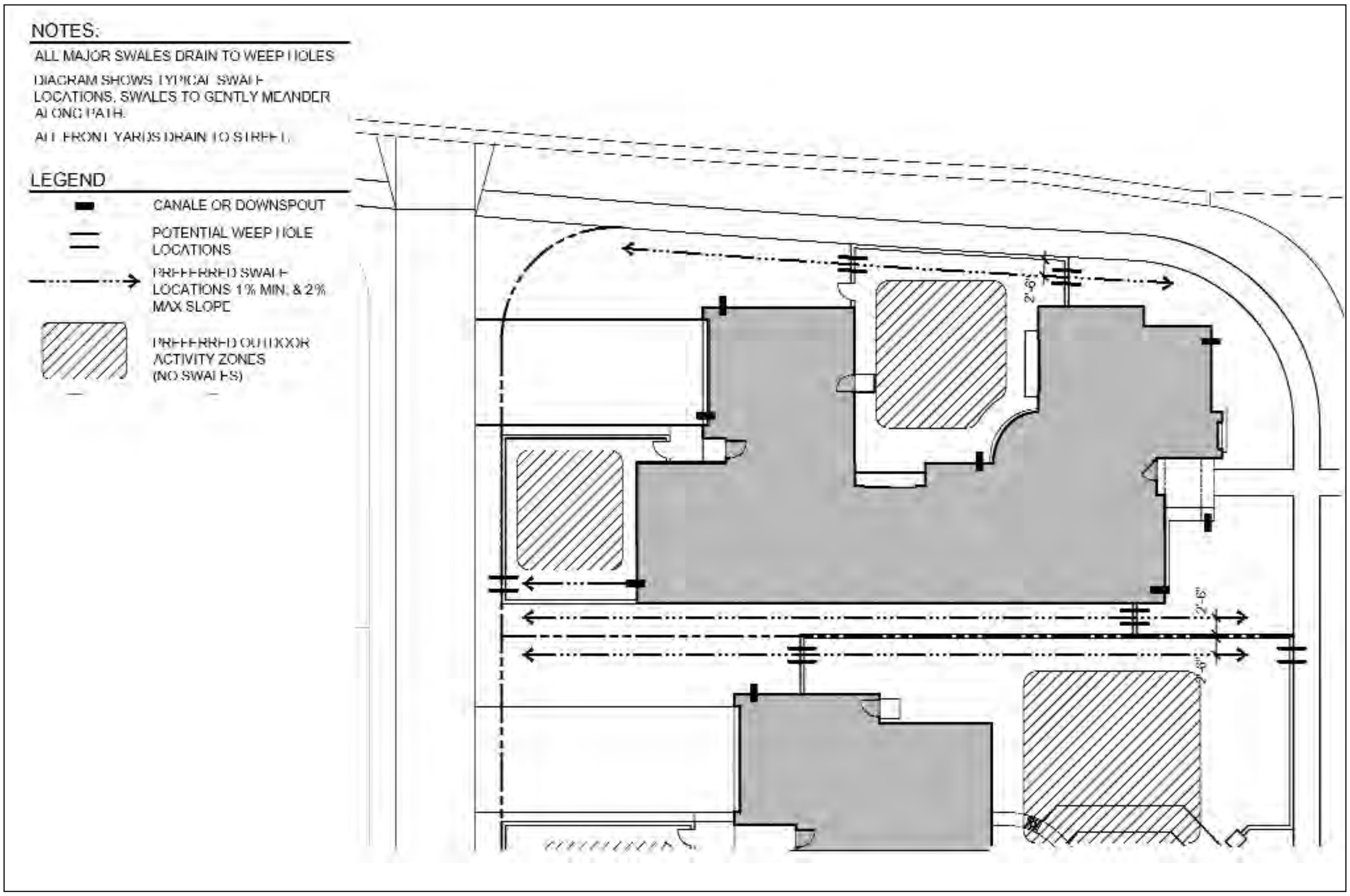
GARDEN LOT SCHEMATIC DRAINAGE PATTERN 2
WINDMILL RIDGE UNIT II

3. Lot Design



COURTYARD LOT SCHEMATIC DRAINAGE PATTERN 1
WINDMILL RIDGE UNIT II

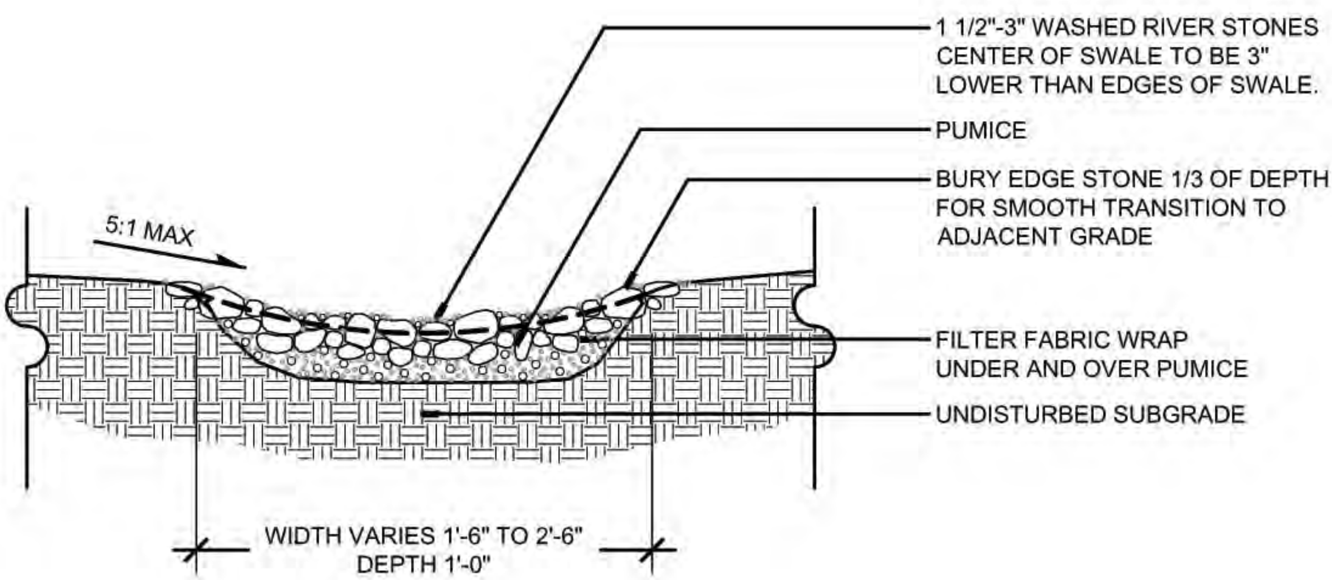
3. Lot Design



COURTYARD LOT SCHEMATIC DRAINAGE PATTERN 2
WINDMILL RIDGE UNIT II

3. Lot Design

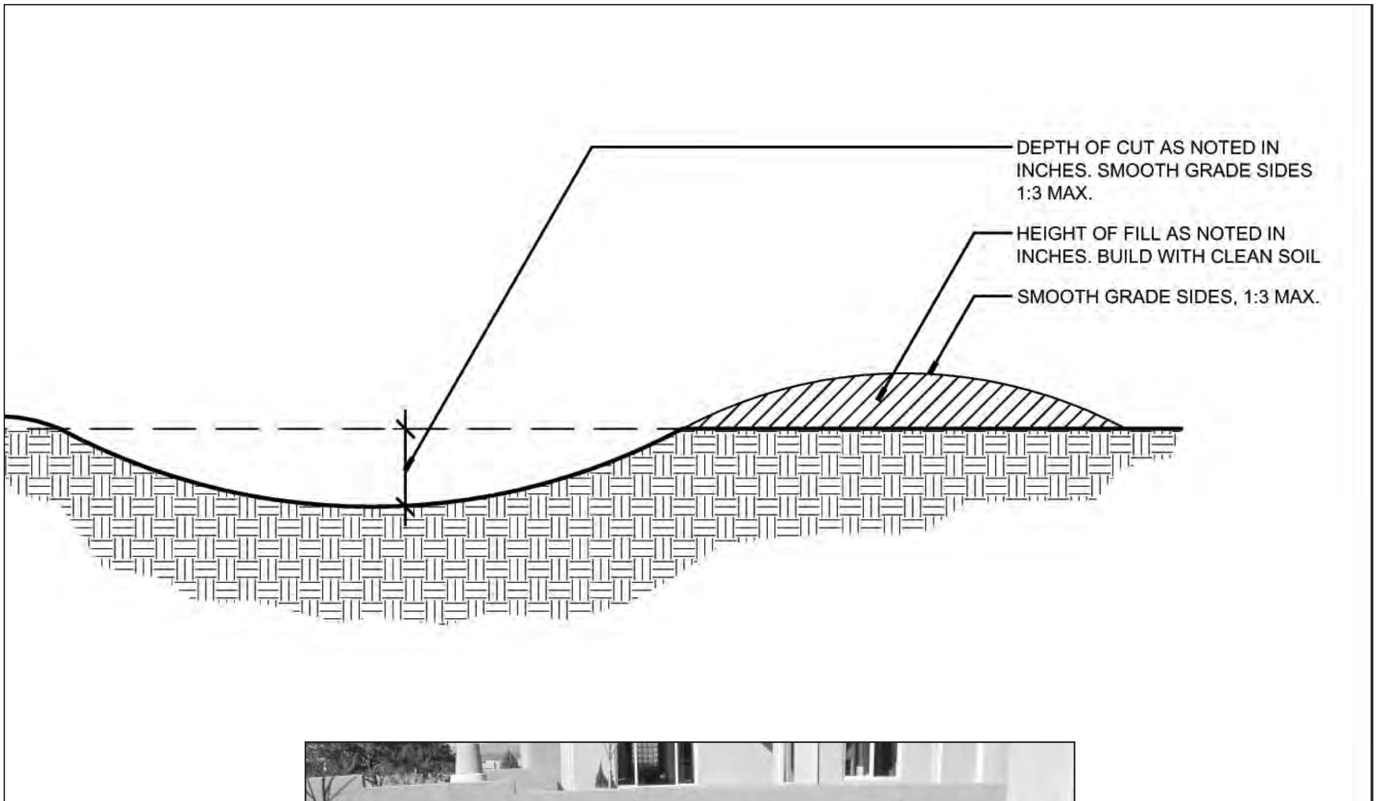
WATER-HARVESTING SYSTEM - COBBLE SWALE
WINDMILL RIDGE UNIT I



COBBLE DRAINAGE WAY IN CRUSHED STONE YARD

3. Lot Design

WATER-HARVESTING SYSTEM - TYPICAL BERM SECTION
WINDMILL RIDGE MODEL HOME COMPLEX



ON-LOT GRASSED DRAINAGE SWALE

3. Lot Design

RESIDENTIAL XERISCAPE AND STONE DRAINAGE WAY WATER-HARVESTING SYSTEM
THE VILLAGE AT RANCHO VIEJO UNIT I

3. Lot Design

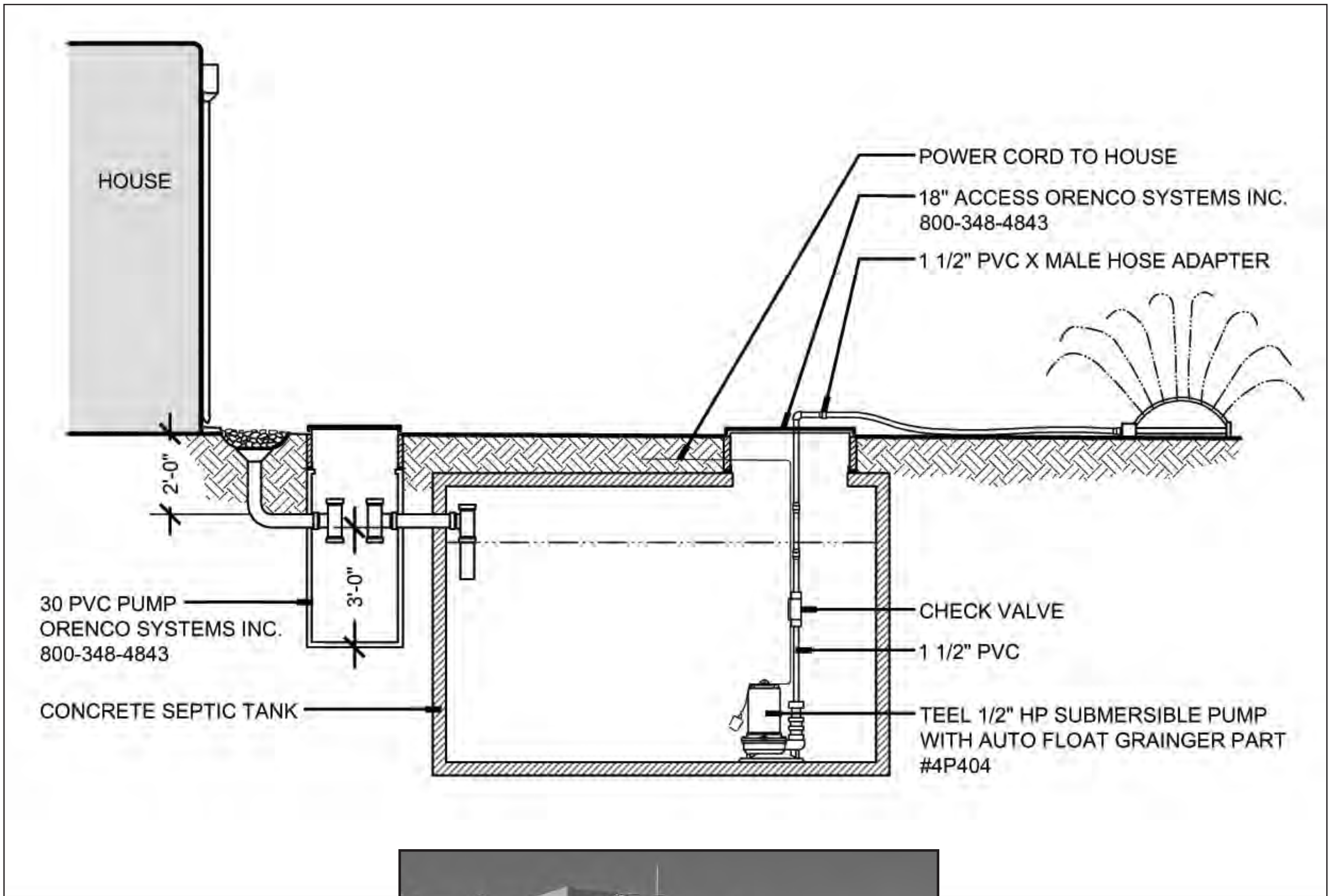
WATER-HARVESTING SYSTEM - COBBLE DRAINAGE WAY IN LAWN AREA
WINDMILL RIDGE UNIT 1 - MODEL HOME VISTA SERIES

3. Lot Design

WATER-HARVESTING SYSTEM - COBBLE DRAINAGE WAY AND CRUSHED STONE YARD
WINDMILL RIDGE UNIT 1 VISTA SERIES

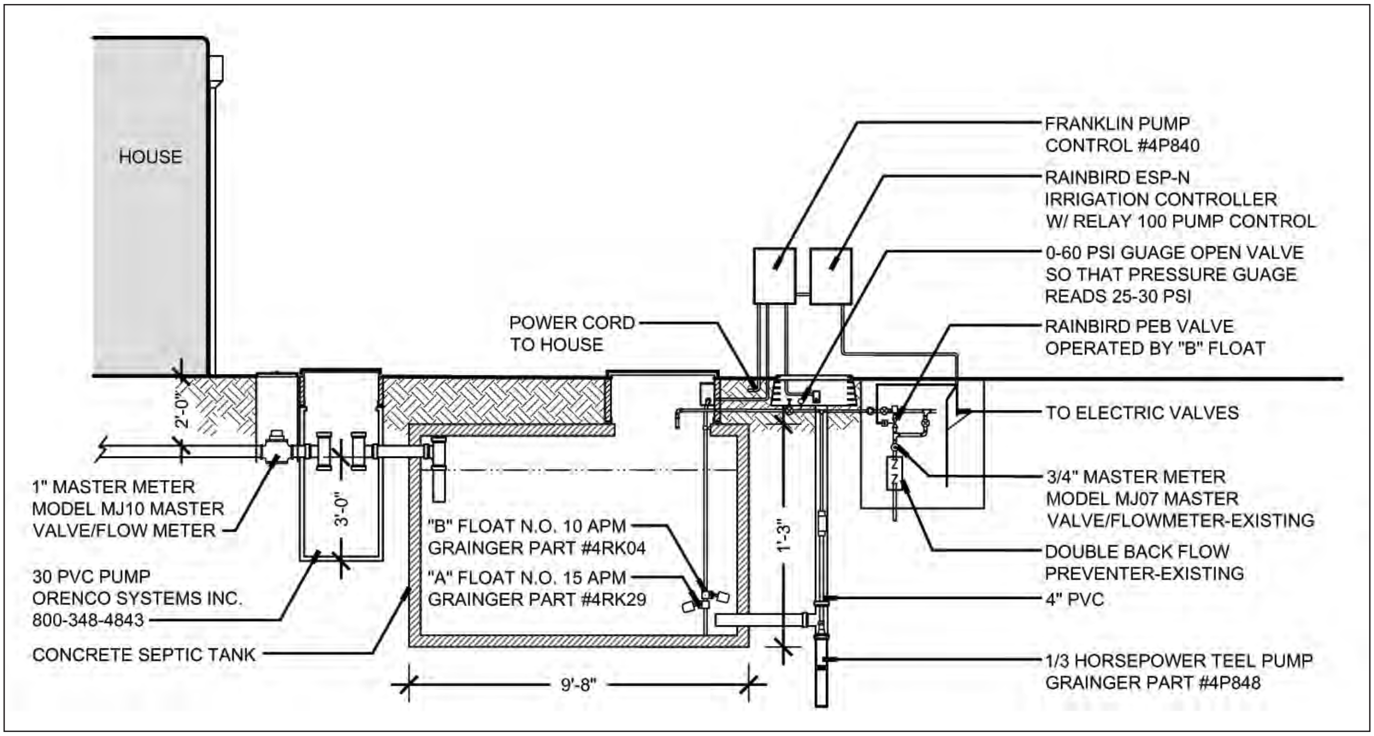
3. Lot Design

WATER-HARVESTING SYSTEM - 1,000 GALLON RESIDENTIAL CISTERN FOR SPRINKLER
THE VILLAGE AT RANCHO VIEJO - RESIDENTIAL



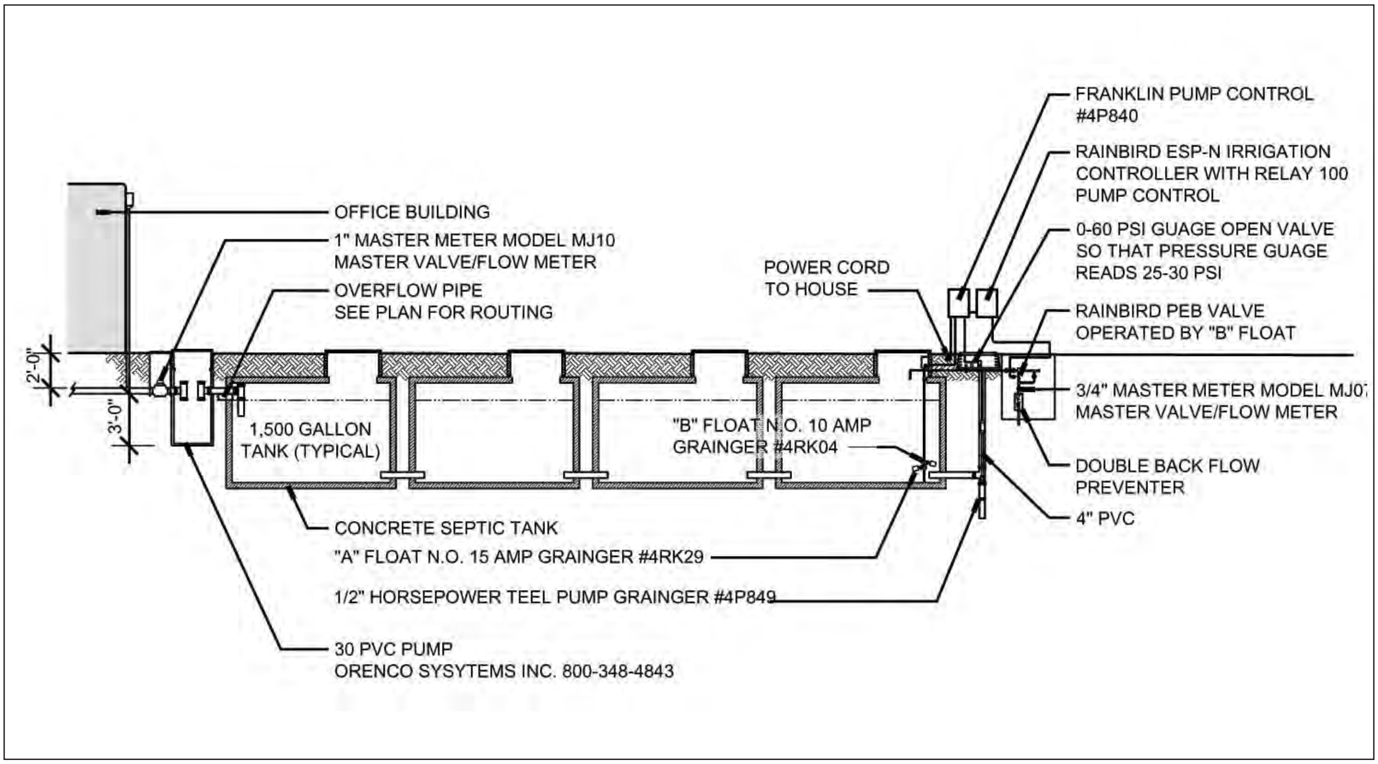
CISTERN INSTALLATION
THE VILLAGE AT RANCHO VIEJO

3. Lot Design



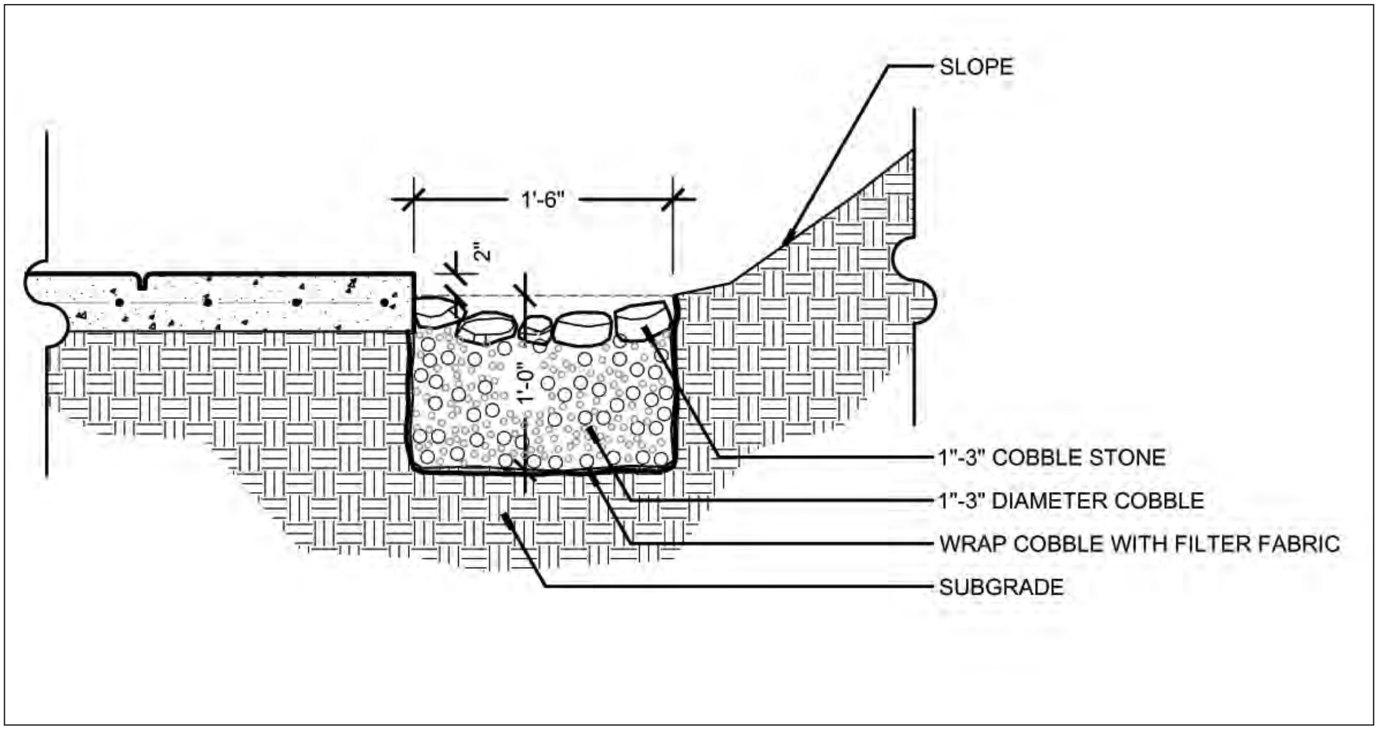
WATER-HARVESTING SYSTEM - 1,000 GALLON RESIDENTIAL CISTERN FOR IRRIGATION SYSTEM (SECTION)

3. Lot Design



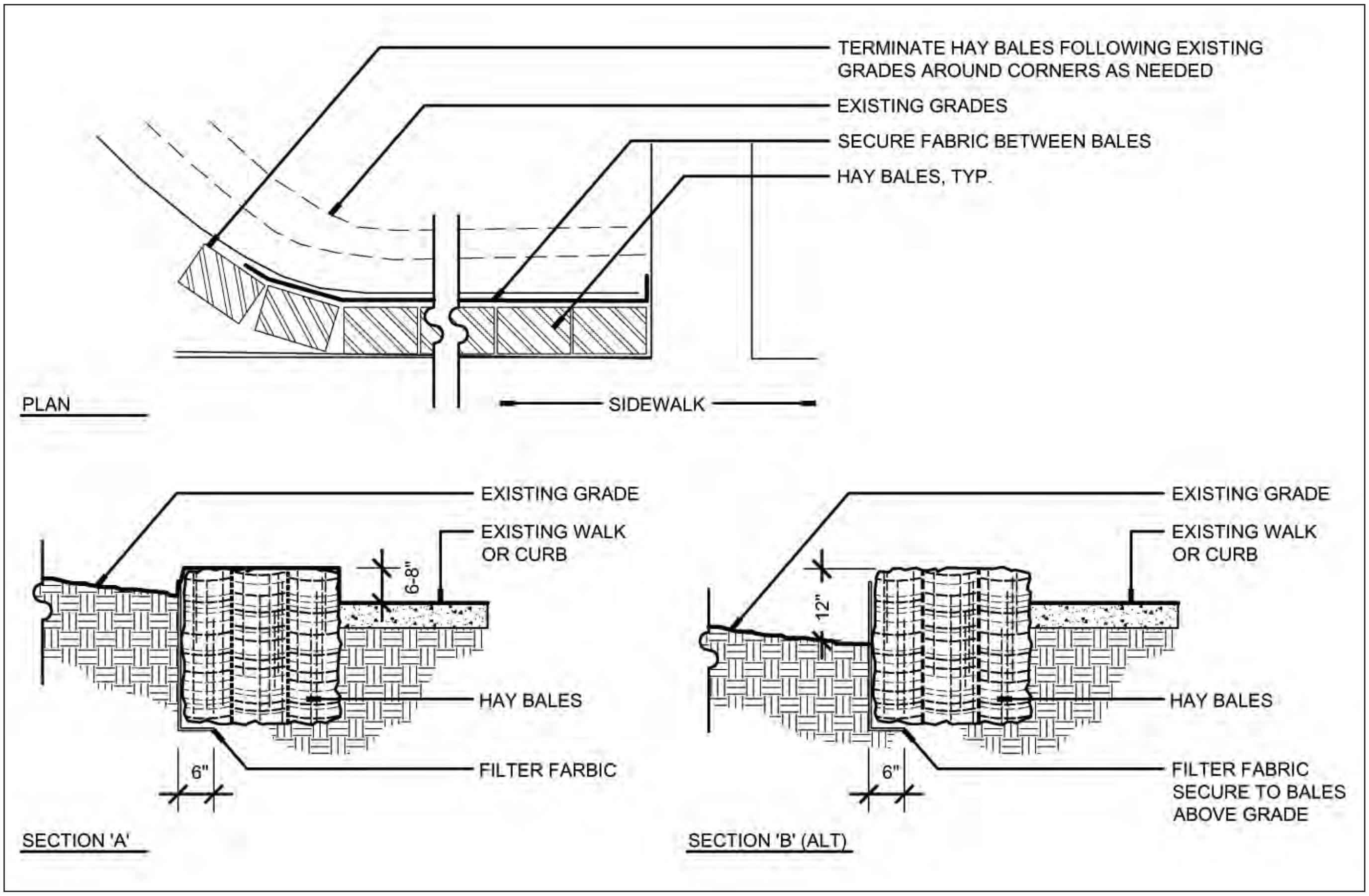
WATER-HARVESTING SYSTEM - 6,000 GALLON CISTERN FOR COMMERCIAL OFFICE BUILDINGS

3. Lot Design



WATER-HARVESTING SYSTEM - GRAVEL TRAP
THE VILLAGE AT RANCHO VIEJO - TRACT G

3. Lot Design



ON-LOT SEDIMENT EROSION CONTROL
WINDMILL RIDGE UNIT II

4. Village Roadways and Open Space

SYMBOLS KEY

MP	Master Plan	WR	Windmill Ridge	RV	Rancho Viejo
SD	Schematic Design	Y	Yes	SWM	Surface-Water Management
DD	Design Development	N	No	HOA	Homeowners Association
CD	Construction Docume	DW	Design Workshop, Inc.	NPDES	National Pollutant Discharge Elimination Systems

SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
4.0 Village Roadways and Open Space		Designed			Implemented	RV Comments	Future Changes to Implement
4.1 Roadway Design		Plans	Details	Specs			
4.1.1 Hardscape Design							
	Roads are designed to drain to landscape planting areas or large-scale detention ponds whenever possible to replenish the aquifer.	CD	Y	Y	Y		Review site to confirm the design meets NPDES requirements.
	Low-flow crossings at the road are utilized in areas of gentle slopes.	N	N	N	N	This is not recommended on-site. Not done for roadways due to the silting that occurs as well as freezing water in some locations.	None
	Roadway grates installed where water cannot be safely moved out of driveway depressions.	N	N	N	Not Really Needed on Site Yet	Problems that may require this solution have been resolved.	Consider only as situations arise in the future.
	Parking lot paving and roadways are pitched and designed with curb cuts as needed, to depressed basins designed to collect water off of paved areas and direct it to plantings or drainageways.	CD	Y	Y	Y - Where Designed	Most of the parking lots' storm water ends up in catch basins but where they have adjacent plantings, redesign can occur.	DW and RV to look into opportunities to use pervious paving systems on commercial and office lots and to direct drainage into open space or plant-bed areas.
4.1.2 Curb and Gutter Design							
	Rolled or flat curbs are designed and installed to allow storm water to drain uniformly along roadways into stabilized shoulders and drainageways.	CD	Y	Y	Y - Only in Select Locations	This hasn't been very successful in some areas, as it often creates swales that are too deep and become roadway safety hazards. Rolled curbs also makes management of the surface water more difficult to manage.	DW to work with RV and the civil engineer to develop new curb diagrams and guidelines/criteria for curb selection that best handle the storm water in a cost-effective but sustainable manner. DW will determine the appropriate curb detail at the development stage, based on the criteria outlined for curb selection.
	Where traditional straight curb and gutters are installed, curb cuts are provided at regular intervals and gutter pans scored to direct water into stabilized drainageways and collection areas or planting areas.	Y	Y	N	Y - Only a Few Locations in The Village at RV	This isn't really needed because of how and where we are going to use the straight curbs. Drop inlets will outfall to the ponds.	Continue to look for opportunities based on specific roadway shoulder conditions and discuss with RV and the Engineer at the preliminary design stage.
	The appropriate swale and curb and gutter design has been selected to route and harvest water as desired on site.	Y	Y	Y	Y - In Some Locations	Coordination between RV, DW and the civil engineer needs to occur early in the planning process. Curb and gutter type should be selected based on safety, ability to handle the water properly, the adjacent grades, etc.	See curb details and comments - Section 4.1.5
4.1.3 Grading of Roadway Shoulders and Parkways							
	Top and toe of slopes are eased/gently transitioned into the adjacent grades.	CD	Y	Y	N	Grading at these locations needs to be improved on in the field.	DW to work with the civil engineer to review grading plans early in the process so these changes can be implemented in the field.
	New slope banks are contour-graded to mimic existing flowing landforms and gradients present on site.	CD	Y	Y	N	Work with the civil engineer to ensure that the critical slope and erosion control information and details are located on the engineers drawings to minimize slope grades and potential subsequent erosion.	DW to work with the civil engineer and RV to review grading plans to create as natural a slope forms as possible on-site, for aesthetics and improved erosion and water-management control.
	Culvert drain pipe is extended beyond drives and roadway crossings by a minimum of 24 inches to allow for gentle transitions of grades and safe pedestrian and vehicular conditions.	CD	Y	Y	Y	Installed at College Park and in WR Unit 2.	Work with the civil engineer to see that this detail is included in construction documents, and implemented where needed in future development areas.
	Drainageways parallel to the road are designed and installed wide enough to allow for the centerline of flow to be meandered in steep areas to slow down water flow and potential erosion or undercutting of bank and allows water to filter into soils more readily.	N	N	N	N	RV agrees that this is a good idea, but need to determine in advance where this can occur. They would like to see more natural-looking solutions with meanders and varying roadway widths as well as tan stone materials, in the drainageway. Details are currently being developed when required.	RV has directed the civil engineer to see that this gets implemented wherever possible. Decisions are based on the amount of open space next to the roadway and the adjacent grades.
	Parkways between the sidewalk and curbs are designed as shallow swales to capture surface-flowing storm water and retain it in areas where it can best be used by plants. Steeper sloped parkways are designed with riffles and other permanent or temporary structures to slow surface waters and drive them into the soil for use by plants.	CD	Y	Y	Y	Installed as needed in all phases of development so far.	RV and DW to continue to investigate better ways to capture and retain water in the medians and reduce erosion especially during times when the County restricts any planting of grasses.
	Mass grading work is completed during the dry season.	CD	Y	Y	Y	Mass grading is completed whenever the soil is dry. Amount of grading is also determined by the balance of cut and fill.	Work to reduce the amount of mass grading in all future development phases.
	All grading work is phased to minimize the area exposed to wind and rain erosion at one time, retaining as much existing vegetation as possible.	CD	Y	Y	Y	Coordination is key to minimizing the number of times you need to adjust the grades. Unit II will be totally mass graded.	Minimizing dust on houses not open yet should be considered because of potential impact on the cistern. Coordinate with schedule of starts. RV to create a budget for the landscape, open space treatment and for water harvesting as an amenity.

E. SURFACE-WATER MANAGEMENT CHECKLIST AND DETAILS

SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
4.0 Village Roadways and Open Space		**Designed**			**Implemented**	**RV Comments**	**Future Changes to Implement**
4.1 Roadway Design - continued		**Plans**	**Details**	**Specs**			
4.1.4 Alleyways							
	Gravel or crushed stone mulch is installed in drainage swales along yard walls and alley drives.	**CD**	**Y**	**Y**	**Y**	Standard practice on all areas of the site.	None
	Yard wall weep holes are stabilized with large cobbles or french drains to prevent erosion.	**CD**	**Y**	**Y**	**Y**	Not on the inside of the walls, but outside the wall is graveled.	None
4.1.5 Culverts and Outfalls							
	Structural elements are integrated naturally into the landscape creating visual amenities as well as potential wildlife habitat and storm water management capabilities.	**CD**	**Y**	**Y**	**Y**	DW and RV need to work more closely with the contracts to ensure that the culvert treatment is consistent with the drawings and intent.	DW to review detail with RV (land development superintendent) prior to start of construction. Schedule meeting with contractor to explain intent and design.
	Culverts at trails are designed with shoulders of a minimum of 2 feet and outfalls designed with wing walls and graded to prevent undercutting of walkways and drainageways.	**CD**	**Y**	**Y**	**N**	The civil engineer drawings do show this. At design stage, we must make sure they are specified on the drawings used by the contractors.	Future changes to be addressed on the erosion and sedimentation control construction/permit documents and implementation monitored by the civil engineer.
	Soils are compacted and stabilized as needed to avoid collapse or undercutting of soils around the culverts or outfalls in all locations. Disturbed areas are immediately seeded to protect the area from erosion and structural failure.	**CD**	**Y**	**Y**	**N**	This is currently being addressed. RV to monitor installations more closely.	Future changes to be addressed on the erosion and sedimentation control construction/permit documents and implementation monitored by the civil engineer.
	Disturbed areas are immediately seeded to protect the area from erosion and structural failure.	**CD**	**N**	**Y**	**Not in Most Locations**	There have been problems with getting plant materials and grasses established during drought periods. This is loosely addressed in the erosion and sediment control drawings of the civil engineer.	When seeding is not allowed, other soil stabilization methods (tackifiers, crimping, etc.) should be utilized and monitored for its effectiveness. See Section 4.2.1 comments.
	Head walls where visible from roads or trails are faced with stone or other materials to screen the structure from view.	**N**	**N**	**N**	**N**	This isn't possible to implement at this time due to high costs and limited budgets.	
	Drainageway pipes are designed not to drop directly into existing arroyos or detention ponds without proper armoring and maintenance. Water quality ponds, plunge pools, or riprap or gabion dissipaters are utilized to limit damage.	**CD**	**Y**	**Y**	**N**	NPDES - Requires all piped storm water to be directed to a detention pond and not into arroyos or piped into open space areas. Currently the outfalls that feed into the arroyos and open spaces exist on-site causing serious erosion problems and sediment deposition downstream. Those that do feed into and from the detention ponds are not being properly armored to stabilize the banks or flow areas. These have been detailed in the civil engineer drawings but this is not being implemented properly.	RV needs to conduct pre-construction meeting and timely review of installation of outfalls construction and stabilization methods. Consider having the civil engineer review his installations and provide recommendations for future improvements of documents and installation techniques.
	Access is provided for maintenance vehicles to the drainage structures.	**CD**	**Y**	**Y**	**Y**	Using the trails for this purpose.	None
4.1.6 Maintenance							
	Erosion control fencing inspected and maintained regularly.	**CD**	**Y**	**Y**	**N**	This is currently being addressed. RV to monitor installations more closely. See Section 3.3.2 comments.	Erosion and sedimentation control to be clearly mapped out on the civil engineer drawings as well as the bid documents, enabling these documents to be bid as part of the contract.
	All culverts and outfalls are cleaned out on a weekly basis.	**N/A**	**N/A**	**Y**	**Y- Cleaned Out as Needed**	Part of the HOA maintenance contract. This is currently being addressed. RV to monitor installations more closely. SWM ponds are cleaned out after big storm events.	The budget cannot support this, so it only can occur once a year after big events.

E. SURFACE-WATER MANAGEMENT CHECKLIST AND DETAILS

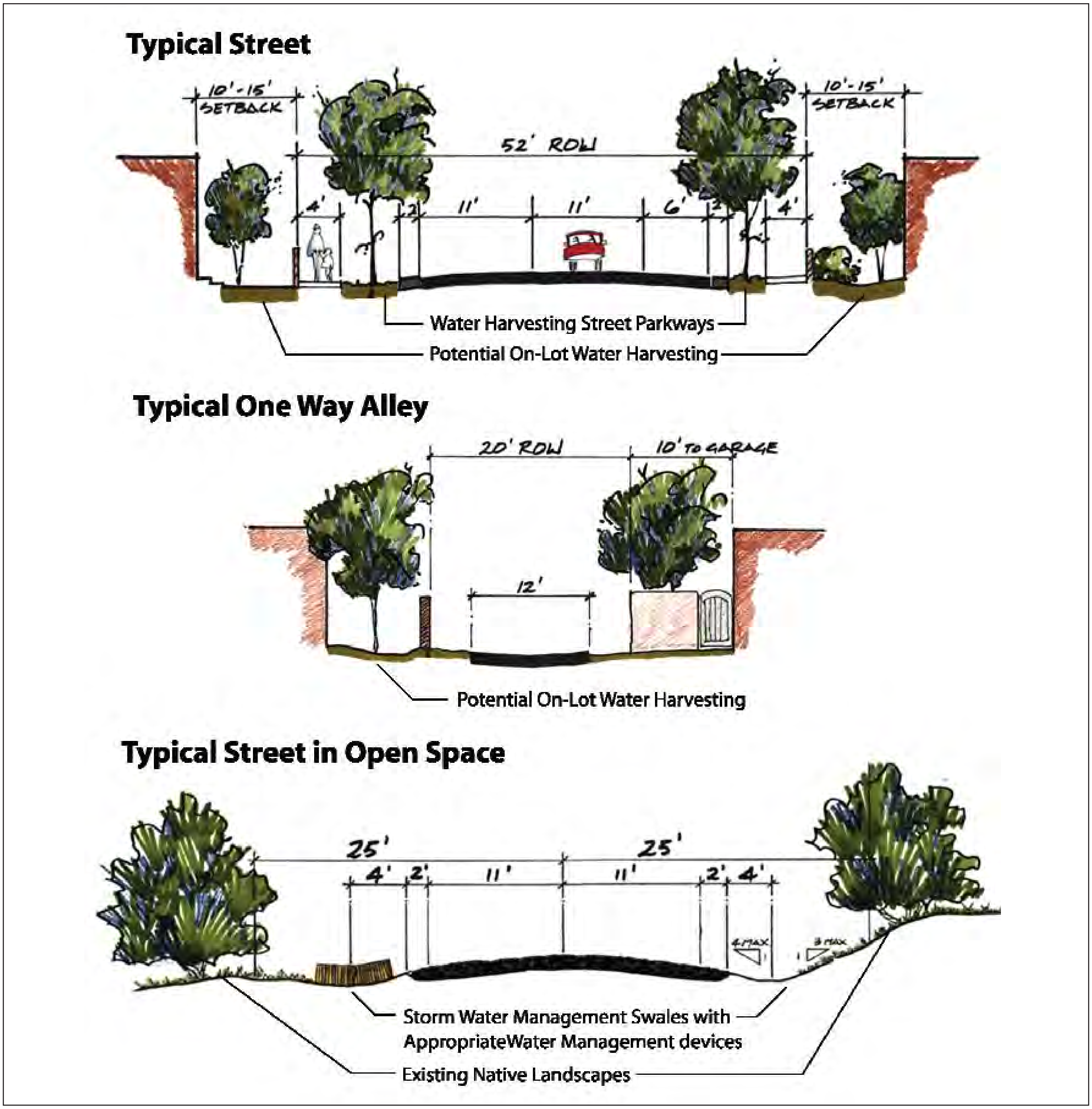
SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
4.0 Village Roadways and Open Space		**Designed**			**Implemented**	**RV Comments**	**Future Changes to Implement**
4.2 Open Space Design		**Plans**	**Details**	**Specs**			
4.2.1 Soil Conservation							
	Soil erosion and sediment erosion control measures are installed prior to any other on-site activities.	**CD**	**Y**	**Y**	**Y - In Some Locations**	Installed after mass grading. Need to review installation and monitor status on a more regular basis. (RV- Land Development Superintendent)	DW to provide a silt fencing plan to be included in the civil engineers' construction documents.
	Site grading and drainage systems are designed to prevent any sediment-laden water to leave any areas of the site.	**CD**	**Y**	**Y**	**Y - In Most Locations**	Will meet NPDES requirements in all future development.	Civil engineer is creating the new details to meet NPDES requirements.
	Natural Water Distribution Systems						
	Where appropriate, channels, ditches and swales have been graded to minimize erosion and are seeded or sodded with native grasses to stabilize soils and allow water to infiltrate into the subsoil.	**CD**	**Y**	**Y**	**Y**	Success in establishing seeded drainageways is sometimes achieved by grading the swale side slopes at 1 to 2 percent, mainly in open spaces. Drought was a barrier to successful germination in many locations in 2001 and 2002.	DW to work with contractor to determine what mix or soil conditions may be required to improve our success with this installation. Field verify that check dams and other soil erosion methods are installed prior to seeding. Soil amendment options are being tested by Tall Grass Restoration, for better seed coverage and established during all times and especially during drought, in areas of high visibility and highly erodible areas.
	Stone and hay bale trench interceptor and spreader swales: Shallow ditches are constructed parallel to the slope contours allowing storm water to spill evenly along the entire length and down the slope. By dispersing the flow, it slows the run off enough to allow it to infiltrate into the subgrade if the grade does not exceed 3:1 in slope.	**CD**	**Y**	**N**	**Possibly Some Places**	Implemented in open space areas south of Richard Avenue in Windmill Ridge.	The design team (RV, DW and the civil engineer) to review new development areas to determine where these systems would be the best solution and the most cost-effective.
	Ladder swales: A series of swales are constructed from a drainage ditch along the driveways extending from the main ditch. These are similar to rungs on a ladder and are designed to collect or spread water to slow the flow rate and allow storm water to filter into the subsoil.	**CD**	**Y**	**N**	**N**	Currently they do not appear to be installed on site. Ladder swales would be more likely to be installed in open space areas. RV and DW to evaluate on a site by site basis.	These structures should be installed as part of the site grading and early in the process to maximize the effectiveness of the swales.
	French drains or dry wells: Cylindrical holes are constructed and filled with gravel to catch and infiltrate storm water.	**CD**	**Y**	**N**	**Y**	Installed under canales in some homes. These systems have not been effective in WR due to clay soils. Implement only where soils allow for necessary drainage away from structure footing and into the subsurface areas.	Contractors to install these structures only on future sites where soil types are appropriate for this type of drainage system and where cost reduction is a priority.
	Parking lot paving is pitched to drain to depressed islands designed to collect water off of paved areas through curb cuts and direct the storm water to plantings beds or lawn areas.	**N**	**Y (DW)**	**N**	**N**	There are very few parking lots associated with the residential lots except for those adjacent to the park or open space areas. Currently the civil engineer has designed these to drain into the street.	DW's details need to be included on the engineers' drawings if they are going to be built to achieve this strategy. Redesign of these areas to be worked out with the engineer to drain into open space/planting areas. DW and RV to coordinate these designs with the civil engineer and to confirm that streetscape designs are meeting NPDES requirements for water quality.
	Piped or open culverts are provided where storm water must cross concrete walks in community parks and open space areas. Grades are eased along edge of concrete and swales sodded.	**CD**	**Y**	**Y**	**Y - In Some Locations**	Location and design need to be more closely considered and reviewed on site to accommodate as-built conditions. Concrete work needs to be carried at least 6 inches below the finished grade of the swale to avoid exposure and undercutting of the down-turned drainageway edge.	DW will review grading plans and identify potential culvert locations in parks and open spaces on plans for bidding. DW will detail the concrete turndown at open culverts and piped conditions to resolve the current problems with the installations. RV will review in field during the construction to ensure culverts are properly constructed and concrete finished to the quality desired.

E. SURFACE-WATER MANAGEMENT CHECKLIST AND DETAILS

SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
4.0 Village Roadways and Open Space		**Designed**			**Implemented**	**RV Comments**	**Future Changes to Implement**
4.2 Open Space Design		**Plans**	**Details**	**Specs**			
4.2.1 Soil Conservation - continued							
	Loss of soil during construction by SWM runoff and/or wind erosion is prevented through the use of:						
	Grassed swales designed to slow run off from the tops of slopes.	CD	Y	Y	Y - In Some Locations	Location and design need to be more closely considered and reviewed on site.	DW to create a section detailing proposed swale design at top of slope. DW to review the civil grading plans to determine where this is an appropriate detail and provide recommendations for avoiding potential concentrated runoff and subsequent soil erosion. Coordinate new detail with the civil engineer at the development plan stage.
	Soil stabilizer/tackifiers applied and reapplied on a timely basis.	CD	Y	Y	Y - As Needed	Installed as needed. On vacant lands: Use crimping with hay first, then if needed use a tackifier. There may be a potential problem with removal and cleanup.	Evaluate on a yearly basis to determine best means of management and impacts of solutions on future development.
	Sediment traps are installed at critical locations around culverts, basins, and outfalls.	CD	Y	Y	N	Will meet NPDES requirements in all future development.	New details from the civil engineer will address this issue. Continue to review best option for future improvements.
	Phase construction to minimize water and wind erosion.	CD	Y	Y	Y	This is naturally phased by the limits of the site.	RV to work more closely with the civil engineer on this.
	Natural vegetation maintained or new plantings installed to stabilize disturbed soils.	CD	Y	Y	Y	RV's desire is to stabilize the disturbed areas with native vegetation and to reduce the amount of disturbance as a whole.	New details from the civil engineer will address and delineate locations for this. The design team needs to continue to review best option for future improvements. RV to review site on a regular basis to ensure the details implemented as specified.
	Stone or hay bale weirs/check dams are installed in appropriate drainageway locations (recommended every 50 feet).	CD	Y	Y	Y - Hay bales in Some Locations	Hay bales have been used in some locations. They are cost-effective and can be used in other locations as an inexpensive solution. These breakdown in one to two seasons, based on rainfall received.	New details from the civil engineer will address and delineate locations for this. The design team needs to continue to review best option for future improvements. RV to review to ensure the details implemented as specified.
	Sediment erosion fencing installed as specified on engineers plans.	CD	Y	Y	N	RVs' land development superintendent will supervise and monitor all future fencing installations on a regular basis.	Civil engineer is creating the new details to meet NPDES requirements.
	Crimp or disk hay into the soils.	N	N	N	N	Has not been used on site so far, but is being reviewed as an option.	Test the crimping of straw for stabilization on the commercial lot. DW to follow up with RV and Tall Grass Restoration to determine the best installation method. Utilize native grass hay bales whenever possible.
	Gabions installed at major drainageway outfalls.	CD	Y	Y	Y - In Some Locations	Used at the outlet ends of culverts and along drainage ways. Most seem to be completely silted over.	New details from the civil engineer will address and delineate locations for these. The design team needs to continue to review best option for future improvements. RV to review to ensure the details implemented as specified.
	Culverts graded to limit hazardous conditions for vehicles but capable of managing major storm events.	CD	Y	Y	Y	Not a problem in the new development areas - See Section 4.1.5 comments. This is typically detailed on the civil engineers drawings.	None
	Channels, ditches and swales are seeded or sodded with native grasses where appropriate.	CD	Y	Y	Y - When Seeding is Allowed	Native grass seed should be used. DW to look into alternate solutions for establishing grasses during drought restrictions. Sod is too expensive to use on a site this size.	Soil amendment options are being tested by Tall Grass Restoration, for better seed coverage during droughts in areas of high visibility and highly erodible areas. Using these soil amendments, native grasses may possibly be established at any time of the year.
	Native plantings are specified for plantings on-site and installed in appropriate areas to aid in the removal of contaminants and collection of sediments from upstream drainage areas and collection basins.	CD	Y	Y	Y	Currently part of DW's landscape construction documents.	Continue to improve the plant lists based on site conditions and lessons learned in previous development areas.
	Bio-engineering and bank stabilization construction is installed prior to erosion along arroyos or other sensitive drainageways that are impacted by construction or disturbance of adjacent soils.	CD	Y	Y	N	RV's land development superintendent to supervise and monitor on a regular basis.	If the erosion control systems are installed where specified, this may not be as severe of a problem. However, yearly RV to review arroyos and major drainageways for progressive degradation due to erosion.
	Stockpiles of topsoil are protected from erosion and deterioration of the soil health. Stockpiles are kept shallow and seeded to stabilize and allow micro-organisms to remain alive and active.	N/A	N	N	N	The intent is to move to protecting the soil better in all new phases of work.	DW to provide RV with guidelines for stabilizing and protecting the soil quality. Stockpiles should be seeded with blue grama grasses only. No annual seeding of rye or barley, etc.
	Control damage to the natural and newly built site components. Damage is most often caused by the unapproved random driving routes and parking practices of the contractors.	Y	Y	Y	Y - In Some Locations	Problem mainly is occurring with the custom build contractors and on the conservation lots. Contractors are not using the designated routes.	Fence the building lots as they are being developed. Get a dollar amount upfront that you hold as a deposit in case damage to existing trees, culverts, paths, etc., occurs. Work with the contractors to educate them on what we are trying to achieve and help them establish a sense of ownership.
	Access is provided for maintenance vehicles to the swales and other drainage structures.	Y	Y	Y	Y	Paved trails are used to provide access.	None

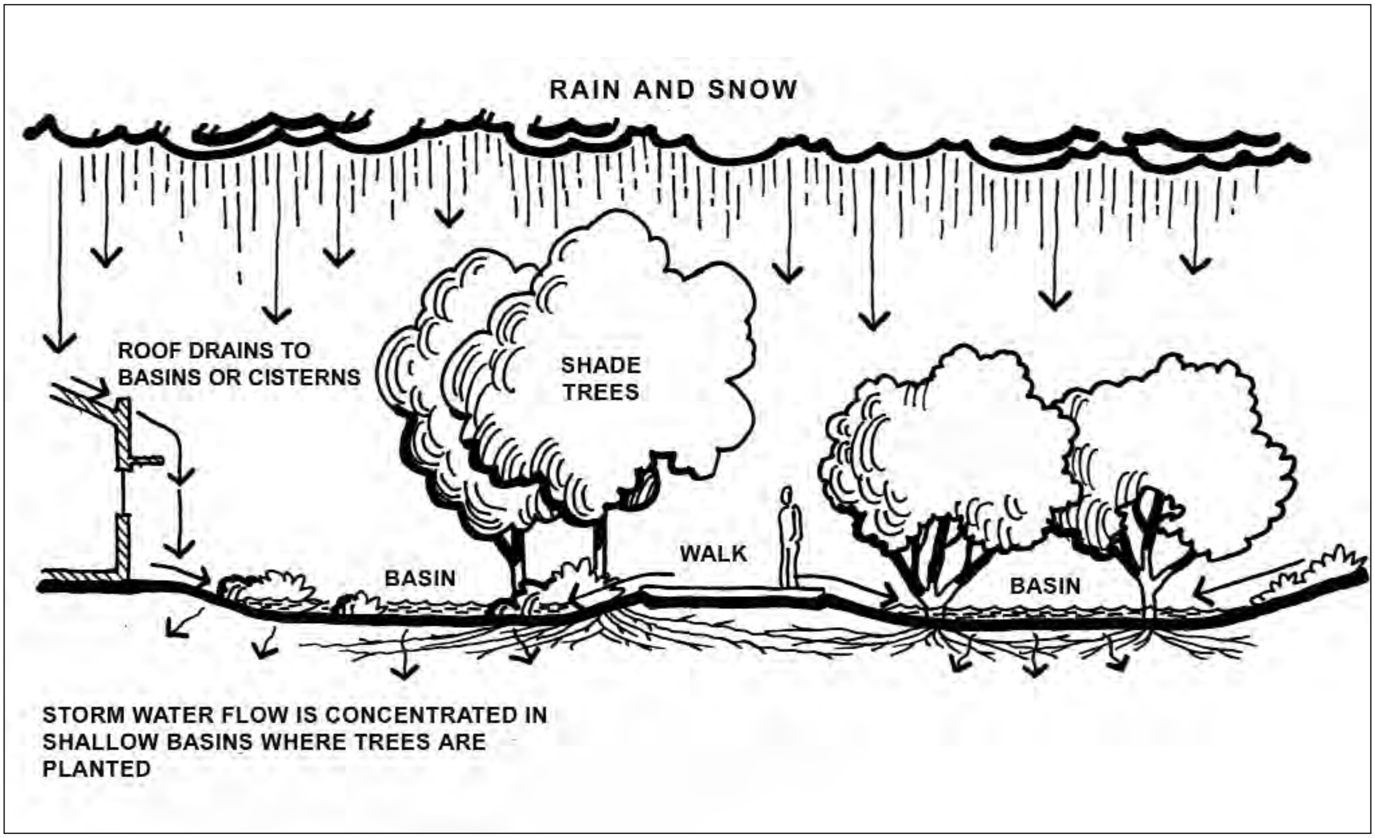
SYSTEM	PROPOSED STRATEGY	DESIGN AND IMPLEMENTATION STATUS					
4.0 Village Roadways and Open Space		**Designed**			**Implemented**	**RV Comments**	**Future Changes to Implement**
4.2 Open Space Design		**Plans**	**Details**	**Specs**			
4.2.2 Planting of Roadways and Adjacent Drainageways							
	Soils are scarified to mitigate construction compaction and to allow seeding to establish and increase its ability to absorb water prior to planting.	Civil	Y	Y	N	Soils are roughed on the surface to allow for seeding to become established but this may not be effective enough. Care must be taken not to increase potential soil erosion and loss from this effort.	DW to work with Tall Grass Restoration to test soils and find a better solution to get the seeded grass areas to establish more consistently. Suggested alternatives include improved soil amendments and soil imprinting.
	Irrigation: Where irrigation is used, sensors are used to monitor the effectiveness of the systems.	N	N	N	N	Permanent irrigation systems are currently being used in select open space areas such as the plazas and shared park areas.	DW is proving production information and costs and will identify the cost benefits of putting in such systems, including maintenance, and evaluating potential locations. Consider rain shut-off devices and irrigation meters for future systems as well as rain sensors. Train personnel to monitor soil moisture levels and water only at level required. Evaluate total loss of potable water due to infrastructure leaks. Train personnel to recognize signs of potential leaks and to repair immediately.
	Channels, ditches and swales are seeded or sodded with native grasses where appropriate.	CD	Y	Y	Y - When Seeding is Allowed	Seeded native grasses should be used and are used on site currently. Sod is too expensive to use on a site this size.	DW to look into alternate solutions for establishing grasses during drought restrictions. See History of Seeding summary in Appendix D.
	Trees, shrubs and grasses or other vegetation is retained wherever possible.	CD	Y	Y	Y - In Some Areas	Needs improvement. See Section 1.1 comments.	Needs Improvement. See Section 1.1 comments
	Vegetated areas are left in place as long as possible to reduce erosion, preserve wildlife habitats and enhance property values.	CD	Y	Y	Y - In Some Areas	Needs improvement. See Section 1.1 comments.	Needs Improvement. See Section 1.1 comments
	When clearing and grubbing of plants is required, grubbing of tree roots is held back until grading is to proceed, as the roots can provide substantial erosion control.	CD	Y	Y	Y - In Some Areas	Needs improvement. See Section 1.1 comments.	Needs Improvement. See Section 1.1 comments
	Temporary covers (seeding or 6-month biodegradable erosion control blankets) are installed on bare areas during dormant season as construction proceeds.	CD	Y	Y	Y - In Some Areas	This has only been effective in keeping the slopes from eroding but seeded grasses have not established well in many locations. Crimped straw with a tackifier is an alternative to consider.	Incorporate these areas into the soil test to determine why some seeded areas are successful and others are not. See Appendix D.
4.2.3 Detention Basins							
	Located and designed for hydraulic effectiveness. Ideally these are implemented in a series of smaller detention areas that are deeper and therefore have less surface exposed to evaporation.	CD	Y	Y	Y-Windmill Ridge	This is planned for the Unit II area of Windmill Ridge.	DW to work with the civil engineer to ensure that the series of water-quality ponds do not degrade the adjacent landscape or natural drainageways.
	Detention basins are designed to pond and slow water to or from drainageways to allow for sediment and contaminants to settle out of the water before it leaves the basin.	CD	Y	Y	Y	The basins are being detailed on the civil engineers' drawings. Detention basins are designed to meet this requirement, but there may be an opportunity to soften the forms and make them more of an amenity and habitat.	DW to discuss options for creating natural forms that fit more closely with the natural landforms and are visually attractive as well as functional.
	Detention basins are planted with native grasses (wet meadow) species to assist with reducing run off velocities, reducing evaporative loss, filtering of pollutants and sediment and soil erosion control.	N	N	N	Y- Native Grasses Only	Currently side slopes are only seeded. Look into options for seeding the bottom of the detention ponds and outfall areas with wetland and wet meadow plantings that will improve the water quality and still meet NPDES requirements.	Review opportunities to provide a better aesthetic by reshaping the ponds into more natural forms, create habitat, work to improve replenishment of the aquifer as well as deal with sediment removal. Needs to meet NPDES requirements.
4.2.4 Maintenance							
	Erosion Control Fencing inspected and maintained regularly.	N/A	N/A	Y	Y	Not really being monitored enough to determine if fencing is installed properly or maintained properly.	Needs to be monitored more regularly by RV (Land Development Superintendent) See Section 4.1.6 Comments.
	All culverts and outfalls are cleaned out on a yearly or seasonal basis.	N/A	N/A	Y	Y	Cleaned out only as needed. See Section 4.1.6 comments.	None
	All areas of the site are inspected frequently and any problems or failures corrected immediately, especially during the rainy season.	N/A	N/A	N/A	Y	Monitoring needs to be more regular. Currently we are responding only to major weather events.	RV to monitor more closely in future (Land Development Superintendent).
	Temporary irrigation is provided for seeded areas if quick establishment is needed.	N	N	N	N	Too expensive and not really possible due to the size of the site.	May be possible in the future depending on changes in technology. Re-evaluate every 2 years to determine if cost-effective solutions are readily available.
	Access is provided for maintenance vehicles to the swales and other drainage structures.	Y	Y	Y	Y	Paved trails are used to provide access.	None
	Create target efficiency budgets for each major water zone based on the outdoor landscape area use.	N/A	N/A	N/A	N	Not currently implemented.	Need to discuss this further with RV to develop a means of achieving the audits once the targets are set.
	Inform the Homeowners Association representative and hire landscape contractors experienced in maintaining communities that are striving to reduce their water use and protect the surface-water management systems in an efficient and cost-effective manner.	N/A	N/A	N/A	Y- To a Small Extent	Some training of the HOA representative has occurred to date with DW providing an introduction to the landscape vision and maintenance requirements.	Continue to work to improve the quality of the maintenance contractor and HOA representative. Encourage educational programs for homeowners to better understand how to maintain their landscapes and water use properly.

4. Village Roadways and Open Space



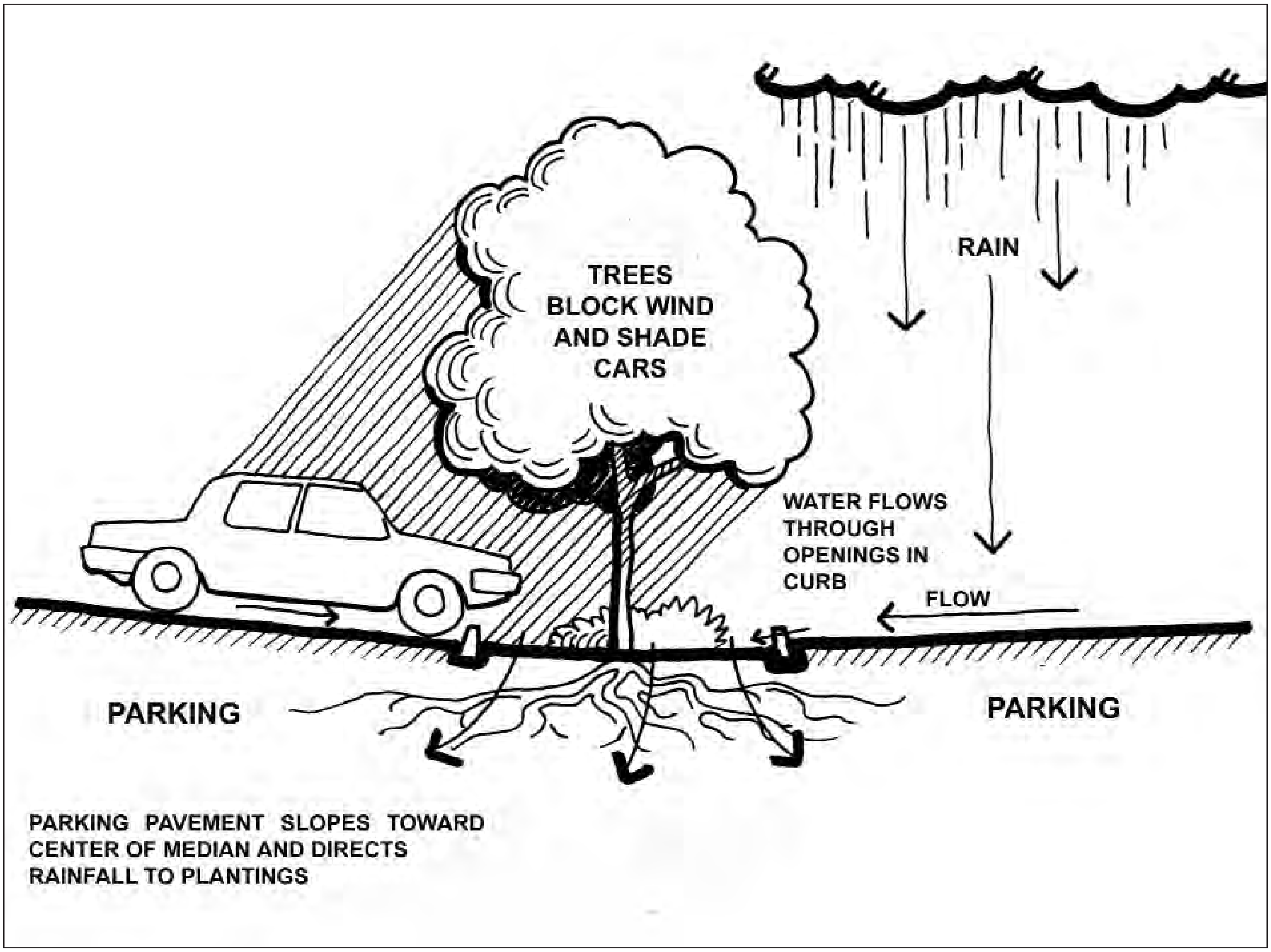
TYPICAL STREET CROSS SECTIONS FOR WATER HARVESTING

4. Village Roadways and Open Space



WATER-HARVESTING SYSTEM AT OPEN SPACE
WINDMILL RIDGE UNIT II

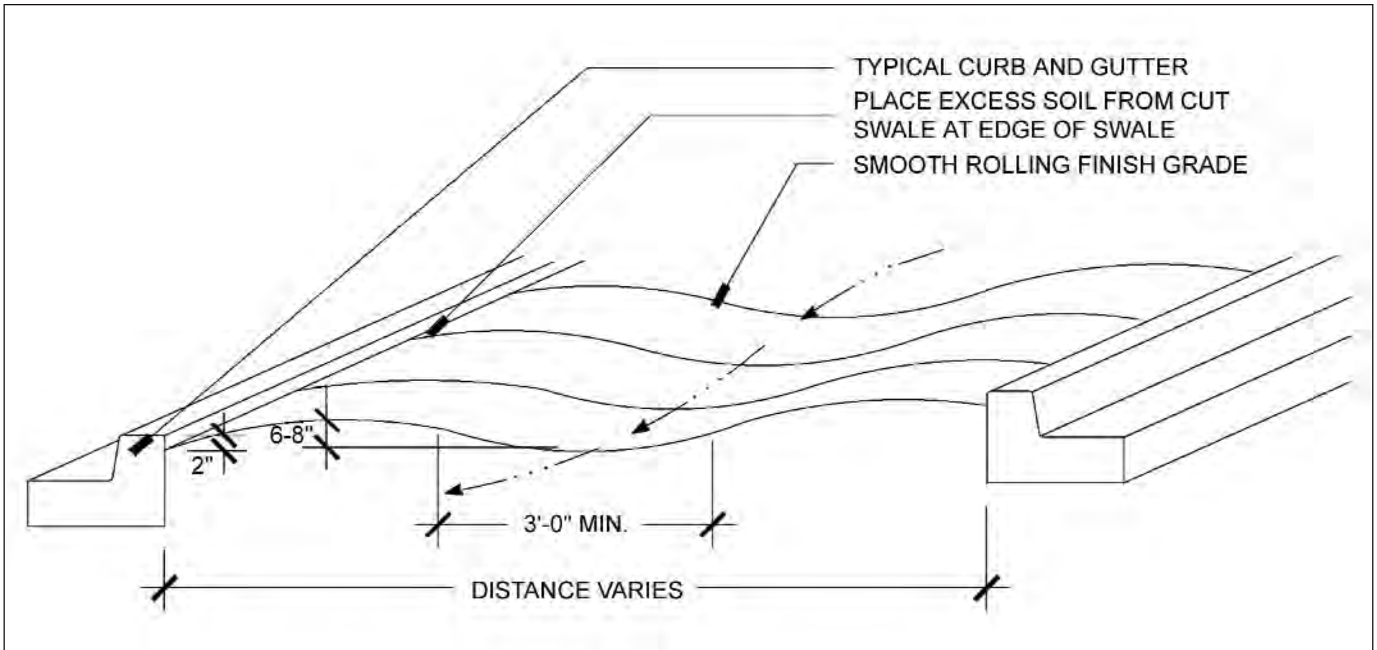
4. Village Roadways and Open Space



WATER-HARVESTING SYSTEMS AT PARKING LOT MEDIAN
WINDMILL RIDGE UNIT II

4. Village Roadways and Open Space

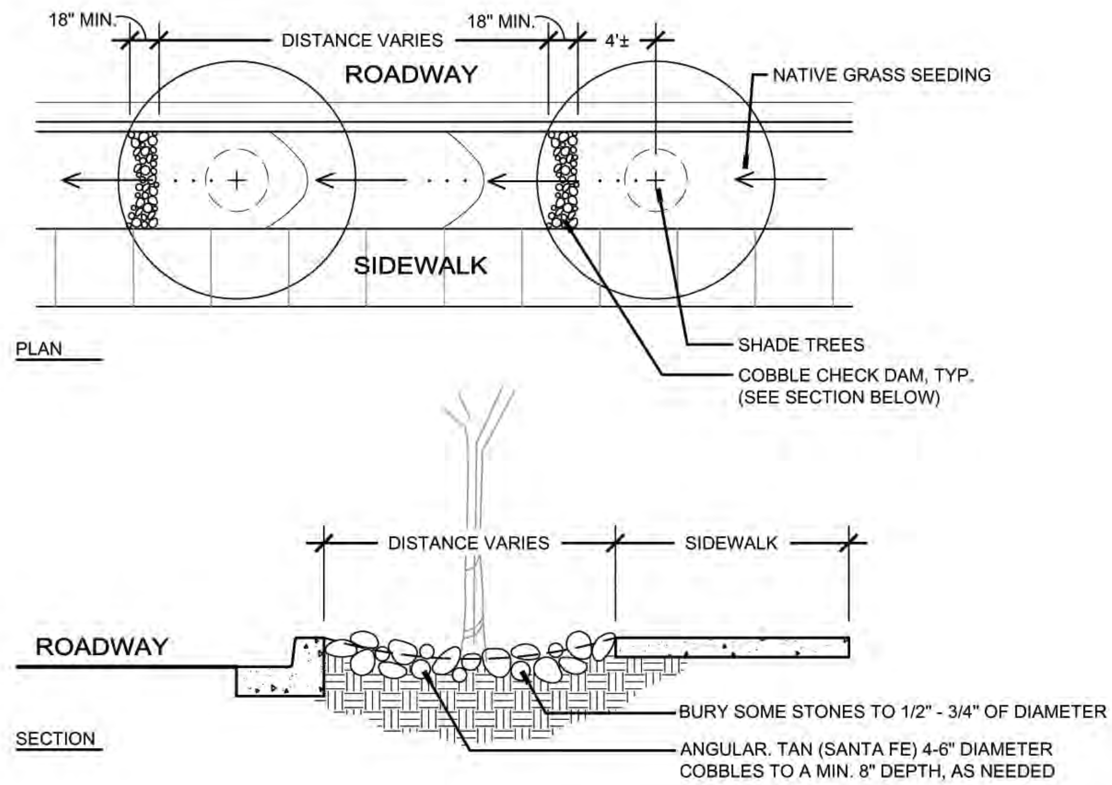
WATER-HARVESTING MEANDER AT CURBED PARKWAY MEDIAN
WINDMILL RIDGE UNIT II



WATER-HARVESTING SWALE IN FLAT-CURBED PARKWAY

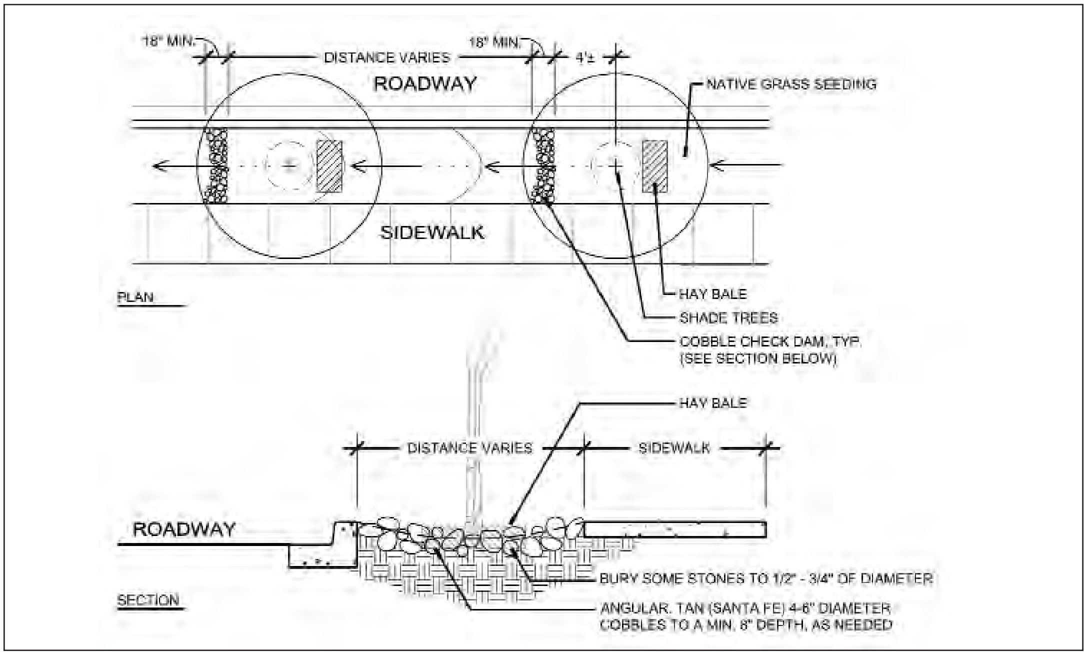
4. Village Roadways and Open Space

WATER-HARVESTING SYSTEMS - COBBLE CHECK DAM IN PARKWAY STREETSCAPE
THE VILLAGE AT RANCHO VIEJO AND WINDMILL RIDGE PHASE I AND UNIT II

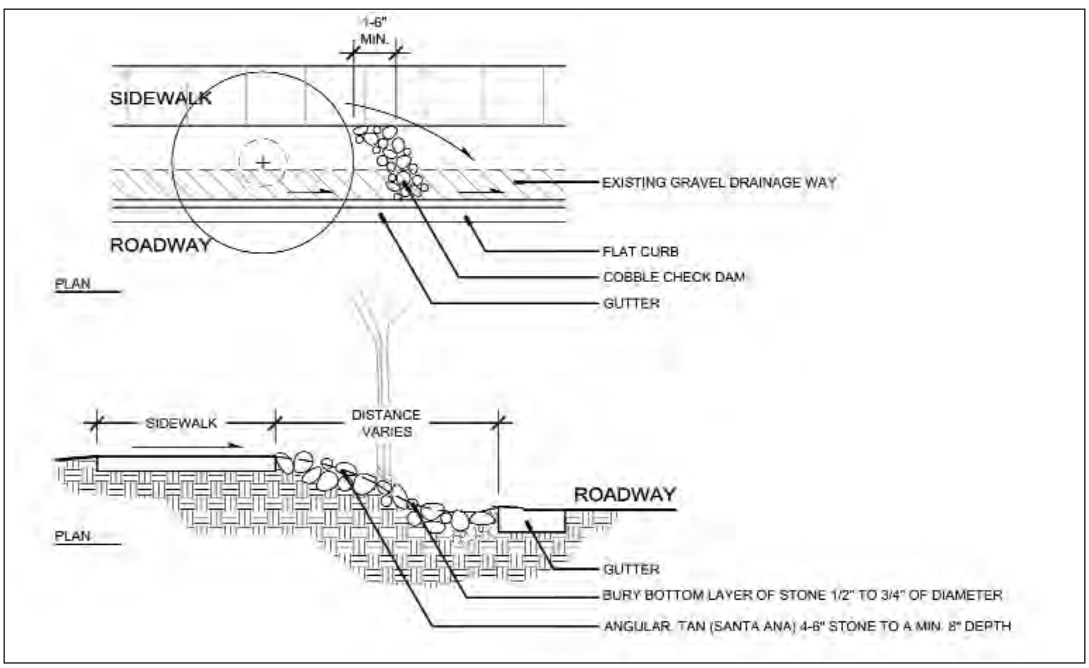


COBBLE CHECK DAM WITH NATIVE PLANTINGS

4. Village Roadways and Open Space

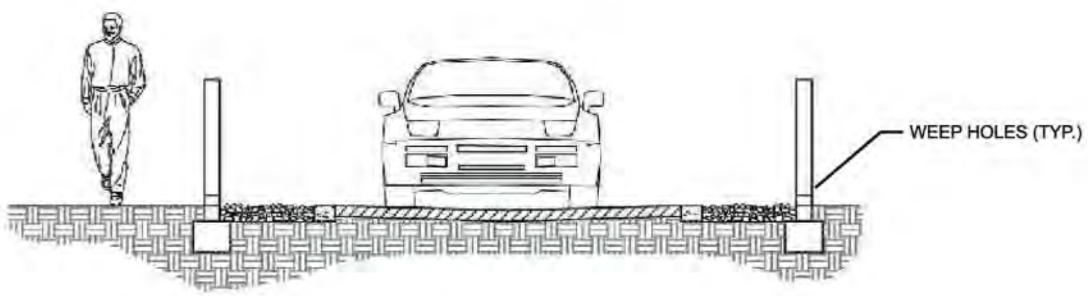


COBBLE CHECK DAM WITH STRAW BALE IN PARKWAY STREETSCAPE
THE VILLAGE AT RANCHO VIEJO AND WINDMILL RIDGE PHASE I AND UNIT II



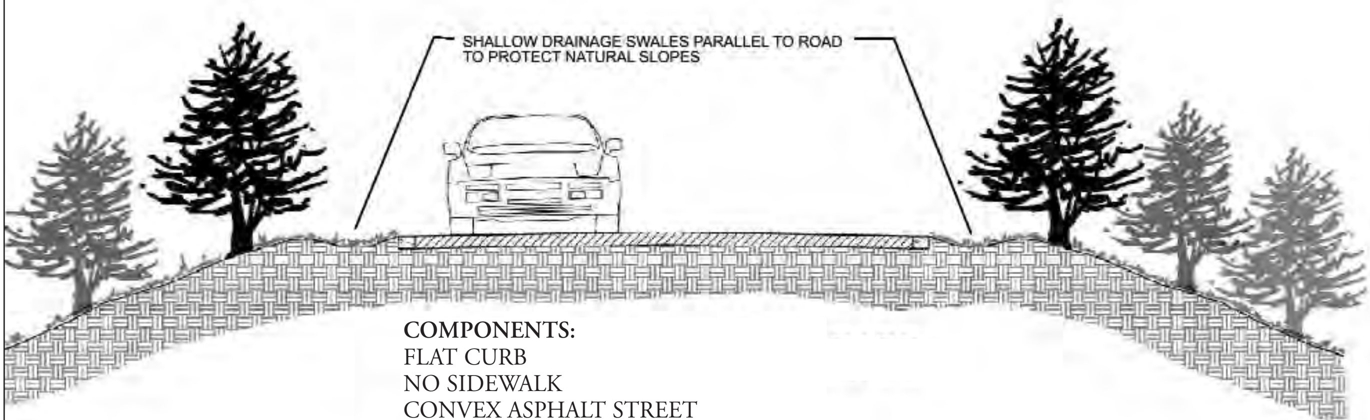
COBBLE CHECK DAM ON STEEP SLOPE IN STREETSCAPE/PARKWAY
THE VILLAGE AT RANCHO VIEJO - SOFTWIND STREET

4. Village Roadways and Open Space



COMPONENTS:
FLAT CURB
CONCAVE ASPHALT ALLEY
GRAVEL MULCH ADJACENT TO YARD WALLS
WEEP HOLES IN YARD WALLS
NO PLANTING

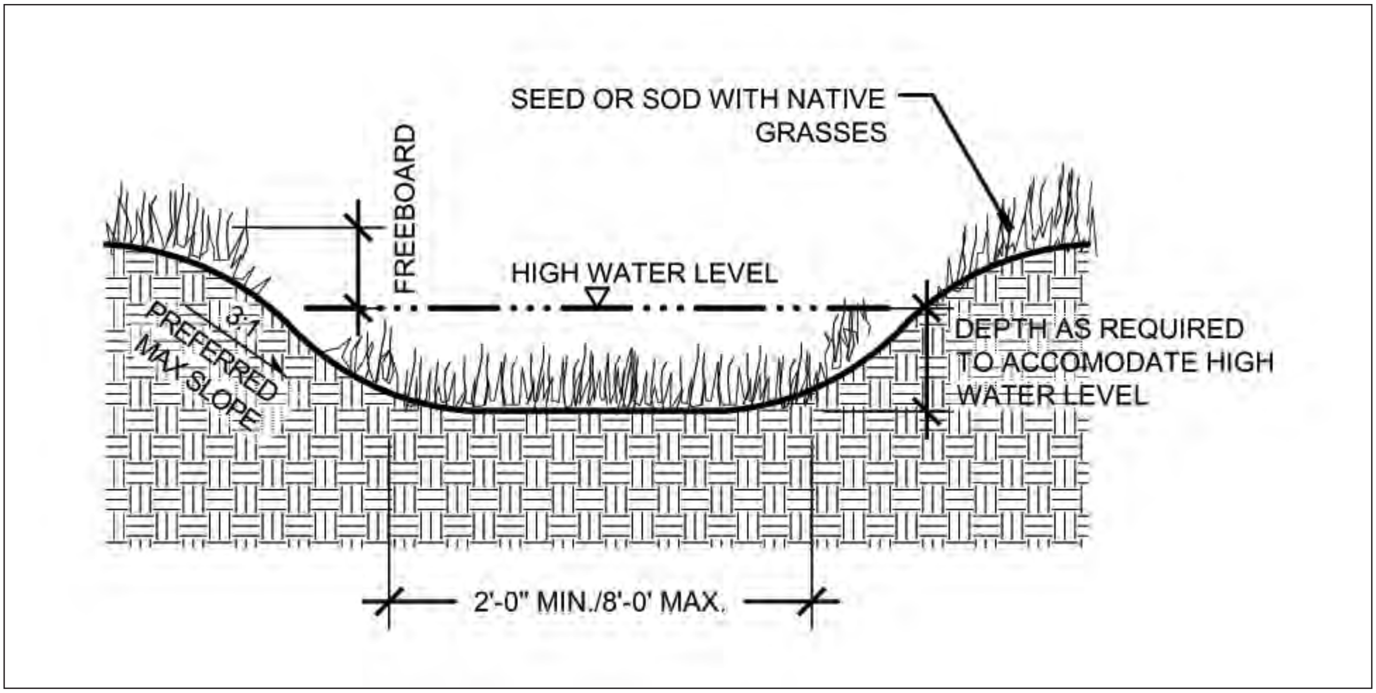
TYPICAL SECTION OF FLAT CURB IN ALLEY
WINDMILL RIDGE



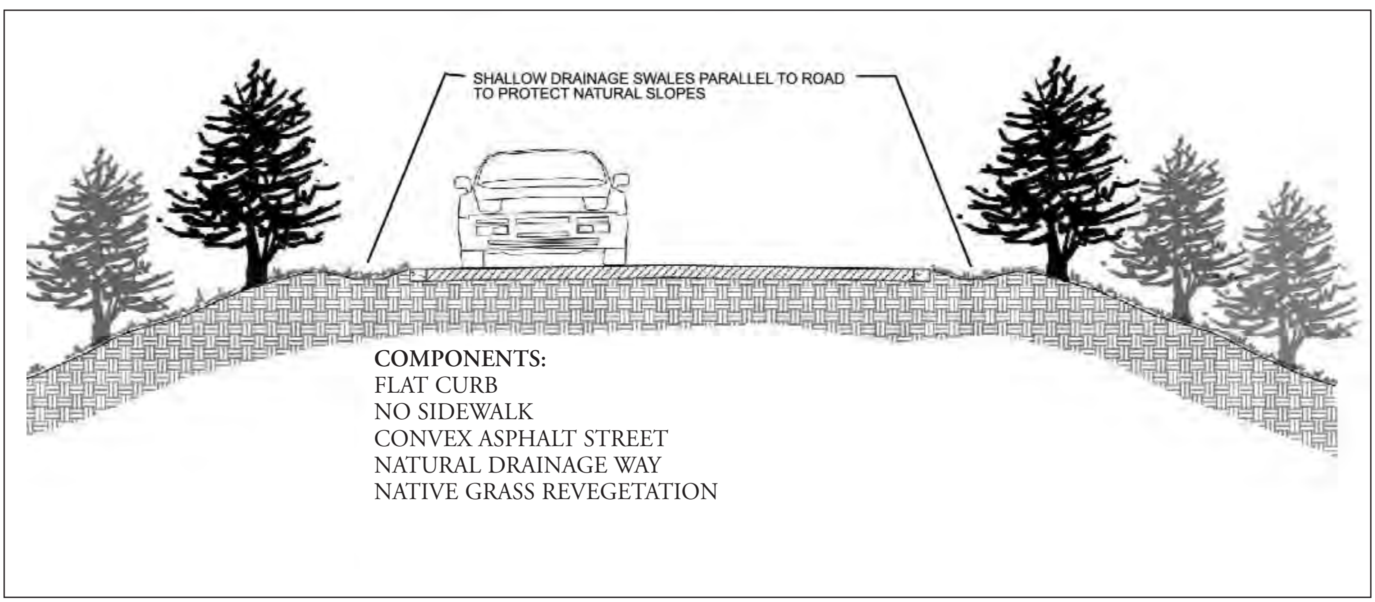
COMPONENTS:
FLAT CURB
NO SIDEWALK
CONVEX ASPHALT STREET
NATURAL DRAINAGE WAY
NATIVE GRASS REVEGETATION

TYPICAL ROLL CURB SECTION AT CONSERVATION/ESTATE LOT DRIVEWAYS AT TOP OF SLOPE
WINDMILL RIDGE

4. Village Roadways and Open Space

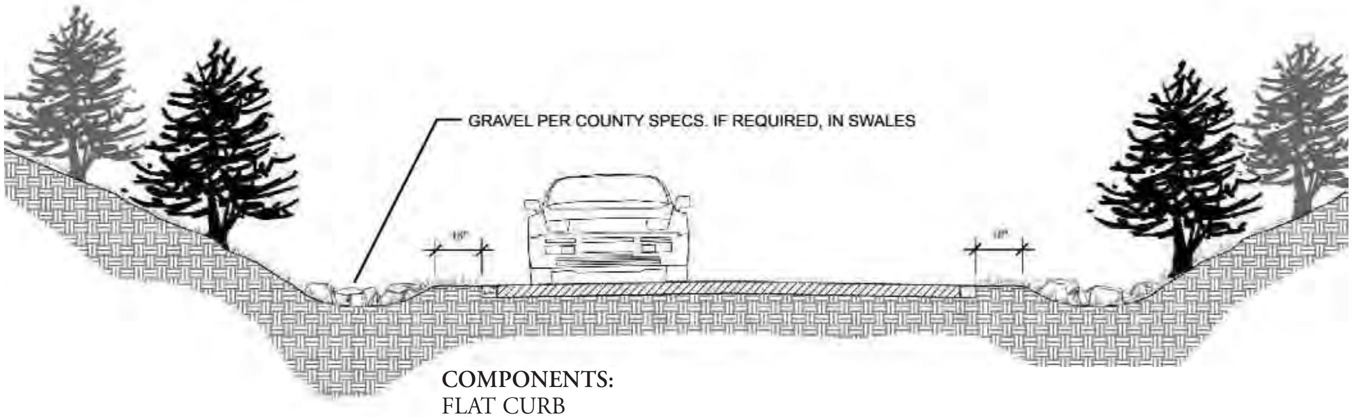


GRASSED SWALE SECTION
WINDMILL RIDGE UNIT II



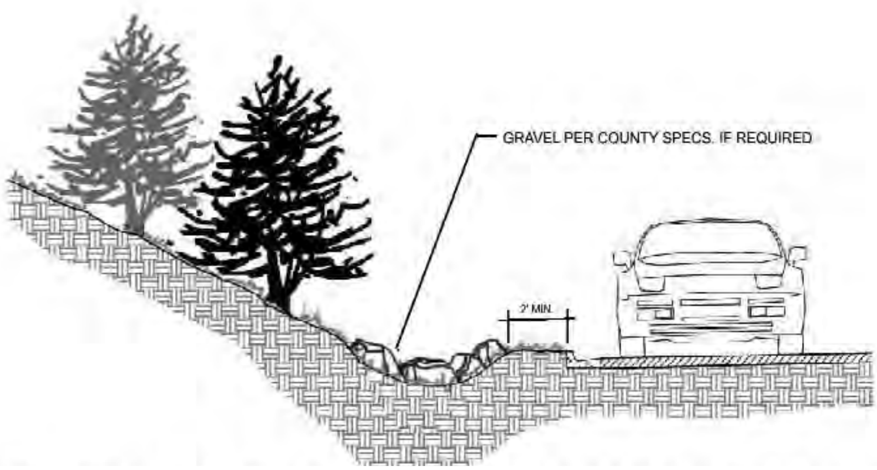
TYPICAL FLAT CURB SECTION AT TOP OF ADJACENT GRADE
WINDMILL RIDGE

4. Village Roadways and Open Space



COMPONENTS:
FLAT CURB
NO SIDEWALK
CONVEX ASPHALT STREET
MEANDERING DRAINAGE WAY
WATER VELOCITY REDUCTION IN SWALE UTILIZING CHECK DAMS
HAY BALE SWALES
SPLIT ROCK PER COUNTY MAINTENANCE SPECS
NATIVE GRASS REVEGETATION

TYPICAL FLAT CURB SECTION AT BOTTOM OF ADJACENT GRADE
WINDMILL RIDGE

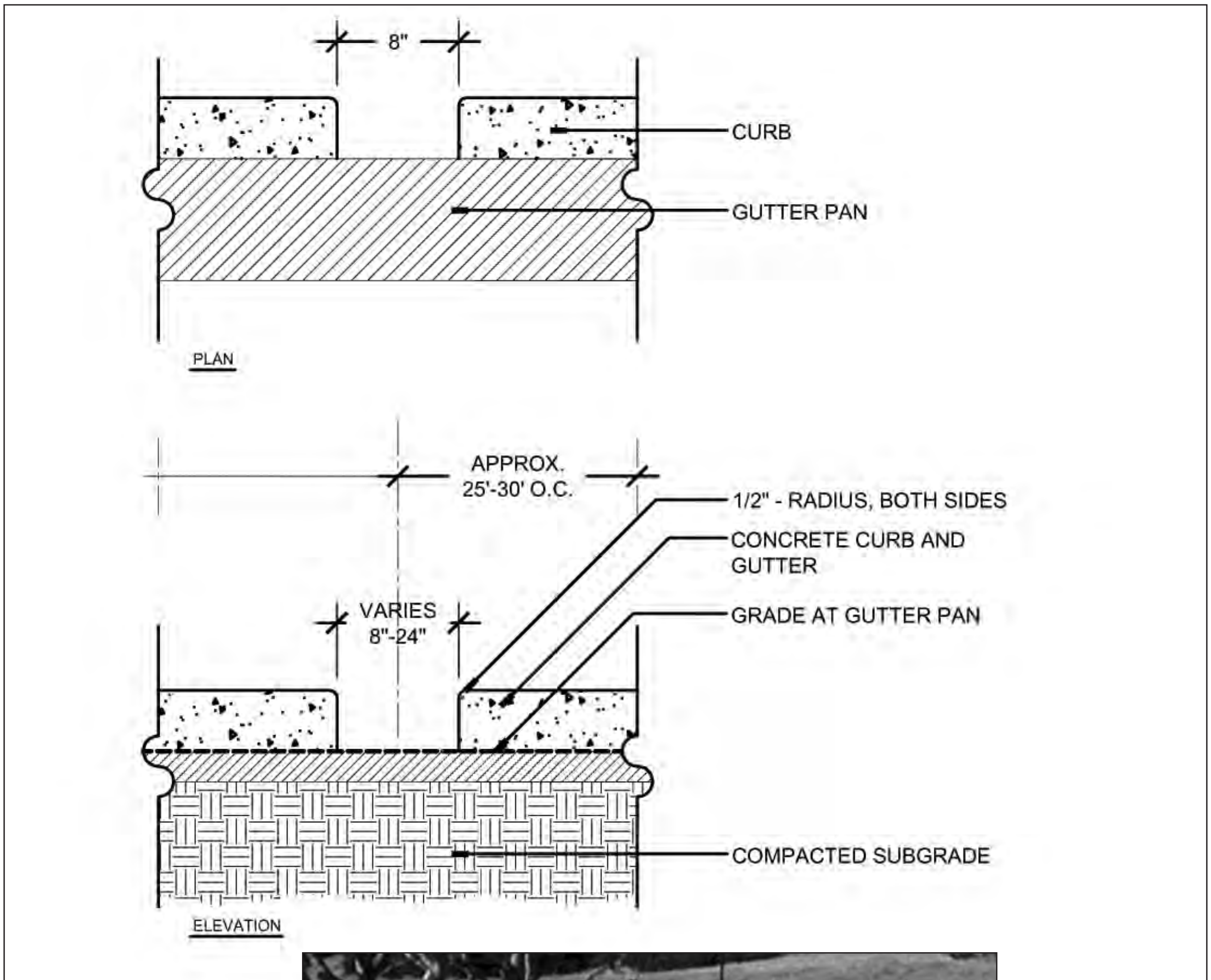


COMPONENTS:
STANDARD CURB
NO SIDEWALK
CONVEX ASPHALT STREET
2-FOOT SHOULDER AT ADJACENT GRADE
NATIVE GRASS AND TREES ON SLOPE

STANDARD CURB SECTION ADJACENT TO DEEP DRAINAGE SWALE
WINDMILL RIDGE

4. Village Roadways and Open Space

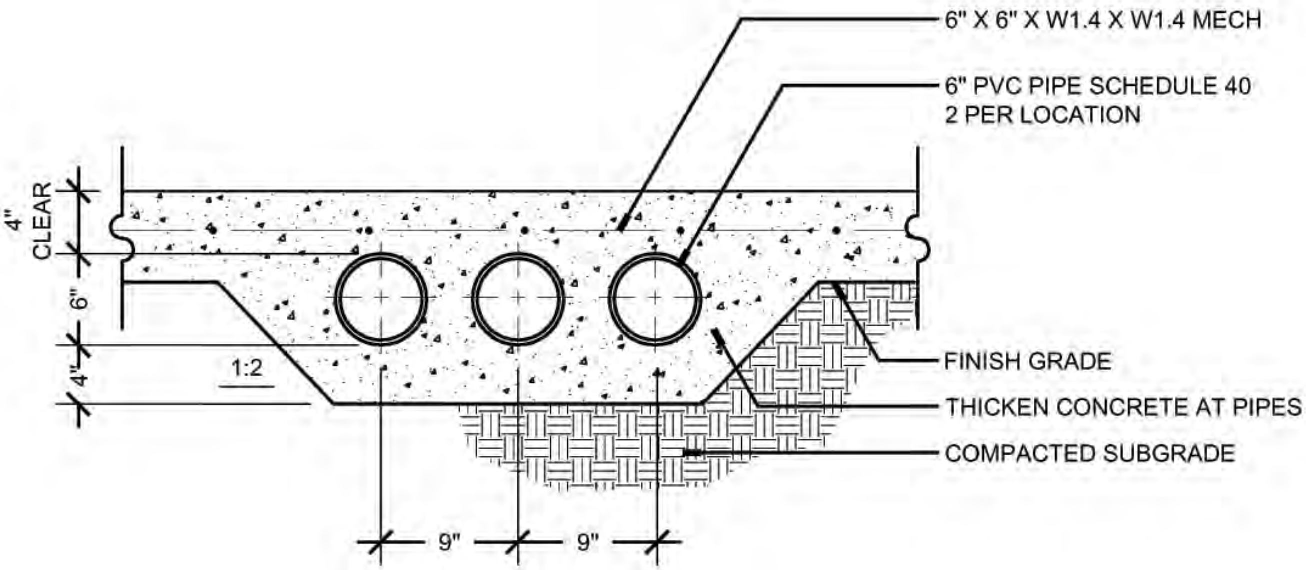
CONCRETE CURB AND GUTTER PAN
WINDMILL RIDGE RESIDENTIAL ROADWAYS



CURB CUT AND DRAINAGE WAY AT SIDEWALK - DIAMOND 10 PLATING

4. Village Roadways and Open Space

SIDEWALK CULVERT SECTION
WINDMILL RIDGE UNIT II

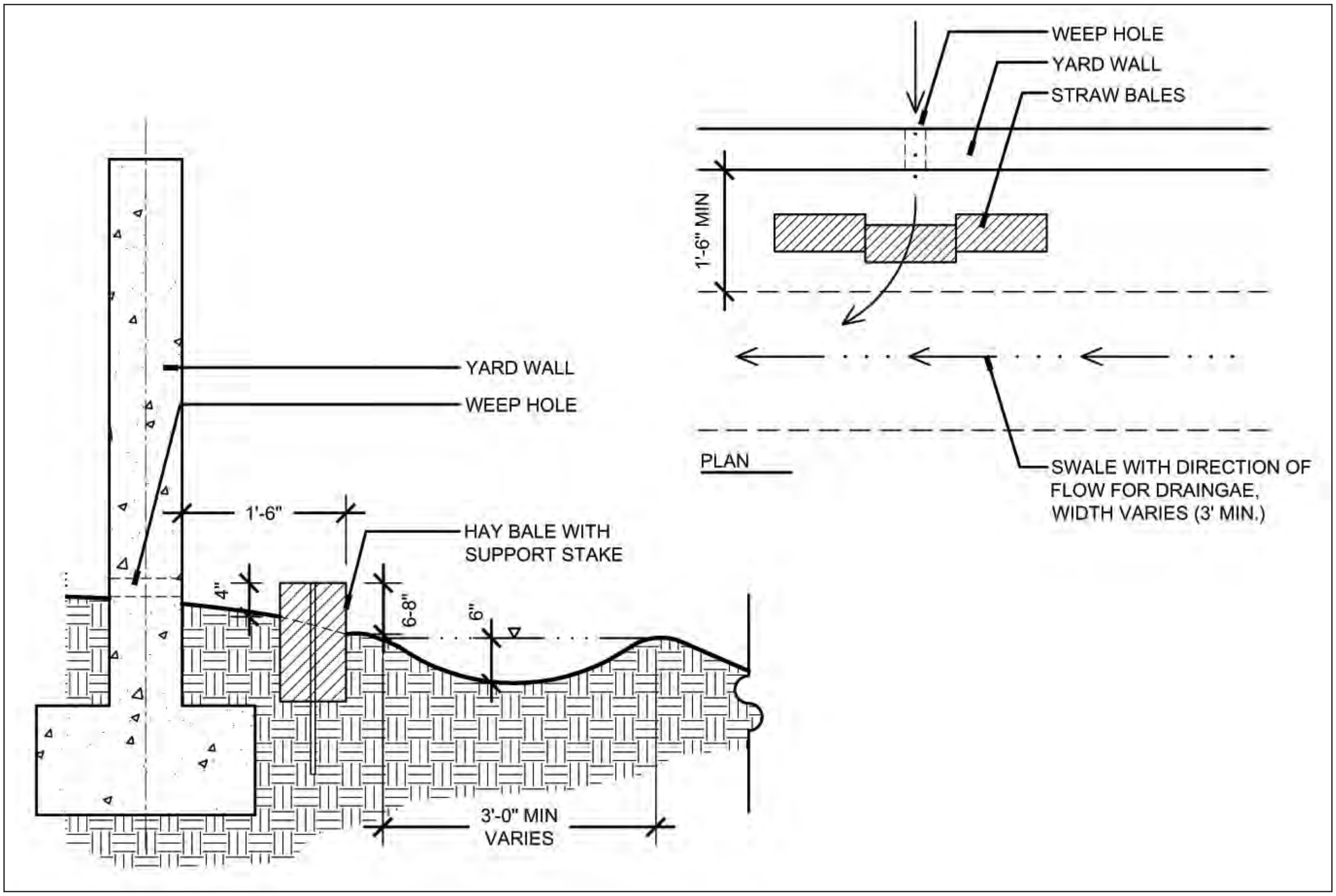


TYPICAL SIDEWALK CULVERT

4. Village Roadways and Open Space

DRAINAGE WAY SIDEWALK CULVERT AT PARK OPEN SPACE (PRIOR TO GRASS INSTALLATION)
WINDMILL RIDGE - UNIT I PARK

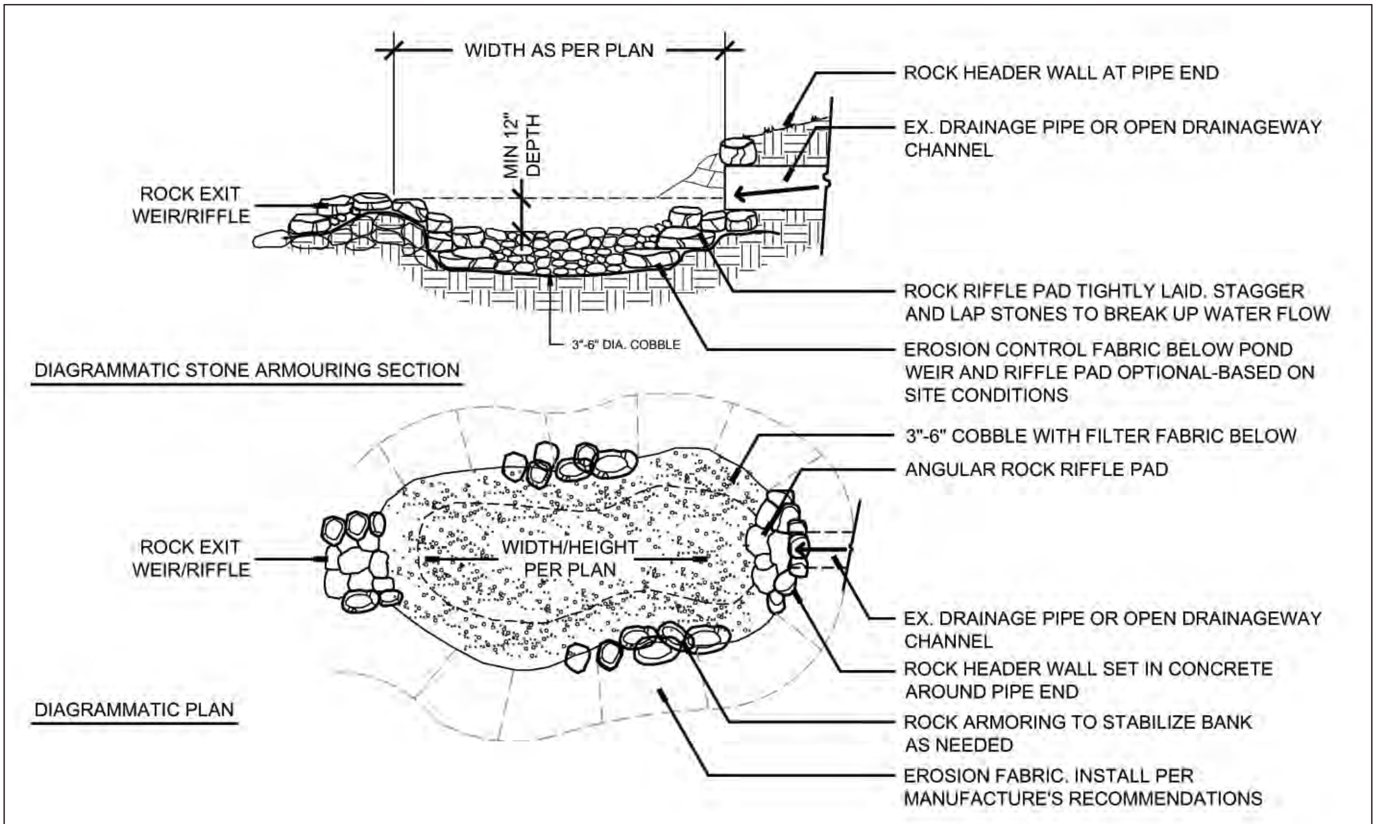
4. Village Roadways and Open Space

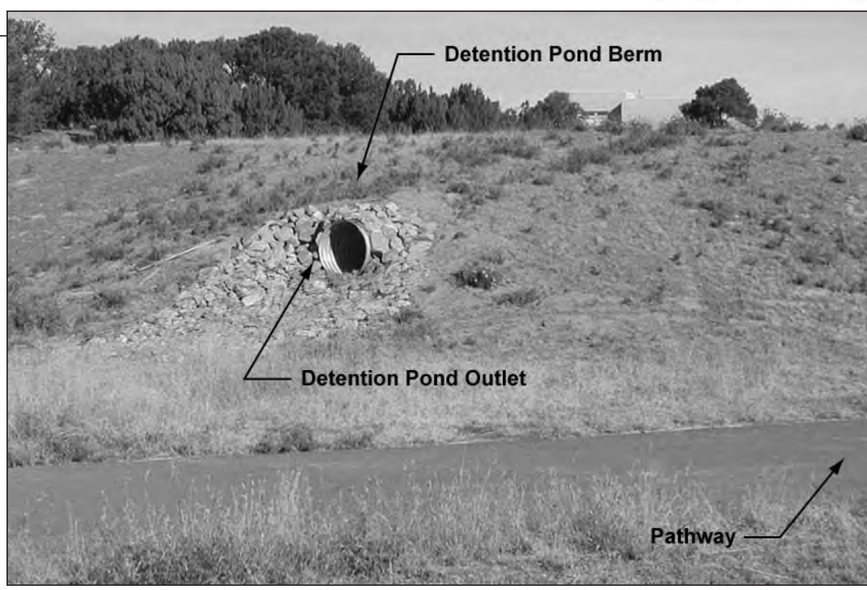


DRAINAGE WAY AT YARD WALL WEEPHOLES (TOP OF SLOPE)
WINDMILL RIDGE UNIT II

4. Village Roadways and Open Space

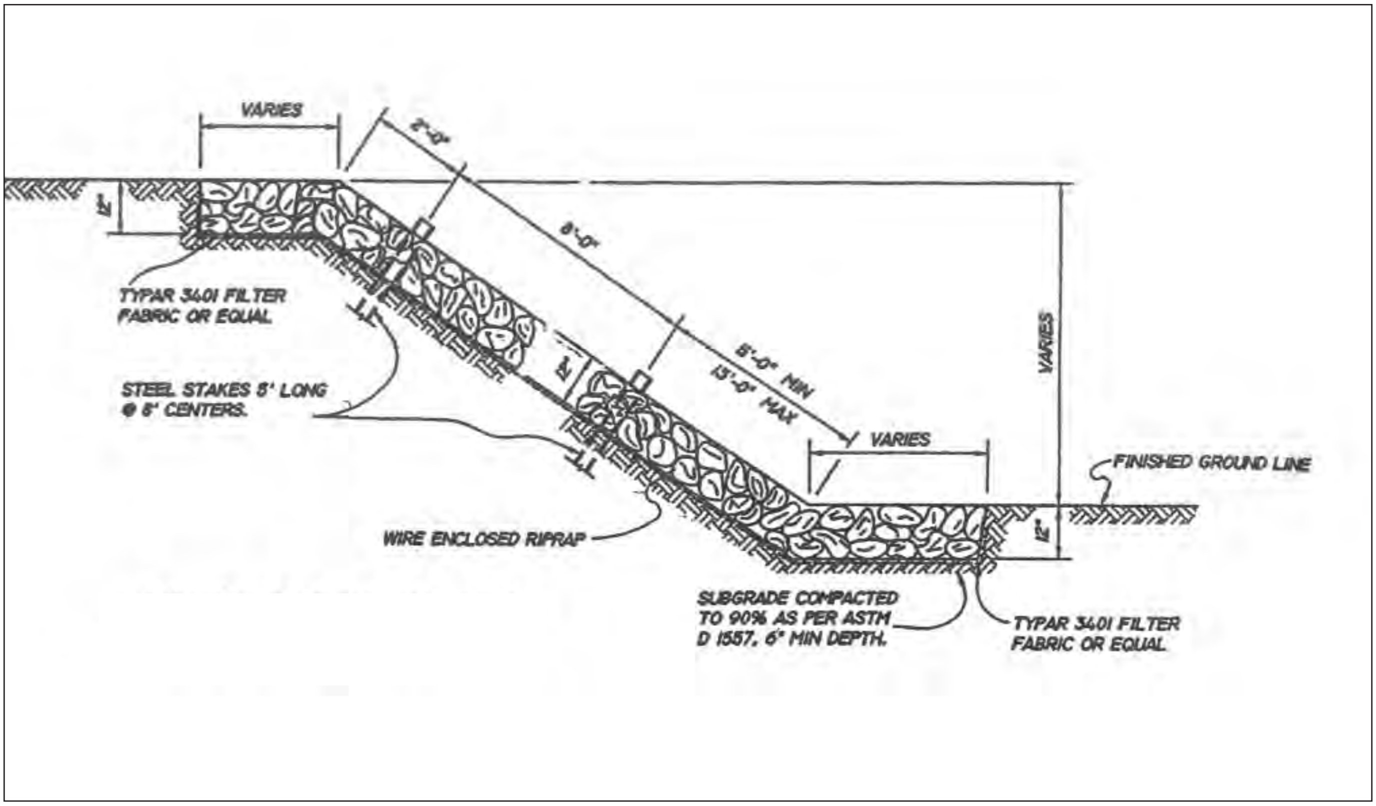
DETENTION/WATER QUALITY BASIN
WINDMILL RIDGE UNIT II





DETENTION POND OUTFALL ARMORING

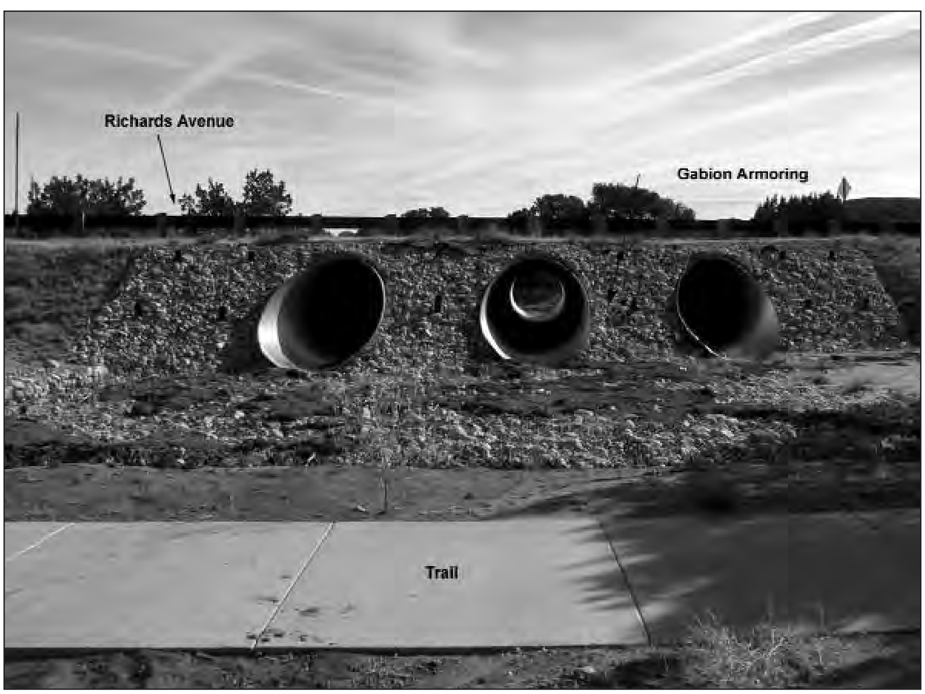
4. Village Roadways and Open Space



RIP RAP SLOPE STABILIZATION
THE VILLAGES AT RANCHO VIEJO

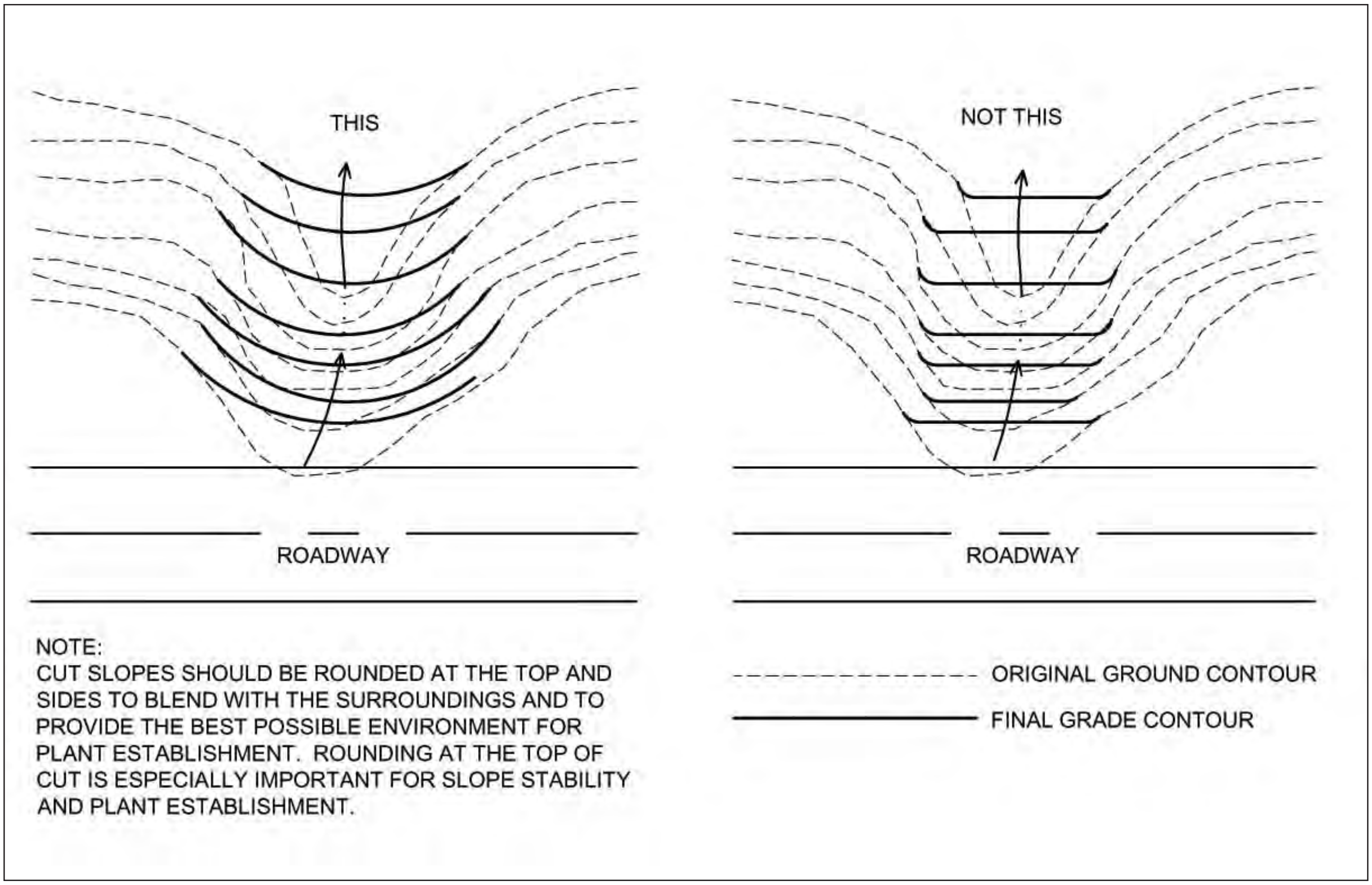
4. Village Roadways and Open Space

GABION SUPPORTED TRAIL
WINDMILL RIDGE - WEST OF RICHARDS AVENUE



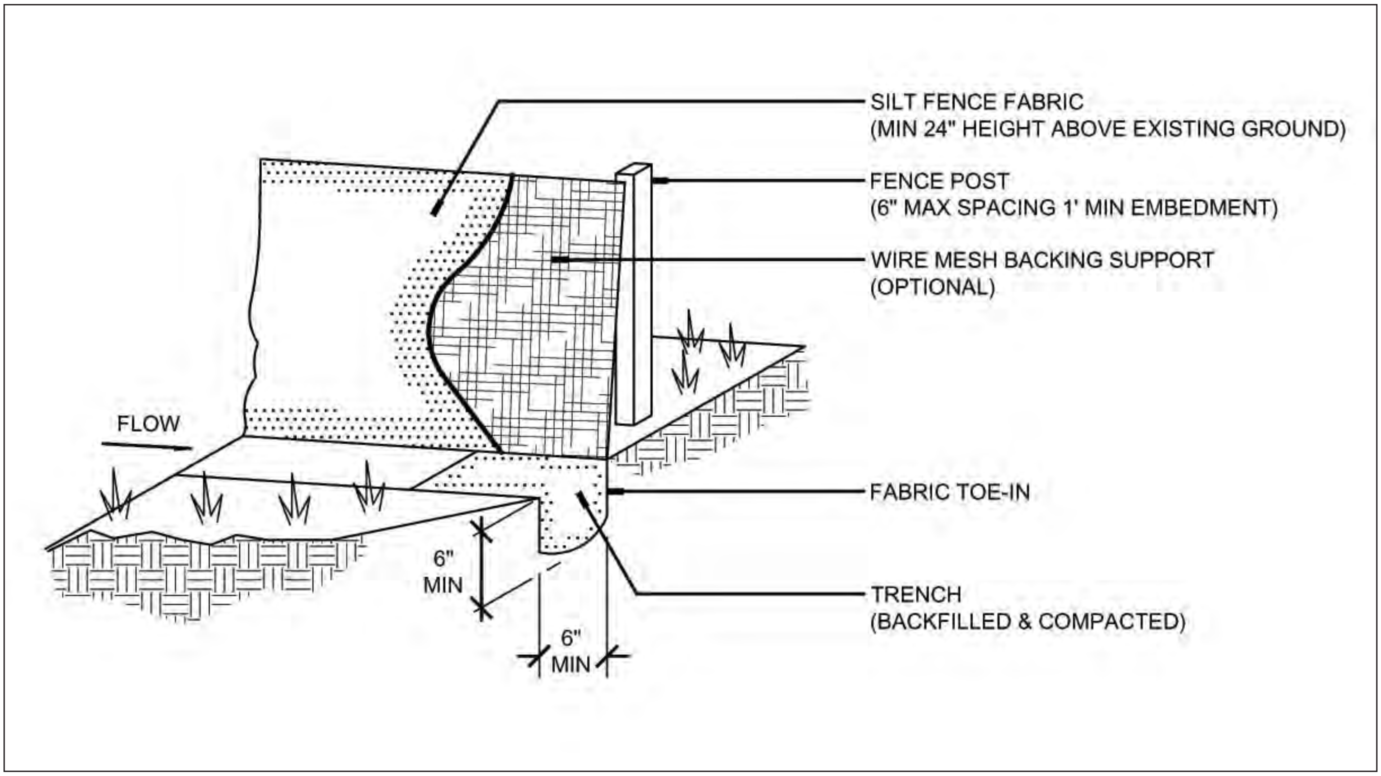
GABION AND ARMORING AT MAJOR ARROYO DRAINAGE WAY
WINDMILL RIDGE - RICHARDS AVENUE

4. Village Roadways and Open Space



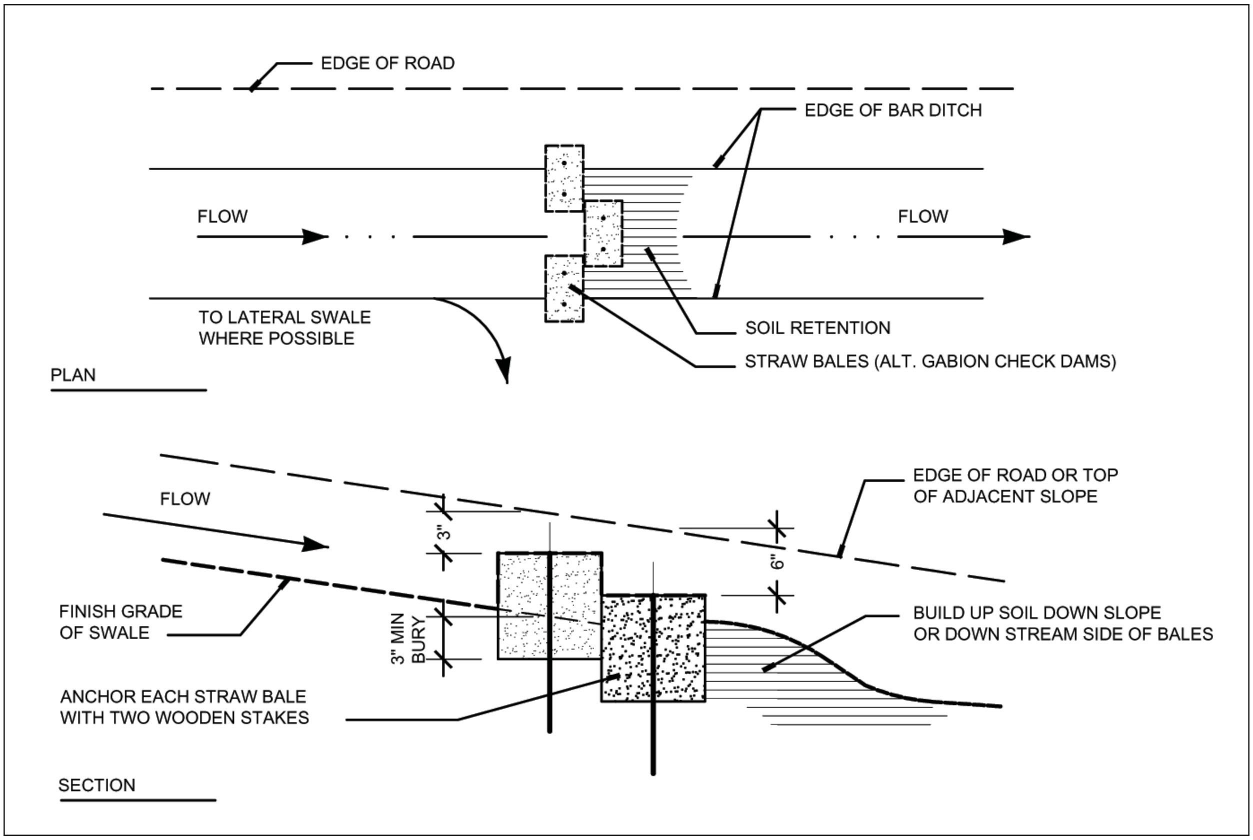
TYPICAL RECOMMENDED SLOPE DRAINAGE WAY GRADING PLAN
WINDMILL RIDGE UNIT II

4. Village Roadways and Open Space



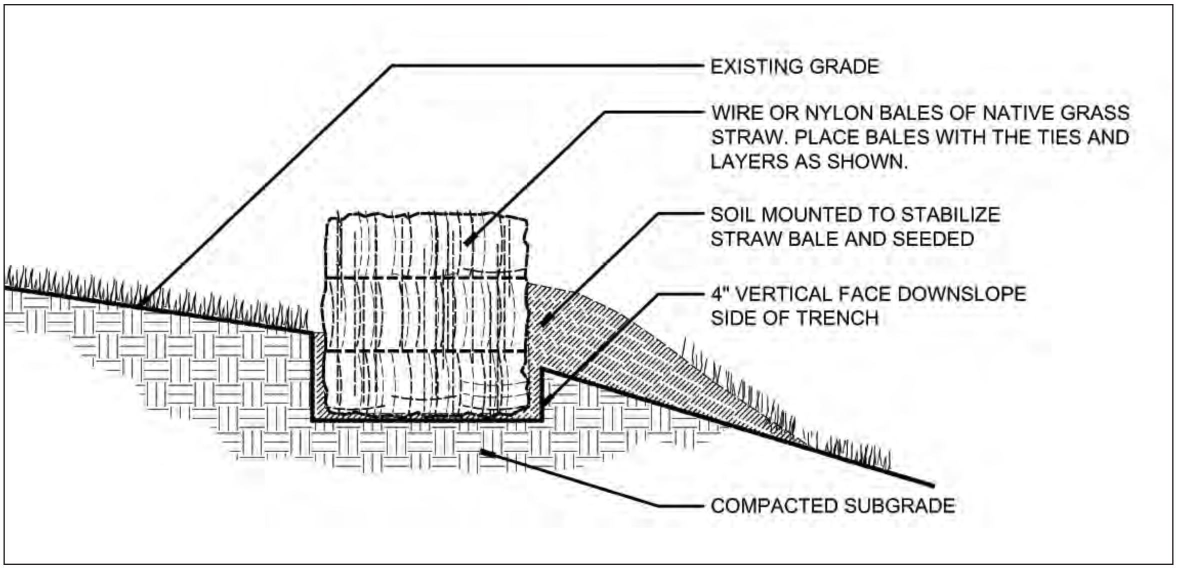
TEMPORARY SILT FENCE AT TOE OF ALL FILLS OVER 3-FEET
THE VILLAGE AT RANCHO VIEJO

4. Village Roadways and Open Space

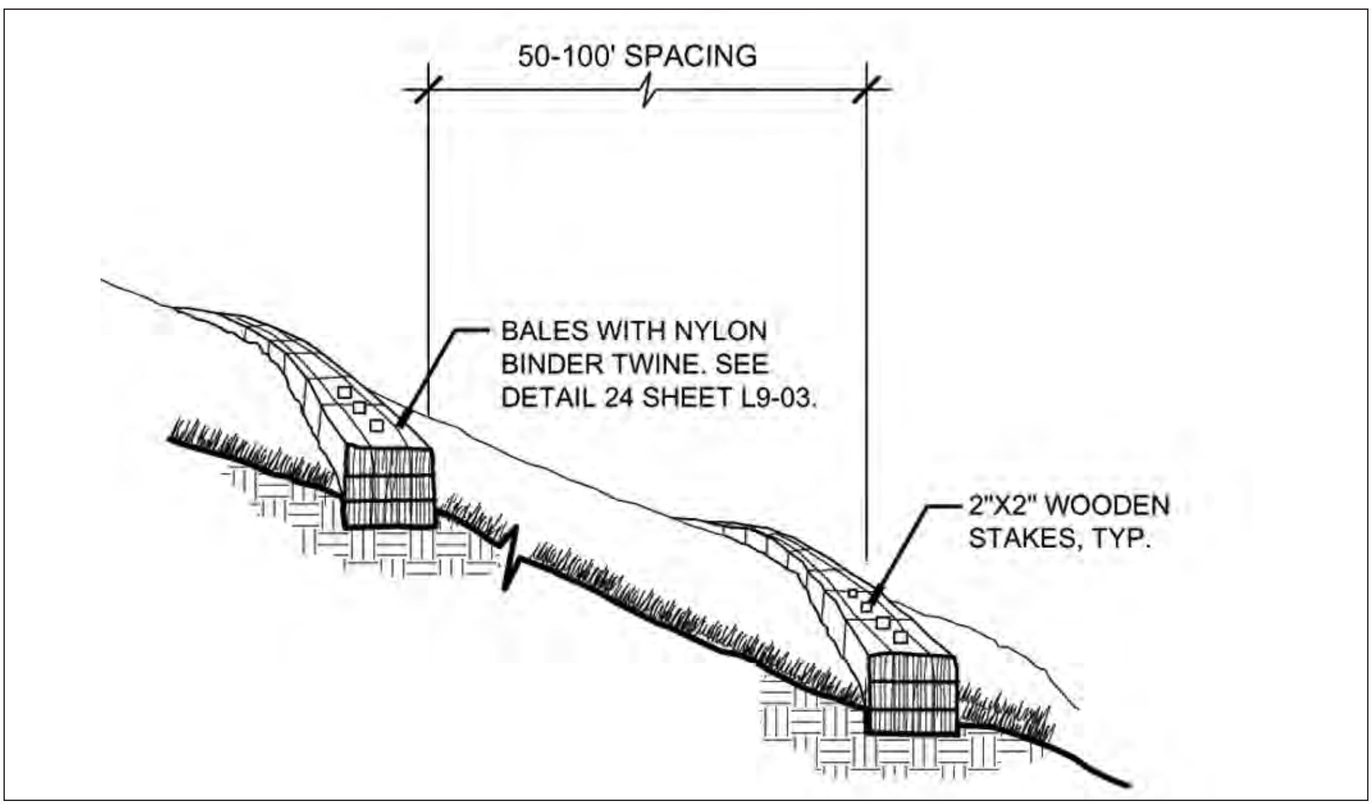


HAY BALE CHECK DAM
THE VILLAGE AT RANCHO VIEJO

4. Village Roadways and Open Space

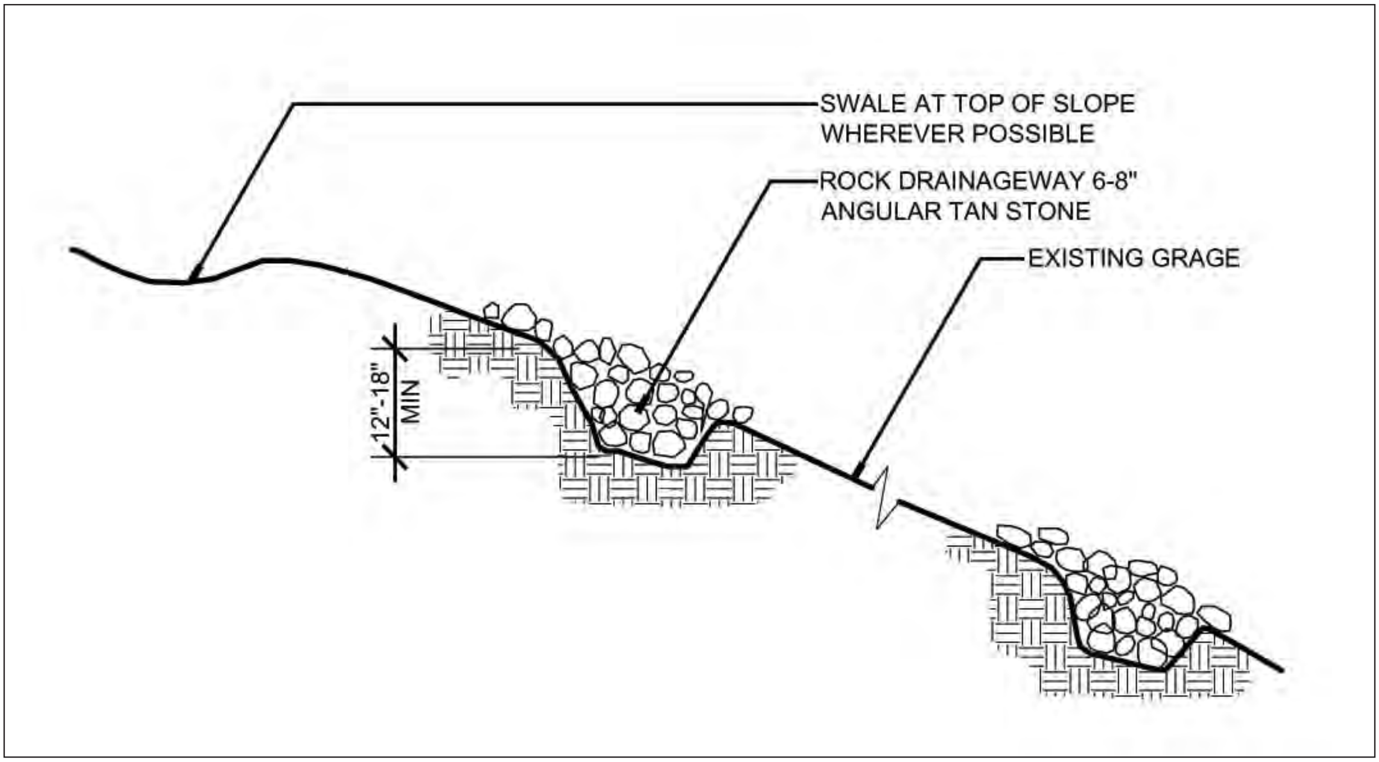


HAY BALE INTERCEPTOR
WINDMILL RIDGE UNIT II



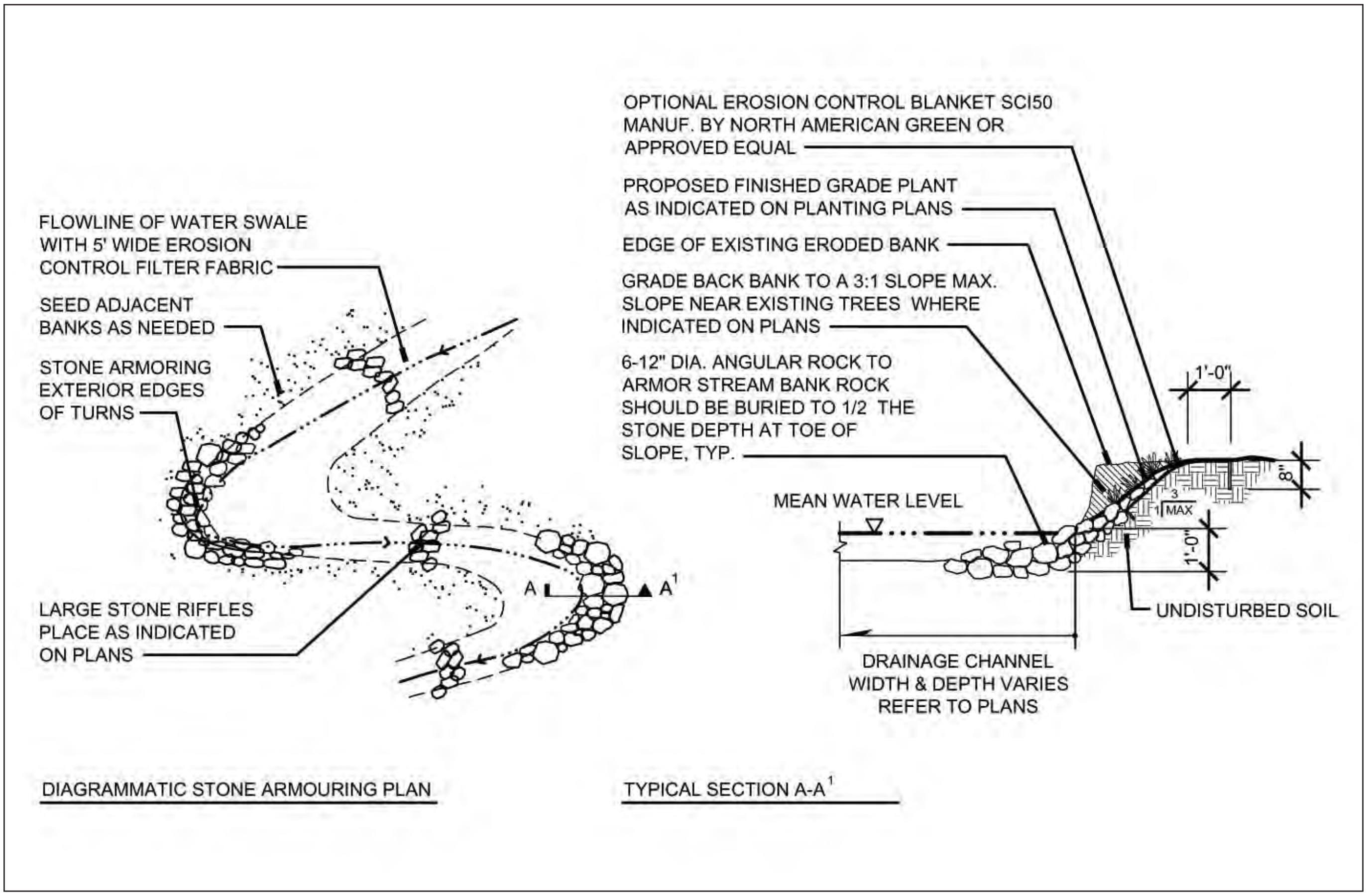
HAY BALE INTERCEPTOR - CROSS SLOPE SECTION
WINDMILL RIDGE UNIT II

4. Village Roadways and Open Space



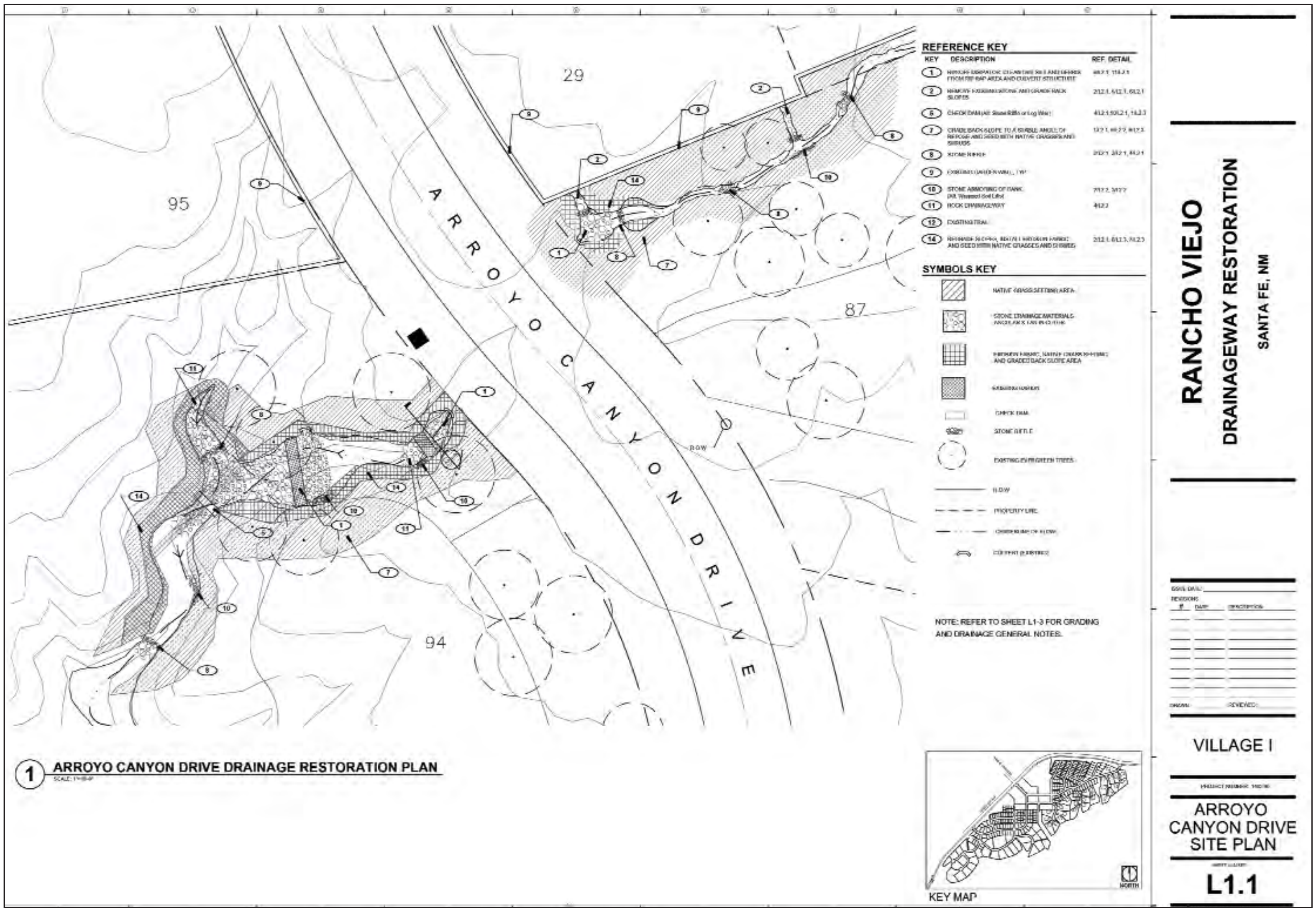
STONE TRENCH INTERCEPTOR/SPREADER SWALE
WINDMILL RIDGE UNIT II

4. Village Roadways and Open Space



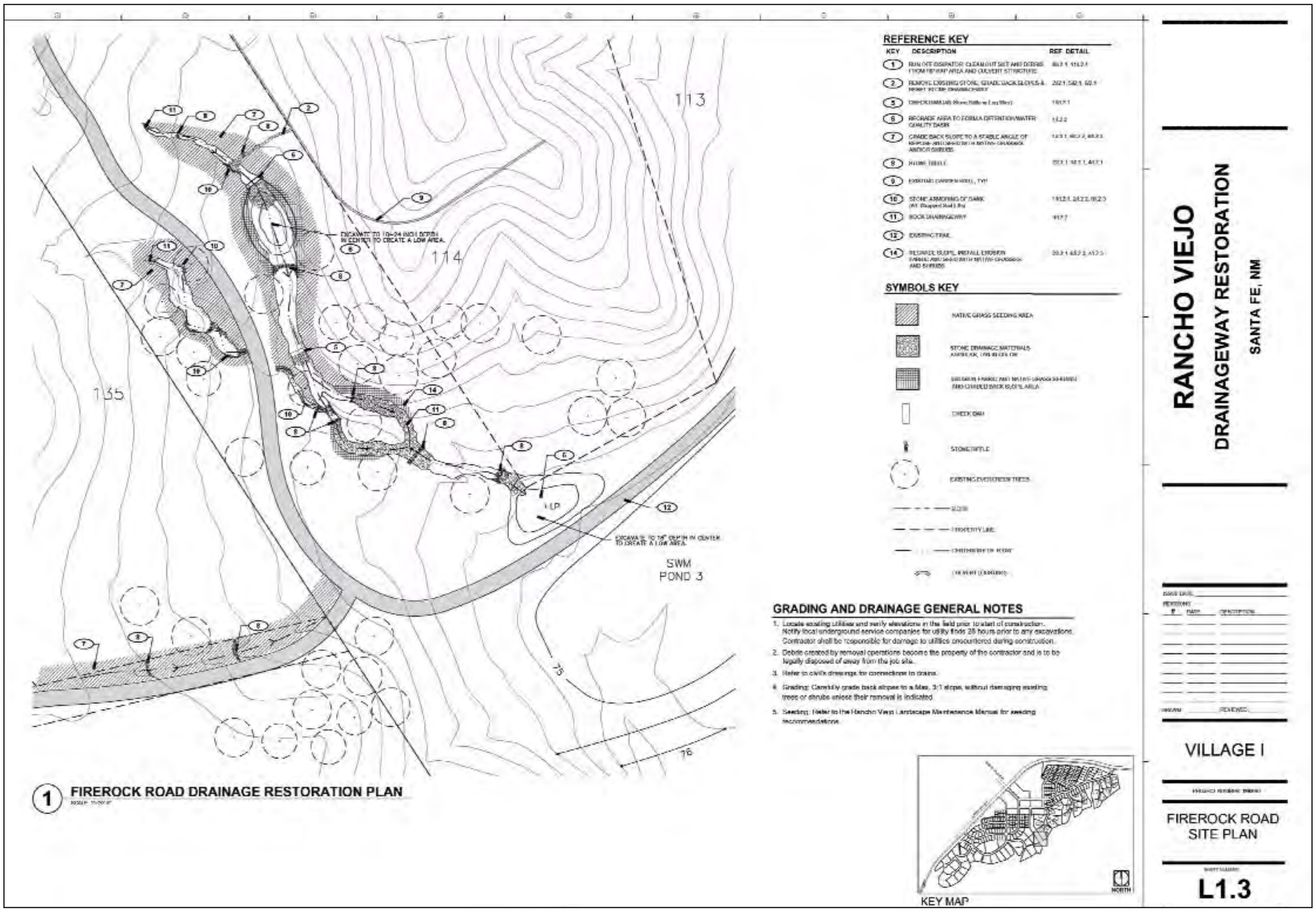
STONE ARMORING AT DRAINAGE CHANNEL
THE VILLAGES AT RANCHO VIEJO

4. Village Roadways and Open Space



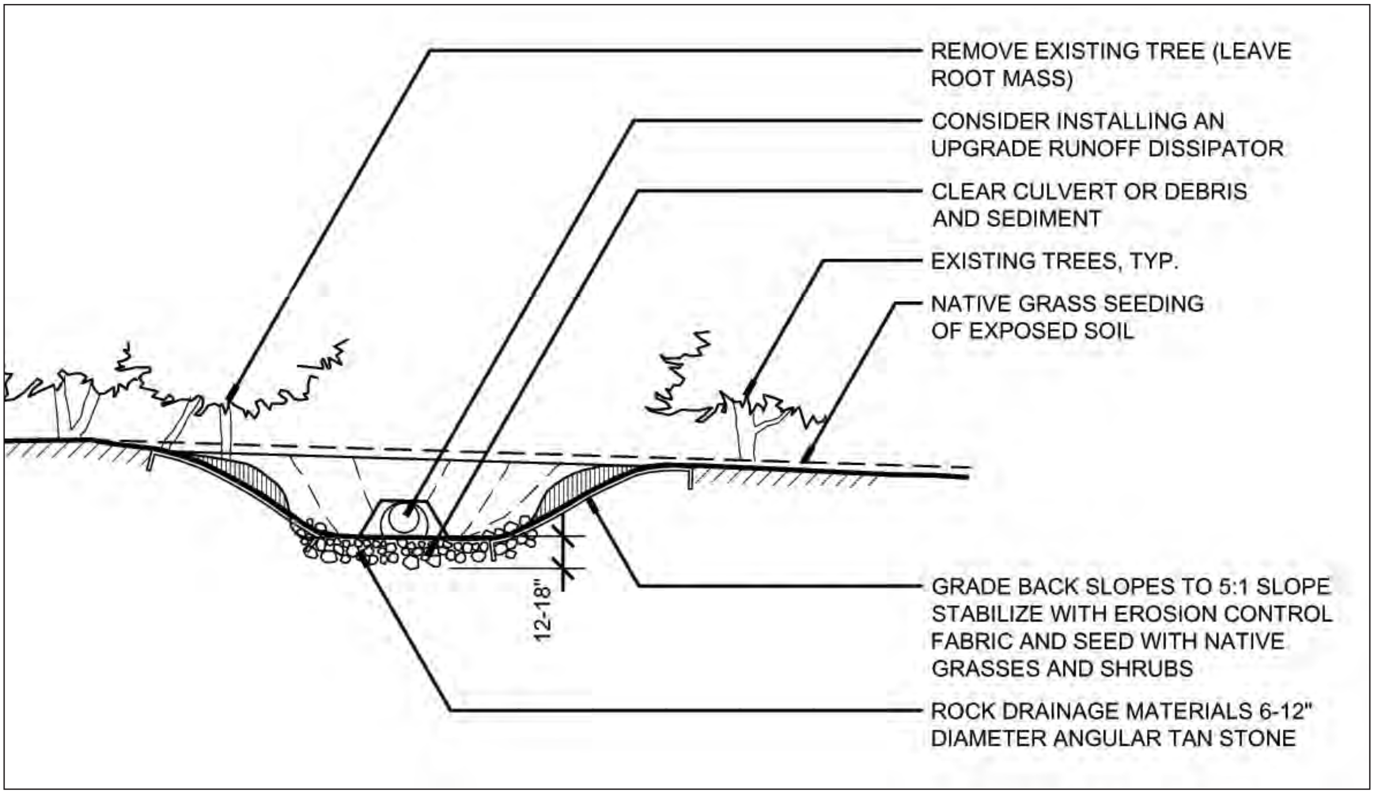
EXAMPLE DRAINAGE WAY RESTORATION PLAN
THE VILLAGES AT RANCHO VIEJO UNIT II - ARROYO CANYON DRIVE

4. Village Roadways and Open Space

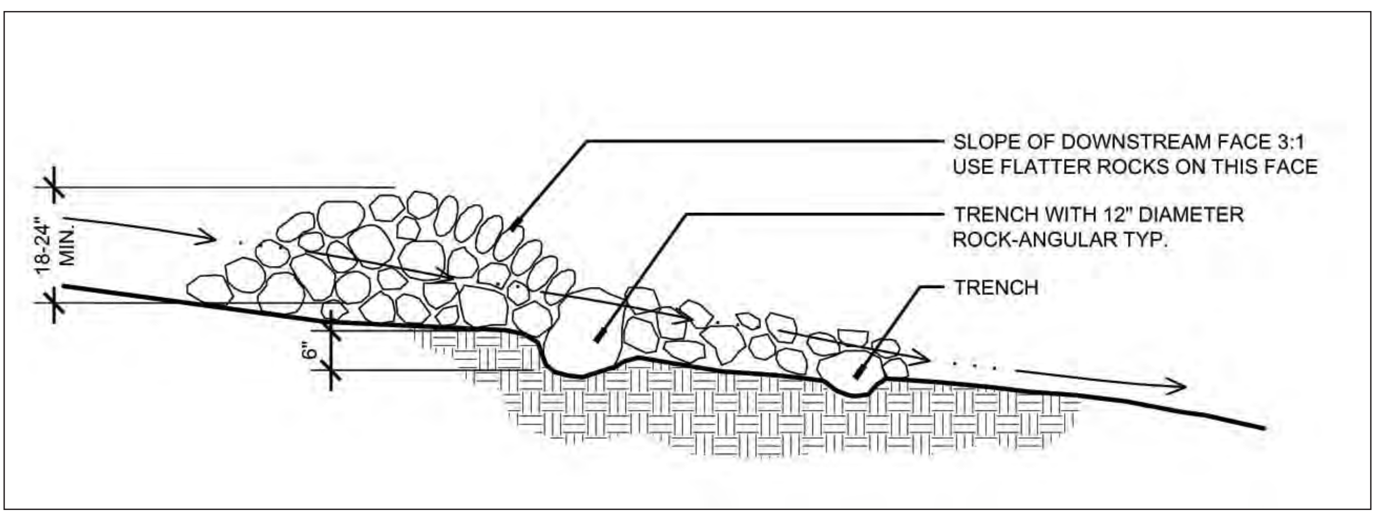


FIREROCK ROAD DRAINAGE WAY RESTORATION PLAN
THE VILLAGES AT RANCHO VIEJO UNIT II

4. Village Roadways and Open Space

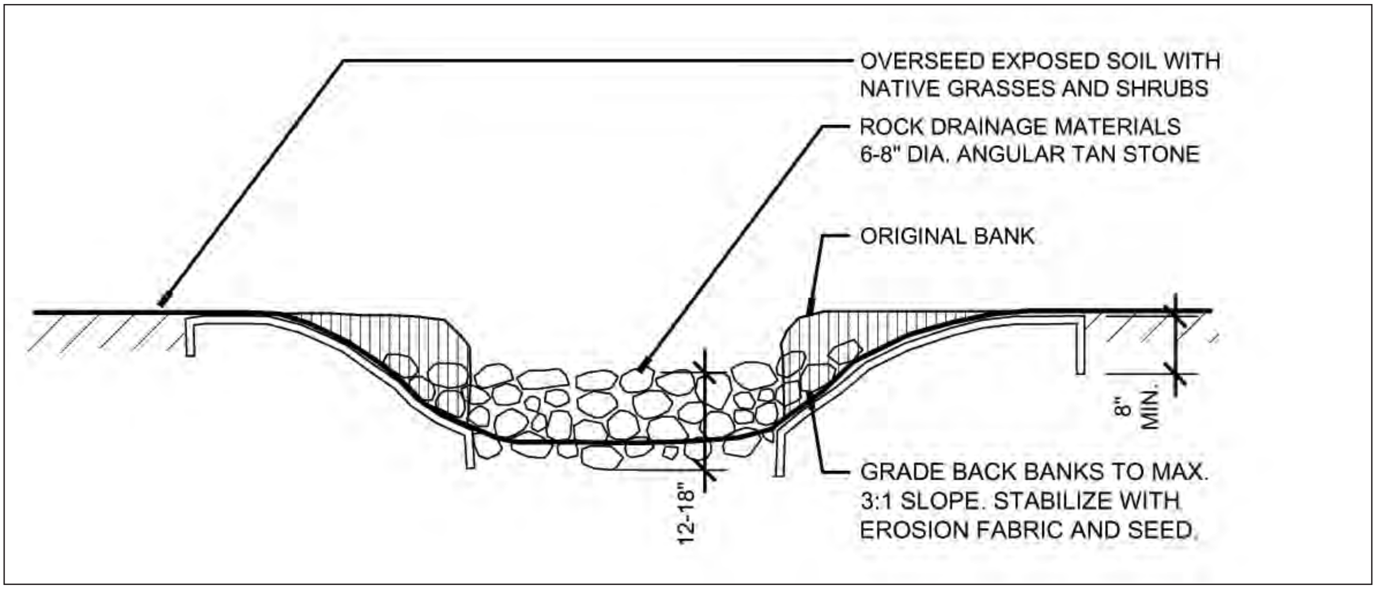


TYPICAL CULVERT SECTION
THE VILLAGES AT RANCHO VIEJO

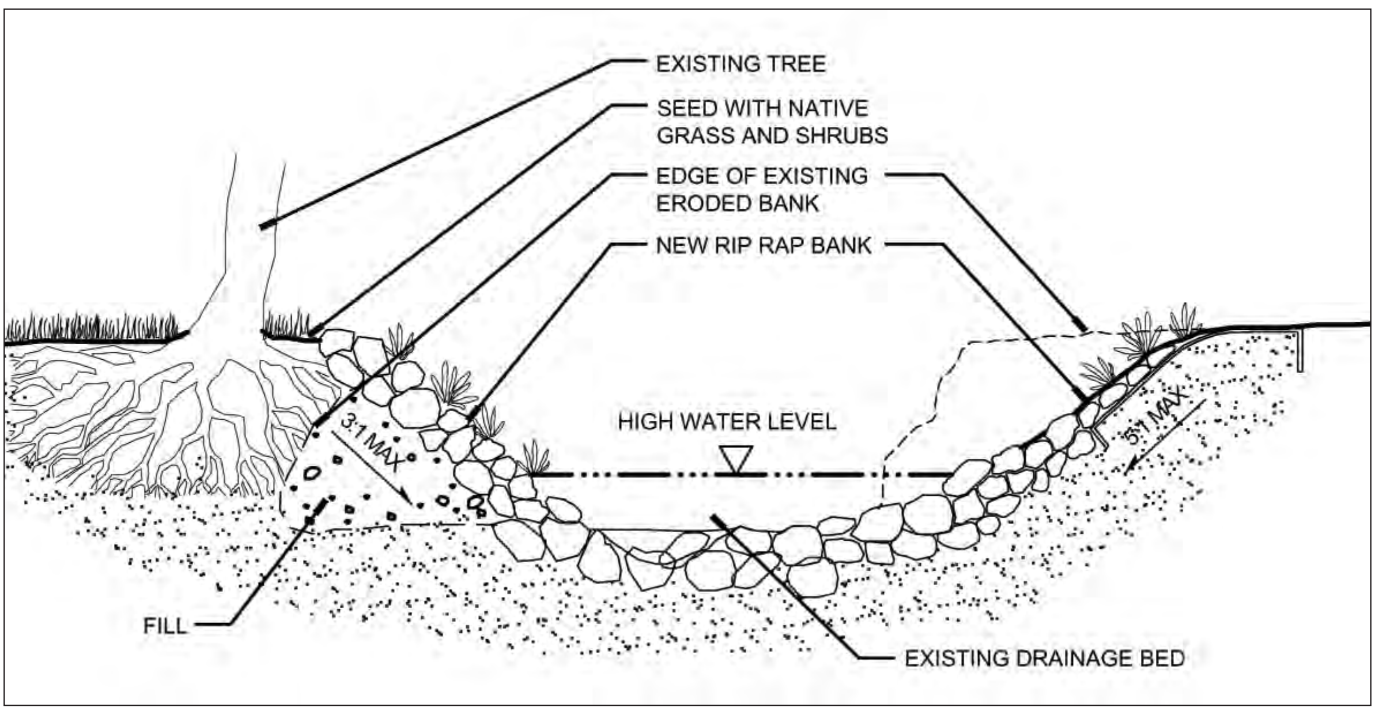


STONE RIFFLE/WEIR CROSS SECTION - ARROYOS AND MAJOR DRAINAGEWAYS ONLY
THE VILLAGES AT RANCHO VIEJO

4. Village Roadways and Open Space

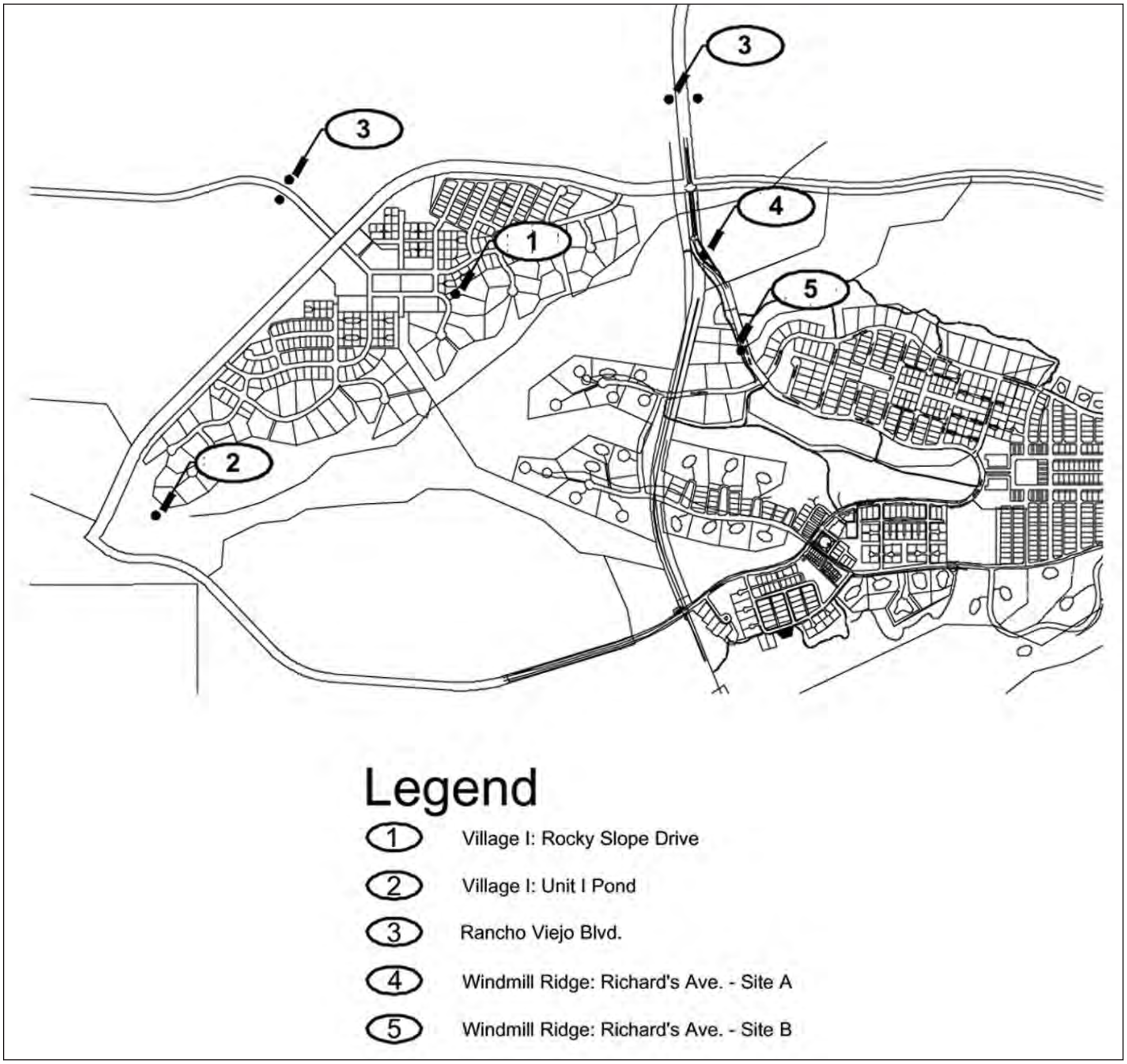


TYPICAL RIFFLE/STONE WEIR SECTION
THE VILLAGES AT RANCHO VIEJO



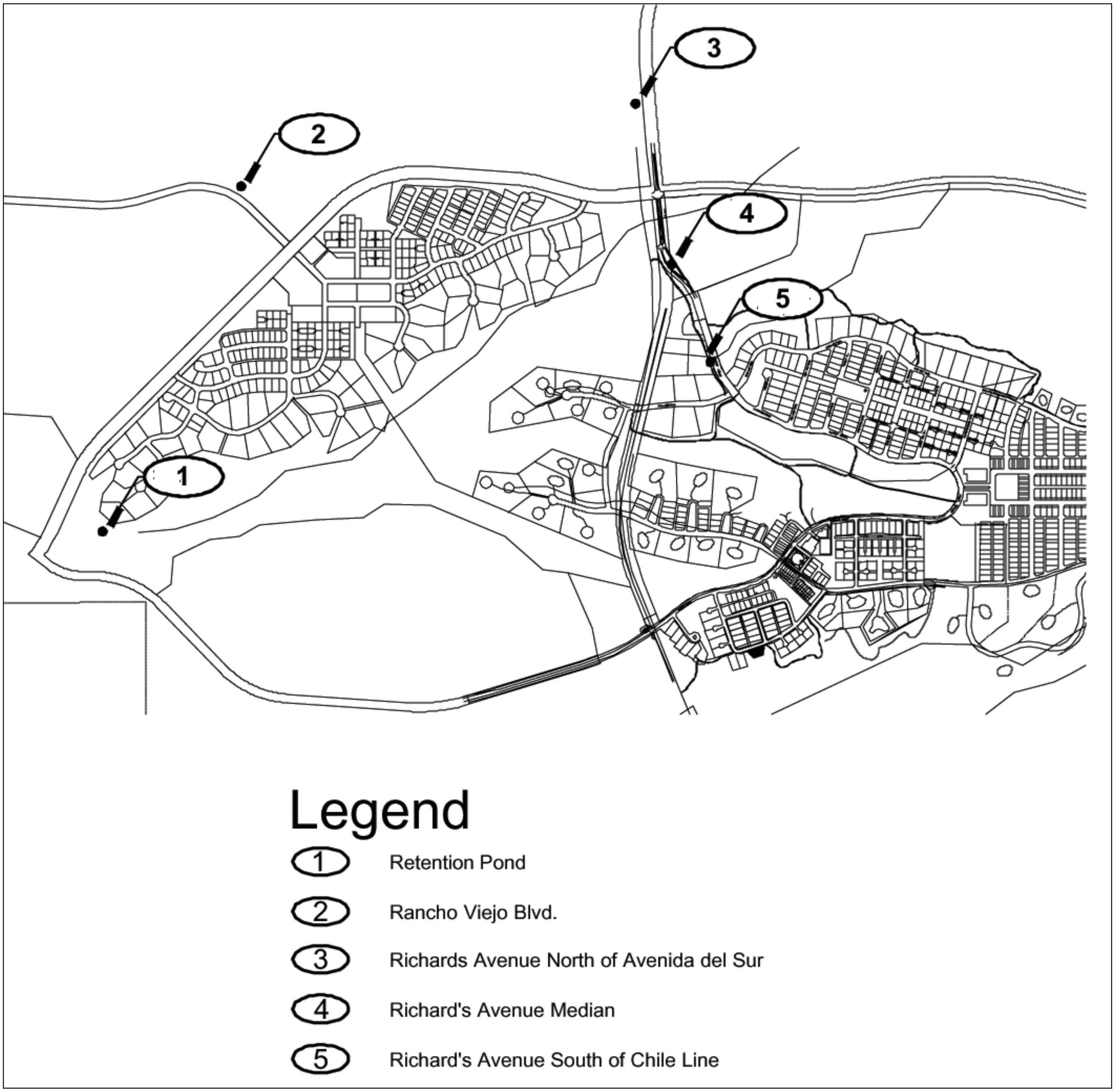
SLOPE STABILIZATION SECTION AT EXISTING TREES - ARROYOS AND MAJOR DRAINAGEWAYS ONLY
THE VILLAGES AT RANCHO VIEJO

4. Village Roadways and Open Space



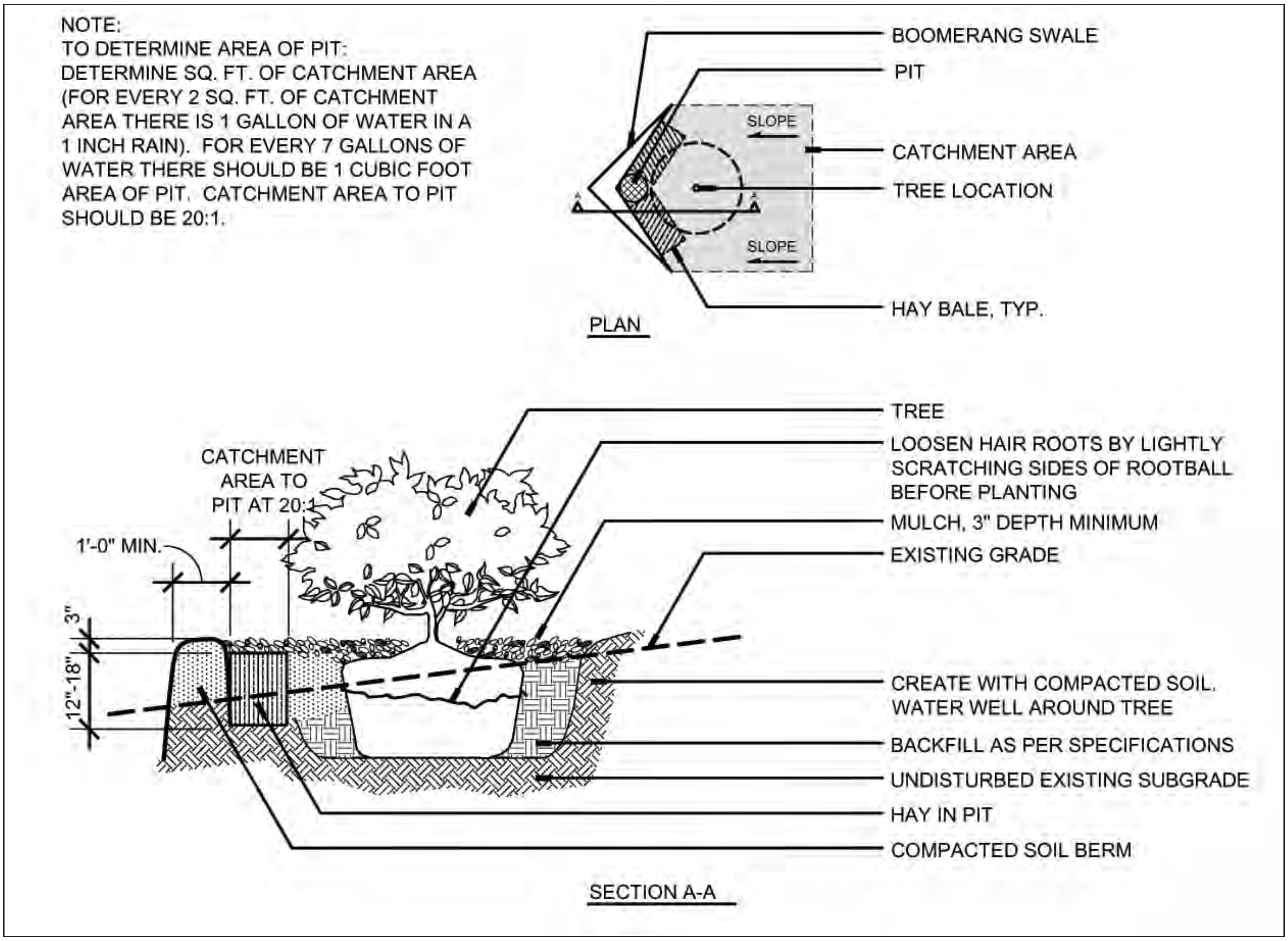
NATIVE GRASS SEED/WILDFLOWER TEST LOCATIONS PLAN
THE VILLAGES AT RANCHO VIEJO UNITS I AND 2 AND WINDMILL RIDGE UNITS 1 AND II

4. Village Roadways and Open Space



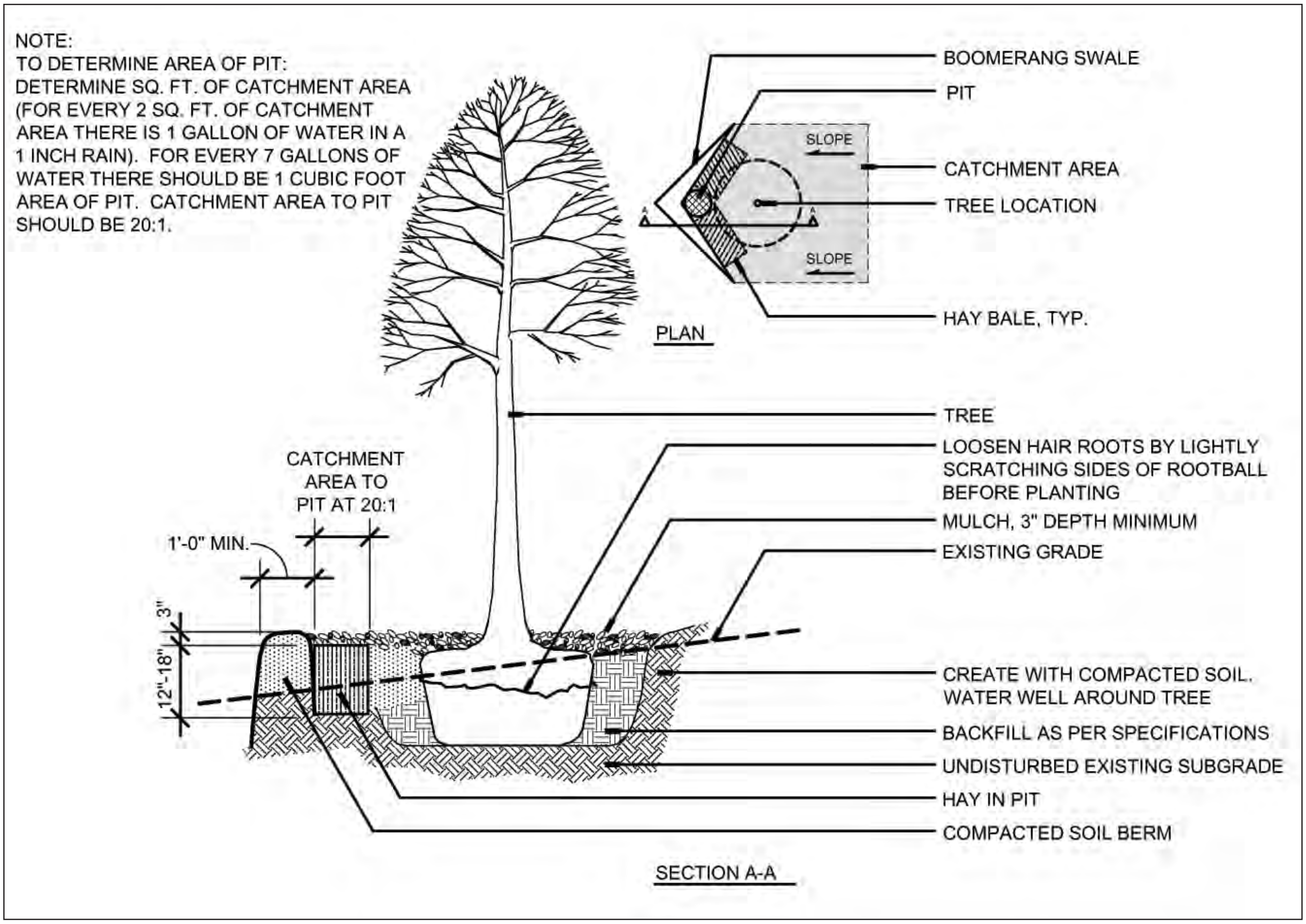
SOIL TEST LOCATIONS PLAN
THE VILLAGES AT RANCHO VIEJO AND WINDMILL RIDGE UNITS 1 AND 2

4. Village Roadways and Open Space



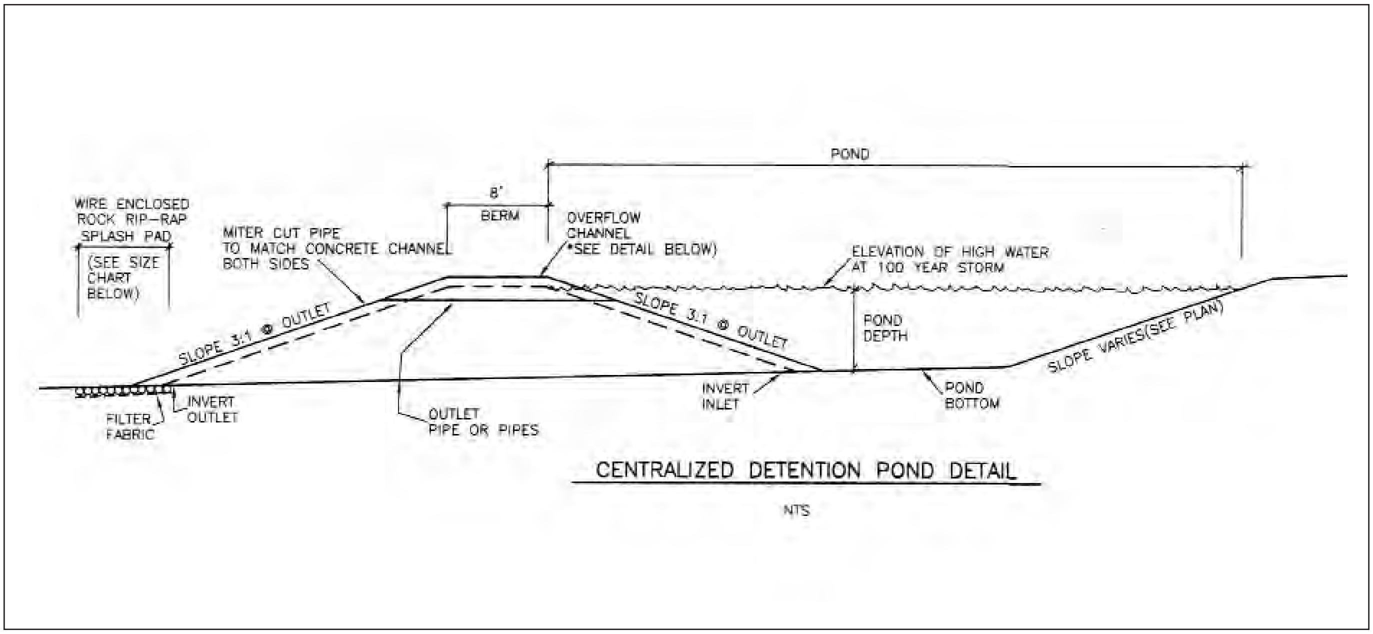
WATER HARVESTING SYSTEMS - SHRUB BOOMERANG
WINDMILL RIDGE UNIT II

4. Village Roadways and Open Space



WATER-HARVESTING SYSTEMS - TREE BOOMERANG
WINDMILL RIDGE UNIT II

4. Village Roadways and Open Space



CONVENTIONAL DETENTION POND SECTION
THE VILLAGES AT RANCHO VIEJO

Shape detention ponds in natural forms to fit existing contours. Plant edges with wetland plants to assist with improving water quality, soften engineered edges and provide a visual amenity and wildlife habitat.

GRASSED DETENTION POND
THE VILLAGES AT RANCHO VIEJO

F. APPENDIX - A

Plans, images and Detail Sources

F. APPENDIX - A

Plans, Images and Detail Sources

Details **Page Number**

F. APPENDIX - B

Definitions

Berm: Low, gently rising and rolling, man-made landform with concave and convex slopes used to screen, emphasize or feature plant material, or add interest to the ground plane. Berms can be constructed on the periphery of parking areas to provide screening. When berms will be turfed, the designer must consider mowing operations and irrigation efficiency when deciding slope, height, and plant layout. Berms can be used in large, flat open areas to help define a space, direct movement, or to direct or intercept runoff. Berm slopes need to be soft and gentle and carefully integrated into the overall grading plan of a project. Excess soil from building foundation excavation operations may be used to create berms.

Catchment/Collection Area: Any area from which water can be harvested. The best catchments have hard, smooth surfaces, such as concrete or metal roofing materials. The amount of water harvested depends on the size, surface texture and slope of the catchment area.

Conveyance Systems: Directs the water from the catchment area to the storage containers. Can include gutter and downspouts and pipes.

Distribution System: In a simple water-harvesting system, the distribution system connects and directs water flow from the catchment area to the landscape holding area. Examples include gutters, downspouts, gently sloped lawns and walkways, channels, ditches, and swales, standard or perforated pipes and drip irrigation systems, as well as curb cuts on streets or parking lots graded to drain to the open-space areas. In complex water-harvesting systems that utilize cisterns, the distribution system directs the water from the storage containers to landscape areas through systems such as hoses, constructed channels, pipes, perforated pipes or a drip system.

Inert Materials: Inorganic, naturally occurring elements that add interest and character. Examples of inert materials are boulders, river run stone, decomposed granite, and cobbles. It is important to carefully choose inert materials that will be widely installed over an installation. Their impact is comparable to, and as important as, choosing colors for buildings. Large expanses of inert materials can have a significant visual impact.

Landforms: Natural or man-made topographic features in the landscape. Landforms such as berms, swales, terraces, and ditches are often used in landscape design.

Landscape Holding Area: Stores water in the soil for direct use by plants, i.e., depressed landscape areas and storm-water detention areas.

Pitting: Small soil pits created to improve the soils' ability to capture water.

Soil Imprinting: A tractor pulling spiked barrels is used to create soil imprints which aerate and allow water to be caught. This reduces wash out and creates more permeable surfaces for native grass and wildflower seed to establish itself.

F. APPENDIX - B

Definitions

Sustainable Design: Probably the most widely accepted definition of sustainability is meeting the needs of today's population without diminishing the ability of future populations to meet their needs. Also defined as the capability of natural systems to maintain themselves over time. Sustainability recognizes that humans are an integral part of the natural world and that nature must be preserved and perpetuated if the human community is to sustain itself indefinitely.

Swale: Low-lying, usually grassy, linear depression that is used to divert and carry water through or away from a site. Swales are the most commonly used storm-water practices and are used to collect storm-water from roads, driveways, parking lots and other hardscape surfaces. Swales do not need to be deep with straight sides, they can be more effective if they have gently sloping sides and are wider than they are deep. The best swales are vegetated to prevent the slopes from eroding and to help filter pollutants during and after rainstorms. As an integral part of the design, swales should be located, graded, and planted as part of the overall landscape design.

Swale Options:

- Concave Swales: Depressions planted with grass or plants serve as landscape holding areas, containing water, increasing water penetration and reducing flooding.
- Pocket Swales and Planting Basins: Smaller areas with a crescent-shaped berm to hold water in a basin for trees.
- Net and Pan Systems: System of interconnected berms forming diamond shapes or boomerangs on hillsides. System collects and concentrates water at the lower point of each diamond where a tree is planted.
- Hay-Bale Swales: Hay bales buried up slope of trees to trap water and make available to the tree root systems.
- Ladder Swale: Series of swales from a drainage ditch such as a bar ditch along a driveway. They extend from the main ditch similar to rungs on a ladder and they can be designed as collection or spreader swales.
- Parallel Swales: Ditches are placed parallel to slopes to disperse water over the site.
- Spreader Swales: Shallow ditches on contours which spill along their entire length to create an even sheet of water flowing down a slope.

Terrace: Natural or man-made, relatively flat area. Terraces are used when the natural slope of a site is severe and a usable level area is required. Terraces can be used for a variety of activities and allow the designer the opportunity to balance cut and fill, sometimes reducing the overall cost of the project.

F. APPENDIX - B

Definitions

Wash/Ditch/Arroyo: Linear and usually steep-sided water drainage courses that collect or conduct runoff. Although these landforms are usually a necessity rather than an aesthetic design element, the designer can affect their location, bank slopes, and planting to help integrate them into the landscape design composition.

Water Harvesting: The capture, diversion and storage of rainwater for plant irrigation and other uses. Components: The supply (rainfall), the demand (landscape requirements), the system that moves the water to the plants, and storage.

Water-Quality Basins: Provides effective removal of soluble and fine particulate pollutants and can be effective in groundwater recharge.

Water Zones: There are 4 main water zones recognized by most professions:

- ***High Water Zones*** - Soil surface is almost always moist.
  Typically supports cool season turf such as Kentucky Bluegrass, redtwig dogwood, annuals. Requires approximately 18-25 gallons/square feet./spring-fall (20 week season); 3/4-1 gallons/square feet/week; ½ inch added 3 times per week
- ***Moderate Water Zones*** - Requires half of the high water zone water.
  Typical plants: Turf-type tall fescue lawns, potentilla, purple cone-flower. Requires approximately 10-12.5 gallons/square feet/spring-fall (20 week season); 1/2 gallons/square feet/week; ¾ inch added once per week.
- ***Low Watering Zones*** - Soil surface is usually dry.
  Typically supports Buffalograss turf, rabbitbrush, Mexican hat coneflower. Requires approximately 0-5 gallons/square feet/spring-fall (20 week season); 1/4 gallons/square feet/week; ½ inch added every other week
- ***Very Low Watering Zones*** - Too dry for any turf.
  Typically supports yuccas, pinon pines, and rabbitbrush. Requires no irrigation once established.

F. APPENDIX - C

Site Revegetation History

Location	Conditions				Results				Comments
	Aspect	Slope Percent	Seed Mix	Soil Type	First Seeded	Precipitation in Inches	Reseeded Mth/Yr	Success Yes/No	
1. Village I: Rocky Slope Drive	South	2 to 1	A	SP	June-01		Jun-02	No	Area driven over to replace trees - Led to soil compaction not conducive to seed germination. (Both Seedings)
2. Village I: Unit I Pond	N, S, E & W	4 to 1	B	FF	Summer 1999		Summer 2000	Yes	No Comments
3. Rancho Viejo Blvd.	N, S, E & W	2 to 1	B	PB	Summer 1999		Summer 2000	Spotty	Stand of grass good the first year then thinned off the second and third year. There was no followup or maintenance to fill in the thinning spots.
4. Windmill Ridge: Richards Ave. - Site A	East & West	3 to 1	A	PB	Sept. 2001		Summer 2001	No	Seeded late in the year. Mulch may have been raked off.
5. Windmill Ridge: Richards Ave. - Site B	South	Relatively flat	C	SP	Jan. 2002		None	Yes	Medians seeded with just Blue Grama
6. Windmill Ridge: Richards Ave. - Site C	East & West	4 to 1	A	SP	Jan. 2002		None	Yes	No Comments

LEGEND

Seed Mix: A. Blue Grama, Wildflower Mix - Seeded at approximately 100 lbs/acre

B. Blue Grama, Wildflower Mix, Side Oats Grama - Seeded at approximately 100 lbs/acre
C. Blue Grama - Seeded at approximately 100 lbs/acre

Soils: FF: Fivemile Loam-(0 to 5 percent slopes). well-drained soils on flood plains. Permeability is moderate. Runoff is medium, and the hazard of erosion is moderate. Effective rooting depth is about 60 inches. Available water holding capacity is 11 to 12 inches. Moderate shrink-swell potential.

SP: Silver-Pojoaque association, undulating-(5-9 percent slopes). Permeability is slow. Runoff is medium, and the hazard of erosion is moderate. Effective rooting depth is about 60 inches. Available water holding capacity is 10 to 11.5 inches. High shrink-swell potential in subsoil.

PB: Panky fine sandy loam (0 to 5 percent slopes). Permeability is slow. Runoff is medium and the hazard of erosion is moderate. Effective rooting depth is about 40 inches.

SOURCE OF DATA

Santa Fe County Soil Conservation Doc:

United States Department of Agriculture Soil Conservation Service and Forest Service and United States Department of the Interior, Bureau of Indian Affairs In cooperation with New Mexico Agricultural Experiment Station 1975. Soil survey of Santa Fe Area, New Mexico (Santa Fe County and Part of Rio Arriba County). Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250

Seed Mix and Installation:
Wirth, Fred. Tallgrass Restoration/Consultant.
45 Mutt Nelson Rd., Santa Fe, NM 98707, (505) 920-6127

Precipitation Information:
Western Regional Climate Center, Santa Fe 2, New Mexico/Monthly Total Precipitation (inches).
2215 Raggio Parkway, Reno, Nevada, 89512, (775) 674-7010
Website:www.wrcc.edu

F. APPENDIX - D

NPDES Requirements

The Regulation
Since the creation of the Clean Water Act in 1972, the National Pollutant Discharge Elimination Systems (NPDES) program has been a major force in the nations' efforts to protect and restore the quality of our rivers, lakes, and coastal waters. According to the program, any construction activity that includes clearing, grading, or excavation resulting in land disturbance of 5 acres or greater must be conducted in accordance with NPDES General permit No. CAS000002, for Discharges of Storm Water Runoff Associated with Construction Activity (referred to as the Construction Site General Permit).

Sites less than 5 acres are also required to obtain a permit if the project is part of a "larger common plan of development" that will exceed five acres. In March 2003, a Phase 2 rule for "Small Construction Activity" took effect, requiring permits for all construction sites 1 acre or larger. The best management practices outlined in the strategy section of this document are the first steps in meeting the requirements of the NPDES.

General Storm Water Permit for Construction Activities
The provisions of the Construction Site General Permit are summarized below.
Prohibitions: The permit prohibits the discharge of materials other than storm water and states that storm-water discharges shall not cause pollution. In addition, storm-water discharges shall not contain a hazardous substance in excess of "reportable quantities" established by 40 Code of Federal Regulations (CFR) 117.3 or 40 CFR 302.4.

Elimination or reduction of non-storm water discharges is a major goal of the general permit. Non-storm water discharges include a wide variety of sources including improper dumping, spills, or leakage from storage tanks, or transfer areas. The program recognizes, however, that certain non-storm water discharges (e.g., landscape irrigation of erosion control measures, pipe flushing and testing, street washing, and de-watering), may be necessary for the practical performance and completion of construction projects.

The non-storm-water discharges are allowed only if they:
1. Do not contribute to a violation of a water-quality standard
2. Are controlled through implementation of best management practices (BMPs)
3. Are infeasible to eliminate

F. APPENDIX - D

NPDES Requirements

Effluent Limits

Sections 301 and 402 of the Federal Clean Water Act require controls of pollutant discharges to use "best available technology economically achievable" (BAT) and "best conventional pollutant control technology" (BCT) to reduce pollutants, and any more stringent controls necessary to meet water-quality standards. The BMPs emphasize erosion control and pollution prevention methods and may also include structural controls to manage sediment.

Storm-Water Pollution Prevention Plan (Site Specific)

Each permitted construction site must prepare a site specific SWPPP prior to disturbing the site. The major objectives of the SWPPP are to:

1. Help identify the sources of sediment and other pollutants that affect the quality of storm-water discharges, and
2. Describe and ensure the implementation of practices to reduce sediment and other pollutants in storm-water discharges. The SWPPP must include a site description and identify BMPs that address erosion and sediment controls and management of construction waste. The SWPPP must also include post-construction controls and management of non-storm water.

Receiving Water Limits

The permit requires that construction-related activities that cause or contribute to exceedance of a water-quality standard must be corrected immediately and a report made within 14 days.

Monitoring Program

Under the permit, dischargers are required to conduct inspections before and after storm events to identify areas contributing to storm-water discharge and to evaluate the effectiveness of pollutant control measures. Equipment, materials and personnel must be available to respond to any maintenance needs identified in the inspections. If corrective measures are warranted, they must be performed as soon as possible.

Retention of Records

Rancho Viejo must retain the SWPPP, monitoring results, and any associated data for at least three years.

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Schueler, Thomas R. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Washington Council of Governments. July 1987.

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Specifications of Rain Barrels and Cisterns, Low Impact Development Center, Inc., www.lid-storm-water.net2003, 1-6.

LEED Reference Guide, U.S. Green Building Council*,* 1999.

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Product Information Resources:

Cistern - Rain Capture Systems
http://www.consolidatedtreatment.com/manuals/Multi-Flo_Performance_March_2002.pdf
raincapture.com.

Good, Jeff - Irrigation Services/Designers & Consultants,
2190 Highway 304, Belen, NM 87002, (505) 861-1536
Website: www.irrigationservicesinc.com

Harris, Tom - BASF Corporation, Spray Applied Urethanes
1609 Biddle Avenue, Wyandotte, MI 48192, (734) 324-5317
Website: www.basf.com/spray

IAS Laboratories - Soil Consulting & Analyzing
2515 East University Drive, Phoenix, AZ 85034 (602) 273-7248

La Farge Industries - Aggregate
P.O. Box 27328, Albuquerque, NM 87125, (505) 343-7800

Mallory, Gary, Heads Up Landscape Contractors
P.O. Box 10597, Albuquerque, NM 87184, (505) 898-9615

Santa Fe Classic Rock - Stone, Rock, Pebbles, Gravel, Soils
2865 Rufina Street, Santa Fe, NM 87507, (505) 471-3553