Rachel Weston
August 13, 2011

Land-Use Survey and Impact Study of Plymouth Beach Residential Canal

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Biology 482 Limnology
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Abstract

A full examination of the environmental impacts of a man-made canal such as Plymouth Beach would not be complete without considering the land-use of the surrounding area. The general morphology of the canal in itself causes unnatural changes in the wetland ecosystem. By studying the land-use and human impacts on Plymouth Beach canal, I hope to determine possible sources of contamination and high nutrient levels within the canal and the factors which are affecting their concentrations.

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Land-Use Survey and Impact Study of Plymouth Beach Residential Canal

Rachel Weston, University of Michigan Biological Station August 15, 2011

1. Introduction

A full examination of the environmental impacts of a man-made canal such as Plymouth Beach would not be complete without considering the land-use of the surrounding area. The general morphology of the canal in itself causes unnatural changes in the wetland ecosystem. Some of these impacts may include:

- Loss of wetland habitats and other sensitive ecosystems
- Inadequate hydraulic functioning which may reduce water quality through poor flushing, cause sedimentation, or affect structural integrity.
- Impacts caused by storm-water and urban runoff, including erosion and sedimentation away from a canal estate development site. (Canals, 2007)

The Plymouth Beach Canal is located on the East side of Burt Lake, a large inland lake of Northern Michigan. The canal was built in the 1960's and is about 0.50 Kilometers long from the dead end of the canal to the mouth where the canal empties into the lake. Land parcels along both sides of the canal are coded as purely residential. However, there are large parcels along the East side of the canal which are not developed and are in their natural state. Interestingly, most of these undeveloped parcels are up for sale. Development on these sites may exacerbate the negative impacts of the canal on the surrounding habitat. The canal is primarily used for recreational boating. In order to clear out aquatic plants for the boats, the canal is routinely sprayed with two herbicides, thiquat dibromide and reward.

The morphology of the canal is an important factor in studying the canal ecosystem. The Plymouth Beach Canal is a dead-end canal which does not connect through to the lake. This is a major factor in sedimentation, nutrient collection, and water quality in general. The water is stagnant and has poor flushing. Any form of nutrient loading from land-use such as fertilizers, grass cuttings, oil, or road salt is not properly flushed out of the system.

The canal has a seawall which extends along a majority of its length, however the canal is not uniform, some sections of the seawall are either metal or wooden while some sections have no seawall at all. The seawall has an effect on the morphology of the canal and therefore has an effect on the plant and animal life of the canal shore. A seawall affects the canal bottom by causing vertical erosion which destroys the benthic zone of the shore. This is diagrammed in Figure 1. The seawall also affects the flow of the water within the canal, especially where the water of Burt lake flows into the canal.

Figure 1.

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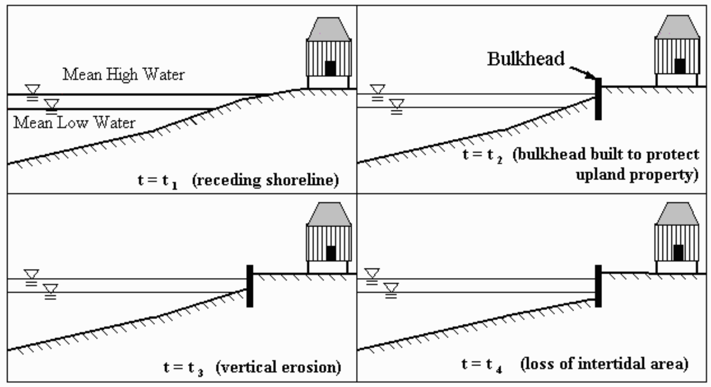

Nitrogen and Phosphorous

The canal is also a good model for nutrient chemistry because unlike the open water of Burt Lake, the canal collects nutrients and sediments. The nutrients are concentrated and may be elevated.

High Phosphorous levels (PO_4)

- Contamination from residential uses (laundry detergents and other household chemicals)
- Runoff from gravel roads which contain Phosphorous

High levels of Nitrate (NO_3)

- Fertilizer runoff from agricultural use and private land use
- Increased nitrate levels may lead to eutrophication

If the Phosphate levels are above 0.025 mg/L, the process of eutrophication in the water is accelerated. A maximum of 0.1 mg/ L is recommended for streams.
Phosphorus is the most important nutrient for productivity in surface waters because it is usually in shortest supply relative to nitrogen and carbon. A water body is considered phosphorous limited if the ratio of nitrogen to phosphorous is greater than 15:1. Phosphorus is normally found at concentrations less than 10 micrograms per liter (ug/l = parts per billion) in high quality surface waters.

Unfortunately, nitrogen and phosphorus are released into the environment as a result of many human activities. According to the Tip of the Mitt Watershed Council, nutrient pollution is the most serious threat to the water quality of northern Michigan's lakes and streams.

Dissolved Oxygen

Four to five parts per million (ppm) of dissolved oxygen is the minimum amount that will support a large, diverse fish population. For example, most fish species will not be able to survive in the anoxic conditions of the hypolimnon. The herbicide treatment is a major cause for the low oxygen levels at the bottom of Plymouth Beach Canal. Even if nitrogen and phosphorous input is increasing, the herbicide treatment will kill the aquatic plants. These plants which were once providing oxygen to the water are now using up oxygen in the process of decomposition. Lower oxygen levels effects which species of animals and plants can live in the canal environment.

Chloride, a component of salt, is one of the common anions found in freshwater and thus chloride levels are directly related to conductivity. Due to the marine origin of bedrock in Northern Michigan, chloride is present in the ground water, usually in concentrations less than 12 mg/l. Surface waters seem to have a normal level of 4 mg/l. Even slight increases in chloride concentration can have a subtle impact on aquatic ecosystems, but most fish and other large aquatic organisms are not directly affected until concentrations reach 1,000 mg/l or more.

Chlorides are common in many products associated with human activities. Chloride is a "mobile ion," meaning it is not removed by chemical or biological processes in the soil and ground water. Increasing chloride levels or levels above expected natural background amounts can indicate impacts from human activities. Chloride levels in nearby lakes and streams have ranged from 1.0 mg/l to 82.9 mg/l with an average of 7.7 mg/l.

By studying the land-use and human impacts on Plymouth Beach canal, I hope to determine possible sources of contamination and high nutrient levels within the canal and the factors which are affecting their concentrations.

2. Materials and Methods

Although indicators for land-use impacts are often difficult to quantify, a detailed land-use survey My research of the land-use includes both the residential land parcels flanking the canals well as the larger valley as a whole. In this study, I examine the nutrient chemistry data taken at ten sites along the Plymouth Beach Canal and compare this data to detailed land-use notes for each parcel. The first sample site is located at the dead end of the canal and I also examine the current land-use of the surrounding area in general and how the human activity and infrastructure of the area may be impacted The surface water samples were tested for total nitrogen(TN), total phosphorous(TP), nitrate, ammonia, chloride, and Si(O2)
I examined chemical nutrient samples for signs of possible contamination and habitat degredation concerns both within the canal and in the open water of Burt Lake.

Classification system

Each land parcel was coded according to a set of selected land types and activity types. This classification system was used in conjuction with chemical nutrient data as well as biological data to find correlations between the land-type and the makeup of the aquatic habitat it affects. The parcels were coded by personal observation and for this reason are subject to error. For example, in the classification system, each parcel could be coded as lawn or fertilized lawn. However, it is difficult to tell for sure whether a lawn was fertilized or not. In general, only lawns with lush dark grass were coded as fertilized. The purpose of the land-use coding was not to obtain an exact representation but to use the land-use observations to give insight into how different sections of the canal are impacting the canal life in different ways. In order to the plant life classification, I coded each land parcel for type of plant life by examining the plant type 1 meter from shore.

Canal Land-Use Classification System

Structure
1. Residential Building
2. No Structure

Land Type
1. Lawn
2. Fertilized Lawn
3. Gravel/Rock
4. Natural Vegetation
5. Lawn with Buffer Zone

Seawall
1. Metal Seawall
2. Wooden Seawall
3. No Seawall

Drain
1. Large drainage
2. Lawn Drain
3. No Drain

Plant Life
1. Submerged Plants (milfoil, pondweed, seaweed, etc.)
2. Scattered water lilies
3. Both submerged plants and water lilies (SCATTERED)
4. Both submerged plants and water lilies (MULTIPLE)
5. Surface Algae
6. No plant life

3. Results

The general observations made for the residential land parcels as well as the land-use of the surrounding area seem to correlate with abnormalities in the nutrient chemistry data.

Chloride

The canal contained unnaturally high concentrations of Chloride. Concentrations in the canal are very high at the end of the canal and continually decrease to the mouth. Chloride concentrations in natural lakes and rivers of northern Michigan have an average chloride concentration of 7.1 mg/ L. The first chloride measurement taken at site 1 of the canal is 71.3 mg/L.

Dissolved Oxygen

The mean dissolved oxygen level within the canal is 5.81 mg/L while the dissolved oxygen reading at site 10 in the open water is 9.35 mg/L. The oxygen more than doubles from site 1 to site 10, as seen in chart A.3. The bottom of site 1 had a dissolved oxygen reading of 4.79 ppm. Site 2 had an even lower reading of 2.07 ppm. At these levels, most fish species cannot survive.

There was a very clear correlation between the aquatic plant life within the canal and the land-type of the parcels. Natural land at the two ends of the canal had an increase in plant matter. This can be seen in the plant life survey map (Map B.3) as well as chart A.4 which shows the plant diversity along the length of the canal.

There was also a similar correlation between plant life and seawall type. Parcels without a seawall had much higher plant diversity and biomass. This correlation can be seen when comparing the seawall map and plant life map. (Maps B.3 and B.4)

Discussion

Any Engineered ecosystems such as the Plymouth Beach Canal will have substantial human-use impacts. The proximity and density of residential land near the canal combined with its small scale leads to a large anthropogenic influence on the canal.

This influence was noted through various chemical and biological parameters. For example, the changes in plant diversity along the canal and the corresponding land-use patterns suggest that terrestrial vegetation has a strong influence on the corresponding aquatic habitat. The natural vegetation may be inputting nutrients and materials into the water which support the growth of plant matter. Also, the natural land has no seawall and therefore The natural land may play a part in buffering the affects of the herbicide treatment and nutrient loading.

The land-use and chemical nutrient data show that there is a clear gradient of both nutrients, productivity, and biological life along the length of the canal. For example, the chloride levels showed a drastic gradient from site 1 to site 10. The increased chloride concentrations at the end of the canal may be related to road inputs and runoff from paved land. Road salt contains high levels of chloride. Road runoff can also explain the increased levels of phosphorous in the canal. Gravel from surrounding roads as well as bordering land parcels may be causing an increased concentration of phosphate.

The canal is highly influenced by the Riparian zone and contains a large amount of allochthonous material. All of the carbon and nutrients from the terrestrial environment build up and are amplified in the system. This is important in relation to human-use because the harmful nutrients which enter the canal will build up over time. In this way, the canal's inability to flush out nutrients causes changes in the biological makeup of the canal. This is a good water system model for how hydrology affects biology.

If homeowners along the Plymouth Beach Canal take into account the health of the canal ecosystem both aquatic and terrestrial, they should consider discontinuing the herbicide treatment. The canal is a healthy habitat distinct from the ecosystem of Burt Lake. For this reason alone, it should be preserved as an aquatic habitat. Increasing the amount of terrestrial natural vegetation and creating natural buffer zones along the canal may help preserve the aquatic plant and animal life within the canal. This idea is supported by the land-use study.

Appendix A.1

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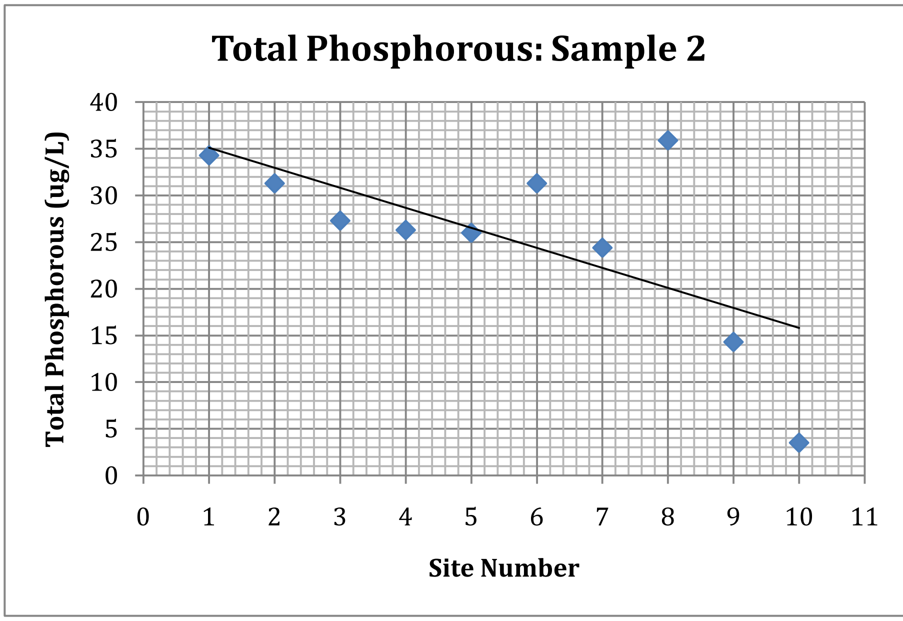
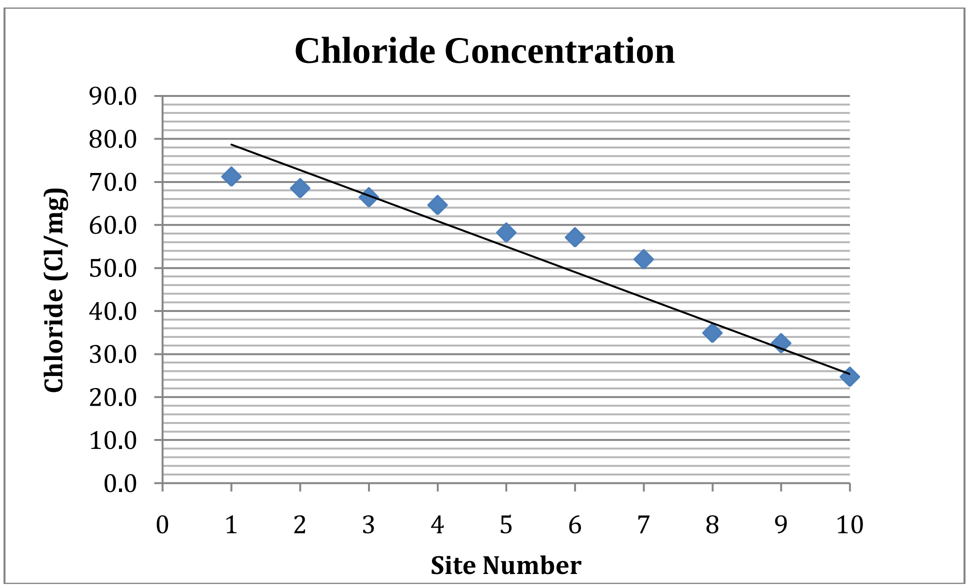
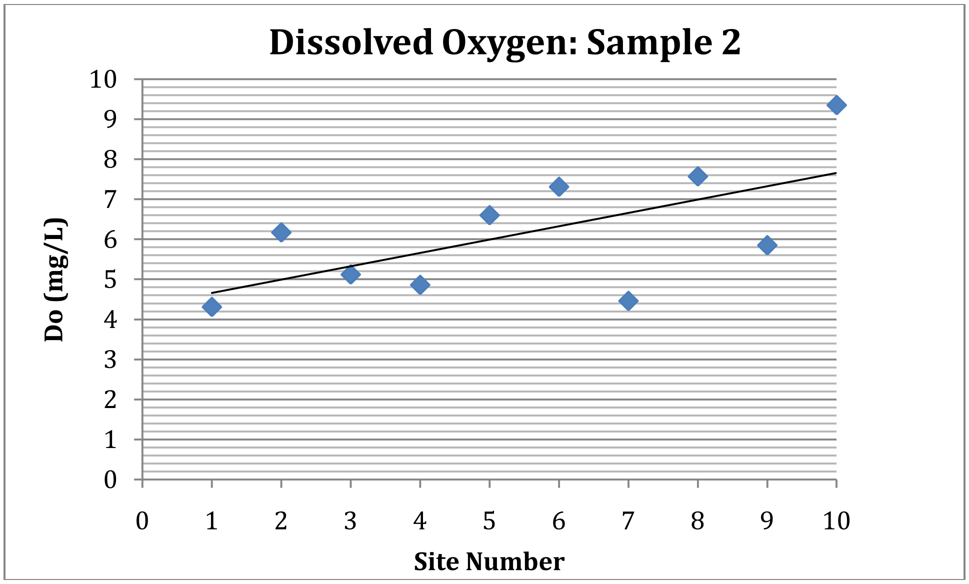


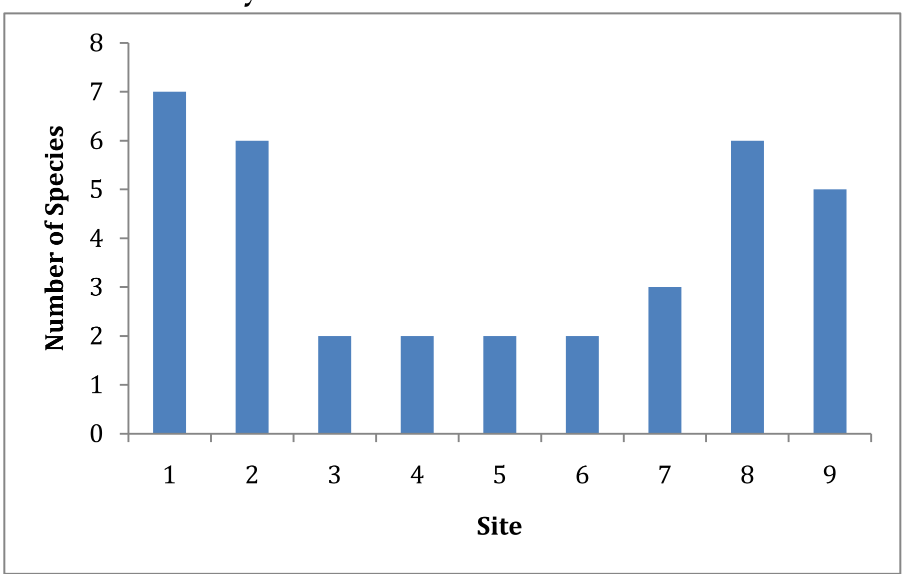
A.2



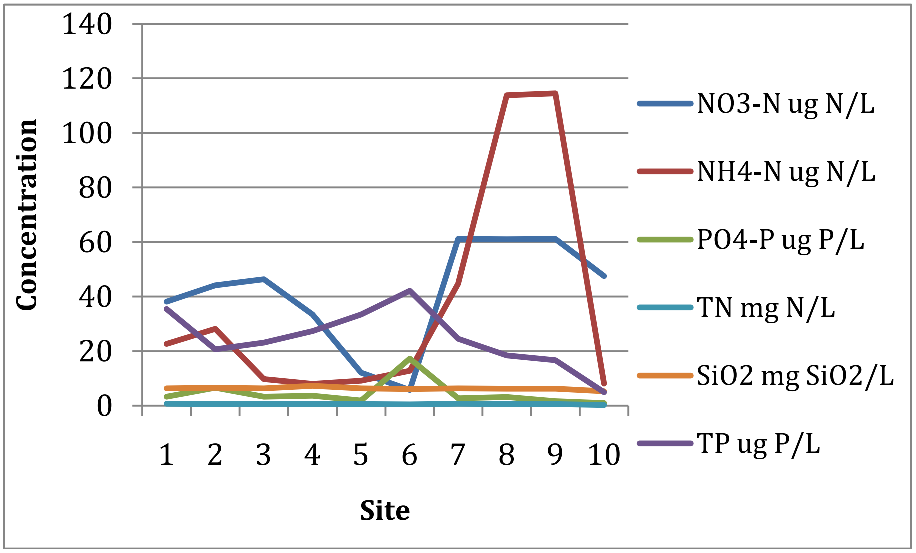
A.3



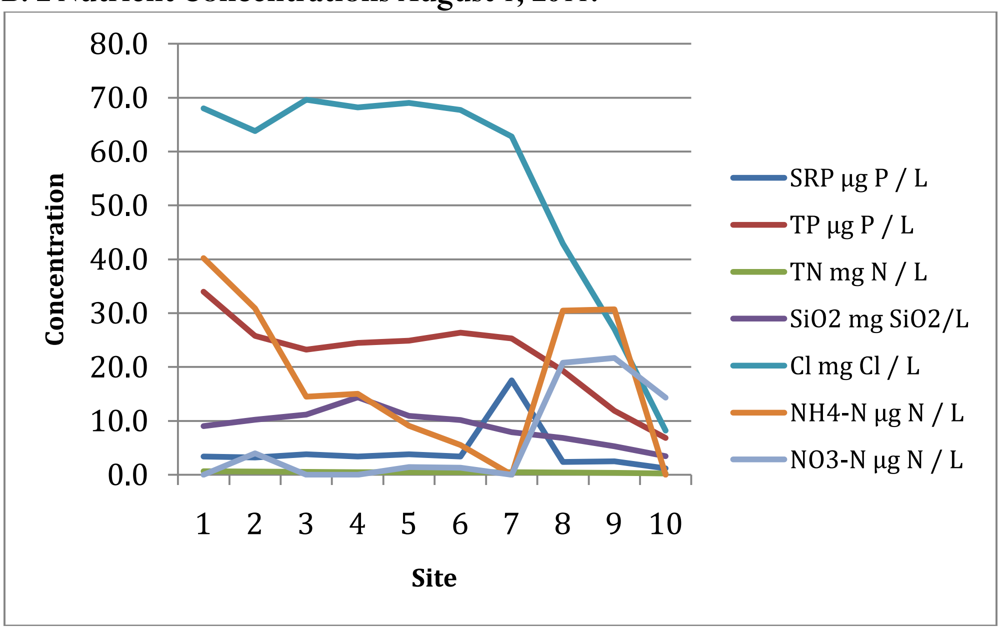
A.4 Plant Diversity



Appendix B.1 Nutrient Concentrations, July 14th, 2011



B. 2 Nutrient Concentrations August 1, 2011.



B.3 Nutrient Concentrations August 8, 2011.

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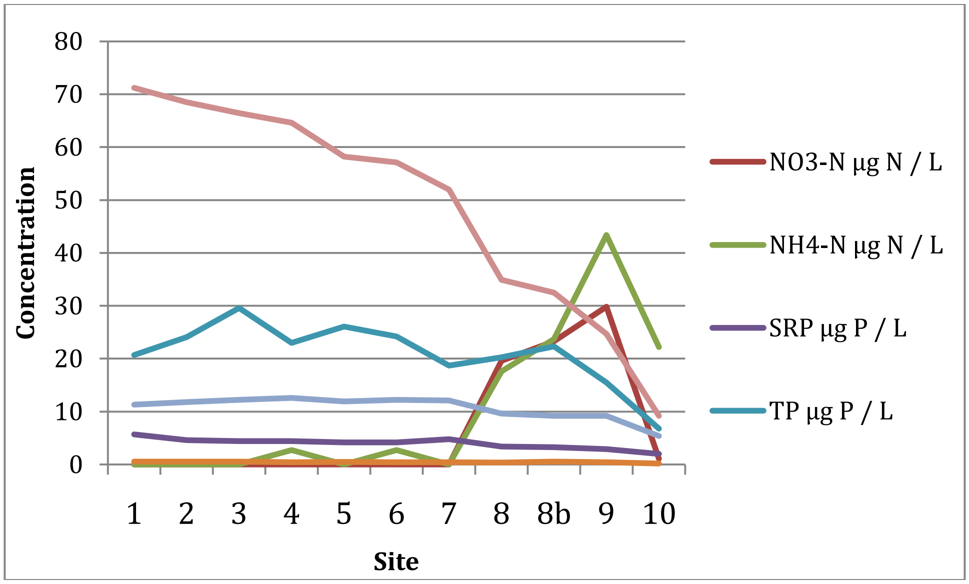

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Appendix B

Land-Type Map B.1

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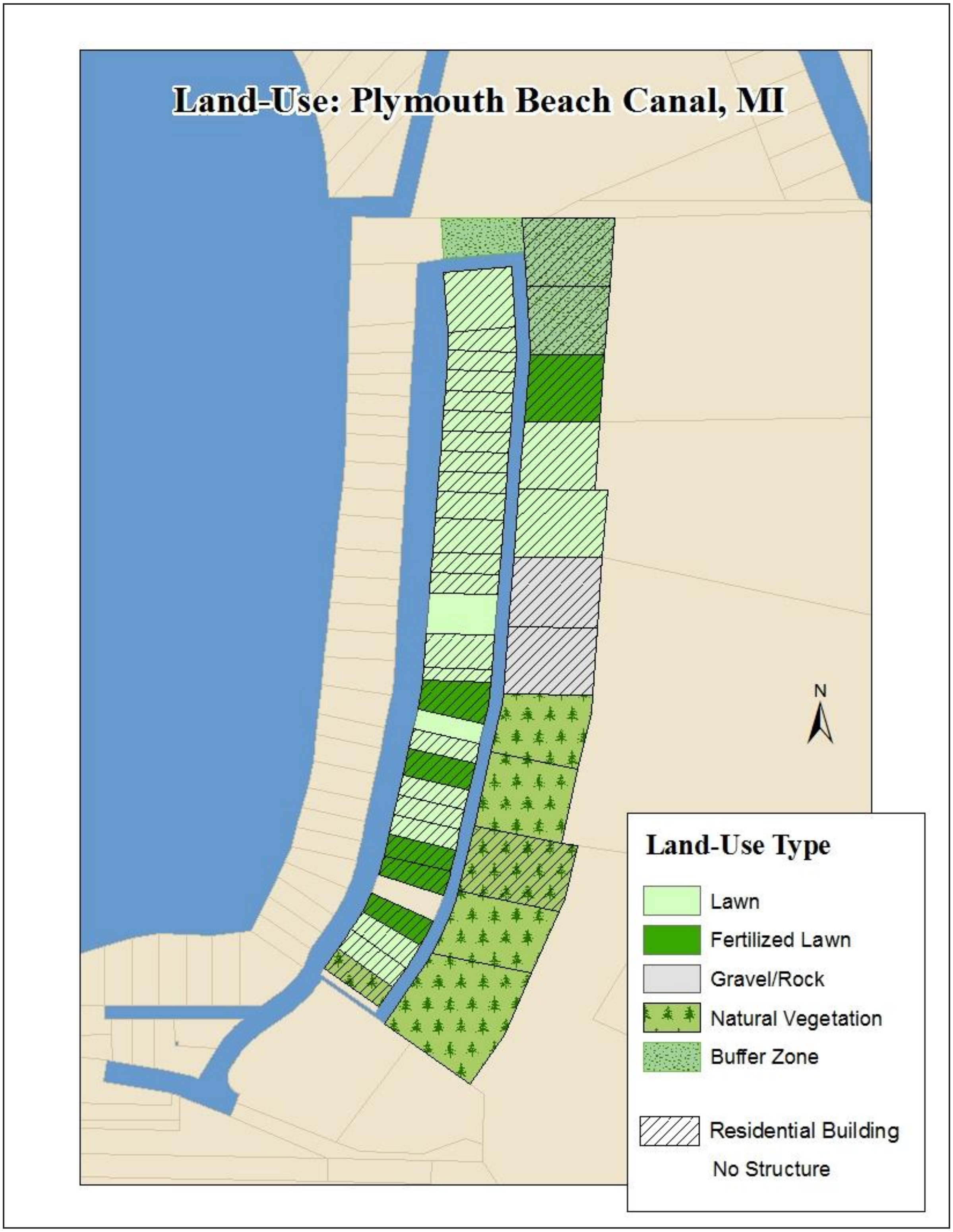

Seawall Type: Map B.2

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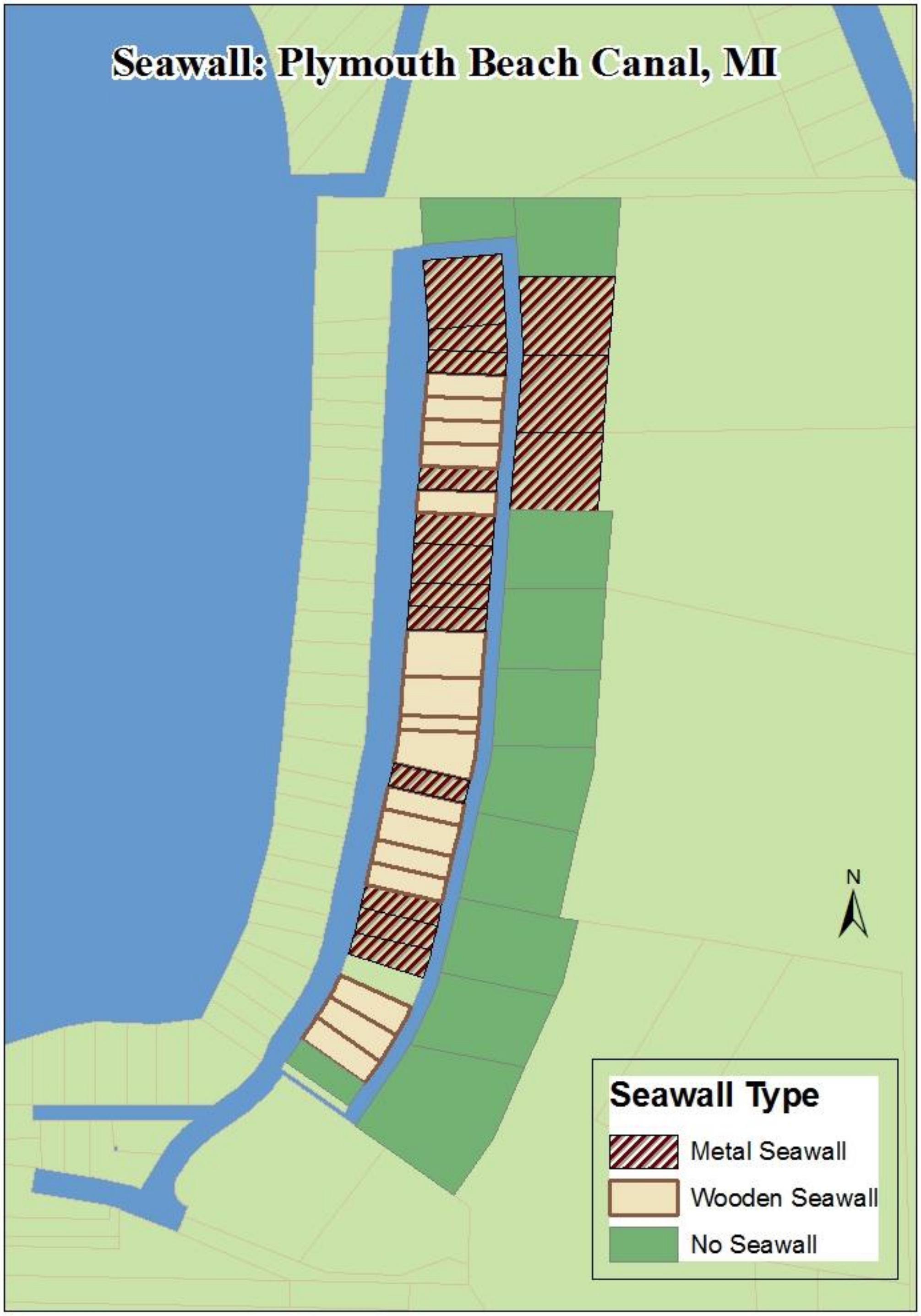

Map B.3 Plant Life