Final Report

A HYDROLOGIC ASSESSMENT OF MENTOR MARSH, LAKE COUNTY, OHIO

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1.0 OBJECTIVES

The objectives of this study were to perform a detailed hydrologic investigation to characterize water movement to, through, and from Mentor Marsh, and to explore relationships between hydrology and wetland ecology.

2.0 RESEARCH STUDY DESCRIPTION

Guided by the components of the mass (water) balance equation we have constructed the hydroperiods for several key hydrologic control points for Mentor Marsh. We began the research by conducting an extensive historical study completed in 2003 (Fineran, 2003) that established the hydrological and ecological history of the site from 1796 to 2000 A.D. During this study we identified and characterized several key hydrologic control points. Concurrently with the historical research study, we began to monitor subsurface water levels in 2001 when we drilled four groundwater-monitoring wells, two south (up-gradient) and two north (down-gradient) of the marsh. After the historical research study was complete, a detailed surface water-monitoring program was started in September 2004. At the same time, we acquired additional funding from the National Oceanic and Atmospheric Administration (NOAA) through the Ohio Coastal Management Program (OCMP) administered by the Ohio Department of Natural Resources (ODNR) to measure total chloride (salinity) levels and expand the hydrologic assessment of Mentor Marsh. The total chloride data has provided valuable information to assess the current condition of salt stress at the marsh. We continued to collect data for the subsurface monitoring program while we conducted the surface water-monitoring program. Final data collection

for both the surface and subsurface monitoring programs occurred April 2006. Final total chloride samples were collected in May 2006.

Early in our research at Mentor Marsh we realized the need to establish the historical (natural) flow regime for the marsh in conjunction with its vegetative history. Vegetative mapping, land surveys, previous water quality studies, historical eye witness accounts, as well as historic Lake Erie water levels were collected and analyzed to establish how alterations to the marsh and its landscape had affected the natural flow regime and wetland ecology of the marsh. The historical research study identified four stresses that drive the vegetative dynamics at Mentor Marsh. These stresses are: flood stress, salt stress, fire stress (disturbance), and shade stress. The current condition of the marsh and its watershed produce flood stress, salt stress, and fire disturbance that favor the proliferation of the aggressively invasive plant species, *Phragmites australis* (Giant Reed) at the expense of the previously dominant and highly diverse swamp forest. The fourth stress, shade stress, is the mechanism by which swamp forest can out-compete *Phragmites*. For this to occur, the other three stresses (flood stress, salt stress, and fire disturbance) must be controlled to allow existing remnant swamp forest areas to expand. Shade stress acts within the ecotone (transition area) between swamp forest and *Phragmites* where the mature (tall) swamp forest trees exert shade stress on the adjacent *Phragmites* stand. This thins the *Phragmites*, allowing trees seedlings to become established and grow within the more open stand of *Phragmites.* When the newly established trees grow to a height that is greater than the *Phragmites* and develop a mature leaf canopy, these mature trees in turn exert additional shade stress expanding the

swamp forest. But for this process to occur, flood stress, salt stress, and fire disturbance must be controlled. The process of shade stress in the swamp forest - *Phragmites* ecotone has not been established by scientific study but field observations confirm its value as a working hypothesis until further study can be made.

So, just as swamp forest cannot tolerate high flood stress, high salinity levels, or frequent fire disturbance, *Phragmites* are shade intolerant. *Phragmites* do not grow within the closed canopy of a swamp forest. Using this knowledge we designed the surface water-monitoring program to assess the current condition of flood stress at the marsh by making detailed measurements at critical control points for the marsh such as its inlet locations, within its basin, and its outlets to Lake Erie. From the results we characterized water movement to, through, and from Mentor Marsh in a way that is meaningful to its wetland ecology and marsh management.

The results of this research study inform our understanding of the current hydrology of the site, how it is different from the historic (natural) flow regime for the marsh, and its affect on the wetland ecology of the marsh. A quantitative baseline has been established that can guide future restoration projects and can be used to measure success. The research results are also valuable to assist managers, decision-makers, and all stakeholders for Mentor Marsh.

In conducting the detailed hydrologic assessment of Mentor Marsh, we measured water levels (surface and subsurface), flow velocities, and stream cross sections. Flow

velocities, used in conjunction with the stream cross sections, will allow calculation of discharge (volume of flow) at those sites with hydrologic control structures. We have also gathered basic hydrologic information to further characterize our results including precipitation, temperature, and Lake Erie water levels. These data were collected at stations that submit their data to NOAA. These stations are in the immediate vicinity of the marsh basin (i.e., precipitation and temperature at Mentor Headlands and Lake Erie water levels at Fairport Harbor).

In addition, survey work completed in January 2006 determined the elevations of sampling locations using a standard datum to compare the hydroperiods of sampling sites with each other and to Lake Erie water levels and for use by future research studies.

3.0 METHODS AND MATERIALS

The water levels at the surface water sampling sites were measured using a hand-held staff gauge. We also tried to record water levels with automated water level logger devices (WL15 Water Level Loggers by Global Water) installed at seven of the eight surface water-monitoring locations.

The redundancy of the collection methods (i.e., hand-held staff gauge and automated water level loggers) was intended to provide a back-up for possible failure of the water level loggers. Also, we wanted to compare results from the two methods. We found the water level logger equipment to be ill suited to wetland environments as compared to the stream environments for which they were designed. The water level data used to calculate

the values provided in this report were collected using the hand-held staff gauge method. The water level loggers never functioned adequately to collect data using the automated method. Numerous attempts to troubleshoot the water level loggers were unsuccessful. Many of the installed loggers became corroded, apparently overtopped by floodwaters during flashy stream flow. Others failed in the field for reasons we were unable to determine. Based on our experience it seems that a modified or new design is needed for these devices to be used in wetlands, especially urban wetland environments. The success of this project can be partially attributed to the built-in redundancy in our collection methods.

Flow velocity was measured using a hand-held flow probe (Global Flow Probe FP201 by Global Water). When the flow rate was very low the flow probe was unable to provide a measurement. Sometimes there was no observable flow, which was recorded in the field book. The water velocity was recorded in feet per second (fps). The flow probe measures instantaneous velocity to the nearest 0.5 fps (Global Water, 2004).

Land Design Consultants, Inc. did the survey work measuring elevations for each of the sampling points at each study site. They used NAD83, Ohio State Plane Zone North, third order benchmarks.

4.0 STUDY SITES

Eight surface water sites were used to assess the hydrology of Mentor Marsh. These sites are shown on Figure 1. They are: the upstream side of the first box culvert located at the

mouth of Shipman Pond near the Headlands Beach State Park exit (Site 1: Headlands Beach); the downstream side of Shipman Pond Bridge located near the entrance to the Headlands Beach State Park Office (Site 2: Shipman Pond); the upstream side of the culvert for Blackbrook stream channel located on Blackbrook Road (Site 3: Blackbrook); the old confluence of Blackbrook and Mentor Marsh located near Kerven Trail (Site 4: Kerven Trail); culverts (A and B) for Mentor Marsh located on Corduroy Road (Site 5: Corduroy Road); the remnant swamp forest located near Grace Court (Site 6: Remnant Swamp Forest); the Marsh Creek stream channel on the downstream side of the bridge on Lake Shore Boulevard (Site 7: Marsh Creek); and the downstream side of the bridge over Mentor Marsh at the Marina (Site 8: Marina). Each of the eight sampling sites were selected to best assess the surface water hydrology for Mentor Marsh including its hydroperiod and water quality issues. Sites 3, 4, and 7 are located up- watershed of the marsh basin. Sites 2, 5 and 6 are located within the marsh basin. And, sites 1 and 8 are major water outlets for the marsh. Site 4 is located directly downstream from the saltfill, which is one of the major sources of salt pollution to the marsh.

There are also two groundwater-sampling sites. Site #9 (Figure 1) is the groundwater-sampling site located near the Marsh House. Two wells were installed at this location to measure groundwater levels south (up-gradient) of the marsh. These wells are designated R1D1 and R1D2. Site #10 (Figure 1) is the groundwater-sampling site located within the forest on Zimmerman Trail. Two wells were drilled at this location to measure groundwater levels north (down-gradient) of the marsh. These wells are designated R2D1 and R2D2. R2D1 was abandoned during drilling. R2D2 was successfully installed.

However, R2D2's upper well casing was vandalized soon after installation. Repairs were made and the well casing redesigned to protect the wellhead from further damage. R2D2 functioned throughout the study.

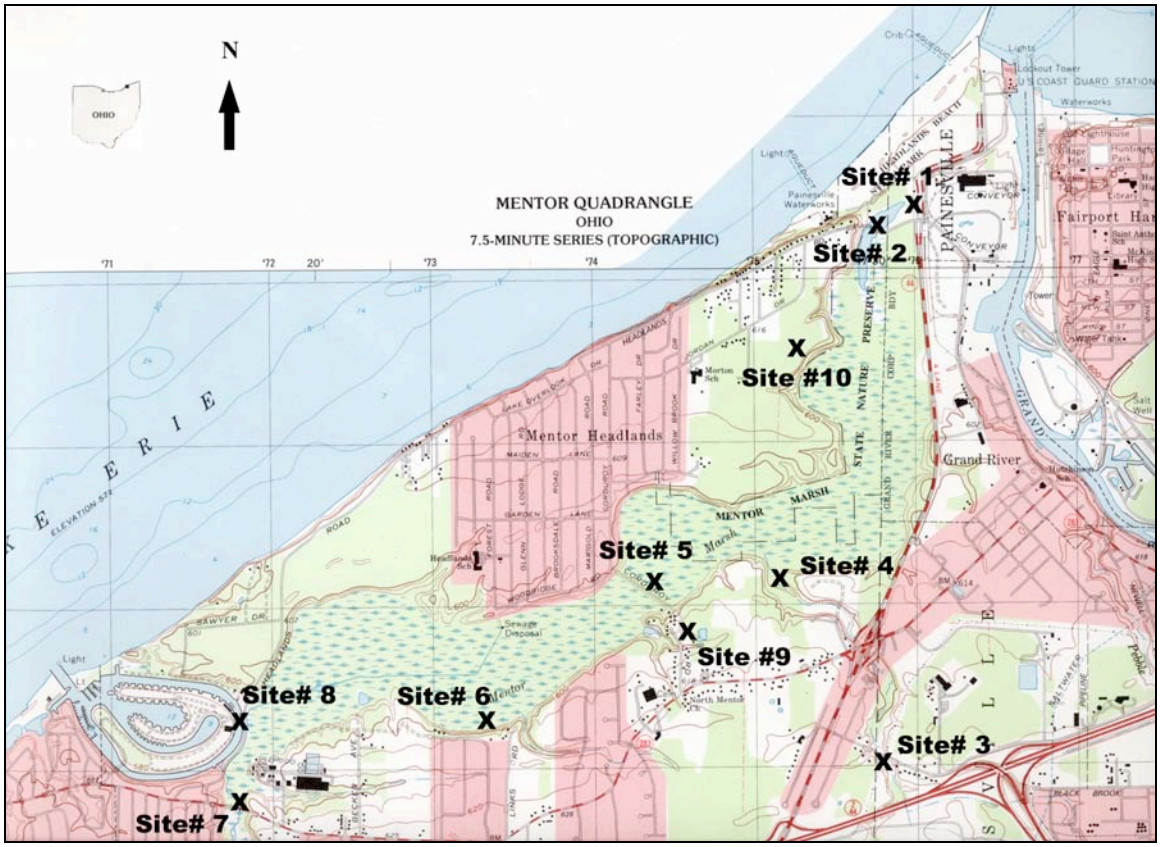

Figure 1: Sampling site locations for hydrology study of Mentor Marsh.

5.0 RESEARCH RESULTS

5.1 Monthly Precipitation for Mentor Marsh (September 2004 - March 2006)

Table 1 and Figure 2 show the monthly precipitation measured in inches for Mentor Marsh recorded at a weather station located on Mentor Headlands north of the marsh. The station identification is Painesville 4 NW (COOP ID 336389). The data shown are from September 2004 to March 2006. Values for April 2006 were not yet available from the National Oceanic and Atmospheric Administration, National Climatic Data Center (NOAA NCDC) at the time this report was written (September 2006).

Values for departure from normal are also given in Table 1. Departure from normal is the amount of precipitation above (positive) or below (negative) normal for the month and is reported in inches.

Month	Monthly Precipitation (in.)	Departure from Normal (in.)
Sep-04	2.38	-1.62
Oct-04	2.10	-1.17
Nov-04	2.87	-0.69
Dec-04	4.33	1.31
Jan-05	4.75	M
Feb-05	1.68	-0.12
Mar-05	1.12	-1.64
Apr-05	3.57	0.26
May-05	2.83	-0.22
Jun-05	3.79	0.01
Jul-05	4.37	1.17
Aug-05	1.43	-2.35
Sep-05	3.21	-0.79
Oct-05	2.96	-0.31
Nov-05	2.69	-0.87
Dec-05	1.33	-1.69
Jan-06	1.56	M
Feb-06	2.66	0.86
Mar-06	2.49	-0.27
Apri-06	*	*

Notes: *April 2006 not currently available from NCDC.
M indicates data element is missing.

Table 1: Monthly precipitation for the Mentor Marsh area from September 2004 to March 2006. Data obtained from the NOAA NCDC (2006).

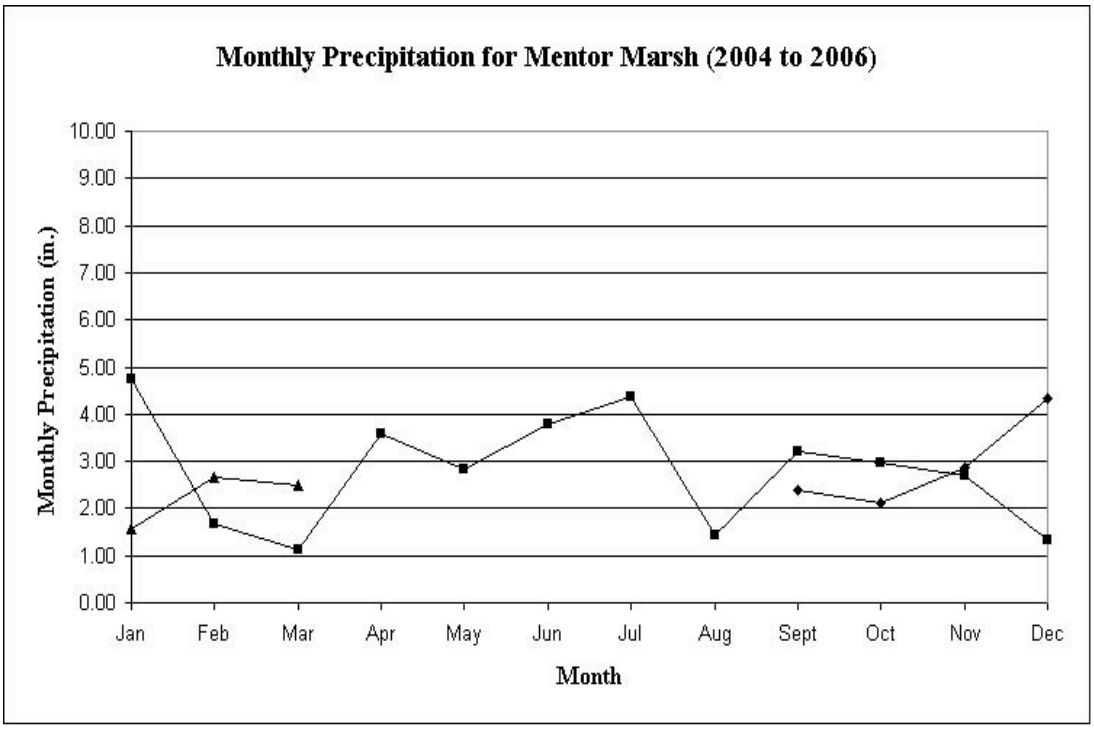

Figure 2: Monthly precipitation for the Mentor Marsh area for September 2004 to March 2006. Data obtained from the NOAA NCDC (2006).

5.2 Lake Erie Water Levels (September 2004 - April 2006)

Table 2 shows the Lake Erie water levels for the Fairport Harbor station, which is near Mentor Marsh. The values provided are from September 2004 to March 2006. The monthly high, monthly mean sea level (MSL), and the monthly low are provided. These data are from NOAA (NOAA, 2006).

Month	Highest (ft.)	Lake Erie MSL (ft.)	Lowest (ft.)
Sep-04	572.49	571.77	571.43
Oct-04	571.90	571.21	570.28
Nov-04	571.61	570.99	570.39
Dec-04	571.89	571.03	570.16
Jan-05	572.70	571.74	570.81
Feb-05	572.11	571.80	571.39
Mar-05	572.39	571.93	571.64
Apr-05	572.76	572.23	571.72
May-05	572.61	572.26	571.75
Jun-05	572.73	572.03	571.71
Jul-05	572.18	571.72	571.17
Aug-05	572.19	571.44	571.02
Sep-05	572.61	571.21	570.05
Oct-05	571.45	571.02	570.59
Nov-05	571.56	570.60	569.68
Dec-05	571.36	570.46	569.62
Jan-06	571.48	570.86	570.39
Feb-06	571.76	571.21	570.64
Mar-06	571.74	571.35	570.91
Apr-06	571.95	571.49	571.10

Table 2: Monthly Lake Erie water levels for Fairport Harbor, Station ID: 9063053, for September 2004 to April 2004. Data obtained from NOAA (2006).

5.3 Hydroperiods for Sample Sites (September 2004 - April 2006)

The hydroperiods measured for sampling site #1 through #8 are presented in this section. The hydroperiods are important products of this research and summarize the results. They are useful for establishing the magnitude and temporal variation, including seasonal effects, of water levels at several important surface water points for Mentor Marsh. The magnitude, duration, and timing of flooding within a wetland are primary factors in determining what plant species can persist at a given site. Plants species have different tolerance levels for flood stress. In other words, wetland plant species, and therefore wetland plant communities, favor a given range within a moisture gradient. If water levels are too deep for too long a time in an area, those plant species that cannot tolerate prolonged flood stress will not live in that area. Flood stress attributed to the modification of the natural flow regime for Mentor Marsh and its watershed has been identified as one of three stresses that negatively impact the marsh (Fineran, 2003). The impacts of these three stress factors are considered negative because: they inhibit the regrowth of the biologically diverse northern freshwater swamp forest that once filled the marsh basin; and they support the continued presence of the aggressively invasive *Phragmites australis* that now dominates the marsh (Fineran, 2003). This research study was designed to establish the current hydrology of the marsh to assess flood stress within the marsh basin. The hydroperiods provide important information to understand the hydrology of the marsh and establish a baseline from which to evaluate any future projects to establish a more natural flow regime to the marsh.

The water levels used to construct the hydroperiods were the monthly average water levels calculated for September 2004 through April 2006 for each location. Each graph shows the hydroperiod using the months of the year ordered from January to December to easily compare hydroperiods and to highlight seasonal effects.

5.3.1 Site #1: Headlands Beach

The sampling point for Site 1 is located on the upstream side of the first box culvert (Figure 3) located at the mouth of Shipman Pond near the Headlands Beach State Park exit. This site is one of two major surface water outlets for the marsh. It is the outlet for all surface waters flowing to the east. This location is of particular concern because beaver dams frequently obstruct the culvert and because it is a modification to the natural flow regime of the marsh.

The presence of the beaver dams was repeatedly observed and recorded throughout this study. The beaver dams raise water levels within the marsh increasing flood stress for the swamp forest tree species. Also, the redirection of the flow from Mentor Marsh through these culverts is a modification of the natural flow regime of the marsh. Waters from the eastern basin of the marsh previously flowed as a stream across the beach to join with Lake Erie (Fineran, 2003). This culvert is the first in a series of culverts that drain the eastern basin of Mentor Marsh into the Grand River.

Figure 3: Surface water sampling site #1 located at the entrance to Headlands Beach State Park. Note the branches sticking up from the beaver dam across the mouth of the box culvert.

The hydroperiod for sampling site #1 Headlands Beach is provided in Figure 4. The water levels show a seasonal pattern: low water levels in late winter (February –March) and late summer (August); and high water levels in early winter (December-January) and spring (April – June). We found that clearing the beaver dam from the culvert was futile because the beavers rebuilt the structure sometimes in a matter of hours (overnight). The beaver dam affects the hydroperiod of the marsh at this location and also at the stream section at Shipman Pond bridge (Site #2), located directly upstream from site #1, by raising the water levels. This increases the magnitude and the duration of flood stress for

locations within the eastern basin. The flow from the marsh was captured and redirected to flow into the Grand River in 1959. At that time, the stream that flowed from the marsh through the beach directly into Lake Erie was filled and the series of culverts installed rerouting the marsh waters to the Grand River. Since then periodic floods have reestablished the stream channel across the beach but it is filled in after the floodwaters recede. This has occurred twice during our research at Mentor Marsh. A flood in June 1997 reestablished a channel across the beach and was filled in by ODNR State Parks. And, a major flood occurred this July 2006 (soon after the final collection of data for this research study) and again the floodwaters reestablished the stream channel across the beach. Once again, ODNR State Parks filled the stream channel back in at great financial cost.

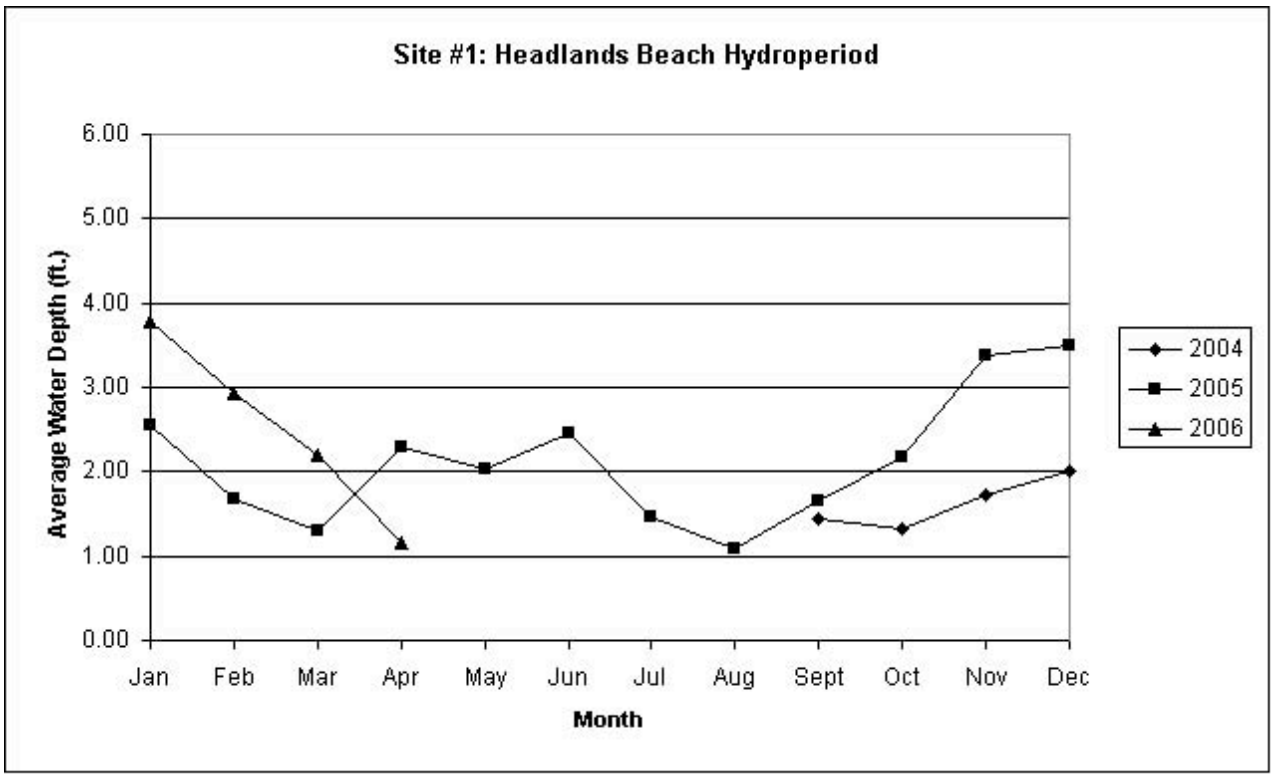

Figure 4: Hydroperiod for sampling site #1 located at Headlands Beach State Park exit.

5.3.2 Site 2: Shipman Pond

The sampling points for Site #2 are located along a cross section of the stream channel located at the Shipman Pond Bridge (Figure 5) near the entrance to the Headlands Beach State Park Office. This site has nine points along the cross section beginning with the west piling of the bridge and ending with the east piling of the bridge. The water depths measured at beam #5 were used to construct the hydroperiod for this location. Beam #5 is located approximately at the center point of the stream section. The water levels and depth to streambed along the cross section can be used to estimate quantity of flow and change in streambed over time.

Figure 5: Surface water sampling site #2 located on the downstream side of Shipman Pond Bridge. The steel pilings (beams) used as reference points can be seen between the wooden railings.

The hydroperiod for sampling site #2 Shipman Pond is shown in Figure 6. The water levels also show a seasonal pattern: low water levels in late winter (February –March) and late summer (August); and high water levels in early winter (December-January) and spring (April – June). As mentioned in the previous section, the beaver dams blocking the culverts that drain Shipman Pond increase the magnitude and duration of flood stress at this site (Shipman Pond). The filling of the stream channel across the beach and rerouting of the flow to the Grand River also effect the hydroperiod at Shipman Pond.

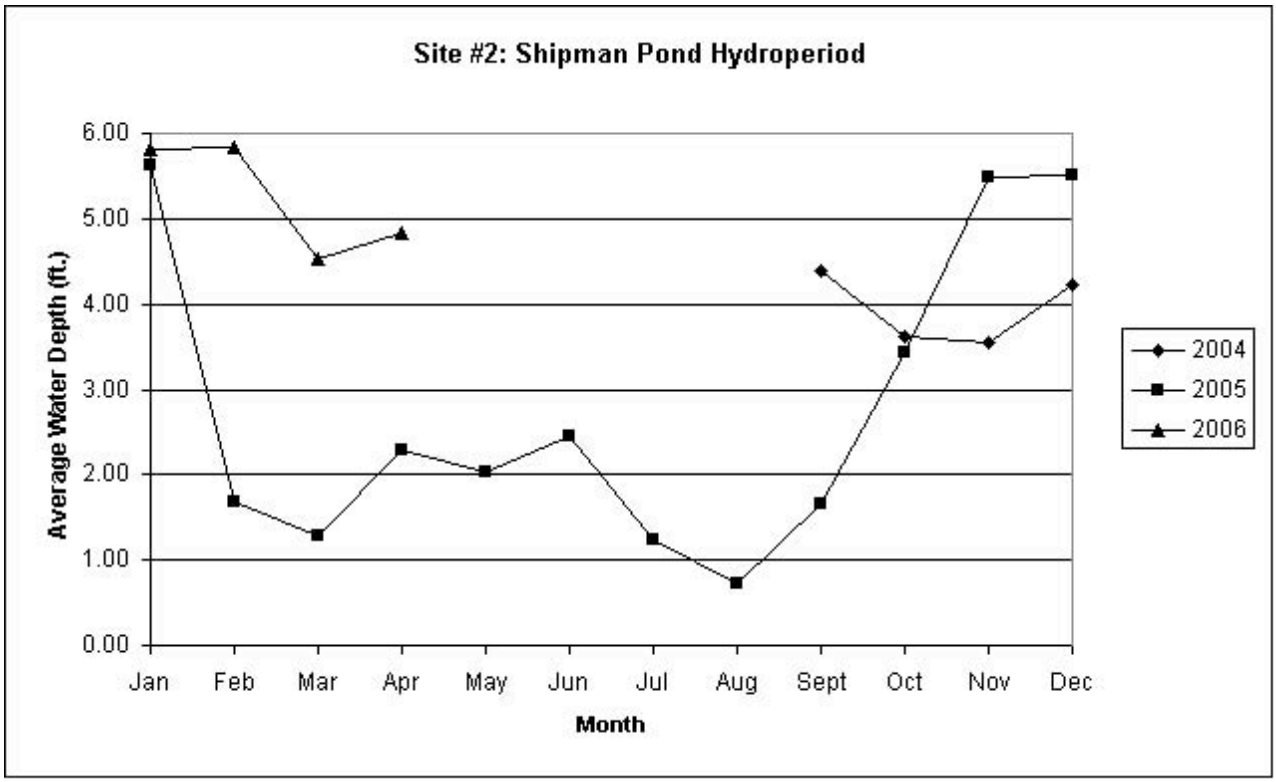

Figure 6: Hydroperiod for sampling site #2 located on the downstream side of Shipman Pond Bridge.

5.3.3 Site #3: Blackbrook

The sampling point for Blackbrook in the upper watershed of the marsh is located on the upstream side of the culvert for the Blackbrook stream channel (Figure 4) located on Blackbrook Road. Blackbrook watershed is the primary surface watershed that feeds the Mentor Marsh basin. It is very important to the marsh both in terms of the amount of surface water entering the marsh and the salt pollution received by the marsh. This sampling point is located upstream of the salt fill but downstream from the surface water entering the marsh from the abandoned brine well fields associated with abandoned industrial works in the area (Fineran, 2003). This location was found to be particularly useful to help characterize the amount and source(s) of salt pollution entering the marsh and to compare it with historic data for the brine fields.

Figure 7: Surface water sampling site #3 located on the upstream side of culvert for Blackbrook Road. Water levels were measured on the centerline of the culvert. The water level logger for the site is shown in the lower right corner of this photograph.

The hydroperiod for sampling site #3 Blackbrook is shown in Figure 8. The water levels show much less variation in depth than other sites such as Shipman Pond (site #2), the Remnant Swamp Forest (site #6), and the Marina (site #8).

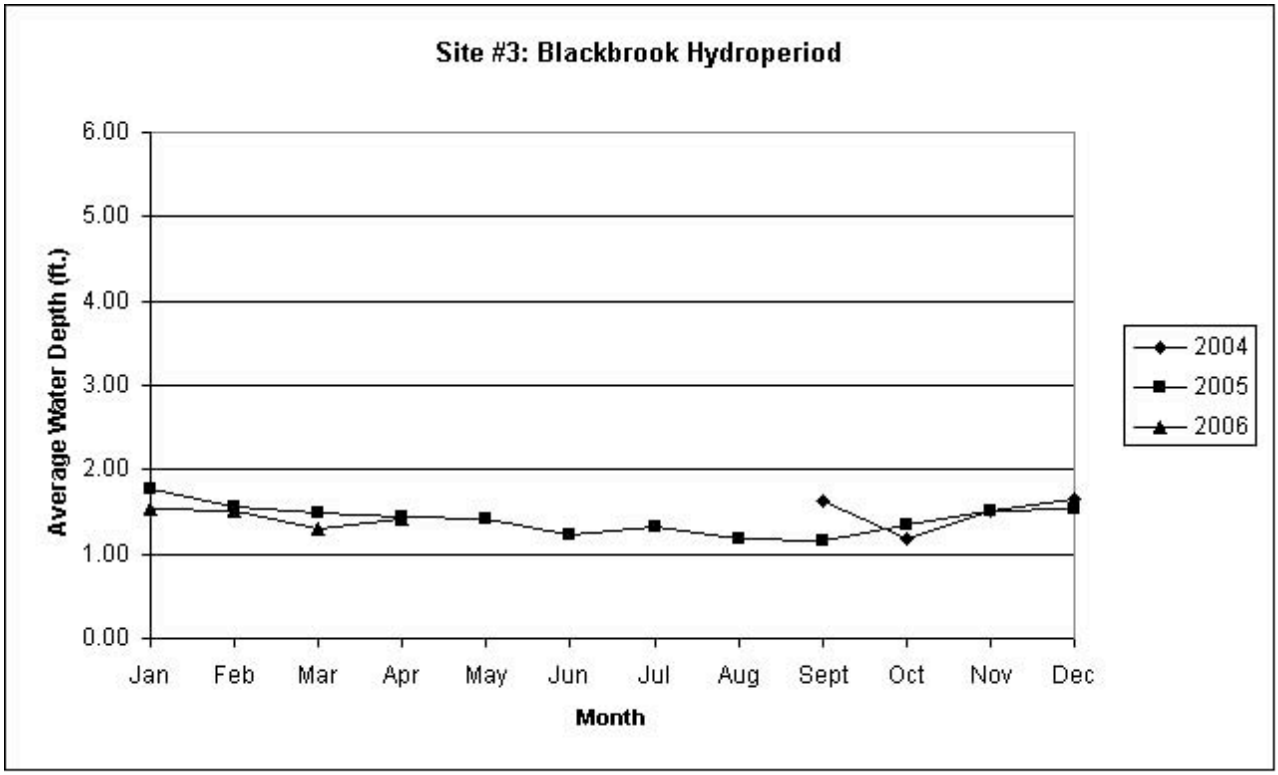

Figure 8: Hydroperiod for sampling site #3 located on the upstream side of the culvert at Blackbrook Road.

5.3.4 Site #4: Kerven Trail

The sampling point for Site #4 is located within the old confluence of Blackbrook and Mentor Marsh (Figure 9) located near Kerven Trail. This sampling site is important because of its location directly downstream from the salt fill and because it has the highest elevation within the Mentor Marsh basin. Contamination of water quality at this location effects the entire marsh as the total chloride results show. The salt fill has been

and continues to be identified as the major source of salt pollution to the marsh (Jones, 1975; Fineran, 2003).

Historically, waters entering the marsh flowed both to the east (toward Shipman Pond) and to the west (toward the Marina) from this location. After Blackbrook was filled with salt tailings from Morton Salt's Fairport Mine, the stream was rerouted to the east diverting more of the flow to the east. Although less water from the upper watershed of Blackbrook reaches this location because of the rerouting, water from overland flow and direct precipitation still flows from the salt fill and the surrounding area, through the old confluence, and into the marsh.

Figure 9: Aerial view of surface water sampling site #4 located within the mouth of Blackbrook stream. The sampling location is located in the upper left corner of the photograph. Kerven Trail leads to this site along the western (left) forested bank as shown in this photograph. The tan colored vegetation filling the streambed of Blackbrook is *Phragmites*. Mentor Marsh is directly north (top of photograph) of this site (see Figure 1).

The hydroperiod for sampling site #4 Kerven Trail is shown in Figure 10. The water depths are much lower than other stream locations within the marsh and its watershed. This can be at least partially attributed to the rerouting of Blackbrook to the east. Historic photographs of this location (Fineran, 2003) show the stream basin covered with low shrubs and trees; a stark contrast to the *Phragmites* that now fill the old confluence (Figure 9). The hydroperiod shows water levels that could support shrub-scrub or swamp

forest plant species but total chloride measurements show salt stress is well above that tolerated by freshwater species.

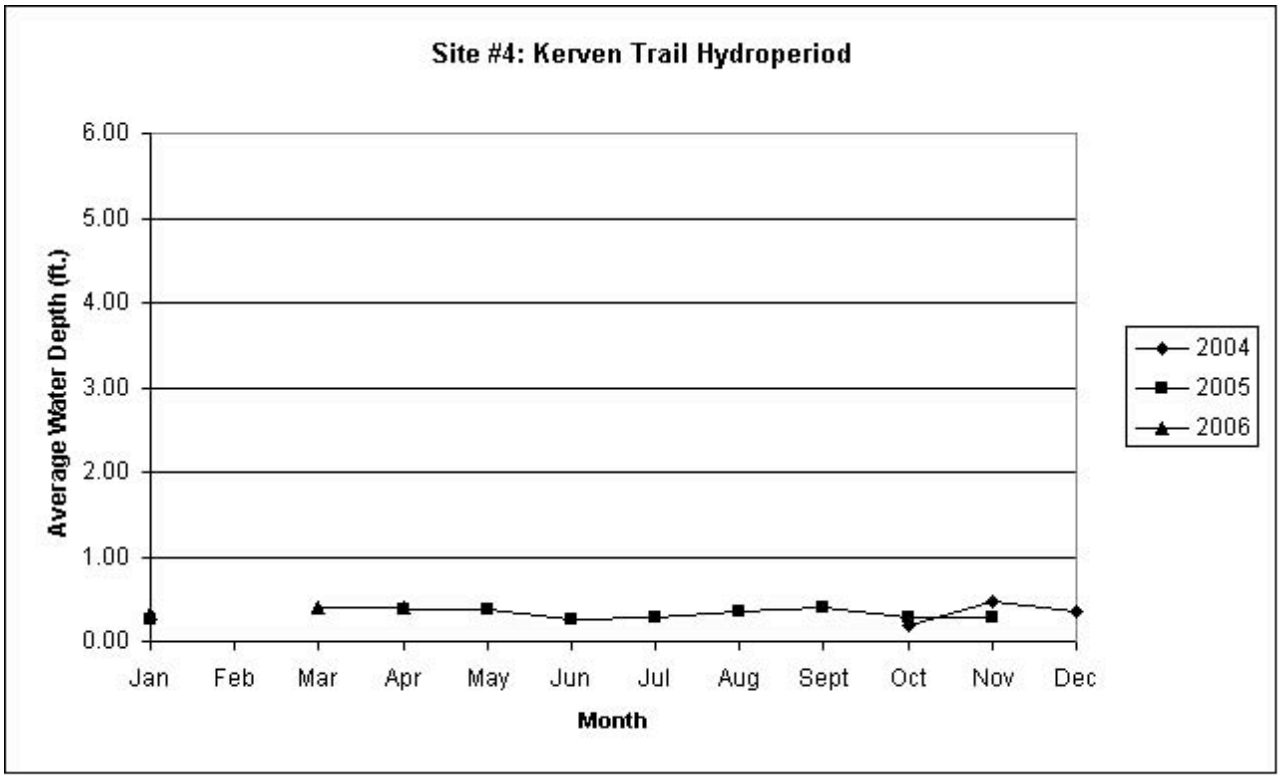

Figure 10: Hydroperiod for sampling site #4 located within the mouth of Blackbrook near its confluence with Mentor Marsh.

5.3.5 Site #5: Corduroy Road

The sampling points for Site 5 (Figure 11) are located at culverts (A and B) on Corduroy Road. The hydroperiod for this site was constructed using data measured at culvert A located nearest the center point for the marsh at this location. Corduroy Road is a road built within the marsh itself. The engineering plan drawings for the road show a design to direct water flowing from the east to the west within the marsh through the culverts.

Figure 11: Surface water sampling site #5 located on the upstream side of the culverts for Corduroy Road. The water level was measured from the invert of each culvert. This photograph shows the survey of the water level logger. The surveyor is standing on top of Culvert B.

The hydroperiod for sampling site #5 Corduroy Rd. is shown in Figure 12. The water levels are measured from the invert of the culvert pipe, not from the bottom of the streambed. They measure how full the culvert is flowing. The values show little variation in water depth over time. No flow through the culverts was ever observed or at least we were unable to detect any indication of flow either visually or with the flow probe. The culverts do not appear to carry any flow under Corduroy Rd. It is unknown if this is owing to blockage within the culverts or some other cause. No blockage is visible near the ends of the culvert. This lack of drainage within the center of the marsh contributes to higher water levels and increased flood stress for the vegetation. Corduroy Road seems to

effectively act as a dam across the marsh increasing the magnitude and duration of flood stress within the marsh.

Corduroy Road is itself another modification of the natural flow regime for the marsh. Corduroy Road was built in the early 1800's for people to travel to and from Mentor Headlands. Mentor Headlands is like an island surrounded by Lake Erie and Mentor Marsh on all sides (Figure 1). The bridges at Shipman Pond, the Marina, and Corduroy Road provide access to Mentor Headlands. Gault (1957) indicates that in the 1800's there was an elevated bridge in the center section of Corduroy Road. The stream flowing in the center of the marsh passed under the bridge.

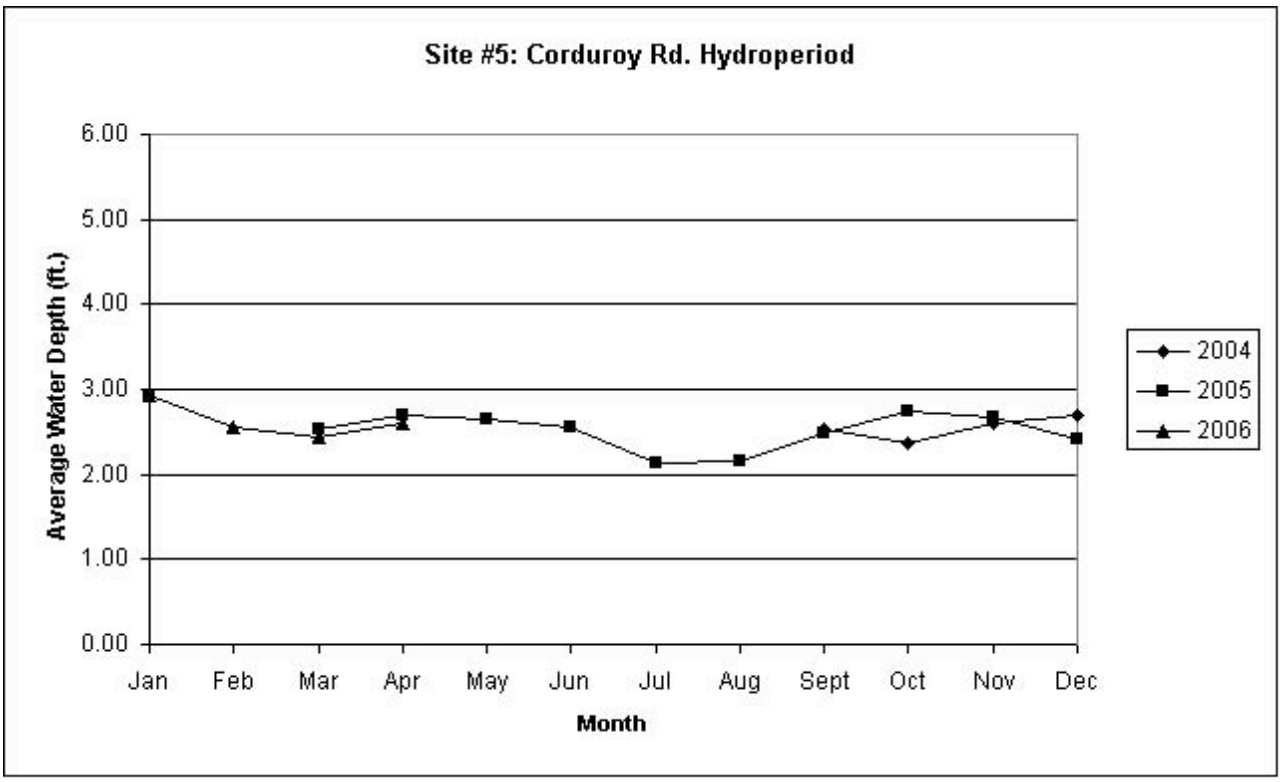

Figure 12: Hydroperiod for sampling site #5 located on the upstream side of Corduroy Road near the center of the marsh basin.

5.3.6 Site #6: Remnant Swamp Forest

Sampling site #6 (Figure 13) is located within the remnant swamp forest located near a residential street named Grace Court. Site #6 is a very important sampling site because we can use it to determine the hydroperiod and salt pollution levels in an area that still supports native swamp forest species. We can compare the results with other areas of the marsh that have experienced extensive invasion of *Phragmites*.

Figure 13: Surface water sampling site #6 located on within the remnant swamp forest within the western basin along the southern edge of the marsh. This photograph shows the elevation of the top of the water level logger being surveyed (dated January 2006).

The hydroperiod for sampling site #6 Remnant Swamp Forest is shown in Figure 14. The water levels were measured from the ground surface to the water surface. The spongy

texture of the ground surface made it difficult to determine the exact location of the ground surface. This introduces more uncertainty in the measurement of water levels at this location than many of the other sampling locations. However, the amount of uncertainty introduced is considered insignificant for the purposes of this study.

The hydroperiod shows water levels supportive of swamp forest. Similar to Kerven Trail there is a seasonal (summer, early fall) draw down of water levels where the surface is dry (i.e., zero water level measured from the ground surface). Flooding occurs in the winter and in the spring but even then the magnitude of flooding is small or at least not of long duration. The remnant swamp forest is located on a relict point bar with a slightly higher elevation than to the north within the marsh basin. This provides a refuge for the remnant swamp forest where it experiences lower flood stress and lower salt stress than other areas of the marsh.

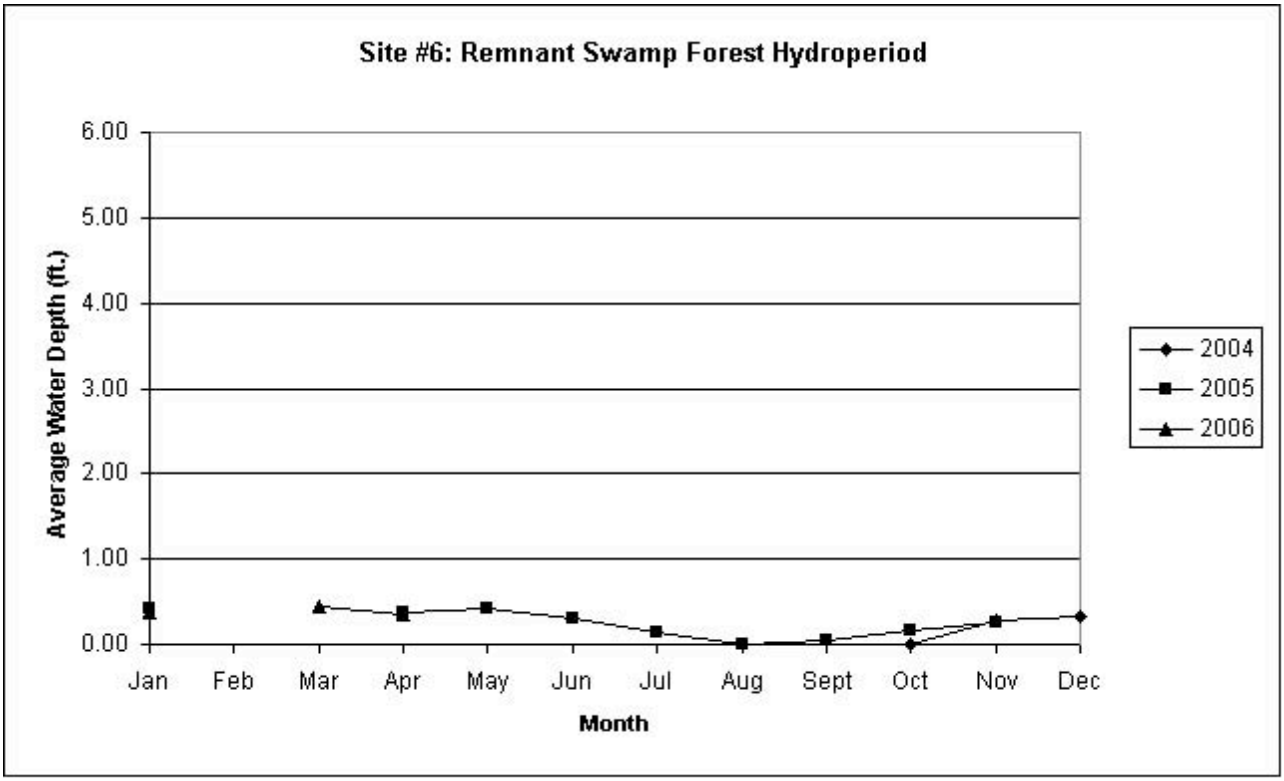

Figure 14: Hydroperiod for sampling site #6 located within the remnant swamp forest on the southern edge of the central basin of Mentor Marsh.

5.3.7 Site #7: Marsh Creek

The sampling points for site #7 (Figure 15) are located along a cross section of the Marsh Creek stream channel on the downstream side of the bridge on Lake Shore Boulevard. Site #7 is upstream of Mentor Marsh. The Marsh Creek watershed is separate from the Blackbrook watershed. Although Marsh Creek watershed is larger than the Blackbrook watershed, the water from Marsh Creek watershed enters at the far western end of the marsh, joins with waters from the rest of the marsh, and then flows into the marina and then into Lake Erie. Therefore, very little of the marsh receives water from the Marsh

Creek watershed stream flow. This is part of the natural flow regime of the marsh and can be attributed to the relict riverine morphology of the marsh. The waters of the Grand River once flowed within the marsh channel from east to west. Water within the central and western basins of the marsh also flow from east to west (Figure 1).

Figure 15: Surface water sampling site #7 located on the downstream side of the Marsh Creek bridge on Lake Shore Boulevard.

The hydroperiod for sampling site #7 Marsh Creek is shown in Figure 16. The water levels were measured along a cross section of the Marsh Creek stream channel located at the bridge on Lake Shore Boulevard (Figure 1). The water depths measured at the 15' mark on the bridge structure were used to construct the hydroperiod for this location. The 15' mark is located near the center of the stream section. The water levels, depth to streambed, and flow velocities along the cross section can be used to estimate quantity of flow and change in streambed over time.

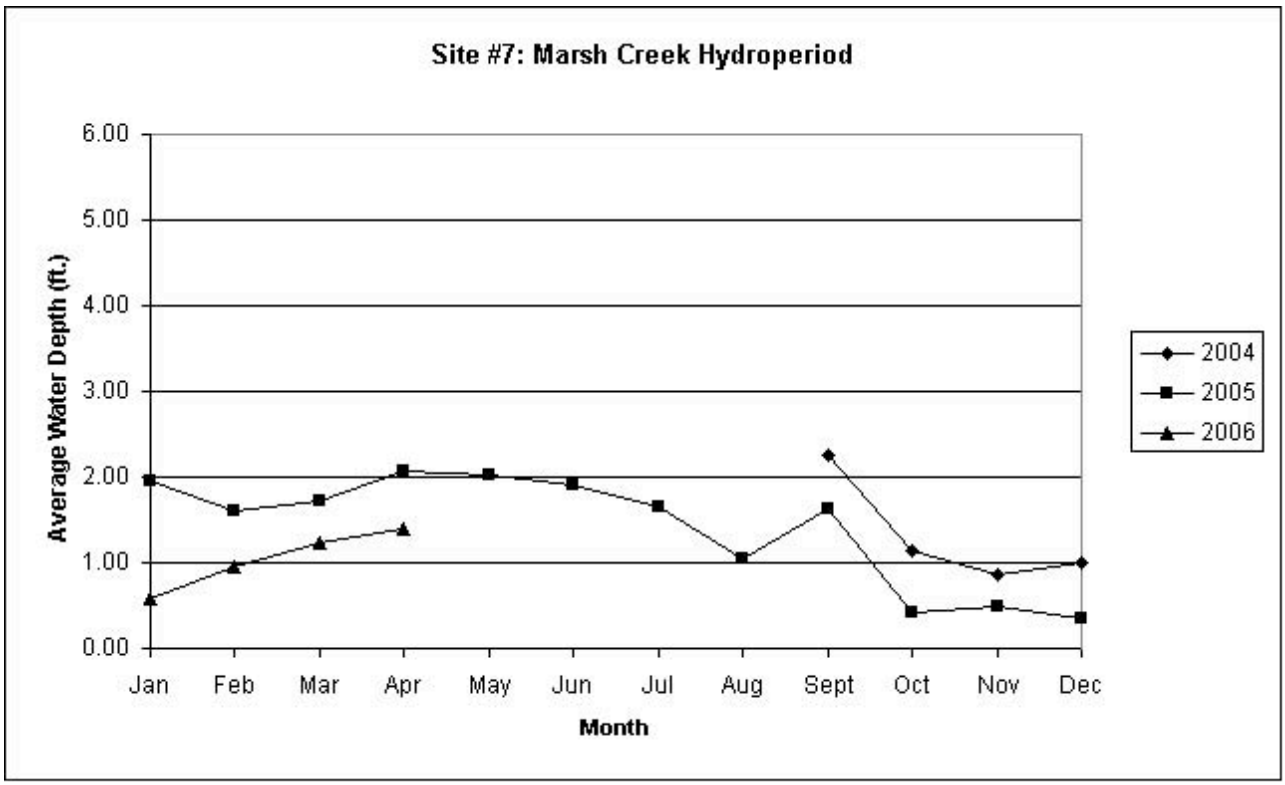

Figure 16: Hydroperiod for sampling site #7 Marsh Creek located on the downstream side of the bridge on Lake Shore Boulevard.

5.3.8 Site #8: Marina

The sampling points for site #8 (Figure 17) are located along a stream channel cross section in Mentor Marsh located on the downstream side of the bridge at the Marina. This site had twelve points along the cross section running from the south piling of the bridge to the north piling of the bridge. The water levels, depth to streambed, and flow velocities measured along the cross section can be used to estimate quantity of flow and change in streambed over time. This site is one of two major surface water outlets for the marsh. It is the outlet for surface waters flowing to the west within the central and western basins as well as the water coming from the Marsh Creek watershed.

Figure 17: Sampling site #8 located on the downstream side of the bridge at the Marina. The vertical beams of the bridge shown in this photograph were used as reference points to measure water depths along a cross section of the stream at this location.

The hydroperiod for surface water sampling site #8 Marina is shown in Figure 18. The water depths measured at beam #6 of the bridge structure were used to construct the hydroperiod for this location. Beam #6 is located near the center of the stream section. Another factor in the hydroperiod at this location is the seiche effect of Lake Erie. Reversals in flow directions were observed on many occasions at this location. The proximity of Lake Erie indicates this location is strongly affected by seiche events.

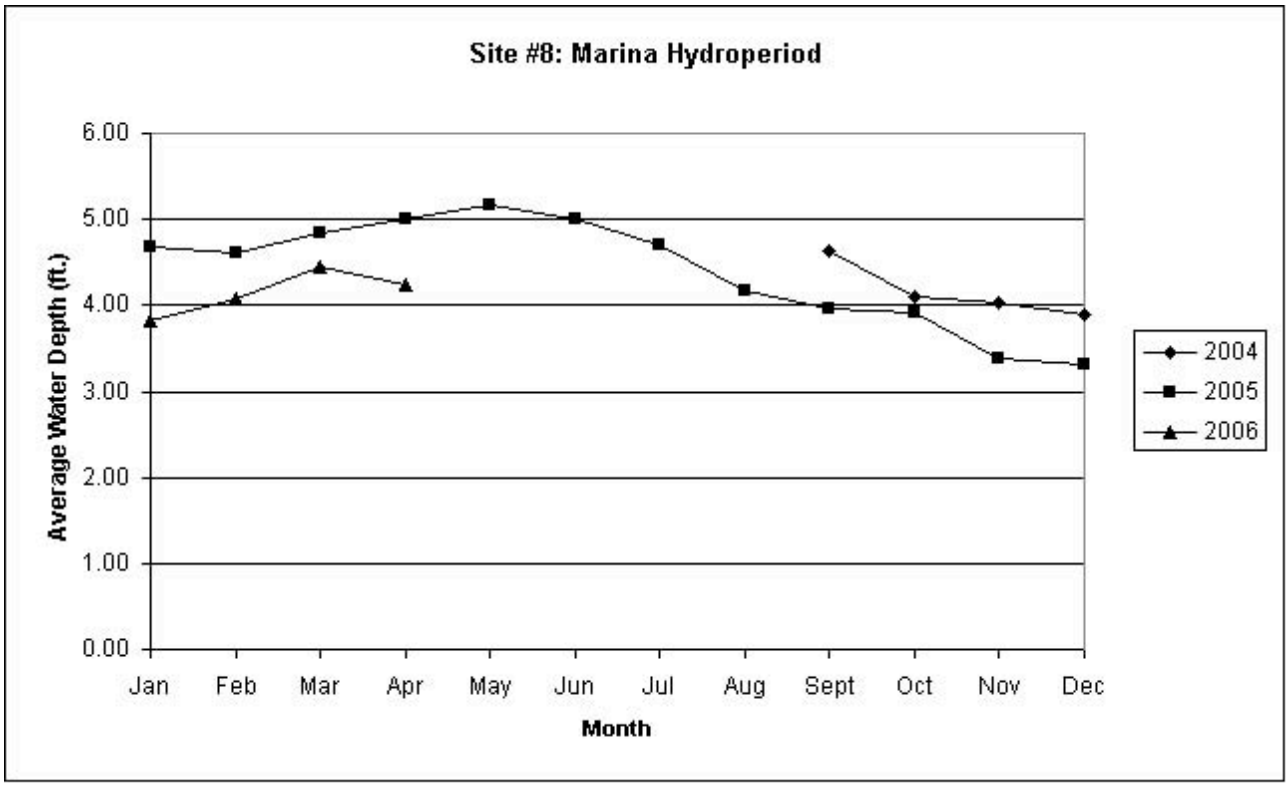

Figure 18: Hydroperiod for sampling site #8 Marina located on the downstream side of the bridge at the Marina.

5.4 Surface water elevations for sites 1, 2, 3, 5, and 8

The elevations of all reference points used in this study were surveyed so that the measurements could be converted to a standard elevation datum. Using the surface water elevations, water levels can be compared between sites and with Lake Erie water levels. Figure 19 shows the average monthly water surface elevations for sampling sites 1, 2, 3, 5, and 8 for the year 2005. The higher elevation of Blackbrook reflects its location high in the watershed of Mentor Marsh. The second highest water surface elevation at Corduroy Road indicates its proximity to the highest point in the marsh basin at the old confluence

between Blackbrook and Mentor Marsh. The water surface elevations of Shipman Pond and Headlands Beach sites are very close, which indicates little drainage across this area. The Marina has the lowest water surface elevation. This is because it is near the western outlet for the marsh and because of the relict riverine morphology of the marsh basin discussed in the last section.

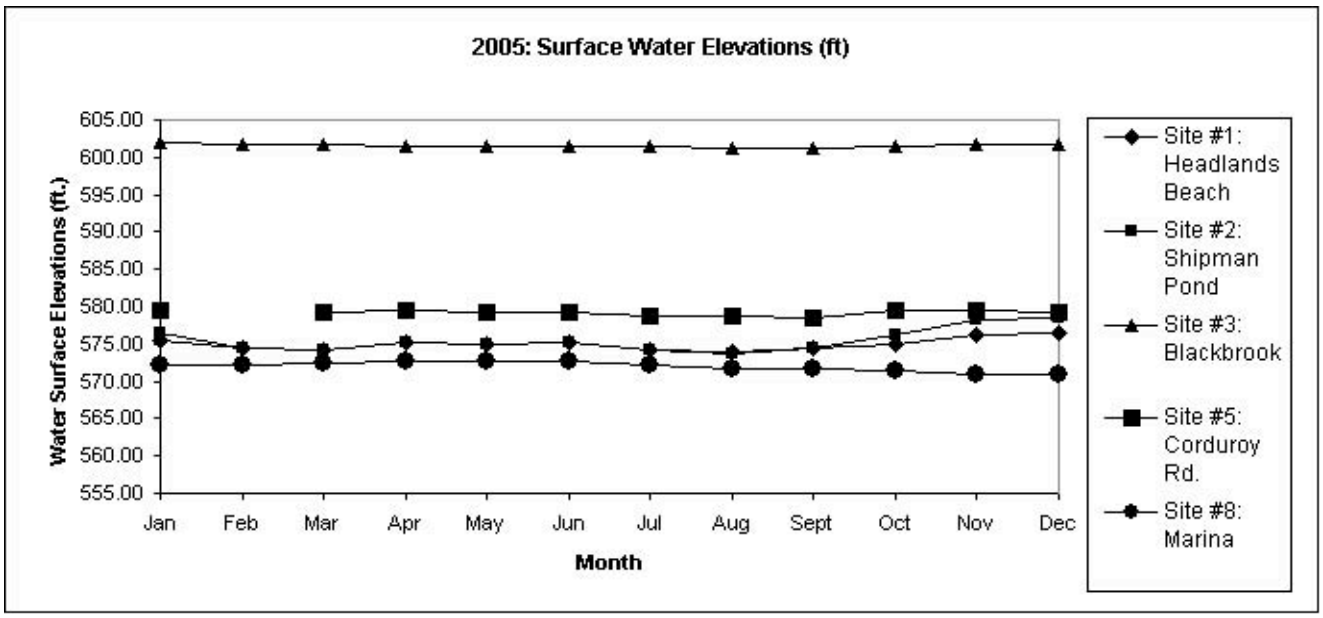

Figure 19: Surface water elevations for sites 1, 2, 3, 5, and 8.

5.5 Ground water monitoring wells

The groundwater monitoring wells were installed in 2001. During the installation, cores were drilled and split spoon samples collected. Brief descriptions of the samples are discussed to portray the lithology of Mentor Marsh and the properties of the subsurface materials from ground surface down to bedrock.

To summarize the lithology results, we found that blue-gray silty clay dominates the subsurface from 6 feet below the surface down to shale bedrock at approximately 60 feet. This blue-gray silty clay is a silty and highly variable till known as a meltwater till (ablation till). Groundwater flows through the meltwater till until it reaches the marsh basin as baseflow and then continues to Lake Erie. To understand the characteristics of meltwater till we can compare it to another type of till called basal till (lodgment till). Basal till is more compact and is often a poor carrier of groundwater flow. However, meltwater till often more permeable with flow paths more likely to have been established during the melting of the glacier. An unpublished study by Pavey and Stone produced a stratigraphic map that included the marsh area. A general interpretation of the map shows approximately 10 feet of sand, followed by 10 to 15 feet of silty clay, and then a thick layer of meltout till (Guy pers. comm., 2002). This map supports our interpretation of the till encountered during the drilling of the wells as meltwater till and helps explain the water bearing strata found.

The depth to shale bedrock at the Zimmerman Trail location (near Jordan Road, north of the marsh basin) is 62 feet. The depth to shale bedrock at the Marsh House (Carolyn

Sweet Nature Center on Corduroy Road, south of the marsh basin) is 58 feet. The Zimmerman Trail location has a surface elevation of approximately 613 feet. The Carolyn Sweet Nature Center location has a surface elevation of approximately 607 feet. This gives an approximation of the elevation of bedrock for both of these locations as 551 and 549 feet, respectively. This agrees with White's (1980) map showing bedrock contours (red contour lines) with bedrock elevation of 550 feet in this area.

The water-bearing strata on top of bedrock is a known feature within this area. Old well logs were researched to provide additional information on the lithology of the area in different locations around Mentor Marsh. The findings showed similar lithology to the findings described above. White (1980) discusses the importance of the water bearing strata flowing on top of bedrock to those using groundwater for household use in the area. He states,

> At places upon the bedrock at the base of the till sequences is a zone of a few inches to feet or more of more porous and permeable material in which ground water is present generally in small amounts…By drilling below this zone into the underlying shale, some storage may be provided so that a supply for a single house can be maintained by very careful and economical use.

White (1980) also discusses other sources of groundwater to be found within the till sequences in the area,

> Because till has very low permeability it is not a good source of water. It is now known that more water moves through joints in till than through intergranular spaces. Sand layers between tills may be water bearing, and some wells have found supplies in such water-bearing layers.

These water-bearing strata within the till sequences are more important to the possible groundwater contribution to the marsh than the water flowing on top of bedrock. It appears that the groundwater encountered south of the marsh basin is at a depth to

daylight at the level of the marsh. Water may flow through water bearing strata such as this one, carrying water from the upper subsurface watershed to the marsh basin thereby contributing base flow to the marsh, which is a relict river segment (Fineran, 2003). The groundwater encountered north of the marsh basin, that is at a depth to daylight at the level of Lake Erie, may flow through another such water bearing strata carrying water from the subsurface watershed to Lake Erie. This groundwater flow pattern would not be unexpected considering the relict riverine geomorphology of the marsh, its position in relation to Lake Erie, and within the Lake Erie watershed. Until better measurements are available to quantify the contribution of groundwater to the marsh system, the relative contributions of water from these subsurface sources to the marsh remain uncertain.

5.5.1 Site #9: Marsh House wells (R1D1 & R1D2)

The ground water sampling points for site #9 (Figure 20) are located in front of the Marsh House on Corduroy Road just south of the marsh. Three holes were drilled at this location. The first hole drilled was used as a lithology test hole (R1D3) sampling to bedrock, which was encountered at 58 feet. In the second hole drilled (R1D1), a deep groundwater monitoring well was installed to monitor groundwater flow on top of the shale bedrock. In the third hole drilled, a shallow well was installed to monitor groundwater flow in a silty water-bearing strata within the meltwater till at a depth of 23 feet, believed to interface (daylight) at the approximate level of the marsh basin.

The lithology test hole (R1D3) showed a lithology with the following sequence, measured in depth below ground surface (bgs) in feet: 0 to 1’ topsoil (silt loam); 1 to 7’

clay and silt; 7 to 53’ clay changing to till interspersed with small sand and gravel layers; 53 to 58’ gravel and sand with water; and at 58’ shale bedrock encountered. The lithology of the second hole for deep groundwater monitoring well (R1D2) was not collected but a similar sequence appeared, with water encountered within a few feet of bedrock. The well was set to capture the water flowing in this sand and gravel layer carrying water on top of bedrock. The lithology of the third hole for the shallow groundwater-monitoring well (R1D1) was collected and recorded. It showed a lithology with the following sequence: 0 to 1’ topsoil (silt loam); 1 to 6’ loam, then silt and clay with trace gravel; 6 to 13’ moist blue-gray silt; 13 to 18’ blue-gray clay with little silt and trace gravel (till); 18 to 22’ well integrated clay and gravel with some sand; and 22 to 23’ sand and gravel with water.

Figure 20: Ground water sampling site #9 located at the Marsh House on Corduroy Road. The two white PVC pipe casings shown in the photograph enclose the tops of wells R1D1 and R1D2. This sampling site is located south of the marsh.

The water levels for well R1D1 is shown in Figure 21. As discussed above, this well was completed in a shallow silty water-bearing layer above the glacial meltwater till. The water levels show seasonal fluctuations in water levels that appear to be a smoothed version of precipitation amounts for the area.

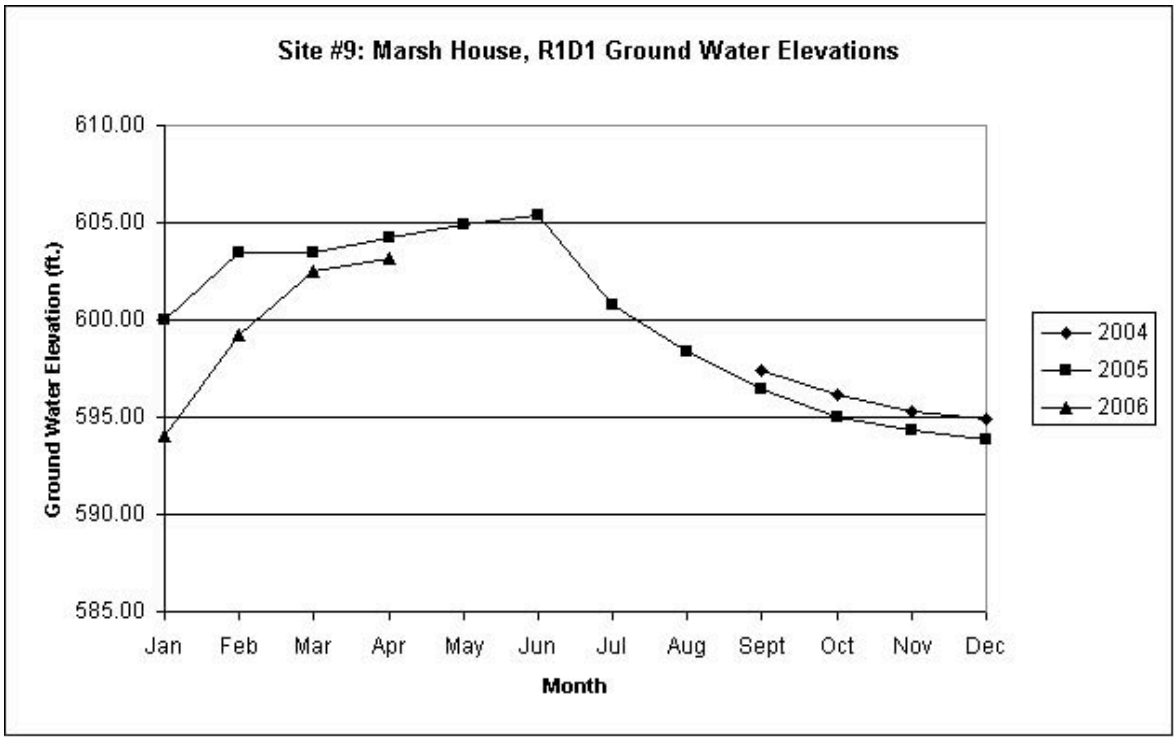

Figure 21: Ground water elevations for sampling site #9 Marsh House, well R1D1.

The water levels for well R1D2 are shown in Figure 22. As discussed above, this well was installed to monitor groundwater flow on top of the shale bedrock beneath the glacial meltwater till. The water levels show little but perhaps some seasonal fluctuations in water levels. There is a slight decline in water level for the month of August.

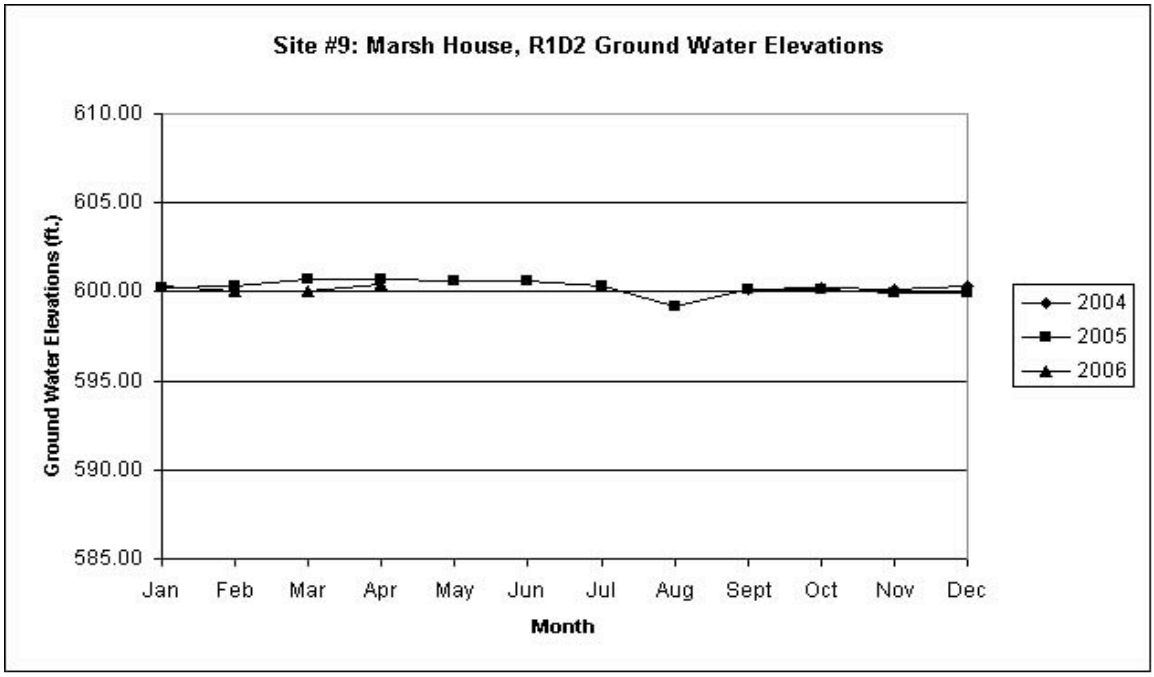

Figure 22: Ground water elevations for sampling site #9 Marsh House, well R1D2.

5.5.2 Site #10: Zimmerman Trail wells (R2D1 & R2D2)

The ground water sampling points for site #10 (Figure 1) are located within the forest just east of Zimmerman Trail. Two holes were drilled (Figure 23) at this location, which is on the uplands north of the east central basin, west of eastern basin, and adjacent to Zimmerman Trail, located south of Jordan Drive (Figure 1). The first hole drilled at this site was used as a lithology test hole (R2D1) sampling to bedrock with no well set. Shale bedrock was encountered at a depth of 62 feet. In the second hole (R2D2), a groundwater-monitoring well was installed to collect water from a water bearing strata at a depth between 33 to 43 feet, which is believed to be at a level that would interface (daylight) at approximately Lake Erie level to the north.

The lithology test hole (R2D1) showed a lithology with the following sequence, measured in depth below ground surface (bgs) in feet: 0 to 2’ topsoil (loam); 2 to 7’ layers of fine sand interspersed with silt and some clay; 7 to 45’ clay with some silt layers interspersed with clasts and some moist layers (till); 45 to 62’ very dense, hard till, clay with some silt and scattered clasts; and at 62’ shale bedrock was encountered.

The lithology of the second hole for the groundwater monitoring well (R2D2) was also collected showing the following sequence: 0 to 0.5’ topsoil; 0.5 to 3’ medium sand changing to silt; 3 to 28’ blue-gray clay with some silt and sometimes moist; 28 to 38’ blue-gray clay, wet with poor recovery (2.5 out of 10’ recovered); and 38 to 43’ no recovery. The well was set to capture the water bearing strata encountered within the meltwater till between 32 and 43 feet. Referring to the lithology test hole (R2D1) we

found very wet silty layers at depths where we had poor recovery in the set well indicating these were possible water bearing strata. Subsequent data collection confirmed this.

Figure 23: Sampling site #10 located along Zimmerman Trail on Mentor Headlands north of the marsh. This photograph shows wells R2D1 and R2D2 when they were installed on September 11, 2001; a day we will never forget.

The water levels for well R2D2 are shown in Figure 24. The results for this groundwater monitoring well, set to collect water from a water bearing strata at a depth between 33 to 43 feet, is very similar to the results found for well R1D2 located south of the marsh (see previous section) both in the pattern of water levels and their seasonal fluctuations. Again, the water levels show seasonal fluctuations in water levels that appear to be a smoothed version of precipitation amounts for the area. The pattern of rise and fall of water levels appears to repeat from year to year.

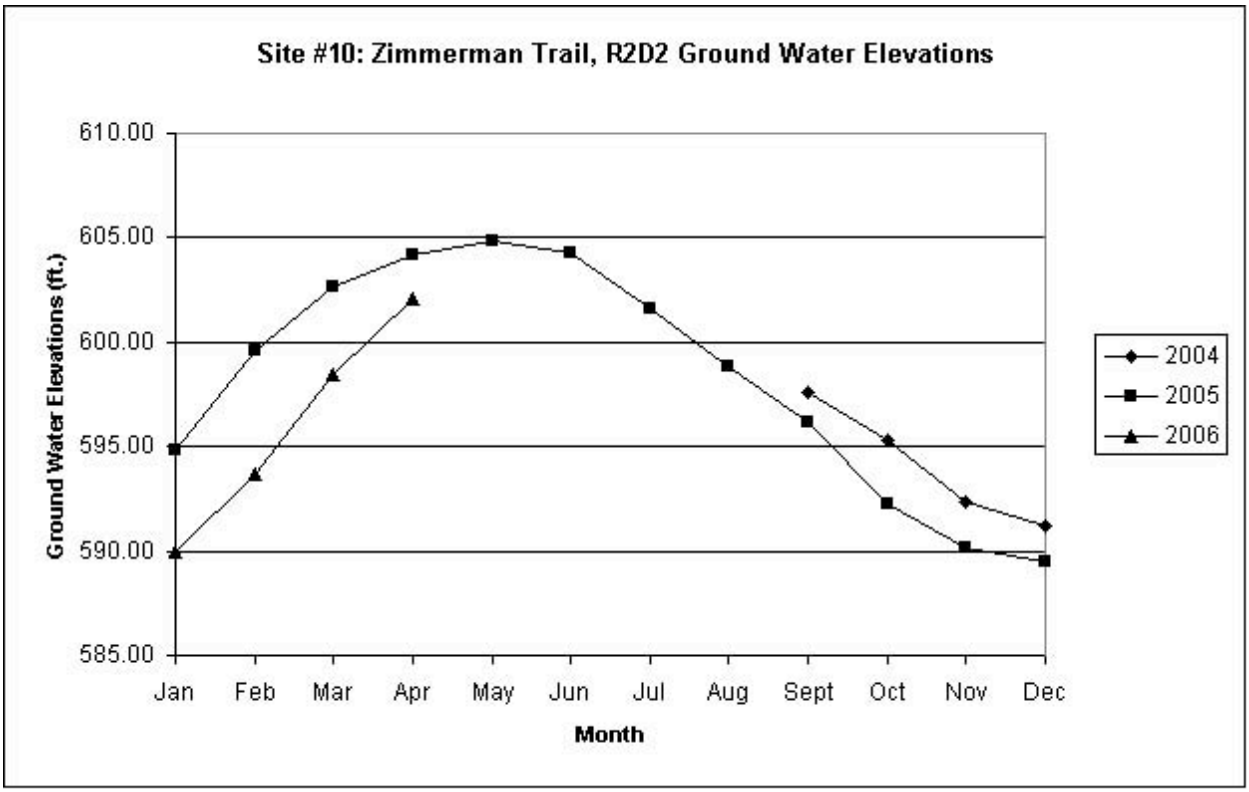

Figure 24: Ground water elevations for sampling site #10 Zimmerman Trail, well R2D2.

6.0 CONCLUSIONS & RECOMMENDATIONS

The results of this research study indicate several modifications to the historical (natural) flow regime of Mentor Marsh have occurred (Fineran, 2003) with higher levels of flood stress for swamp forest plant species. The results also indicate that Mentor Marsh continues to experience very high levels of salt pollution that can be attributed to three known sources (Jones, 1975; Fineran, 2003): the salt fill within the stream channel of Blackbrook, the abandoned brine fields in the upper watershed of Blackbrook, and road salt application.

Modifications to the natural flow regime of the marsh have caused increased flood stress for many locations throughout the marsh. This has negative consequences for the wetland ecology of the marsh. The increases in magnitude and duration of flood stress decrease the amount of land within the marsh that can support swamp forest plant species. Hydroperiods constructed for sites 1, 2, 5, and 8 provide a quantitative baseline that can guide future restoration projects and can be used to measure success for these projects. The research results provide valuable quantitative information to assist managers, decision-makers, and other stakeholders for Mentor Marsh.

Another important finding of this research study was the identification and quantification of the salt pollution coming from the upper watershed of Blackbrook. Site 3 Blackbrook was initially selected to characterize the water flow and water quality within Blackbrook's upper watershed. We expected the water to have relatively low salinity levels because of its location upstream from the salt fill. Instead we found the salinity

levels were very high at sampling site #3. These results indicate that the abandoned brine fields described by Jones (1975) and Fineran (2003) have once again become a major source of salt pollution to the marsh. It is our recommendation that action be taken to remediate the abandoned brine field sites before more development occurs. As the soils are disturbed it appears salt is released from the soil and washed into Blackbrook and is carried downstream into Mentor Marsh. The rerouting of Blackbrook is ineffective to keep the salt pollution from the old brine fields from reaching the marsh.

We also recommend that management and conservation agencies and organizations consider projects to assess the potential for restoration of a more natural flow regime to the marsh. There are several areas where stream restoration could greatly enhance the swamp forest's ability to expand within the marsh basin by reducing flood stress. Stream restoration at the mouth of Shipman Pond should be considered as one way to reduce flood stress in the eastern basin of the marsh. This would likely lower repair and maintenance costs for Headlands Beach State Park and perhaps prevent the closure of this popular beach during high demand months. One strategy managers may want to consider is to mimic the natural flow regime that once existed in this area as described by Fineran (2003). A reference site to guide the restoration could be Conneaut Township Park Beach (Figure 28). The managers of this beach maintain the natural flow regime of Conneaut Creek by allowing it to flow to its natural confluence with Lake Erie (Figure 28). This is strikingly similar to Mentor Marsh's confluence with Lake Erie before it was rerouted in 1959 (Figure 29).

Figure 25: Photographs showing Conneaut Creek's confluence with Lake Erie at Conneaut Township Park Beach, August 2006.

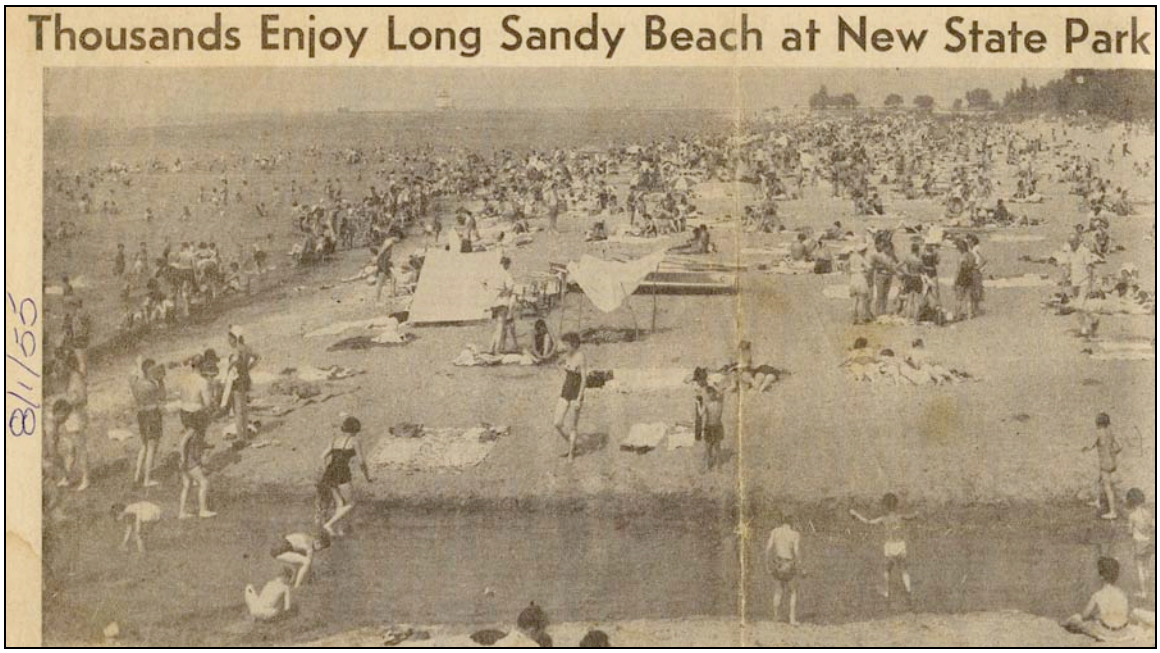

Figure 26: Newspaper clipping showing Mentor Marsh's (Blackbrook's) confluence with Lake Erie at Headlands Beach State Park, August 1955 (source: ODNR, 2002).

Reduction in *Phragmites* should be a high priority for all stakeholders for the marsh. The persistence of large contiguous stands of *Phragmites* within the marsh basin is a fire hazard for structures surrounding the marsh. Anyone caught in the marsh basin during one of the fast moving grass fires that occur regularly (Fineran, 2003) could die. It is often juveniles that set these fires from within the marsh. A program of fire prevention and education is critical. It is also important to recognize and control all the factors that support the persistence of *Phragmites* at Mentor Marsh: flood stress, salt stress, and fire disturbance.

Expansion of swamp forest would increase the biodiversity of the Mentor Marsh. When one considers that Mentor Marsh is a State Nature Preserve, a Cleveland Museum of Natural History nature preserve, and it is designated a National Natural Landmark it seems reasonable to try to recover some of the loss in biodiversity at this site. The swamp forest's natural ability to out-compete *Phragmites* through shade stress (Fineran, 2003) indicates Mentor Marsh has excellent potential to recover its swamp forest.

The complete removal of the salt fill within the Blackbrook stream channel followed by the restoration of the natural flow regime of Blackbrook to its old confluence with Mentor Marsh remains the most crucial action that must be taken for the recovery of swamp forest and the control of potentially catastrophic fires within the marsh basin. Figure 30 shows an aerial view of the salt fill placed in Blackbrook stream channel. The salt from Morton Salt's Fairport Harbor mine has been reexposed with the failure of the landfill cap system (see area within the red circle, Figure 30). It seems insupportable to

maintain a failed landfill that contains a substance that is lethal to native freshwater plant species, and supports the persistence of *Phragmites,* within a stream channel that feeds directly into Mentor Marsh. Harm to structures and human life from future *Phragmites* fires could be catastrophic.

Although the complete eradication of *Phragmites* within the marsh basin would be difficult, and perhaps impracticable, it is perhaps unnecessary. Many of these concerns could be addressed by simply increasing the amount of swamp forest in critical areas. This could act as a type of firebreak, because swamp forest burns more slowly than a grass fire. If so, this would give fire departments more time to arrive and get the fire under control before structures are damaged and human life is lost.

The results of this research study increase our understanding of the current hydrology of Mentor Marsh. They detail how the current hydrology is different from the historic (natural) flow regime for the marsh. And, the results have important implications for the wetland ecology of the marsh.

Figure 27: Aerial view of the failed landfill cap showing exposed salt (see area within red circle marked on the photograph). This photograph shows the location of the saltfill within the Blackbrook stream channel directly upstream from Mentor Marsh. Sampling site #4 is located in the upper left corner of the photograph. A water quality sample collected at the base of the saltfill in May 2006 had total chloride of 9,000 mg/l.

7.0 BIBLIOGRAPHY

Fineran, Stacey A. 2003. Assessing spatial and temporal vegetative dynamics at Mentor Marsh, 1796 to 2000 A.D. Ph.D. Dissertation. The Ohio State University, Columbus, Ohio.

Gault, Homer J. 1957. History of Mentor Headlands and Vicinity. North Mentor Service Circle, Mentor, Ohio.

Global Water. 2004. FP101-FP201 Global Flow Probe Users Manual. Mentor, Ohio.

Guy, Donald. 2002. Geologist. Ohio Department of Natural Resources, Division of Geological Survey, Lake Erie Office. Sandusky, Ohio. Personal communication.

Jones, K. 1975. The continuing story of Mentor Marsh. The Cleveland Museum of Natural History, Cleveland, Ohio.

National Oceanic and Atmospheric Administration (NOAA). 2006. Lake Erie water levels. http://tidesandcurrents.noaa.gov

National Oceanic and Atmospheric Administration, National Climatic Data Centers (NOAA NCDC). 2006. http://www.ncdc.noaa.gov/oa/ncdc.html

Ohio Department of Natural Resources. 2002. Headlands Beach State Park files: media clippings, miscellaneous photos and records. Ohio Department of Natural Resources, Division of State Parks, Headlands Beach State Parks, Mentor, Ohio.

White, George W. 1980. Glacial geology of Lake County, Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Report of Investigations No. 117, Columbus, Ohio.

APPENDIX

Elevation Data

Site Number	Site Name	Location Description	Elevation
1	Headlands Beach	Invert	572.85
2	Shipman Pond	Beam #5	586.95
3	Blackbrook	Invert	600.12
4	Kerven Trail	Spike	584.63
5	Corduroy Road	A (north) B (south)	576.70 576.13
6	Remnant Swamp Forest	Spike	576.92
7	Marsh Creek	15'	584.57
8	Marina	Beam #6	583.32
9	South Wells (Marsh House)	R1D1 R1D2	611.00 611.08
10	North Wells (Zimmerman Trail)	R2D2	615.21

Table A.1: Elevations for sampling sites measured in January 2006.