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2016 BELLE ISLE COMPREHENSIVE HYDROLOGIC ASSESSMENT

Prepared by:

Prepared for:

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1 | OVERVIEW

REPORT OBJECTIVES

In response to tasks 2A and 2B of the Lake Okonoka Habitat Restoration project, this report aims to gain an understanding of the current hydrology on Belle Isle specific to the +/- 200 acre natural area referred to as the wet-mesic flatwoods forest (flatwoods).

Since the mid-late 1800's, this unique natural system has been altered in several ways:

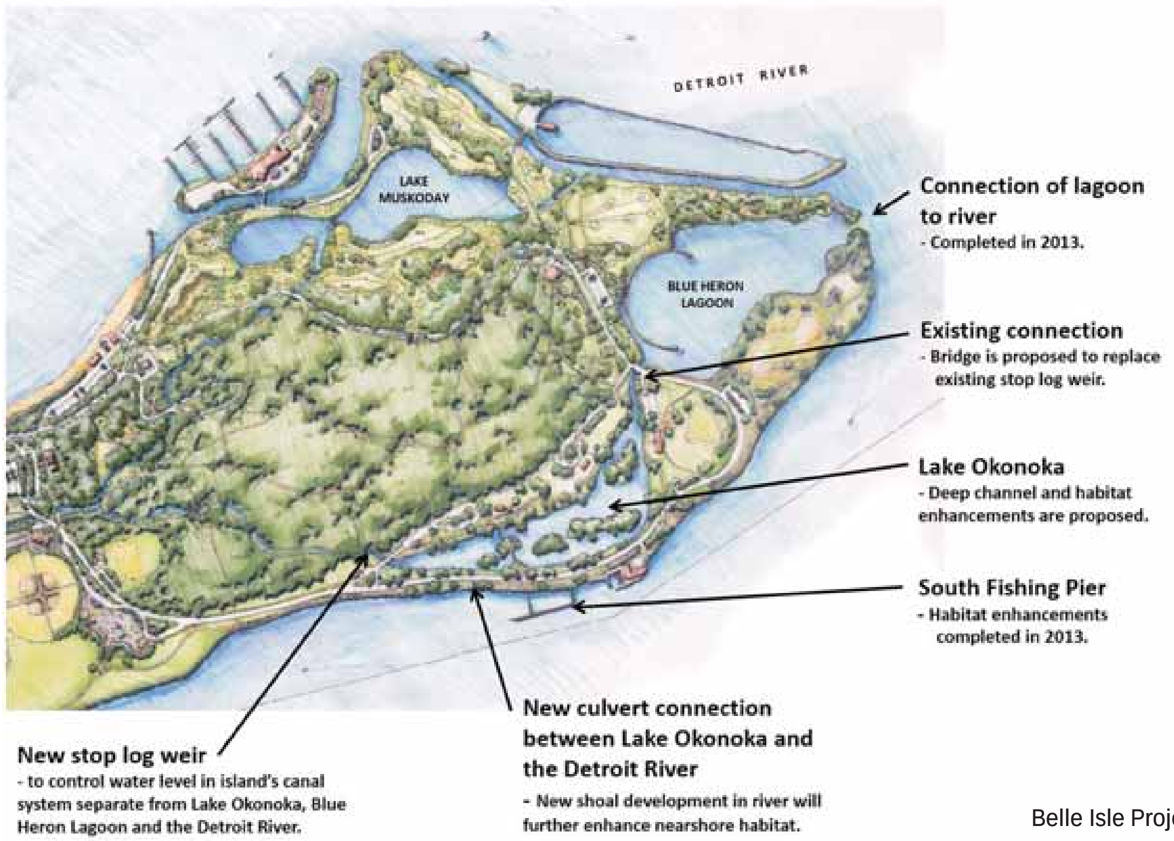
- Expansion of the island by approximately 100 acres on three sides of the flatwoods altered its natural drainage patterns that was influenced by the Detroit River's natural water fluctuations. Construction of Lakes Muskoday, Okonoka and the Blue Heron Lagoon within naturally occurring pre-settlement wetlands appeared to have less impacts on the flatwoods hydrology compared to the cut and fill used to dike and define these water features for the Isle's perimeter road system.
- Construction of Sylvan and Nashua Canals through the flatwoods for recreation purposes changed drainage patterns, effecting pool water levels in some of the contigious wooded areas.
- Ditching and swale construction throughout the flatwoods have altered natural drainage patterns and artificially drained large areas allowing for the introduction of non-native, upland shrub species.
- Construction of roads (fill) through the flatwoods blocked natural drainage patterns to the Detroit River and perimeter wetlands. Cast iron culvert and equalizer pipes were installed as an attempt to minimize these flow disruptions, but most are only partially functional.
- Construction of extensive meandering hiking and equestrian trails (fill) created impacts similar to the road systems. The cast iron equalizer pipes have mostly filled with soil and organic matter or were not set at the correct elevations.
- Buildings, recreational uses and parking lots along and within the perimeter of the flatwoods encroached into the woodland in several locations.
- Fill associated with roads and trails converted pre-settlement wetlands to linear uplands that have been overtaken by a number of non-native shrubs and herbaceous plant species.
- Emerald ash borer decimated one of the predominant and significant mature tree species. Fallen dead trees have blocked drainage patterns and impounding water. Canopy cover has also been reduced allowing for the establishment of reed canarygrass (*Phalaris arundinacea*), amur honeysuckle (*Lonicera maackii*) and phragmities (*Phragmities australis*).

Collectively, these alterations have created a complex set of conditions across the flatwoods where some areas appear to be excessively dry, while others excessively wet. To add to this complexity, Task 3 of this federally funded program focuses on the development of detailed permit drawings that connect Lake Okonoka to the Blue Heron Lagoon and the Detroit River for the purpose of creating fish nursery habitat for river species. This project builds upon the Phase 1 work in 2013 where the Blue Heron Lagoon was brought on-line with the Detroit River system in an attempt to provide fish nursery habitat adjacent to well documented spawning shoals on the east side of Belle Isle. Constructing this project in the near future will result is some restorative benefits to the flatwoods between Lake Okonoka and Woodside Drive.

Michigan Department of Natural Resources (MDNR) has raised concerns that this Task 3 habitat enhancement could adversely impact the flatwoods and has brought forward a series of subtask to aid them in understanding the dynamics of this unique habitat.

The specific directives of the hydrologic investigations and evaluations, as established by the MDNR, are as follows:

- Compile and review existing relevant documents on the site infrastructure including the lake and canal pumping system.
- Supplement existing bathymetric surveys for the impacted lakes and, if possible, the canal segments flowing through the flatwoods.
- Supplement existing topographic and utility surveys to verify infrastructure impacts.
- Delineate wetlands and approximate boundaries of 'vernal' pools in the flatwoods.
- Determine impacts of the Sylvan and Nashua Canals on the hydrology of the flatwoods.



Belle Isle Projects

- Determine impacts to the flatwoods if Lake Okonoka is connected to the Detroit River.
- Determine the impact of actively used and abandoned roads and trails on the flatwoods surface water hydrology.
- Investigate relationships of the flatwoods mature trees with surface water and groundwater systems.
- Investigate blocking or unblocking drains.

These directives are answered in this report either directly or indirectly through the analysis of flatwoods systems both on a macro- and micro-scale.

The analysis and recommended outcomes are presented in four parts:

- **Flatwoods Systems Analysis**
  A description of the flatwoods natural and human introduced systems are described for the entire flatwoods. This systems analysis focuses on describing overall relationships and influences on the hydrologic functions of the flatwoods compared to historical functions. The systems are described generically and supported with graphics.

- **Detailed Flatwoods Systems Analysis**
  The flatwoods is divided into eight cells due to its extensive fragmentation. The cells are defined primarily by roads and trails that play a significant role on shaping the current characteristic of the flatwoods. This detailed analysis is necessary since the scale of the system's influences on current hydrology vary from one location to the other and a closer analysis of each area is required.

- **Restoration Strategies**
  Both generic and specific restoration strategies are presented under this section. Generic applies to the strategies where existing data was insufficient to make specific recommendations and would be considered data that is part of the next phase of work. One example is the surface water connectivity between pools that were historically connected but now fragmented by roads or trails. Generically, these connection points can be identified, but the specific elevations of these connection points require a more thorough topographic survey to set the appropriate elevations to accurately restore the connectivity.

- **Next Steps**
  A list of needs and priorities are presented to guide next phases of work-the design and permitting phase followed by implementation.

2 | BACKGROUND

HISTORY

The history of Belle Isle is well documented, and research of historic documents show human interaction with the Isle extending back to the late 1600's when French explorers first visited the Detroit region. It is not the intent of this report to repeat Belle Isle's history other than to highlight significant events that have bearing on the current conditions of the flatwoods.

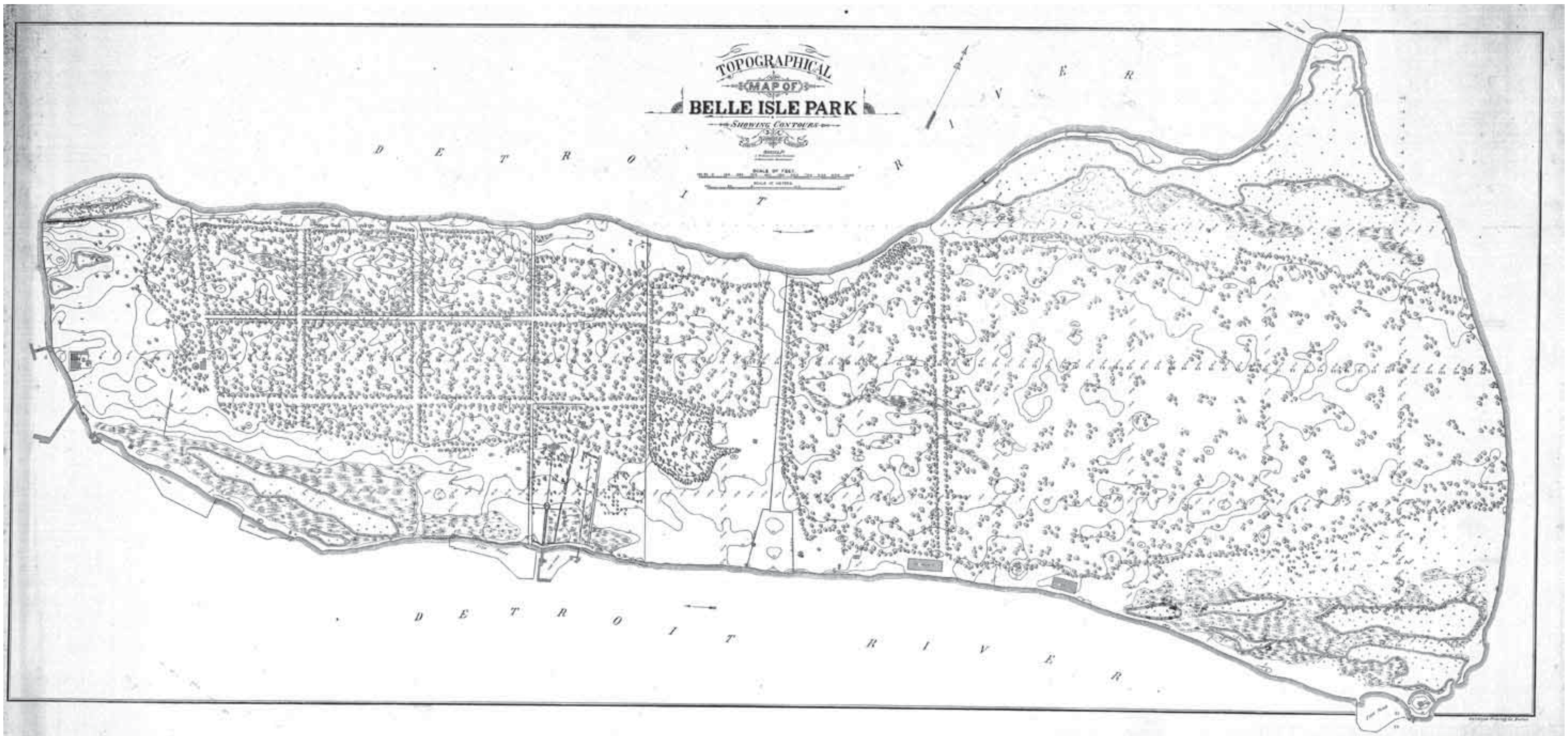


Figure 1. Historical Survey

Prior to European settlement, Native Americans occupied the region, but little information is available on their activities on Belle Isle. Accurate mapping of the island extends back to the 1860’s when Belle Isle was purchased by the City of Detroit for development as a park (Figures 1 and 2). This mapping provides sufficient clarity to recognize the outline of the flatwoods, historic shorelines, coastal wetlands, topography, bathymetry and structures.

Figure 2. Historical Bathymetry

TIMELINE

A timeline of critical events the relate specifically to the flatwoods is summarized to the right.

The take home message on the history of Belle Isle relating to the flatwoods is clear. The aerial extent and drainage patterns of the historic (pre-park) flatwoods is very different than what exists today. While the original master planners (Fredrick Law Olmsted and John Donaldson) recognized the importance of maintaining the flatwoods in a natural state, both designers set forth the framework for many of the recreation amenities and infrastructure improvements that contributed to and continues to contribute to the slow degradation of the flatwoods, which is the focus of this investigation.

- 1879................................ Belle Isle as a Park
- 1880's............................. Trail and Road Construction
- 1883-1890 .... Canal and Lake Construction
- 1905 .... City of Detroit Water Intake System
- 1910................................ Sylvan Canal
- Late 1920's and 1930's. Fill on East Shore for Blue Heron Lagoon and Livingston Light House
- 1922 .... Golf Course (upgraded several times since)
- 1942, 1970's................... Coast Guard Complex
- 1952 .... Golf Course Practice Center (putting and driving range)
- 1900? 1950's .... Pumping system (upgraded in 1990's)
- 1979................................ Safari Zoo Construction (prior exhibits extend back to 1895)
- 1977 and 2005 .... Nature Zoo
- 1980's............................. South Fishing Pier
- 2002 .... Detailed Tree Survey Conducted in Flatwoods
- 2002 .... Emerald Ash Borer Introduced to North America (southeast Michigan)
- 2013................................ Blue Heron Lagoon Opened up to the Detroit River and South Fishing Pier Habitat Restoration

3 | INVENTORY AND ANALYSIS

DATA COLLECTION

Data collection of previous Belle Isle studies and construction documents was completed in cooperation with the MDNR and the Friends of the Detroit River (FDR). Maps were collected dating from the late 1800's to 2014. Many of the maps pertained to the recent construction of roads and utilities. Most of the analysis graphics presented in this report utilize a topographic map provided by the MDNR and date back to the 1990's, generated from aerial photography (Figure 3). Supplemental ground based survey around Lake Okonoka was completed by SmithGroupJJR in 2015 and added to the survey. An evaluation of overlapping area from both surveys was conducted to determine the accuracy of the original survey, but was unsuccessful. Spot ground surface elevations on the 1990's survey are shown to 0.1 foot, but it is likely that these are accurate to only +/- 0.25 foot or more. Also shown on this survey is the outline of pools or standing water that has been referred to as vernal pools. These outlines were determined to not be reliable without an actual date that the boundaries were delineated since the pools configurations fluctuate over the course of a year. Also missing from the survey is the bathymetry of each pool, which vary in depth from several inches to several feet.

Information provided on the 1990's survey determined to be accurate include:

- Buildings, structures and some utilities
- Roads, trails and foot paths
- Canals, lakes and the Detroit River
- Drainage ditches
- Some drainage pipes
- Pools/ponding water at the time of the survey
- Few large canopy trees and canopy outline (although the loss of a closed canopy cover in certain locations due to the introduction of the emerald ash borer did not exist in the 1990's)

During 2015, SmithGroupJJR conducted six site reconnaissance visits (three in spring, two in summer one in fall) and recorded additional information including:

- Additional trails and foot paths
- Additional drainage ditches
- Pools/ponding water
- Topography
- Site utilities
- Drainage structures including equalizer pipes

This data was then compiled and added to the 1990's survey, which is presented in a series of graphics throughout this report.

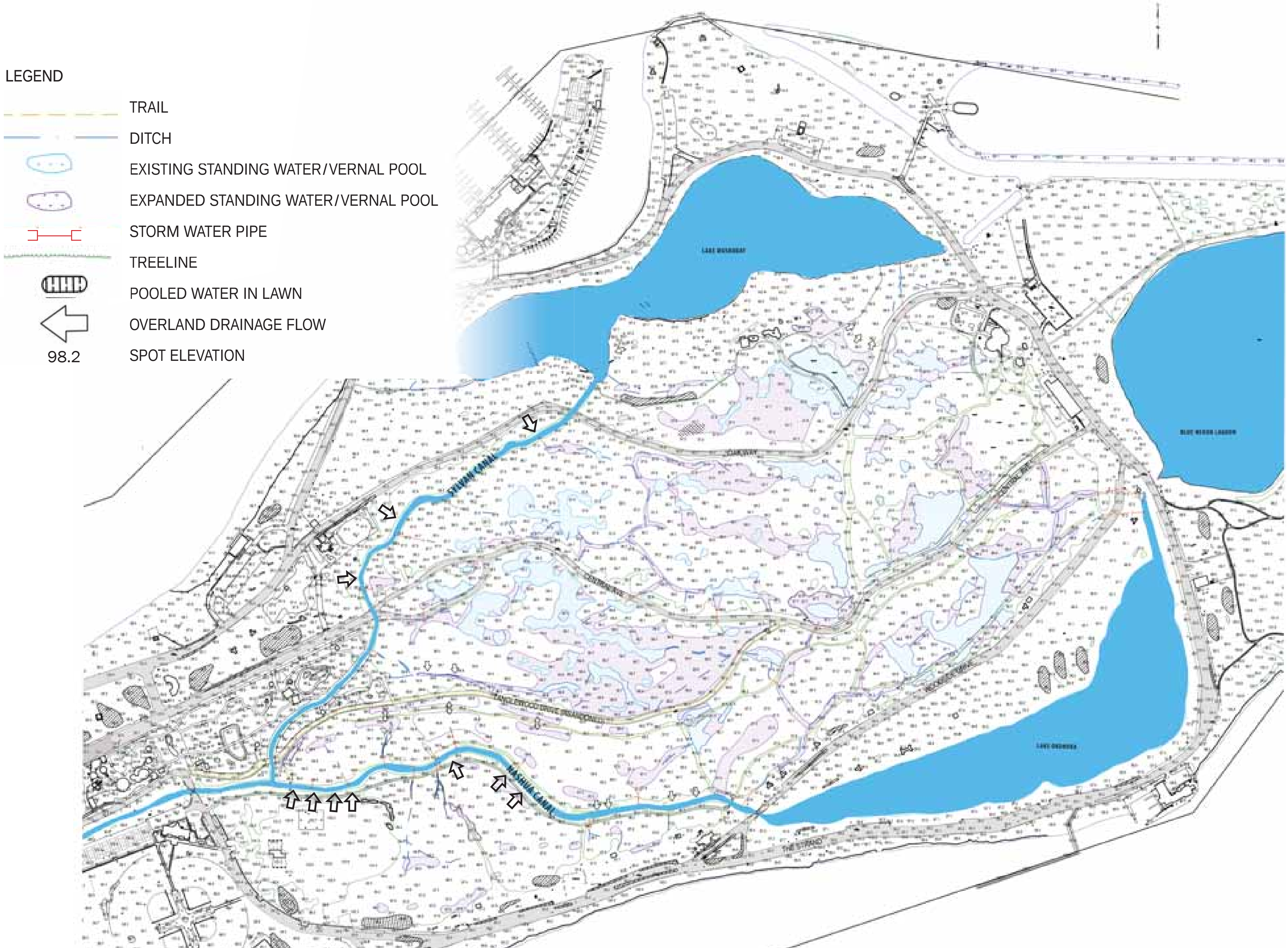


Figure 3. Existing Conditions Survey (Circa 1990's)

FLATWOODS SYSTEMS ANALYSIS

As suggested above, the flatwoods today looks very different than the flatwoods back at the time Belle Isle was purchased by the City of Detroit to be developed as a park. Through the review and analysis of relevant data, it has become clear that there are a number of changes both natural and human introduced fragmenting the flatwoods and altering its ecology.

The list of flatwoods wide systems was developed and evaluated based on the MDNR directives identified above. Information included under this analysis section describe and depict conditions across the flatwoods while more specific causes and effects observations are described under the D*etailed Flatwoods Systems Analysis* section.

Systems categories are:

Hydrology

- Ponding
- Topography and Drainage Patterns
- Detroit River Influence
- Canals and Lakes
- Ditches and Culverts

Land Use

- Buildings and Site Features
- Roads, Parking and Pedestrian Trails

Utilities

- Sanitary, water and storm

Soils

Terrestrial and Aquatic Ecology

- Mature Trees
- Emerald Ash Borer
- Understory (including invasive species)
- Herpetofauna
- Mammals and Birds
- State and Federally Protected Species

HYDROLOGY

The hydrology of the flatwoods is influenced by several related systems that drive the movement of surface water and include:

- Ponding
- Topography and Drainage Patterns
- Detroit River Influence
- Canals and Lakes
- Ditches and Culverts

PONDING

One of the defining characteristics of the flatwoods is the presences of an expansive surface water system of (vernal) pools that fluctuate considerably over the course of the year. Its association with the large diameter canopy trees is important since these trees are also a defining characteristic of the flatwoods and some of the species are not water tolerant for extended periods of time. Prolonged extremes of wet or dry conditions adversely impact their vitality and this seems to be the case as observed today. Prior to park development, the flatwoods trees were in balance with pool formation (including high and low cycles), and the restoration of this balanced

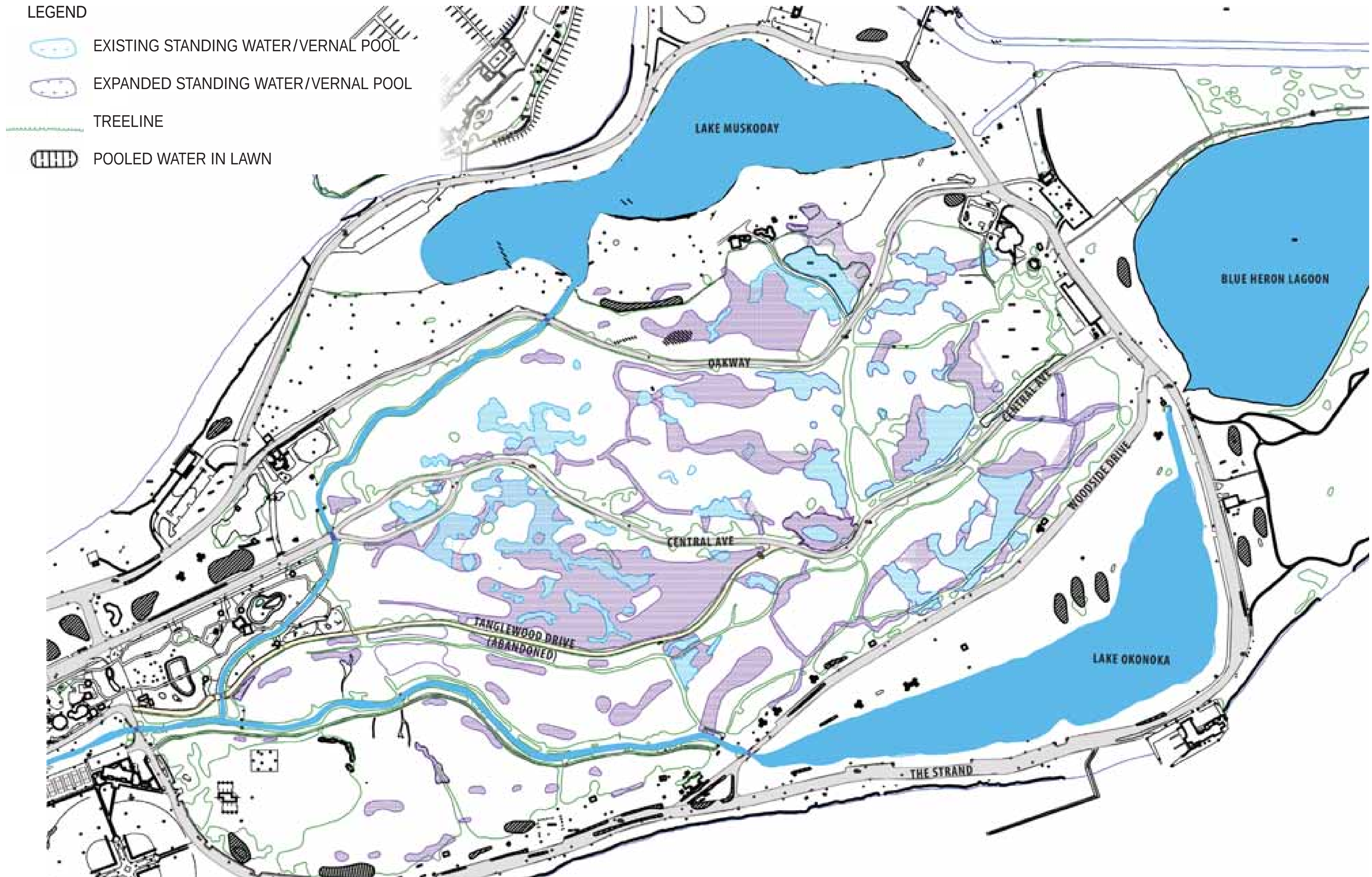


Figure 4. Forest Hydrology-Pools

condition is essential to the long-term health of the flatwoods ecology and preservation of large trees.

Overall, the mapping of the high and low water elevations of the pools is a complex topic and more than just weather dependent. Review of all available historic documents provided no additional insight on this topic. System categories that influence pool formation are discussed throughout this analysis section, including:

- Precipitation (Snow and rain)
- Micro-topography
- Detroit River (during high water cycles)
- Excavation of the lakes and canals through the flatwoods
- Extensive ditching and culvert pipes
- Road and trail construction (fill)
- Emerald ash borer
- Soils

In 2015, southeast Michigan experienced an above average winter and spring for snow and rain, while summer and fall experienced below average rainfall. During late winter and early spring, the flatwoods pool system were the most extensive and occupied large areas with shallow water ranging in depths from 3 inches to over 3 feet, although no pool bathymetry is available to confirm precise depths within each pool. The aerial extent of the observed pool system was expansive and occupied large areas of the flatwoods with interconnected natural and constructed swales and ditches that partially flooded roads and trails, and inundated many areas for most of the spring and summer months (Figure 4). By late-fall, most of the pools were reduced in size or completely absent of standing water with only saturated soils remaining. While this condition is applicable to the calendar year 2015, it may not have been the case in the past or will be in the future. Climate change will also influence precipitation patterns in the future, but to what degree is uncertain.

General observations of the pools indicate that some areas currently are holding too much surface water, while others are not holding enough and that the causes vary based on location within the site. Pools that appeared to be in balance included water adapted tree species with flared collars (*buttresses*) at water- or ground-level and the absence of understory vegetation. This is an indication of a persistent condition that may have extended back to the late 1800's before park construction. At pools where excessive water was present, some tree species were under stress or dead, remaining trees did not appear to have flared collars and persistent standing water was observed through late summer and early fall. The understory was observed to be dense with large colonies of ash (*Fraxinus spp.*), maple (*Acer spp.*) seedlings or spicebush (*Lindera benzoin*) suggesting that this condition is more recent. Areas that were excessively dry contain no standing water, even though topography suggests that it should and ditching appears to be the cause of this condition. Tree health was considered good but Amur honeysuckle (*Lonicera maackii*) was observed to be the most abundant understory species and is an upland species that may have taken hold due to draining.

TOPOGRAPHY AND DRAINAGE PATTERNS

Historically, Belle Isle was much smaller in size than today (Figure 5). While the enlargement of the island has benefited recreational uses and improved pedestrian and vehicular circulation, it has created adverse effects on hydrology specific to the flatwoods. The historical survey of the island and river bathymetry Figures 1 and 2) reveal that the drainage patterns of the flatwoods occurred in three directions (Figure 6). A natural ridge follows the approximate center of the flatwoods with the highest historical elevations occurring east of the Sylvan Canal including the now closed Safari Zoo. Drainage patterns to the north and south historically discharged into the wetland complex that represented a gradual transition from the flatwoods by approximately 2.5 feet. The eastern end of the flatwoods drained directly

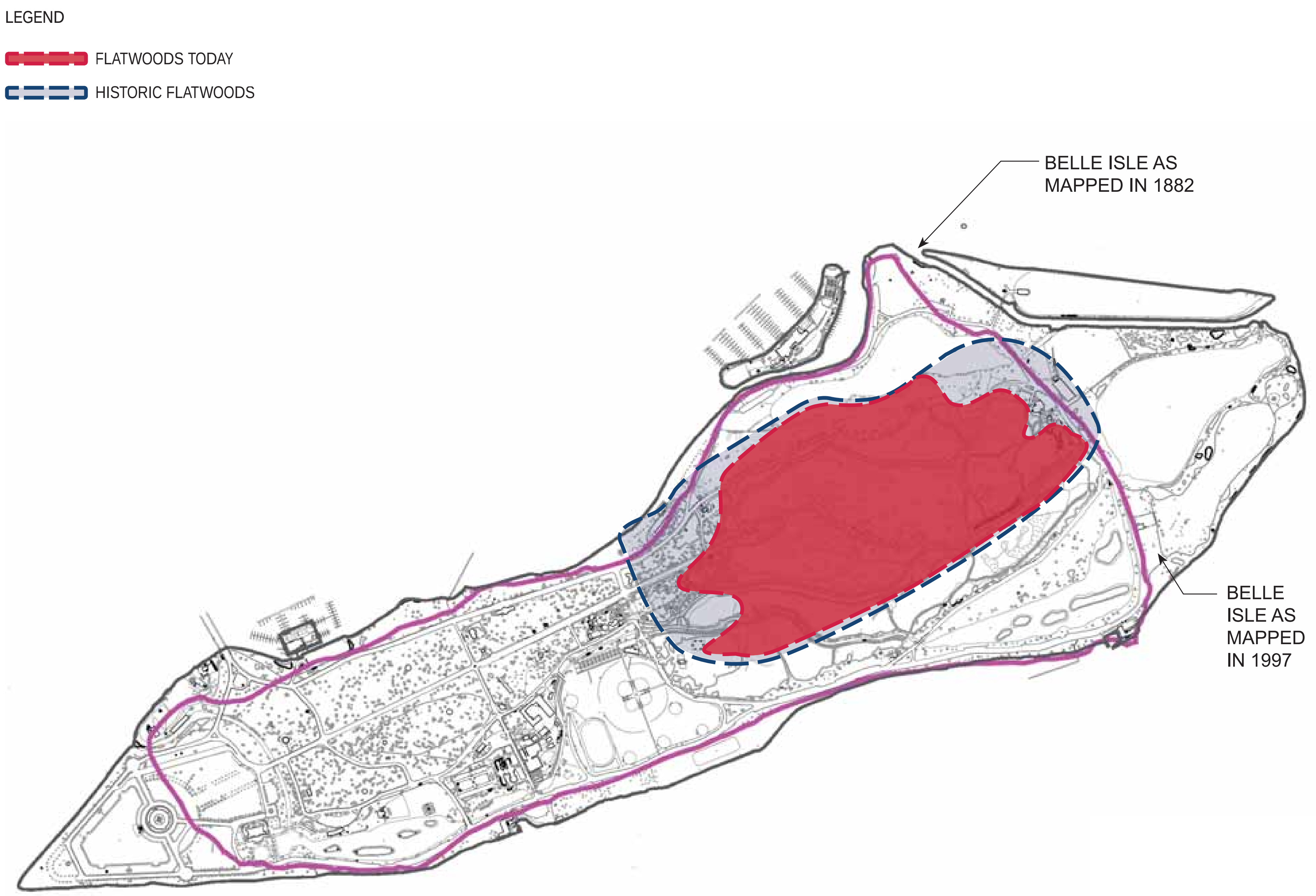


Figure 5. Historic Belle Isle & Flatwoods Overlay

into the Detroit River and also changes grade by approximately 2.5 feet. These slopes are extremely flat and translates to 2.5 inches elevation change for every 100 liner foot. Today, these landforms are still evident (Figure 7) but most of these historic patterns have been altered and is discussed further in the *Land Use* section.

Within the flatwoods, micro-topography is relatively undisturbed except for impacts associated with ditches, roads and trails. These subtle grade changes (typically between 3 and 12 inches) are characteristic of flatwoods and allows for seasonal ponding (rain events and snow melt) and the creation of a diverse tree canopy comprising species that withstand wet and dry conditions. Prior to park construction, these areas of lower micro-topography filled in the early spring, after major storm events and in some cases from high river levels but quickly drained down to static conditions where evaporation and transpiration gradually reduced most to all of the pools to saturated conditions. The arrangement of large canopy

Figure 6. Historic Drainage Patterns

Elevations Table			
Number	Minimum Elevation	Maximum Elevation	Color
1	93.38	96.00	
2	96.00	96.30	
3	96.30	96.70	
4	96.70	97.00	
5	97.00	97.30	
6	97.30	97.70	
7	97.70	98.00	
8	98.00	98.30	
9	98.30	98.70	
10	98.70	99.00	
11	99.00	99.30	
12	99.30	99.70	
13	99.70	100.00	
14	100.00	100.30	
15	100.30	100.70	
16	100.70	101.00	
17	101.00	112.86	

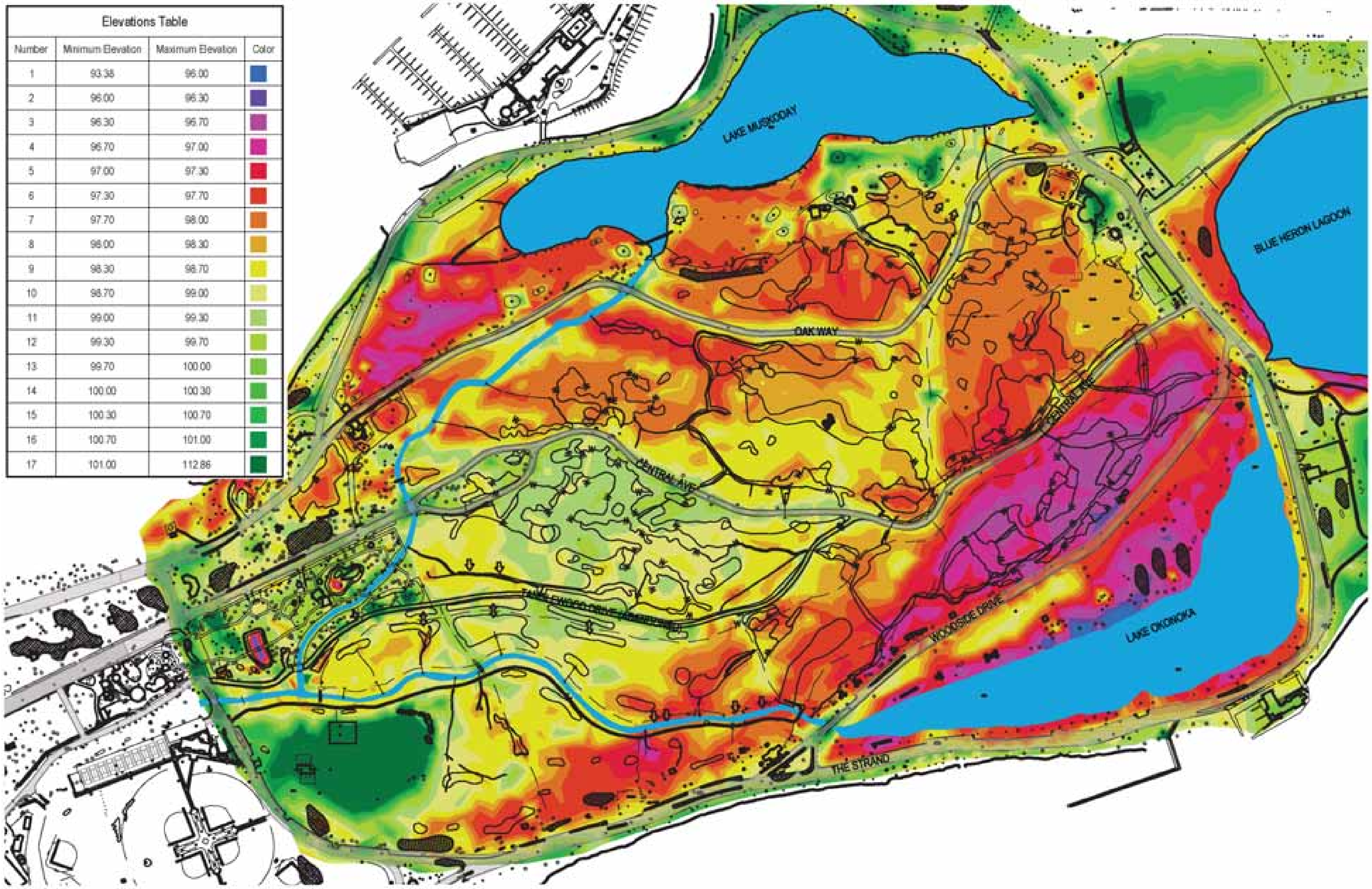


Figure 7. Slope Analysis

trees evolved around this micro-topography with wetland species becoming established in lower elevations and less water tolerant species becoming established on the higher elevations where pool hydrology was temporary or short-term. The construction of park amenities around and through the flatwoods altered this natural drainage pattern preventing the rapid drawdown of excessive pool water or in some instances preventing the development of any pools.

The ability to accurately plot these historic pools and better understand the static elevations of each is part of the next phase of study where more accurate topographic information and tree locations and species can be plotted and analyzed.

Head of Belle Isle:
City of Detroit Datum (CDD)

- Average Historical Mean Elevation: 94.7 CDD
- OHW: 96.9 CDD
- 100-year Flood: 98.0 CDD
- LWD: 92.8 CDD

DETROIT RIVER INFLUENCE

Until the introduction of the internal lakes and canal pumping system that regulates the water levels of these features, portions of the flatwoods hydrology and all of the adjacent coastal wetlands the flatwoods drained to were physically connected to the Detroit River. For over a century, Great Lakes water levels (including Lake St. Clair and the Detroit River) have been continuously monitored and recorded by the Army Corps of Engineers and National Oceanic and Atmospheric Administration (NOAA). This comprehensive data base has enabled hydrogeologists and engineers to understand (but not predict) high and low water cycles and establish several critical elevations that can be applied to the topography of the flatwoods.

Within the flatwoods, natural elevations range between 98.8 and 96.4 with almost half of the elevations below the 100-year flood elevation (Figure 8). While the 100-year flood datum is not as significant as the Mean or OHW, it is clear that in addition to precipitation and snow melt, the lower elevations of the flatwoods were periodically influenced by these fluctuations for extended periods of time. Conversely, low water cycles of the Detroit River had little to no impacts on flatwoods hydrology but most likely effected the wet meadow and shallow water emergent wetlands that the flatwoods freely drained into. Being up to 2.5 feet lower than the perimeter of the flatwoods, this wetland complex included a wet meadow wetland (absence of trees and now occupied by the closed golf course and picnic grove) transitioning down to a shallow water emergent wetland (absence of topography and now occupied by Lakes Muskoday and Okonoka) before draining to the Detroit River. 2015 geotechnical investigations along the shoulder of The Strand encountered the original organic matter layer of the shallow water emergent wetland and the recorded depth from the road surface suggests this elevation to be between 93.5 and 94.0 CDD which indicates that these wetlands also served as potential coastal fish nurseries.

Fredrick Law Olmsted originally recommended that these lower areas be filled and converted to upland areas, but due to cost concerns, this was not done and instead excavated and diked to make water features that exist today.

The Lake Okonoka Habitat Restoration project will restore connectivity of this water body to the Detroit River, which will restore this historic connection to the river for a portion of the flatwoods. The canals and Lake Muskoday will remain off-line from the Detroit River except when park managers intentionally allow this to occur.

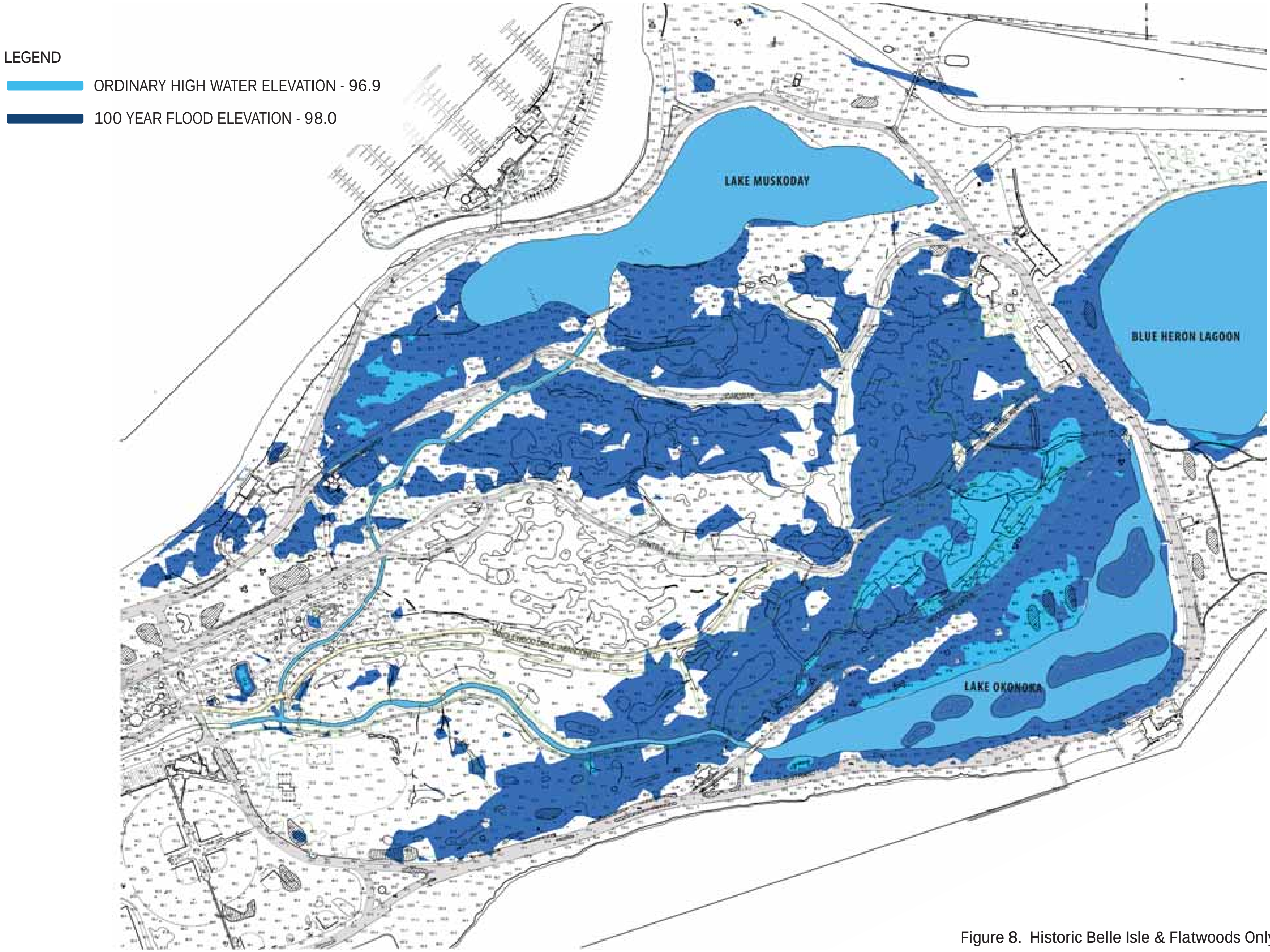


Figure 8. Historic Belle Isle & Flatwoods Only

CANALS AND LAKES

The canals and lakes that exist on Belle Isle were constructed in the 1880’s, and it appears that for an extended period of time (up until the 1950’s), were on-line with the Detroit River. A portion of Sylvan Canal and all of Nashua Canal were constructed through the flatwoods, while the lakes were excavated from historical wetlands with spoils used to construct low-head berms around their perimeters for roads and trails. The perimeter road system was raised a second time to prevent flooding. During low river cycles, recreational boating and fishing opportunities within the canals and lakes became significantly diminished due to excessively shallow water until the pumping system was installed.

The canals and lakes are currently designed to be operated at fixed water levels, independent from river water levels. The system includes a pump station upstream from Lake Muskoday with stop log structures to the Detroit River at the west end of the canal system and at the east end where Lake Okonoka discharges into the Blue Heron Lagoon. By taking these systems off-line with the Detroit River, it inadvertently removes the flatwoods as well. The pump station (and the adjustable overflow structures) are engineered to pump water from the Detroit River into the canals during times of low river levels or from the canals into the Detroit River at times of high river levels or large rain events when flooding becomes a problem. In either case, the pumps are intended to run for some length of time on a regular basis to supply fresh water to the canals and lakes.

The plan to bring Lake Okonoka back on-line with the Detroit River will partially restore river connectivity to the flatwoods. This should become apparent whenever river levels approach or exceed OHW, which has been the case for the last couple years. There are no current plans to do the same for Lake Muskoday and the canal system, although the pumps are expensive to operate and maintain, and the MDNR is seeking more cost effective means for optimizing water quality, habitat and recreation.

The canal system has altered the hydrology of some areas of the flatwoods where their construction has intercepted historical surface flow to the north and south (Figure 5) and is most evident along Nashua Canal in the spring and following large storm events. This condition was further exasperated through the construction of ditches within the flatwoods that discharge into the canals at elevations lower than the top of the bank and will be discussed in the *Ditches and Culverts* section.

DITCHES AND CULVERT

Ditches and culverts are constructed features that are extensive throughout the flatwoods. Most of the ditches are shallow and narrow (less than 18 inches deep by 4 feet wide). There are several levels to this system and the common motive behind them is to remove ponding water created by the construction of the numerous roads, bridle trails and foot paths installed during the park’s construction in the late 1800’s.

Ditches and culverts are discussed together since most to all of the ditches end with a culvert pipe outlet or an underground storm sewer that drains directly to the canals and lakes described above (Figure 9). The purpose of the culverts is to allow water to flow under the trails and roads. Pipe sizes and materials vary and most of the smaller pipes appear to be original small diameter clay pipe and cast iron. Newer culvert pipes are Polyvinyl chloride (PVC), corrugated plastic and concrete.

There are four levels of ditches found in the flatwoods and are described as follows:

Level 1. This drainage system has the most significant impact on the flatwoods hydrology. There are four level 1 ditches, of which two discharge to Sylvan Canal and one each to Lake Muskoday and Lake Okonoka. These features are the most significant of the ditches, in that they extend deep into the flatwoods, are the

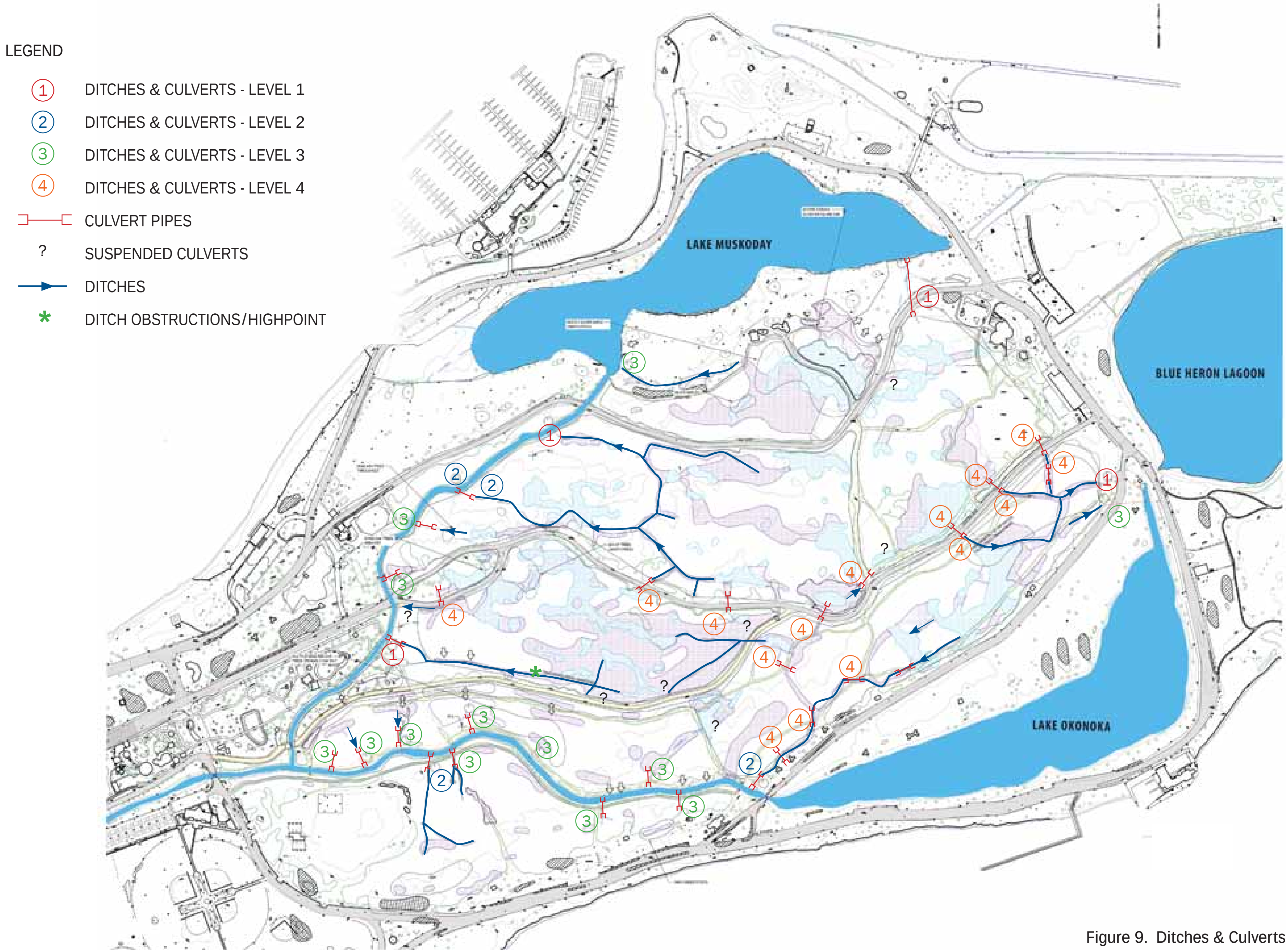


Figure 9. Ditches & Culverts

deepest and widest, have a well-developed network of lateral ditches and/or serves as the only outlet for that area. Three of the outlet culverts are located in some of the lowest topographic elevations within the flatwoods and somewhat follow the historic drainage patterns. The fourth ditch adjacent to Safari Zoo actually reverses the direction of the historic flow and discharges into Sylvan Canal. The impacts on pool development within the influences of the ditching is clear. Pool development is almost non-existent except within the actual banks of the ditches and ponding water is only evident during spring runoff. The level 1 underground storm sewer system draining the flatwoods to Lake Okonoka will be removed as part of the work associated with the habitat enhancements and will be converted to overland flow.

Level 2. This drainage system is similar to level 1 except that the impacts associated with this system are not as extensive. There are three level 2 ditches and all discharge into the canal system. They also extend deep into the flatwoods, but are not as wide and deep as level 1. Two are located at some of the lowest elevations in the flatwoods. One drains in the opposite direction of the historic drainage patterns, while the remaining two ditches generally drain in the direction of the historic patterns, except that they are intercepted by the canals. The impact of pools development within the influences of the ditching is also associated with these features but not as extensive.

Level 3. This drainage system is numerous along the canals, and focuses on the removal of individual pools rather than larger areas. Level 3 ditches are more like swales (shallow and narrow), are typically less than 50 feet long and daylight to the canals through mostly clay pipe. Ten of the 13 level 3 ditches generally follow historic drainage patterns, except that they are intercepted by the canals.

Level 4. This drainage system can be described as equalizer pipes, in that they are not intended to drain pools but to convey water from one side of the road or trail to the other. The seven level 4 equalizer pipes below Central Avenue are also associated with shallow ditches due to the method of construction. Small diameter cast iron pipes were set below the road pavement and aggregate base requiring the pipes to be set lower than the contiguous wetlands. As such, ditching was extended from these locations to connect to the level 1 and 2 ditches to facilitate water movement. Many of these pipes are now plugged with soil and barely functioning, increasing the size of the pools and amount of time that standing water is present.

The reminder of the level 4 pipes are associated with historic bridle trails and are now abandoned and overgrown with mostly honeysuckle or fallen ash trees. In these locations, small diameter pipes were either placed on top of existing grade and fill placed above, or they were partially embedded into the soil with ditching similar to what was observed along Central Avenue. In several instances, either the trail has been washed out rendering the pipes non-functional, or the pipes are mostly plugged with soil causing larger pools to form that would otherwise be dry.

There are no observed pipes or drainage systems that would be considered underdrains, which would have been installed to remove standing water through a buried perforated piping system.

In more than one location, fallen ash trees or high points in the swale system are considered obstructions and prevent the ditches from removing ponding water behind the obstruction. This has resulted in excessive ponding in one location and in the remainder, are associated with prolonged standing water that would otherwise be dry.

LAND USE

Land uses have played a significant role in shaping the flatwoods into what exists today. None of the recreation features constructed under this system category have benefited the flatwoods ecology, resulting in alterations to the drainage patterns effecting pool ecology, which in turn has impacted canopy tree vitality.

Land use categories include:

- Buildings and Site Features
- Roads, Parking and Pedestrian Trails
- Canal and Lakes (discussed above)

BUILDINGS AND SITE FEATURES

Buildings and structures have been constructed around and within the perimeter of the flatwoods requiring tree removal, filling and cutting and fragmentation (Figure 10).

Significant buildings and structures include:

- **Belle Isle Nature Zoo including Parking and Animal Enclosures.** This structure and use has removed several acres of flatwoods, placed fill in most areas of the site and has changed historic drainage patterns to the Detroit River (currently Lake Okonoka).
- **Former Golf Course and Related Structures.** Historically, this area received the majority of runoff from the north half of the flatwoods and was part of the wetland complex. Most of the original topography has been preserved except for small areas of fill for tee boxes and greens and a more expansive fill area on the western half of the course. Most of the flatwoods drainage is now diverted to Sylvan Canal and to a lesser degree, Lake Muskoday. Two-thirds of this course is still very wet and can only be seasonally maintained, suggesting restoration opportunities.
- **Oakway Trail Comfort Station and Parking Lot.** Currently closed, the structure is in need of major renovations. The asphalt parking lot storm sewer appears to be connected to the sanitary system on Central Avenue, but the lot contains little fill. This parking lot interferes with the connectivity of flatwoods on both sides of the lot, suggesting restoration opportunities through its removal.
- **Picnic Areas west of the Oakway Trail Comfort Station.** Defined by Sylvan Canal, Oakway Drive, Central Avenue and Vista Drive, this +/- 8 acre area contains many mature flatwoods trees and most of the original topography with ground plain converted to lawn. The site is very wet in the spring (small pools of standing water) indicative of flatwoods hydrology and suggests restoration opportunities.
- **Former Safari Zoo and Related Structures.** Sylvan Canal divides the Safari Zoo into two sections with the majority of the facilities located on the west side. On the west side, fencing, buildings, landform and non-flatwoods vegetation dominate the site. Water recreation via Sylvan Canal is barricaded with fencing. In this location, the flatwoods vegetation and topography has been significantly altered and is not a high candidate for restoration. The Safari Zoo footprint in this location is located along one of the highest natural elevations on Belle Isle and has minimal impacts on the current flatwoods hydrology. On the east side, fencing and changed topography is present and would be a candidate for restoration.
- **Athletic Courts and Field.** This use contains a concrete handball court, asphalt basketball court and a +/- 7 acre field that is occasionally used for open field recreation. The fill in this location is extensive and exceeds 7 feet in the center. The fill extends nearly to Nashua Canal, creating a linear remnant flatwoods band that contains several large flatwoods trees and good seasonal

Figure 10. Land Use Analysis

ponding. Along the east side of the field extending into the natural areas, the flatwoods is partially degraded and may contain low amounts of fill (less than 1 foot). The tree lined perimeter along Vista Avenue contains several large flatwoods trees and original topography with many wet spots in the spring, but the understory has been replaced with turf. Restoration opportunities exist around the entire perimeter and along Nashua Canal.

- **Woodside Comfort Station.** This structure has no current impacts on the flatwoods except that it appears that minor ditching has occurred to the north to reduce ponding in the low areas around the structure. The walkway to the flatwoods and footbridge over the canal will be replaced as part of the Lake Okonoka Habitat Restoration project.

- **Picnic Area.** Much like the former golf course, this use occupies part of the historic drainage patterns for the south half of the flatwoods and was part of the historic wetland complex. Most of the original topography has been altered and fill for picnic shelters and Woodside Drive effectively block the historic surface drainage. Between Woodside Drive and the flatwoods, several abandoned picnic structures and slabs still exists. In this location, standing water is prevalent in the spring and is currently unmaintained. The remainder of the picnic area is maintained lawn. Long-term plans for this area included renovation and expansion of all picnic facilities. As part of the Lake Okonoka Habitat Restoration project, the eastern section of Woodside Drive will be removed and the flatwoods surface hydrology will be restored.

- **Roads, Parking and Pedestrian Trails.** The extensive roads, parking and trail systems extend throughout the flatwoods making this one of the most disruptive uses to the flatwoods hydrology. In almost all instances, these systems have been built on fill with little thought on maintaining pool hydrology and natural drainage patterns (Figure 11). Ditches and culverts were added to the flatwoods in response to the introduction of these features and were previously described above.

- **Roads and Parking.** The perimeter asphalt road system and contiguous parking (The Strand, Lakeside Drive and Riverbank Drive) is an essential use for park users. This system has no direct impacts on the flatwoods hydrology except that they were constructed on fill which removes the Detroit River connectivity to the historic wetland complexes on the north and south side of the flatwoods. Due to their importance, these roads will remain but may be reduced in width in the future.

The internal asphalt road system (Woodside Drive, Central Avenue, Shadownook Street, abandoned Tanglewood Drive, Wildwood Pass, Oakway Trail and Meadow Road) fragment the flatwoods into cells that block historic drainage patterns and create upland shoulders that have become established with predominantly non-native upland plant species. Wildwood Pass on the north side of Oakway is gated and used by maintenance staff, while the south half has been converted to an active trail. Most of the roads have been constructed on less than 2 feet of fill and during the spring when pool development is greatest, standing water can be observed in several locations on opposite sides of the road providing indications of historic drainage patterns. The numerous, level 4 ditches and equalizer pipes were installed in many of these locations to address drainage but are now mostly non-functional adding to the concerns about pool hydrology and its effects on tree vitality.

Figure 11. Roads, Parking & Pedestrian Trails

- **Trails.** The trail system through the flatwoods is extensive and creates similar impacts to the flatwoods hydrology as the internal roads. Trails are categorized as active (asphalt) and abandoned and all were part of the historic trail system constructed for horseback riding and hiking. Most of the trails were constructed on less than 1 foot of fill, and in the spring when pool development is greatest, standing water can be observed in many locations along the active trails as surface flows attempt to make their way to the Nashua Canal. The abandoned bridle trails are difficult to locate and navigate due to the abundance of honeysuckle that has become established in the fill. Like the roads, these trails have numerous level 3 and level 4 ditches and drainage pipes in an effort to keep the trails dry.

UTILITIES

The principal utilities that occur within and adjacent to the flatwoods include water, sanitary, storm, electric, natural gas and communications. Section M of the 2005, *Belle Isle Master Plan -Technical Assessment Report, Part 1*; provides utility layout plans and a comprehensive review of these essential utilities across the entire park. This information is supplemented with utility and topographic data collected by SmithGroupJJR in 2015 as part of the Lake Okonoka Habitat Restoration project and serves as the existing conditions documents for this project.

The documentation is revealing in the following manner:

- Water lines are almost 100 years old, and leaks are becoming more frequent. The flatwoods are bisected with 6 inch and 8 inch mains and the perimeter loop roads contain 6 inch, 8 inch and 12 inch mains establishing a loop system. The water lines through the flatwoods do not appear to have altered its hydrology except for locations where manholes and hydrants have been installed.
- Sanitary systems are as old as the water main system but also include 1950's upgrades including lift stations. Leaks in the system are becoming more frequent. Within the flatwoods, an 8 inch force main follows Central Avenue and an 8 inch force main connecting the Woodside Drive Comfort Station to the Central Avenue force main. The remainder of the lines occur in Lakeside Drive and connect to the Central Avenue force main. The Central Avenue force main is the only sanitary line collecting wastewater from the east side of Belle Isle and is essential. Manholes associated with this main are located within the road pavement and do not impact the flatwoods except as described in the *Roads and Parking* section above. It also appears that two lateral 6 inch lines connect the Oakway Trail Comfort Station and parking lot to the Central Avenue main on the west side of the Sylvan Canal.
- Accurate storm sewer systems alignment drawings are not available around the flatwoods. Many of the drainage structures located within the perimeter road system adjacent to the flatwoods do not provide sufficient information to determine their discharge points and either drain to the lakes or discharge directly to the Detroit River. Along the south banks of the Nashua Canal, three brick storm sewer manholes were observed that appeared to be abandoned and mostly collapsed. Their historic function and drainage areas are unknown.
- The remainder of utilities occur outside the perimeter of the flatwoods and have no direct impacts on the flatwoods hydrology.

SOILS

Natural soils throughout Belle Isle can be described as poorly draining clay, which is consistent with the clay lakeplain glacial soils found in southeast Michigan between Lake Huron and Lake Erie. It is also a primary characteristic of flatwoods soils, which occur almost exclusively on poorly drained glacial lakeplain in southeastern Lower Michigan, to have prolonged pooling of surface water. While no survey data for Belle Isle is available through the Natural Resource Commission, the clay characteristics are consistent with previous soil reports taken from Belle Isle, hand dug test pits and discussions with Detroit Recreation Department staff that previously operated the park.

One of the directives established by the MDNR references the need to determine if groundwater seepage effects pool hydrology and vegetation and if the canal system expedites the removal of pool hydrology through seepage. In response to this directive, test boring were hand dug during early spring 2015 in two locations along Nashua Canal and two locations along Sylvan Canal. In all four instances, the soils were found to be nearly identical and were moist but not saturated. Soils were found to be mineral, heavy, dark colored clay with gray mottling at a depth of 24 inches and exhibiting hydric soils characteristics even when the predominant understory vegetation is honeysuckle. The banks of the canals were closely evaluated for the presence of saturated or seeping soils that would indicate the canals are effecting hydrology. This was not found to be the case, and the only wet soils observed along the banks were associated with level 3 clay tiles that were mostly concealed by sediment.

TERRESTRIAL AND AQUATIC SYSTEMS

Understanding the composition of terrestrial and aquatic systems is important to better detect the health of the flatwoods and will be investigated in a future study. This study initiated the process by focusing on the relationships of the flatwoods vegetation with surface water and groundwater.

TREE CANOPY

During the 2015 data collection period, a tree canopy evaluation (primarily large canopy trees) was conducted in early spring during leaf-out, mid-summer and late-summer at the onset of dormancy.

The following is a summary of these observations:

- In early spring, leaf-out varied across the flatwoods—even within the same species. Areas where leaf-out was slow to occur and behind pace with other trees appeared to have been linked to the presence of standing water. Where extensive pools were present, leaf-out was observed to be impacted by the presence of standing water. In several locations, water related stress caused trees (primarily silver maple) to be as much as two weeks behind adjacent species not inundated. Both large and small diameter trees were observes to be effected by this occurrence. While further study on this topic is still required, this observation indicated that in these locations, trees have not acclimated to the flatwoods hydrology, suggesting that the aerial extent of the observed pools was not a typical occurrence or is the beginning of a trend of larger spring pool formation.

- During the growing season, canopy conditions were visually evaluated for health and vigor, and it became clear that a number of oak species and some maple species are under varying stages of decline or dead. This was mostly attributed to the presence of prolonged standing water (Figure 12). These locations are described in greater detail in the *Flatwoods Enlargement Analysis* section.

- In late-summer, at the onset of plant dormancy, most of the trees shown in Figure 12 are identified as being under stress and were experiencing early dormancy (approximately 2 weeks ahead of the healthier stand of trees, even though many of these areas no longer contained standing water). This suggests that a longer period of inundation is effecting tree vitality throughout the growing season.

While these observations appear to link tree stress with pool hydrology, it is uncertain why these trees are exhibiting stress related changes now and not in the past, except that the pool hydrology is more extensive or prolonged than historical patterns. Other factors such as tree acclimation, climate change, disease and insect problems were not considered and should be as part of the next phase of studies for the flatwoods.

SPECIES DIVERSITY

In 2002, *Tree Survey and Plant Lists for the Woods of Belle Isle Park* was prepared by King & MacGregor for the City of Detroit and represent the most comprehensive evaluation of the flatwoods prepared to-date since Oliver Farwell's publication in 1901. Unfortunately, the graphic showing the locations of the 376 mature trees referenced in the report was not included, making it difficult to determine the exact locations and specific species under stress. The aerial extent of the survey as referenced in the report appears to have only been conducted between Tanglewood Drive and the Nashua Canal, which only represents about 15% of the total flatwoods, but it is uncertain if this was a typographic error.

A few of the highlights found in this report worth mentioning include:

- At the time of the report, emerald ash borer was just introduced to the Unites States, and ground zero was southeast Michigan. At that time, the genus *Fraxinus* represented 26% of total old growth trees and was only exceeded by the genus *Acer* (33%) and *Quercus* (33%).
- The three most predominant species included *Acer saccharinum* (32%), *Fraxinus pennsylvanica* (16%) and *Quercus palustris* (11%).
- Much of the Belle Isle woodland soil was saturated with water in spring, and there were extensive areas of standing water. Consequently, most of the tree species were wetland-adapted.
- The old-growth swamp forest of Belle Isle Park has outstanding regional significance, being a rare remnant of the great lowland forests that once blanketed much of southeastern Michigan and neighboring Ontario. We are fortunate that foresighted leaders protected this woods so long ago, entrusting it to future generations.

EMERALD ASH BORER

The loss of ash trees to the emerald ash borer had significant impacts on the flatwoods and include the following:

- Historical canopy cover of the flatwoods was defined as a closed canopy. Today several locations are now considered semi-open to open canopy. This condition has allowed sunlight to penetrate to the forest floor encouraging dense growth of understory vegetation including the invasive species reed canarygrass (*Phalaris arundinacea*), amur honeysuckle (*Lonicera maackii*), and common buckthorn (*Rhamnus cathartica*) among others.
- Today, 100% of the three ash species have succumbed to the emerald ash borer including the 28 state-threatened pumpkin ash (*Fraxinus profunda*).
- Fallen trees have blocked ditches in at least three locations, increasing the amount of ponding trapped behind the obstructions.
- Reduced transpiration could be linked to increased pool size.

LEGEND

EXISTING STANDING WATER/VERNAL POOL

EXPANDED STANDING WATER/VERNAL POOL

TREELINE

TREES EXHIBITING STRESS

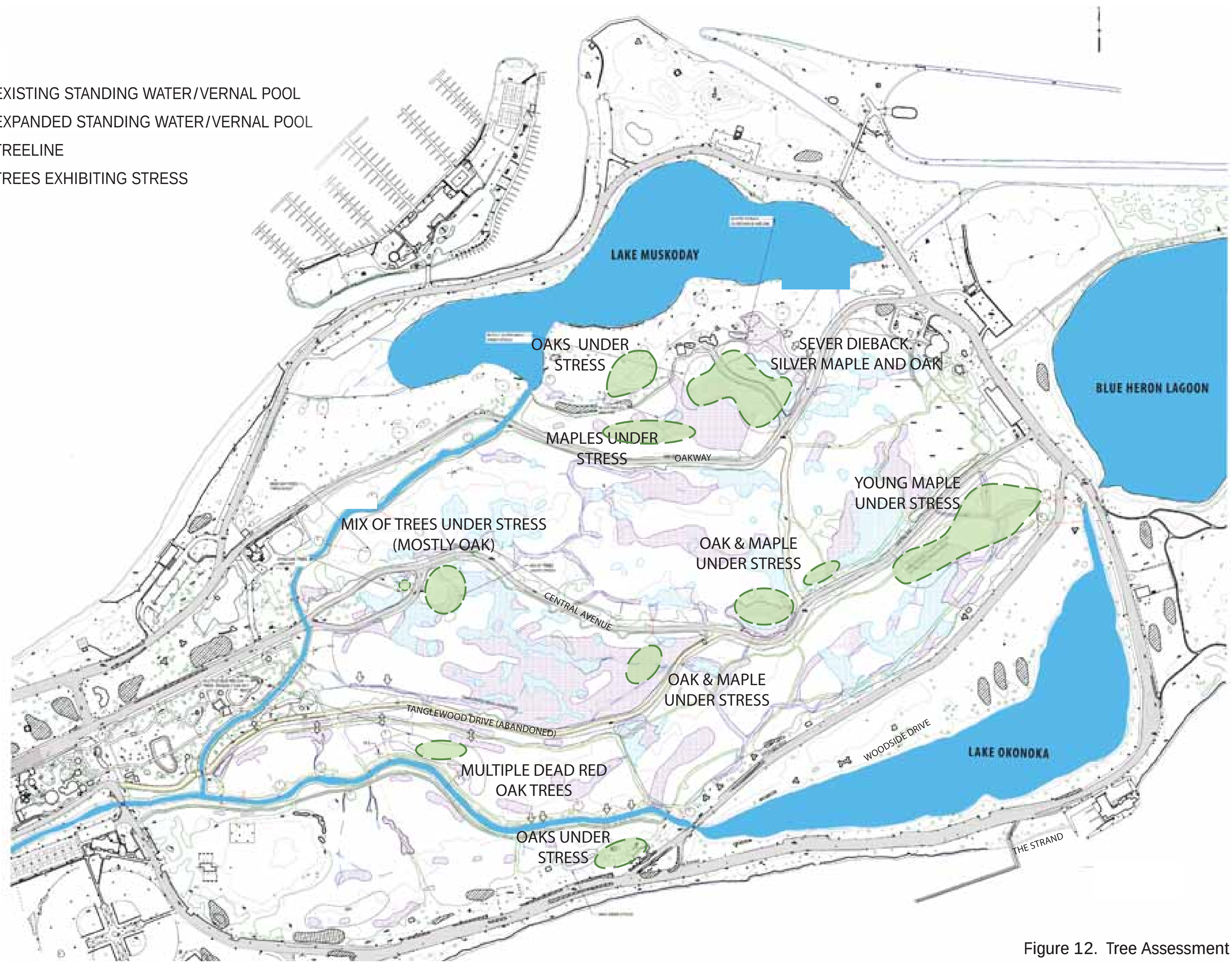


Figure 12. Tree Assessment

While the summary of observations under this system analysis concludes that tree vitality is linked to pool hydrology, to what degree is uncertain. Other topics that would provide added benefits to better understanding this relationship and the other terrestrial and aquatic systems of the flatwoods not part of the current scope include:

- Detailed topographic survey and tree inventory to better understand the long-term relationship of trees to pool hydrology
- Investigations on the abundance of reptiles and amphibians currently occupying the pools and detritus created by fallen and decomposing ash trees
- Migratory and resident birds and mammals
- Rare plants and animal species inventories

During the data collection phase, it became apparent that gaps in some of the existing data and scope of services for this study did not fully address what is needed to draw specific recommendations for addressing all of the MDNR directives. However, this study was not intended to answer all questions since the secondary purpose of this report is to identify a program for the next phase of work, which would include: the completion of additional studies; finalizing and refining recommendations identified in this report; and, preparing preliminary restoration strategies and permit documents to be used for final design and implementation strategies.

SUMMARY OF FINDINGS

The wet-mesic flatwoods on Belle Isle is a rare plant community in Michigan that is heavily dependent upon site hydrology consisting of pools that seasonally fluctuate within and around both wetland and upland plant species. The flatwoods on Belle Isle is particularly unique due to its size and abundance of large diameter trees including several rare species.

Looking back in time to when Belle Isle was first developed as a park, the flatwoods hydrology and vegetation has experienced a number of changes that have directly and indirectly impacted its hydrology and vegetation.

To understand the extent of these impacts, the MDNR brought forward a series of directives that would enable them to better understand the dynamics of the flatwoods now in place and develop guidelines that could be implemented to aid in the restoration of its historic functions.

A series of flatwoods wide systems were evaluated to better understand how the flatwoods has changed from its historic condition, but these systems are too complex to describe at this scale. Under the next section of this report the flatwoods is divided into enlargements (cells), for analysis of the systems impacts at a scale that is more specific and usable.

Conclusions drawn from the data presented above include the following:

- The base survey along with supplemented collected data, provides good information on understanding historic flow patterns and flatwoods wide systems to draw strong conclusions about how these systems interact with and impact the pools and vegetation. It does not provide the level of information needed to draw precise conclusions that can be translated into engineering drawings for use in restoration purposes, which is part of the next phase of work. Critical to this work will be the development of a more definitive understanding of the specific relationships between pool elevations and canopy trees.
- The network of roads, trails and canals (cut and fill), have significantly altered historic drainage patterns of the flatwoods.
- In response to these changes, ditches and culvert pipes were installed to move the seasonal high water beneath the

roads and trails and prevent flooding of these features. Ditches and culverts that were improperly constructed and not maintained, failed over time creating areas that appear to have excessive ponding and flooding, while others were excavated excessively deep creating the reverse condition by drying up historic pools.

- The large canopy trees in certain areas of the flatwoods are showing signs of stress due primarily to standing water over their root zones, suggesting that in certain areas, pool development has increased.
- The canals act as a drainage system for several adjacent areas of the flatwoods since they were excavated through historical drainage patters. In three locations, the surface drainage patterns have been reversed, which also impacts the development of pools that existed before their construction. These canals do not alter the development of pools through groundwater seepage, since the soils are clay and do not readily drain.
- Land uses were introduced that effectively reduced the size of the flatwoods. In some instances, these impacts are not reversible due to costs and need, but in several instances, their removal could enable the implementation of restoration measures that would improve connectivity and overall integrity of the area.
- The emerald ash borer has effectively killed all the mature ash trees including the state threatened pumpkin ash. What was once a closed canopy is now a semi-closed to open area.

FLATWOODS WIDE RESTORATION STRATEGIES

The following restoration strategies are based on the full restoration of the flatwoods to historic patterns and specifics to each are explained in greater detail in the next section.

- Remove all road and trail fill within the flatwoods. Where not possible, reduce footprint of roads or convert to trails and excavate all fill along road edges to original grades.
- Restore surface drainage patterns to historic conditions. Provide drainage connectivity across The Strand to the Detroit River and Riverside Drive to Blue Heron Lagoon via concrete channels or culverts. Within the interior, if roads and trails are not removed, provide boardwalk connections where drainage patterns are restored across these features.
- Restore connectivity of Lake Muskoday and Lake Okonoka to the Detroit River. This will also effect the canals so a dredging program will most likely be required in response to low water level cycles.
- Fill Sylvan Canal between Lake Muskoday, Vista Avenue and Nashua Canal in its entirety to restore historic drainage patterns. This is not a realistic strategy due to its importance within the park so specific strategies are presented below and under the next section to adapt to this permanent alteration.
- Remove all culvert pipes and fill all ditches to match adjacent grades. Where soil is windrowed from original excavations, use this soil as backfill. Under certain conditions, ditches may have to remain as part of preserving the canals but will require control structure(s) to regulate the pools being effected by said ditches.
- Wherever possible, restore historic topography and surface hydrology at the abandoned golf course and picnic area between Lakes Muskoday and Okonoka.
- Remove land uses within the historic boundary of the flatwoods and restore. At a minimum, remove portions of the Nature Zoo pen enclosures, parking lot at the Oakway Trail Comfort Station and restore understory vegetation that has been converted to lawn.
- Establish a tree planting program using Belle Isle genotypes to replace lost ash trees where existing trees are not recolonizing. Ideally, more oak species would be introduced since silver maples are the dominant species and are generally performing well.
- Eradicate invasive species.
- All future utilities should be constructed around the flatwoods and not through. As existing flatwoods utilities become obsolete due to age, abandon in place.

FLATWOODS ENLARGEMENTS – ANALYSIS AND RECOMMENDATIONS

Under this section, the flatwoods is divided into eight cells due to its extensive fragmentation (Figure 13). The cells are defined primarily by roads and trails that play a significant role in shaping the current characteristic of the flatwoods. This detailed analysis is necessary since the scale of the systems influences on current hydrology described above vary from one location to the other and a closer analysis of each area is required.

Restoration strategies are provided at the end of each cell, along with supporting graphics. It should be noted that recommendations associated with elevation changes are approximate or not provided and will require more detailed analysis under the next phase of work when budget is available to perform a more detailed topographic, bathymetric and large canopy tree survey.

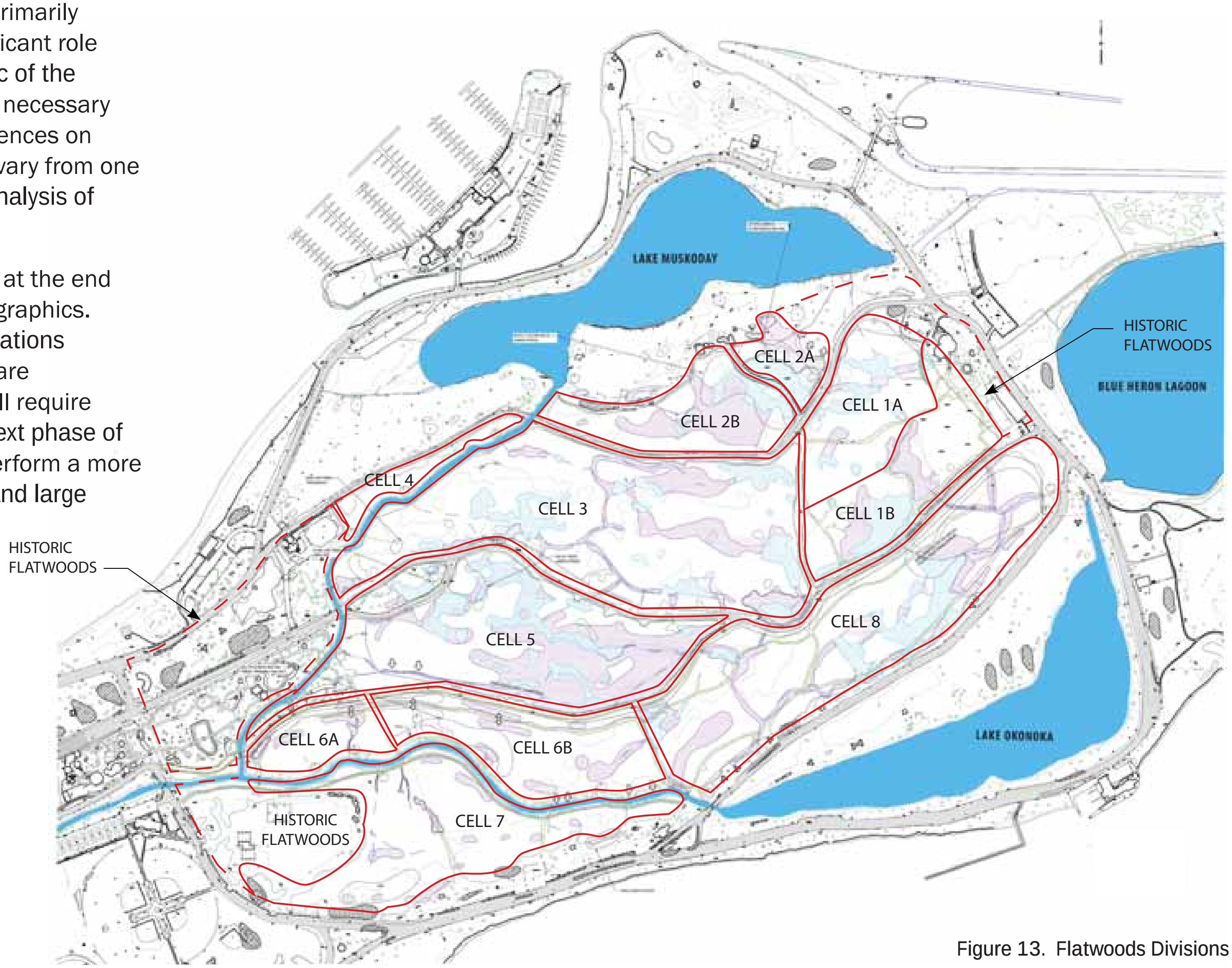


Figure 13. Flatwoods Divisions

CELL 1 ANALYSIS

Defined by Oakway Trail, Nature Zoo/Lakeside Drive, Central Avenue and Wildwood Pass, Cell 1 encompasses +/- 22 acres (Figure 14). The fill for the Nature Zoo, parking and animal enclosures was originally flatwoods. Historically, this portion of the flatwoods drained directly into the Detroit River, which is now occupied mostly by the Blue Heron Lagoon, the driving range and, to a lesser degree, the wetland system that is now Lake Muskoday. Currently, this cell is a split watershed. Cell 1A (northern half) drains to Lake Muskoday via the level 1 drainage ditch and storm sewer pipe, while Cell 1B (southern half) drains into Cell 8 via Central Avenue level 4 equalizer pipes and eventually to Lake Okonoka.

Cell 1A contains some of the highest quality flatwoods hydrology and mature canopy trees with good pool development throughout most of the cell. Trees are mostly oak species and healthy. While Oakway and Wildwood Pass obstruct surface flow, the level 1 drainage ditch and storm sewer pipe located adjacent to the Nature Zoo parking lot releases surplus water via an underground system directly into Lake Muskoday. Historically, most of this cell drained in this direction and through Cell 2. The site is heavily vegetated with trees and understory with several pools that are mostly interconnected through micro-topography. In the spring, these small depressions become one larger pool. Over the summer, these pools decrease in size and become mostly dry as one might expect of a forested pool system.

The level 1 drainage ditch and storm sewer pipe serve as the only source of discharge for this area, and its influence on surface hydrology is most apparent in the vicinity of the parking lot, where a small ditch extends into the woods, preventing ponding. Wildwood Pass is the only foot path (former road) that bisects this area, but its impact on pool development is negligible. However, it does block surface flow from Cell 4 across its entire length.

Cell 1B is remarkably different from 1A and represents one of the most degraded areas in the flatwoods. The path separating 1A from 1B and micro-topography represents the divide between these areas and prevents water from being released to Lake Muskoday. Cell 1B is bisected by numerous foot paths and the effects of trail fill is most apparent on surface hydrology, causing large areas to remain flooded throughout most of the growing season and creating shallow water emergent wetland conditions. Most of this area historically drained to the Detroit River to the east (now occupied by the Blue Heron Lagoon) but now only drains into Cell 8 via three equalizer pipes below Central Avenue. These pipes are set too low and are partially silted in, significantly reducing their ability to release ponding water. The level 4 equalized pipes are connected to well defined ditches that cross Cell 8 (see Cell 8 discussion), and flowing water can be observed at the Cell 2B outlets to Cell 8 in the spring draining to Lake Okonoka.

Most of the historic forest canopy (closed canopy) is absent, and the remaining few oak trees are under stress. Emerald ash borer and excessive ponding appear to be the cause for the absence of forest canopy. A recent program to eradicate phragmites (*Phragmites australis*) in this area has been mostly successful but could result in higher water levels due to decreased transpiration.

Cell 1A Restoration Strategies:

- Raise elevation of the level 1 ditch/outlet to improve hydrology adjacent to parking lot (elevation to be determined) or remove in its entirety.
- Reduce footprint of Oakway Trail to a single-lane or shared-use path including all shoulder fill (below contour elevation +/-98.0), or remove in its entirety, creating surface water connectivity to Cell 2A and Lake Muskoday, which will enable the abandonment of the level 1 ditch/outlet. If allowed to remain, consider the installation of a boardwalk section in the road to allow conveyance of surface water between cells.

LEGEND

- HISTORIC TRAIL
- DITCH
- EXISTING STANDING WATER/VERNAL POOL
- EXPANDED STANDING WATER/VERNAL POOL
- TREELINE
- TREES UNDER STRESS
- EXISTING OVERLAND FLOW
- CULVERT/PIPE
- ? SUSPECTED CULVERT
- EXISTING FILL/DRAINAGE BARRIER
- PROPOSED SURFACE WATER CONNECTIVITY

N

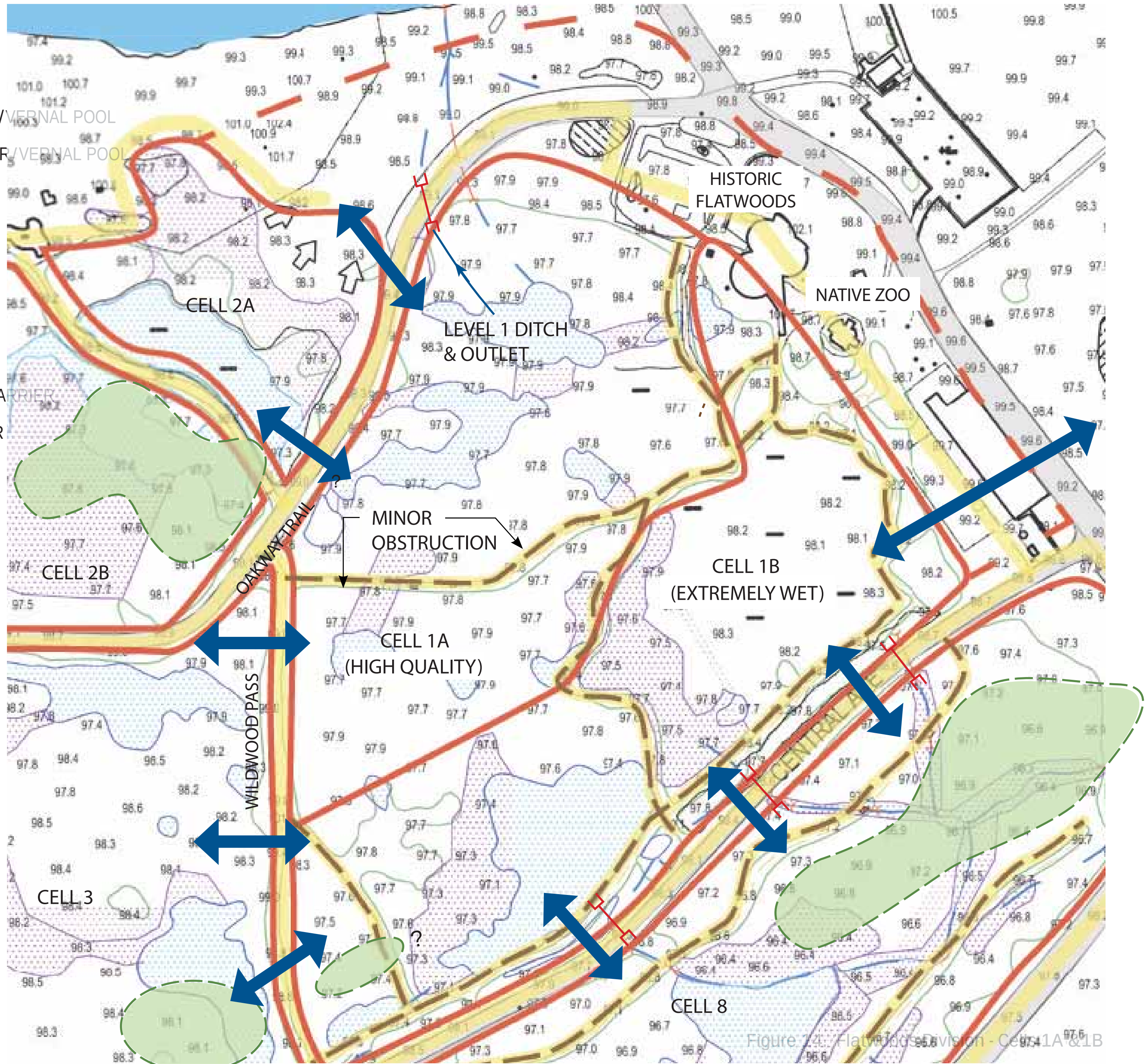


Figure 14: Flatwoods Division - Cells 1A & 1B

- Remove internal foot path fill and restore grades to match existing adjacent elevations.
- Wildwood Pass should be fully removed within this cell unless there is intention to retain this as a path. If retained, construct at least one boardwalk section in a strategic location, creating surface water connectivity to Cell 3 and leave remaining fill in place.
- Control invasive species.

Cell 1B Restoration Strategies:

- Reduce footprint of Central Avenue to a single-lane or shared-use path including all shoulder fill (below contour elevation +/- 98.0), or remove in its entirety, creating surface water connectivity to Cell 8. If allowed to remain, consider the installation of boardwalk sections in the road to allow conveyance of surface water between cells (three locations).
- A decision needs to be made about the long-term habitat of Cell 1B. If it is intended to expand herpetofauna habitat in the flatwoods, plug all level 3 equalizer pipes and maintain system as an emergent habitat and introduce habitat features. Consider shallow excavations and introduction of habitat structures to enhance this new habitat. The cell will drain through the Cell 1A drainage outlet. If the intention is to restore to tree canopy, install boardwalk sections in the road to allow conveyance of surface water between Cells 1B and 8 (three existing locations).
- Remove all internal foot path fill and restore grades to match existing adjacent elevations.
- Wildwood Pass should be fully removed within this cell unless there is intention to retain this as a path. If retained, construct boardwalks the entire length to restore connectivity between cells.
- Consider removal of the corner of the Nature Zoo outdoor exhibits and associated fill up to Lakeside Drive and consider alternate surface water connectivity to the Blue Heron Lagoon (historical condition) via concrete channel through the road.
- Control invasive species.

CELL 2 ANALYSIS

Defined by the abandoned golf course (chain link fence), Oakway Trail and Sylvan Canal, Cell 2 encompasses +/- 14 acres (Figure 15). The northern edge of the existing flatwoods is closely aligned with the historic edge but could extend an additional 50 feet beyond the existing chain link fence that currently defines the wooded edge. In this 50 foot band, a number of large diameter oak trees still exist but the understory has been converted to turf grass species that is currently not maintained. Historically, this cell drained entirely to the north into what is now Lake Muskoday. The golf course was historically wetlands and has been filled in-part around the abandoned buildings, tee boxes and by approximately 4 feet of fill along the north-west side between Lake Muskoday and the cell.

Cell 2 is divided into two cells that are separated by Wildwood Pass, connecting Oakway to the abandoned buildings. At Oakway Trail, the road is fenced off and is seldom used by park staff, bringing into question its importance.

Cell 2A is +/-3 acres and contains mostly standing water that historically drained toward Lake Muskoday. It was also historically connected to Cell 1A and 2B, but no level 4 culverts were observed under Oakway or Wildwood Pass. Wildwood Pass and the golf course fill currently create drainage barriers, and there is no clearly defined outlet such as a drainage ditch or culvert pipe. During extreme high water periods, surface water drains to the east and overflows across mowed lawn before discharging to Lake Muskoday. The original open water pool is the deepest pool in the flatwoods, contains an abundance of herpetofauna and serves as an important habitat. All of the trees within this pool have died, some are still standing and provide excellent habitat for cavity dwelling bird species. This condition has existed for a considerable length of time and is considered a stable system supporting excellent herpetofauna habitat.

Conversely, the eastern half of this cell also contains prolonged inundation and has caused significant dieback to the remaining large diameter oak species. This is one of the pools that seems to be growing in size and could be attributed to fallen ash trees (but is uncertain) or possible plugged level 4 pipes that were not encountered. These dying trees can be clearly seen from Oakway Trail and are most likely beyond the point of recovery even if the excess water is removed. Dense colonies of several juvenile tree species are becoming established in this location indicating that if this excess water is removed, the flatwoods canopy trees will become reestablished.

Cell 2B is +/- 11 acres and contains a large pool adjacent to the Wildwood Pass across from the Cell 2A pool. No physical connection was observed and water in Cell 2B is slightly lower in elevation than 2A. In the spring, this pool enlarges to the west and occupies a substantial portion of the cell's interior that eventually is reduced to a small perennial pool adjacent to Wildwood Pass. The entire cell discharges from a single location directly behind the abandoned golf course building. Due to golf course fill between this discharge and Lake Muskoday, water draining from the cell interior sheet flows westerly just outside the chain link fence (no clearly defined ditch) and eventually discharges into Sylvan Canal at its confluence with Lake Muskoday via a small drain tile and overland flow. It is unclear how far into the golf course the drain pipe extends, but it appears to be no more than 50 feet to 75 feet long. Where the cell surface water discharges into the golf course, the large oak trees are starting to show signs of stress. Adjacent to this point, a small cattail pond exists and is discharging additional water (broken water main) into the swale. The excess water within the interior of the cell and tree decline (chlorine) could be the reason for the current condition.

Within the cell, no surface water discharge to the canal was observed and existing grades are over 1 foot higher than the remainder of this cell, suggesting dredge spoils were placed along the bank. It is difficult to determine the connectivity between Cells 2B and 3 due to the level 1 ditch that parallels Oakway Trail in Cell 3.

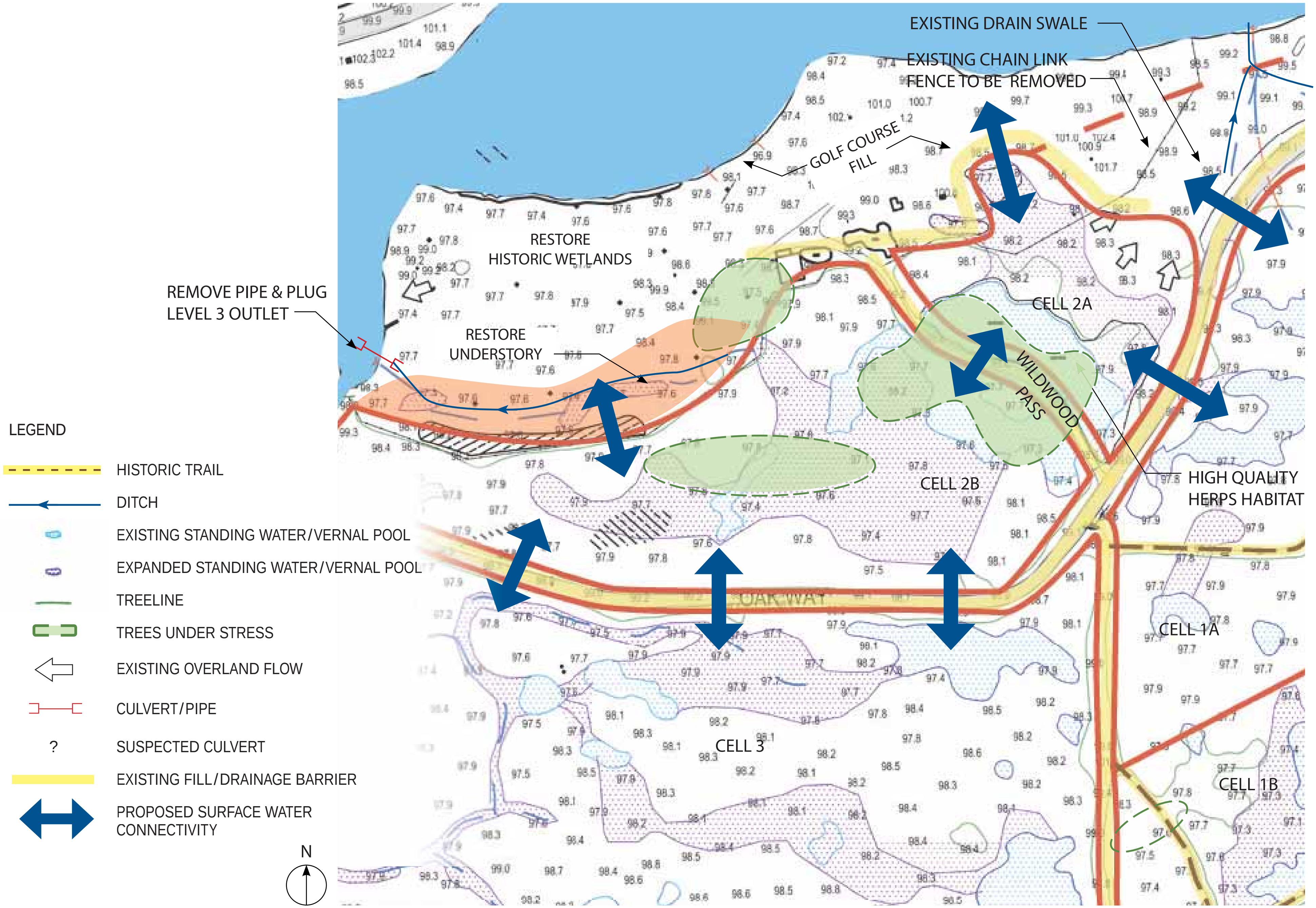


Figure 15. Flatwoods Division - Cells 2A &2B

Tree conditions seem to be mostly good except for a number of maples adjacent to Wildwood Pass within the perennial pool and a smaller cluster of similar species within the interior, suggesting that this cell is exposed to excessive standing water. The loss of ash trees are clearly noticeable, especially along the western edge of the cell approaching Sylvan Canal where tree canopy is open to semi-open, reed canarygrass (*Phalaris arundinacea*) is the predominantly understory vegetation and no seasonal pools were observed. Amur honeysuckle (*Lonicera maackii*) is also predominant in this location due to the absence of historic hydrology that may have been originated from Cell 3.

Cell 2A Restoration Strategies:

- Remove the entire chain link fence along the abandoned golf course.
- Maintain herpetofauna habitat in pool in cell, but reduce the standing water in the rest of the cell by:
    - Installing a water control structure to Wildwood Pass to Cell 2B.
    - Constructing a swale to Lake Muskoday (more difficult since fill removal will be required).
    - Restoring connectivity to Cell 1A or all of the above.
- Maintain maintenance drive since its removal could significantly alter the herpetofauna habitat, even though the habitat is not historic in this location.
- Reduce footprint of Oakway Trail to a single-lane or shared-use path including all shoulder fill (below contour elevation +/-98.0), or remove in its entirety, creating surface water connectivity to Cell 1A. If allowed to remain, consider the installation of a boardwalk section in the road to allow conveyance of surface water between cells.

Cell 2B Restoration Strategies:

- Remove the entire chain link fence along the abandoned golf course.
- Restore the understory vegetation to the outer edge of the tree canopy that currently occurs within the drainage swale to Sylvan Canal.
- Repair the broken water main or abandon in place.
- Consider the restoration of the golf course to wet meadow wetlands between the drainage swale and Lake Muskoday by dispersing the cell discharge water (includes shallow excavations).
- Reduce footprint of Oakway Trail to a single-lane or shared-use path including all shoulder fill (below contour elevation +/-98.0), or remove in its entirety, creating surface water connectivity to Cell 3. If allowed to remain, consider the installation of boardwalk sections in the road to allow conveyance of surface water between cells (possibly three locations).
- Control invasive species.
- Install a second relief point for Cell 2B to the golf course to accommodate the anticipated additional surface water from Cell 3.

CELL 3 ANALYSIS

Defined by Oakway Trail, Sylvan Canal, Central Avenue and Wildwood Pass, Cell 3 encompasses +/- 39 acres including Sylvan Canal (Figure 16). From a hydrologic perspective, the western half is heavily degraded due to ditching. The ditching is extensive and impacts over 50% of the cell. Historically, Cell 3 drained north and northwest across Oakway Trail and the Sylvan Canal through Cell 2B to the wetland complex now occupied by Lake Muskoday and the abandoned golf course. Today, the entire cell drains into Sylvan Canal. The three drainage ditches (level 1 and level 2) were strategically constructed through the lowest elevations of the cell before discharging into the Sylvan Canal. The impacts on pool development from these ditches are evident. Within this zone of influence, pools are small and linear and mostly associated with the ditches or are seasonal (spring runoff). The level 1 drainage outlet and ditch has the greatest impact on cell hydrology and extends furthest into the site. It is deep and wide near its outlet and meanders throughout the western half of the cell. The two level 2 and one level 3 ditches and outlets have localized impacts on cell hydrology. All four outlets contain small diameter cast iron pipes that allowed cell water to drain to the canal below the informal foot path that still exists today. At the level 1 outlet, the culvert is washed out, heavily eroded and a boardwalk section was installed to maintain trail access.

Ponding in the eastern half of the cell is well developed with three linear pools that eventually are drained by the primary ditch and through evaporation. By late summer, pools are dry except for a small area in the southeast corner next to Central Avenue. In at least three locations, equalizer pipes were observed across Central Avenue connecting to and draining Cells 5 and 8, which attempts to follow the natural flow patterns but are mostly blocked, and no flow was observed (see Cell 5 narrative).

Evaluation of the Sylvan Canal banks on both sides and the excavation of a test pit showed no indication of any groundwater seepage into the Sylvan Canal that would have adverse impacts on the cell hydrology.

Tree condition throughout the cell appears healthy except for a small cluster of maples in the southeast corner of the site that is attributed to ponding water. Like Cell 2B, the loss of ash trees is clearly noticeable especially along the western edge of the cell approaching Sylvan Canal where tree canopy is semi-closed to open, reed canarygrass (*Phalaris arundinacea*) is the predominantly understory vegetation, and no seasonal pools were observed. Amur honeysuckle (*Lonicera maackii*) is predominant in this location due to the absence of historic hydrology. No surface water discharges to the canal except at the ditch outlets, and existing grades are over 1 foot higher than the remainder of this cell suggesting dredge spoils were placed along the bank for trail use.

Cell 3 Restoration Strategies:

- Reduce footprint of Oakway Trail to a single-lane or shared-use path including all shoulder fill (below contour elevation +/-98.0), or remove in its entirety, creating surface water connectivity to Cell 2B. If allowed to remain, consider the installation of boardwalk sections in the road to allow conveyance of surface water between cells (two or three locations).
- Reduce footprint of Central Avenue to a single-lane or shared-use path including all shoulder fill (below contour elevation +/- 98.0), or remove in its entirety, creating surface water connectivity to Cell 5. If allowed to remain, consider the installation of boardwalk sections in the road to allow conveyance of surface water between cells (four locations).
- Fill all ditches, plug all outlets to the canal and maintain a land bridge along the east bank (+/- 99.0) to prevent surface water from discharging to the Sylvan Canal.
- Remove Wildwood Pass in accordance with restoration strategies identified for Cells 1A and 1B.
- Control invasive species.

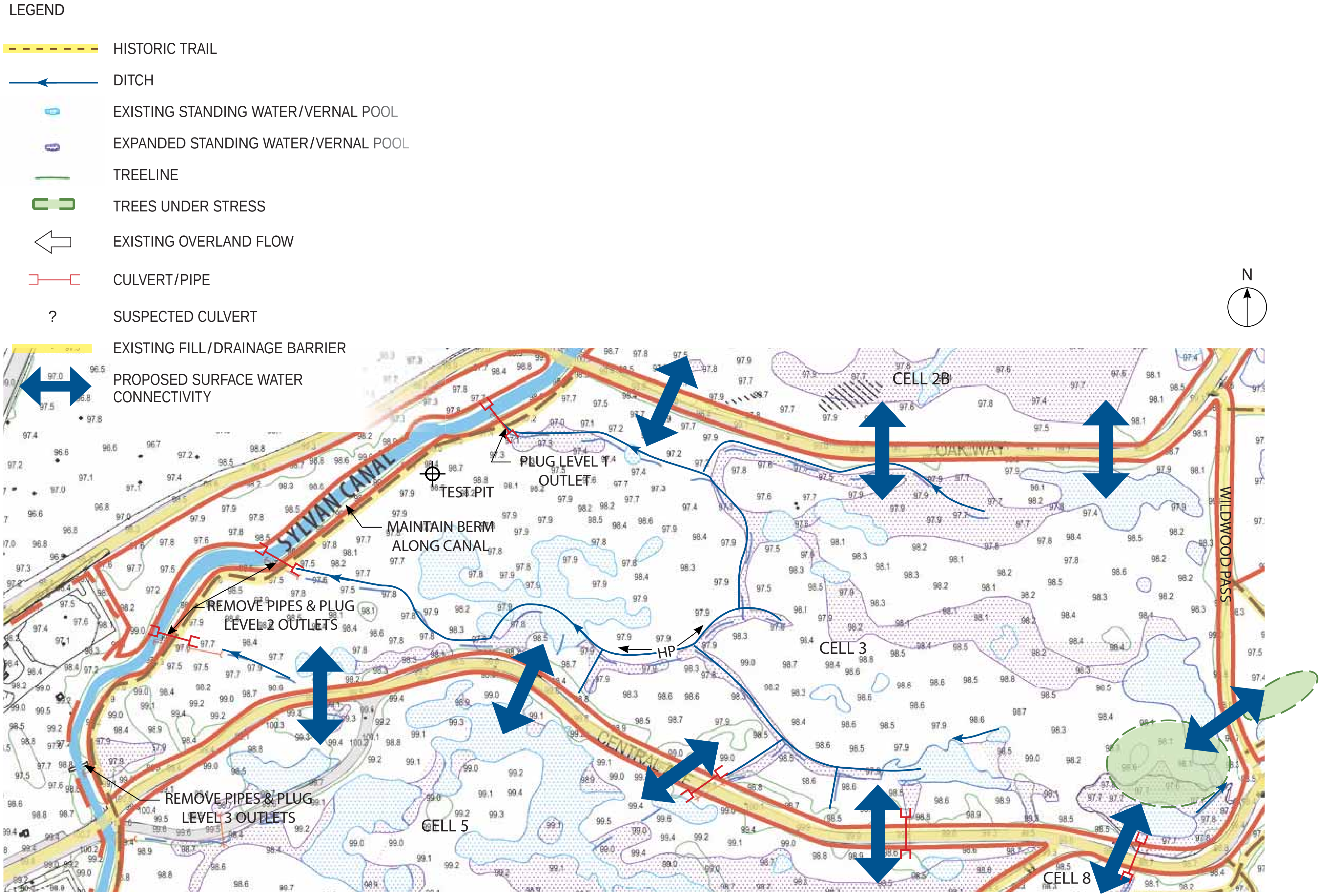


Figure 16. Flatwoods Division - Cells 3

CELL 4 ANALYSIS

Defined by Oakway Trail, Sylvan Canal, Central Avenue and Portage Way, Cell 4 encompasses +/- 3.5 acres (Figure 17) and is a linear landform. The western edge of the flatwoods is currently defined as ending at the parking lot of the Oakway Trail Comfort Station; however, this cell could easily be extended further west to Portage Way and increase this cell to 5.5 acres. The historic boundary of the flatwoods extended further west to Vista Drive, but restoration of this area is unlikely due to its current use and the presence of roads and park structures. Historically, Cell 4 drained north and northwest across Oakway Trail to the wetland complex now occupied by Lake Muskoday and the abandoned golf course. Today, the entire cell drains into Sylvan Canal and possibly the Central Avenue sanitary line via the parking lot storm drains. While no ditches or culvert pipes were observed along the banks, low points in at least three locations effectively drain historic pools that most likely existed in these locations. Ponding occurs in the turf between Sylvan Canal and Portage Way and is problematic for mowing in the spring and after large rain events.

Cell 4 has been heavily degraded and is considered low quality due to several factors.

- The emerald ash borer has killed many of the large diameter trees that occurred within the northeast area.
- Oakway Trail effectively blocks the natural drainage patterns to the historic wetland now occupied by the abandoned golf course.
- Sylvan Canal drains the surface hydrology of the cell.
- The understory vegetation has been converted to lawn between Portage Way and Sylvan Canal.
- The Oakway Trail Comfort Station parking lot occupies a strategic corner of the cell.

The large diameter oak trees situated between Portage Way and Sylvan Canal are healthy, but the natural understory is absent and maintained as lawn.

A poor quality and non-contributing footbridge crossed Sylvan Canal and connects to the Cell 3 trail that parallels the east bank of the canal.

Cell 4 Restoration Strategies:

- Consider the removal of this cell from the flatwoods due to its shape, impacts, and demands for this space (including existing and future parking) and recreation opportunities. If restoration is preferred the following strategies are proposed:

▪ Construct low-head berm along Sylvan Canal to restore pools in natural depressions.

▪ Reduce the footprint of Oakway Trail to a single-lane or shared-use path including all shoulder fill (below contour elevation +/-98.0), or remove in its entirety, creating surface water connectivity to the north side (abandoned golf course) to restore natural drainage patterns. If allowed to remain, consider the installation of boardwalk sections in the road to allow conveyance of surface water between cells (two locations).

▪ Consider restoration of the abandoned golf course to historic wetland. Remove all fencing and fill ditches adjacent to Lake Muskoday.

▪ Remove footbridge across canal.

▪ Remove Oakway Trail Comfort Station parking lot and restore to flatwoods. Follow approximate existing grades of the parking lot.

▪ Maintain Portage Way as a connector between Central Avenue and the Oakway Trail Comfort Station.

▪ Remove turf below oak trees adjacent to Portage Way and restore.

▪ Implement replanting program using Belle Isle genotypes.

LEGEND

- HISTORIC TRAIL
- DITCH
- EXISTING STANDING WATER/VERNAL POOL
- EXPANDED STANDING WATER/VERNAL POOL
- TREELINE
- TREES UNDER STRESS
- EXISTING OVERLAND FLOW
- CULVERT/PIPE
- ? SUSPECTED CULVERT
- EXISTING FILL/DRAINAGE BARRIER
- PROPOSED SURFACE WATER CONNECTIVITY
- PROPOSED BERM

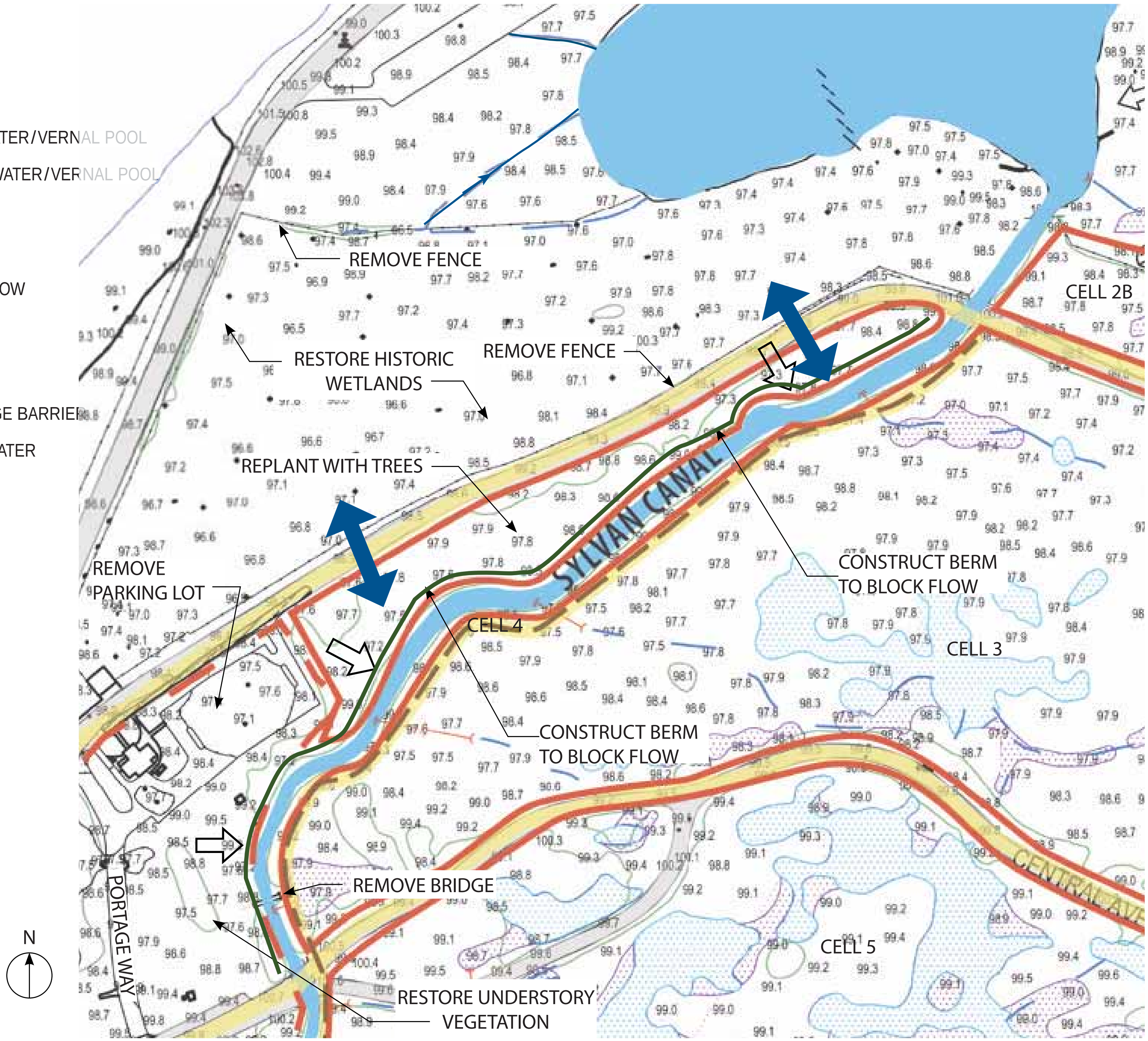


Figure 17. Flatwoods Division - Cell 4

CELL 5 ANALYSIS

Defined by Central Avenue, the Safari Zoo (closed), Sylvan Canal and Tanglewood Drive (abandoned), Cell 5 encompasses +/- 35 acres including the 1.75 acre portion of the Safari Zoo situated on the west side of the Sylvan Canal (Figure 18).

Historically, Cell 5 drainage patterns are complex, flowing in three directions – north, east and south respectively but are now blocked by Central Avenue and Tanglewood Drive. Topography in this cell represents some of the highest elevations in the flatwoods. The level 1 ditch appears to be the only active drainage outlet for this cell extending over half way into the cell, preventing pool development in the western side except within the ditch banks. Even with these higher elevations, micro-topography is expansive and water lines and saturated soils indicate that good pool development in these areas existed prior to ditching. In this location, the ditch is wide and deep and effectively drains this area into Sylvan Canal, which represents the reversal of what occurred historically. Evaluation of the Sylvan Canal banks on both sides and the excavation of a test pit showed no indication of any groundwater seepage into the Sylvan Canal that would have adverse impacts on the cell hydrology. The absence of standing water of any size and abundance of honeysuckle is evidence of the ditch influence on site hydrology.

Conversely, the remainder of the cell appears to be excessively wet, even with extensive ditching in place. The 1990's survey recognizes this pool as one of the largest in the flatwoods and spring runoff nearly doubles its size. This can be attributed in part to blockage in the level 1 ditch and ineffective drainage from the three equalizer pipes (two below Central Avenue and one below Tanglewood Drive) that more closely follow the natural surface flow patterns. The pool is the second deepest in the flatwoods (especially adjacent to Tanglewood Drive) and many of the ditches identified on the survey were not fully verified due to water depth. Most of the expanded pools are very shallow reinforcing the notion that the plugged level 3 and 4 pipes are contributing to this increase in pool size along with spring runoff. By late summer, the expansive pool is only reduced in size by 40-50% with islands appearing in several locations. Within this expanded area, dense colonies of juvenile tree species are becoming established indicating that the duration of the expanded pool is recent. Elsewhere, understory vegetation is mostly absent and some of the trees have developed flared root collars indicating that the pools duration are not recent.

Across the cell, tree conditions appear mostly healthy with a good mix of oak and maple species. In two locations, trees are showing stress attributed to ponding water. At the northwest corner of the cell, adjacent to and within the Central Avenue loop (Shadow Nook), several oak trees are in decline suggesting that the ponding has been occurring for a number of years. At the eastern side of the cell, a large cluster of silver maples are beginning to show water related stress, indicating a more recent occurrence of expanded ponding. Like most of the other cells, the loss of ash trees are clearly noticeable, especially along Tanglewood Drive where walking through the numerous downed trees and dense honeysuckle is extremely difficult.

The Safari Zoo occurs entirely within the historic boundary of the flatwoods, which extended west to Vista Avenue. West of Sylvan Canal, fill, loss of flatwoods vegetation and hydrology has occurred. The portion located on the east side of the Sylvan Canal has been less disruptive to the flatwoods ecology and has restoration potential.

LEGEND

- HISTORIC TRAIL
- DITCH
- EXISTING STANDING WATER/VERNAL POOL
- EXPANDED STANDING WATER/VERNAL POOL
- TREELINE
- TREES UNDER STRESS
- EXISTING OVERLAND FLOW
- CULVERT/PIPE

?

- SUSPECTED CULVERT
- EXISTING FILL/DRAINAGE BARRIER
- PROPOSED SURFACE WATER CONNECTIVITY
- PROPOSED BERM

N

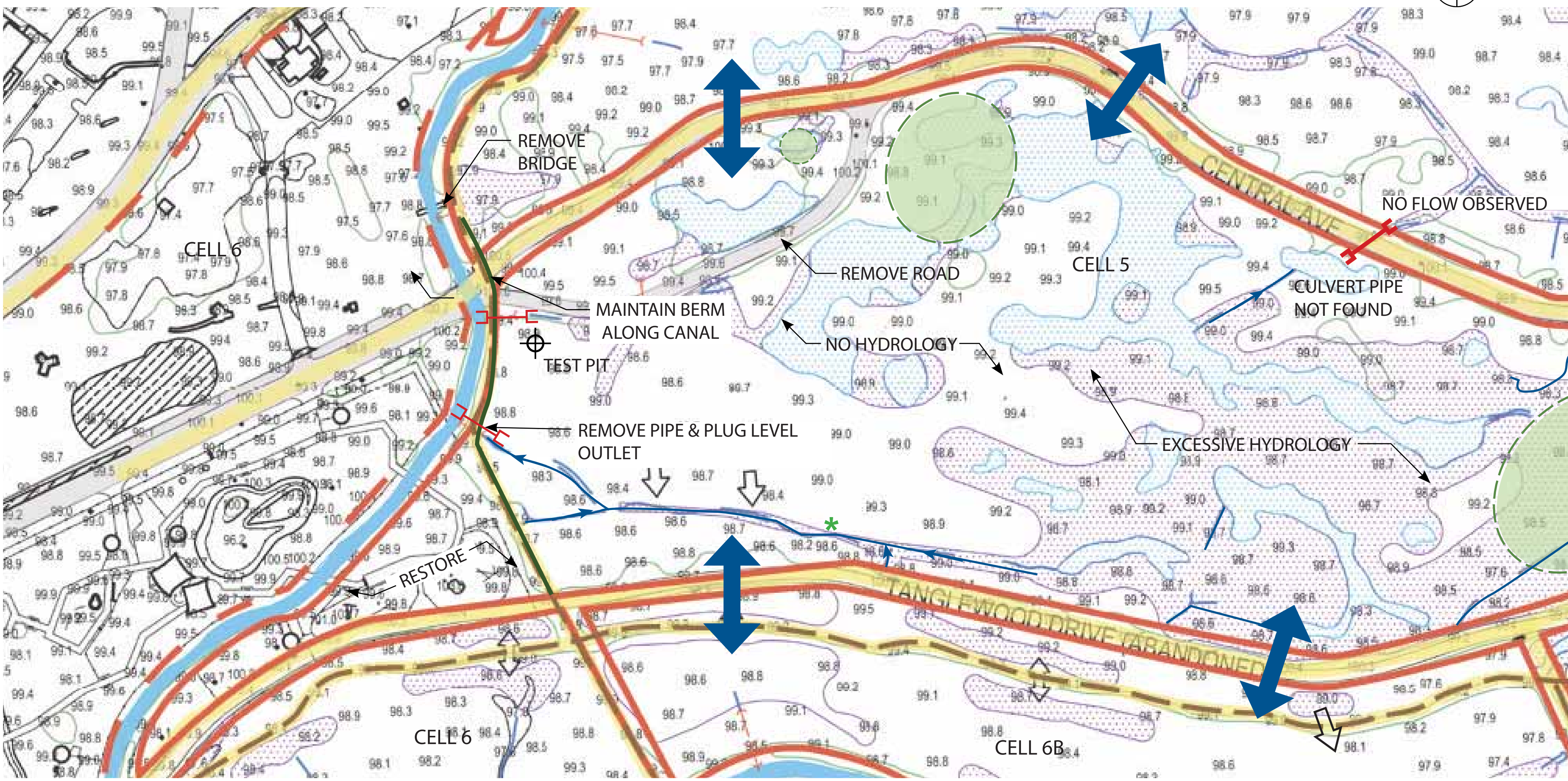
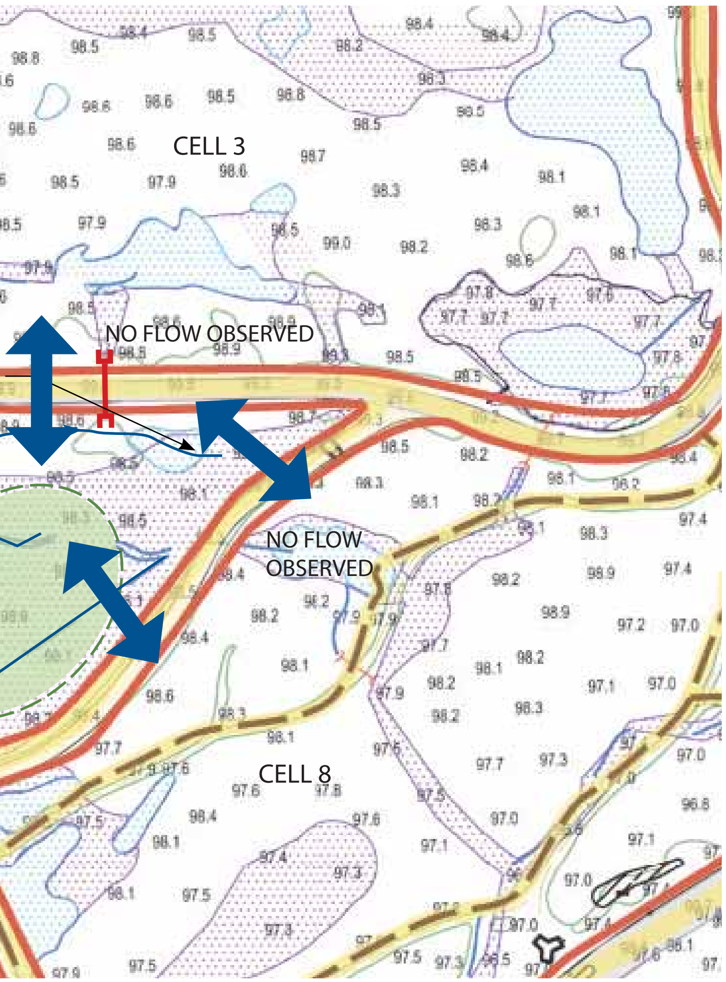


Figure 18. Flatwoods Division - Cell 5



Cell 5 Restoration Strategies:

- Reduce footprint of Central Avenue to a single-lane or shared-use path including all shoulder fill (below contour elevation +/- 99.0), or remove in its entirety, creating surface water connectivity to Cell 3. If allowed to remain, consider the installation of boardwalk sections in the road to allow conveyance of surface water between cells (four locations).
- Fill all ditches, plug the level 1 outlet to Sylvan Canal and maintain a land bridge along the east bank (+/- 99.0) to prevent surface water from discharging to the canal.
- Remove Shadow Nook (Central Avenue loop) including shoulder fill (below contour elevation +/- 98.5) and restore connectivity to cell.
- Remove all Tanglewood Drive fill and reconnect surface flows to the south into Cells 6 and 8. Connectivity to Cell 8 is extremely important for restoring historic drainage to Lake Okonoka (at least two locations), and road removal should extend below elevation +/- 98.5. Construct a boardwalk in this section if trail access is to remain. For the reminder of Tanglewood Drive, historic drainage flowed toward the Detroit River and is now intercepted by Nashua Canal. In this location, full road removal should occur down to elevation +/- 99.0. Refer to Cell 6 for additional recommendations applying to Nashua Canal discharge.
- Restore the portion of the Safari Zoo along the south/east side of the Sylvan Canal (including Tanglewood Drive, all canal crossings and fencing, Safari Zoo amenities and obstructions in the Canal) and restore historical grades to direct drainage into Cell 6A.
- Control invasive species.

CELL 6 ANALYSIS

Defined by Tanglewood Drive (abandoned), a small corner of the Sylvan Canal, Nashua Canal and Cell 7, Cell 6 encompasses +/- 19 acres (Figure 19).

Historically, this cell received surface flow from Cell 5 and drained to the south across Nashua Canal into Cell 6 before discharging to the Detroit River. Current drainage patterns still drain to the south but are now intercepted by Nashua Canal. The cell is completely surrounded by foot paths with the northern path being an active asphalt path (previously a bridle path), while the second is an abandoned grass path that is blocked with numerous fallen ash trees. The northern path parallels Tanglewood Drive and has created a 50 to 60 foot wide linear strip within the cell.

Cell 6 is divided into two areas that are separated by a slightly elevated, unimproved but active foot path (north/south orientation) blocked by a large fallen oak tree.

Cell 6A is +/- 5 acres, and from a hydrologic perspective, is heavily degraded due to three small level 3 ditches strategically located to drain historic pools. At these locations, small diameter clay culvert pipes allow ponding water to drain into Nashua Canal below the abandoned foot path. These drainage structures are effective in removing standing water, and the pools quickly draw down to become saturated depressions. Historically, these three pools appeared to be larger and if not for the ditching and pipes, would top the banks and spill over into Nashua Canal. Evaluation of the Nashua Canal banks on both sides and the excavation of a test pit showed no indication of any groundwater seepage into the canal that would have adverse impacts on the cell hydrology. The asphalt path that parallels Tanglewood Drive is elevated approximately 6 inches, resulting in pool development that stays wet for extended periods. When full, they overflow over the asphalt path and discharge into the remainder of the cell. The path separating Cell 6A and 6B is a barrier that blocks the migration of surface water between pools, and no level 4 pipes were observed. The narrow band of land between Tanglewood Drive and Sylvan Canal is developed as part of the closed Safari Zoo and is described under Cell 5. Both the Safari Zoo and Tanglewood Drive are recommended to be removed and restored. If this occurs, this narrow band will become part of this larger cell, which will provide added hydrologic benefits.

Trees are healthy and predominantly maple with few oak. The loss of ash trees are clearly noticeable, creating a semi-open tree canopy. Honeysuckle is abundant throughout this cell except within the pools.

Cell 6B is very similar in character to 5A, except it is wider, contains greater amounts of ponding water and is +/- 14 acres. The pools function very similar to 5A, being connected to level 3 pipes and short ditches connecting the pools to the pipes (three locations). The eastern–most pool is deeper and larger than the remaining and was observed to be holding water during the fall inspection. This pool appears to be historically connected to the pool across the asphalt path in Cell 8, but no level 4 equalizer pipe was observed. In the spring, water tops the Nashua Canal banks in two locations and artificially establishes a high water elevation for the effected pools. Evaluation of the Nashua Canal banks on both sides and the excavation of a test pit showed no indication of any groundwater seepage into the Nashua Canal that would have adverse impacts on the cell hydrology.

The asphalt path separating Cell 6B from 8 is a barrier that blocks the migration of surface water between pools. This same path that parallels Tanglewood Drive is wetter than 6A and several low, wet areas can be observed on the path throughout the spring.

Tree condition is good and comprised of a diverse mix of maple and oak. The loss of ash trees is clearly noticeable, creating a semi-open tree canopy. Honeysuckle is abundant throughout this cell, except within the pools. In the center of this cell, a cluster of red oaks are dead with no apparent reason since this area is void of any standing water.

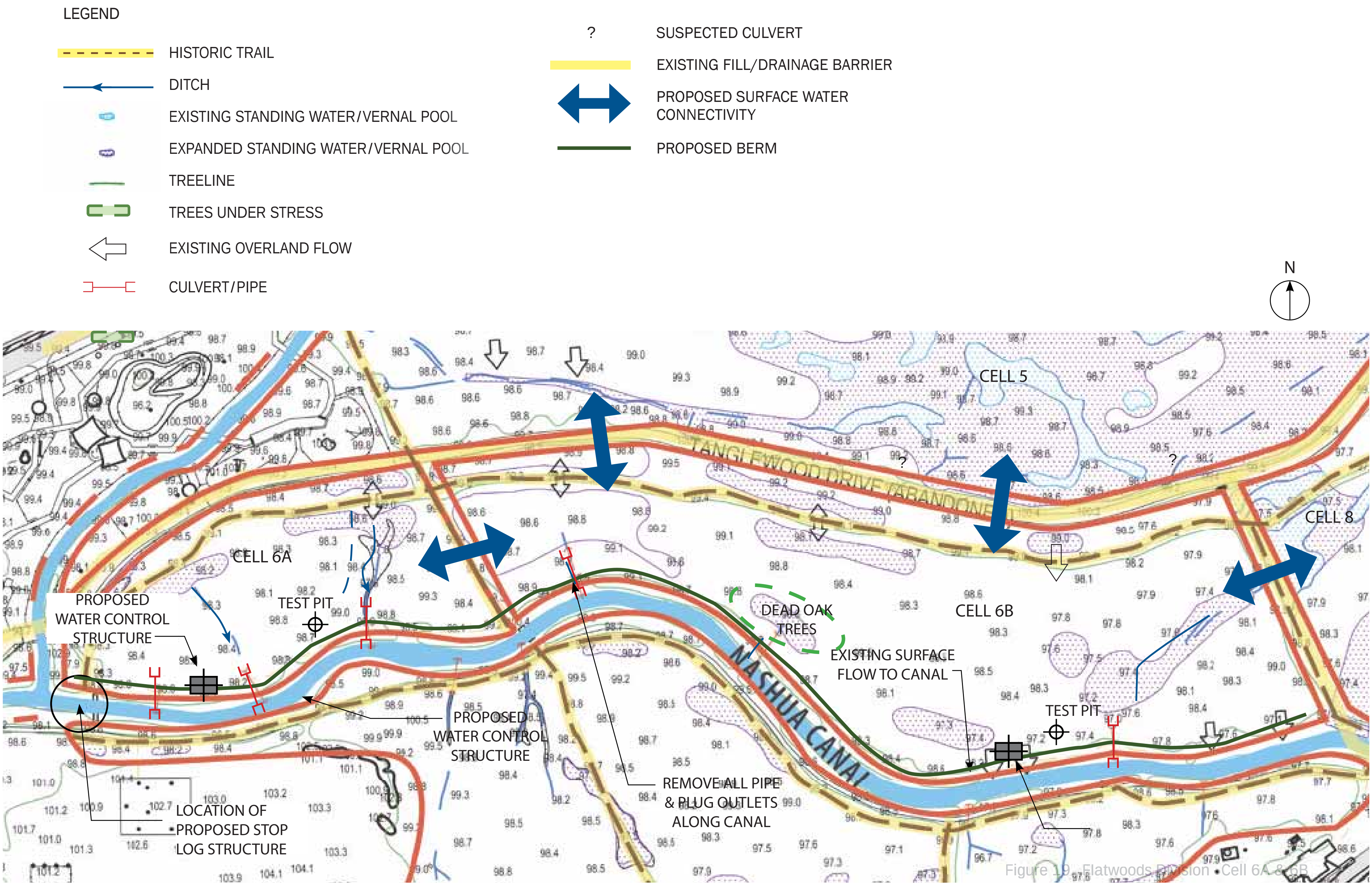


Figure 19. Flatwoods Division • Cell 6A & 6B

One note of interest is that the resident beaver(s) occupy this portion of Nashua Canal, and gnawing on the riparian trees was observed.

Cell 6A Restoration Strategies:

- Consider relocating the proposed stoplog structure form the east end of Nashua Canal to the west end where it joins Sylvan Canal, allowing the canal to be on-line with the Detroit River. Deepen Nashua Canal to follow design guidelines established for Lake Okonoka.

- Construct a shallow, small, low-head berm along the bank trapping additional surface water behind to stop sheet flow to Nashua Canal. An outlet will need to be designed to release excessive water into Nashua Canal.

- Remove all Tanglewood Drive fill and reconnect surface flows between cells (below contour elevation +/- 98.5). If allowed to remain, consider the installation of a boardwalk section in the road to allow conveyance of surface water between cells in conjunction with zoo restoration described under Cell 5.

- Remove the entire loop trail around Cell 6A, and if new trails are desired, construct as a boardwalk.

- Remove all level 3 outlets to Nashua Canal and fill ditches.

Cell 6B Restoration Strategies:

- Construct a shallow, small, low-head berm along the bank trapping additional surface water behind to stop sheet flow to Nashua Canal. An outlet will be required to release excessive water into Nashua Canal.

- Remove all Tanglewood Drive fill and reconnect surface flows between cells (below contour elevation +/- 98.5). If allowed to remain, consider the installation of boardwalk sections in the road to allow conveyance of surface water between cells (two locations).

- Remove the entire loop trail around the cell, and if new trails are desired, construct as a boardwalk.

- Remove all level 3 outlets to Nashua Canal and fill ditches.

- Establish a surface water connection between Cells 6B and 8.

CELL 7 ANALYSIS

Defined by Nashua Canal, Vista Drive and adjacent open field/basketball courts, The Strand and a small segment of Woodside Drive, Cell 7 encompasses +/- 26 acres (Figure 20). Historically, this cell was +/- 11 acres larger, extending west to Vista Drive and south to the edge of The Strand (now used as an open field, basketball and handball courts). In this location, up to 6 feet of fill has been placed over a +/- 7 acre footprint with the remaining perimeter closely following historic grades, except it is now lawn under tree canopy.

This cell historically drained to the south and discharged directly into the Detroit River. Today, the flow is reversed and drains to the north via one level 2 drainage ditch and three level 3 ditches that pass below the asphalt path before discharging into Nashua Canal. The path parallels the entire length of this cell connecting Vista Drive to Woodside Drive. In several locations, excess water accumulating behind the filled path discharges to Nashua Canal via overland flow similar to Cell 6B, preventing better pool development. Much of the current lawn between The Strand and the cell are consistently wet and difficult to maintain, which can be attributed to historical flow patterns that ditching has not effectively drained. The two ditches located in the western half of the cell have effectively drained historically wet areas, and the absence of standing water of any size and abundance of honeysuckle is evidence of its influence on site hydrology. The two smaller ditches on the eastern half are equally effective in removing surface water, given the fact that this area contains some of the lowest elevations in the cell and pool formation is poor. The two small abandoned paths that bisect the cell do not obstruct flow, appear to have been constructed on grade and could not be located due to dense vegetation.

Pool formation throughout the cell is heavily impacted by ditching with the greatest amounts of standing water occurring in the lower elevations along the southern edge of the cell and within the lawn areas adjacent to The Strand. These pools are completely dry in late summer.

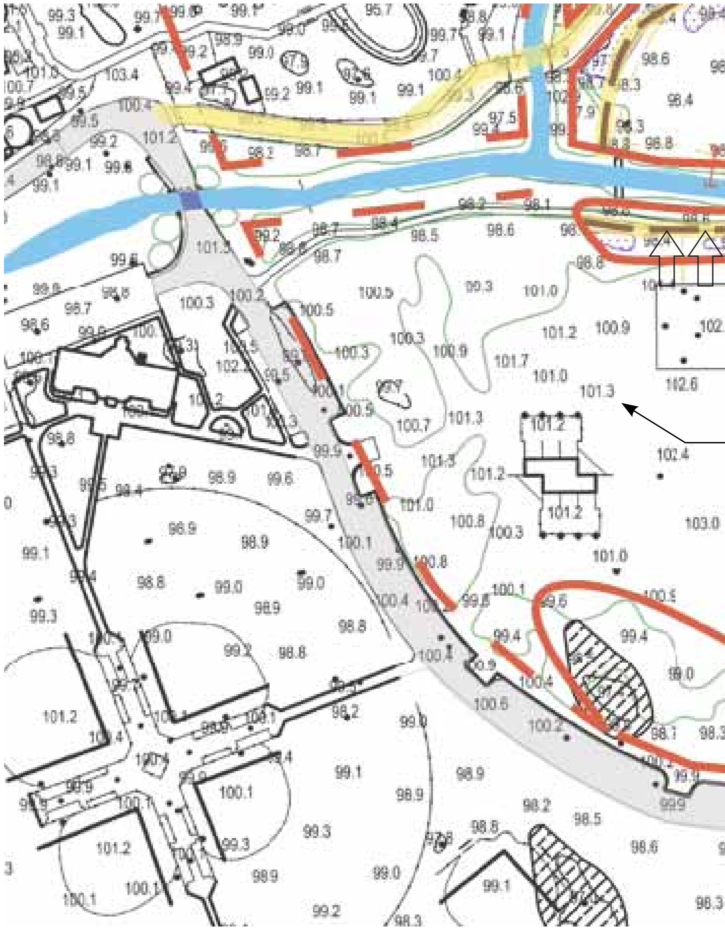
One area of concern is the remaining +/- 50 foot wide by 800 foot long linear section of the cell between the basketball courts and Nashua Canal. Being less than 50 feet wide, runoff from the fill area of the fields collect in these natural depressions and eventually top the asphalt path draining into Nashua Canal. The pools and trees are of good quality.

Additionally, two storm sewer drainage structures can be observed along the Nashua Canal banks, and it is unclear as to whether they adversely impact cell hydrology. It is believed that these structures historically extended through the cell to capture water adjacent to The Strand and do not appear to be functional.

Tree condition is good and represents a diverse mix of flatwoods species. The loss of ash trees are clearly noticeable creating a semi-open tree canopy. Honeysuckle is abundant throughout the western half of the cell. A small grouping of oak trees on the eastern end of the cell are showing signs of stress due to standing water.

Cell 7 Restoration Strategies:

- Remove all level 2 and level 3 culverts to Nashua Canal and fill all ditches.
- Construct a shallow, small, low-head berm along the bank trapping additional surface water behind to stop sheet flow to Nashua Canal. Use top of berm as trail if intending to maintain this use.
- Remove fill and lawn adjacent to The Strand and restore to flatwoods.
- Remove all playground equipment from this same location.
- In up to three locations to be determined, provide culvert pipes or drainage troughs across The Strand to restore historical drainage patterns to the Detroit River.
- Consider restoration of this cell to extend to Vista Drive to follow its original boundary. This will require the removal of a large amount of fill, the basketball courts and the handball court. At a minimum, consider flatwoods understory restoration around the perimeter of this fill to historical west limits (Vista Drive).
- Remove surplus fill placed in flatwoods at northeast corner of mowed field and fill area.
- Between basketball court and Nashua Canal, widen natural areas as much as possible (+/- 100 feet) and install at least one water control structure to maintain linear pools.



LEGEND

- HISTORIC TRAIL
- DITCH
- EXISTING STANDING WATER/VERNAL POOL
- EXPANDED STANDING WATER/VERNAL POOL
- TREELINE
- TREES UNDER STRESS
- EXISTING OVERLAND FLOW
- CULVERT/PIPE
- ? SUSPECTED CULVERT
- EXISTING FILL/DRAINAGE BARRIER
- PROPOSED SURFACE WATER CONNECTIVITY
- PROPOSED BERM

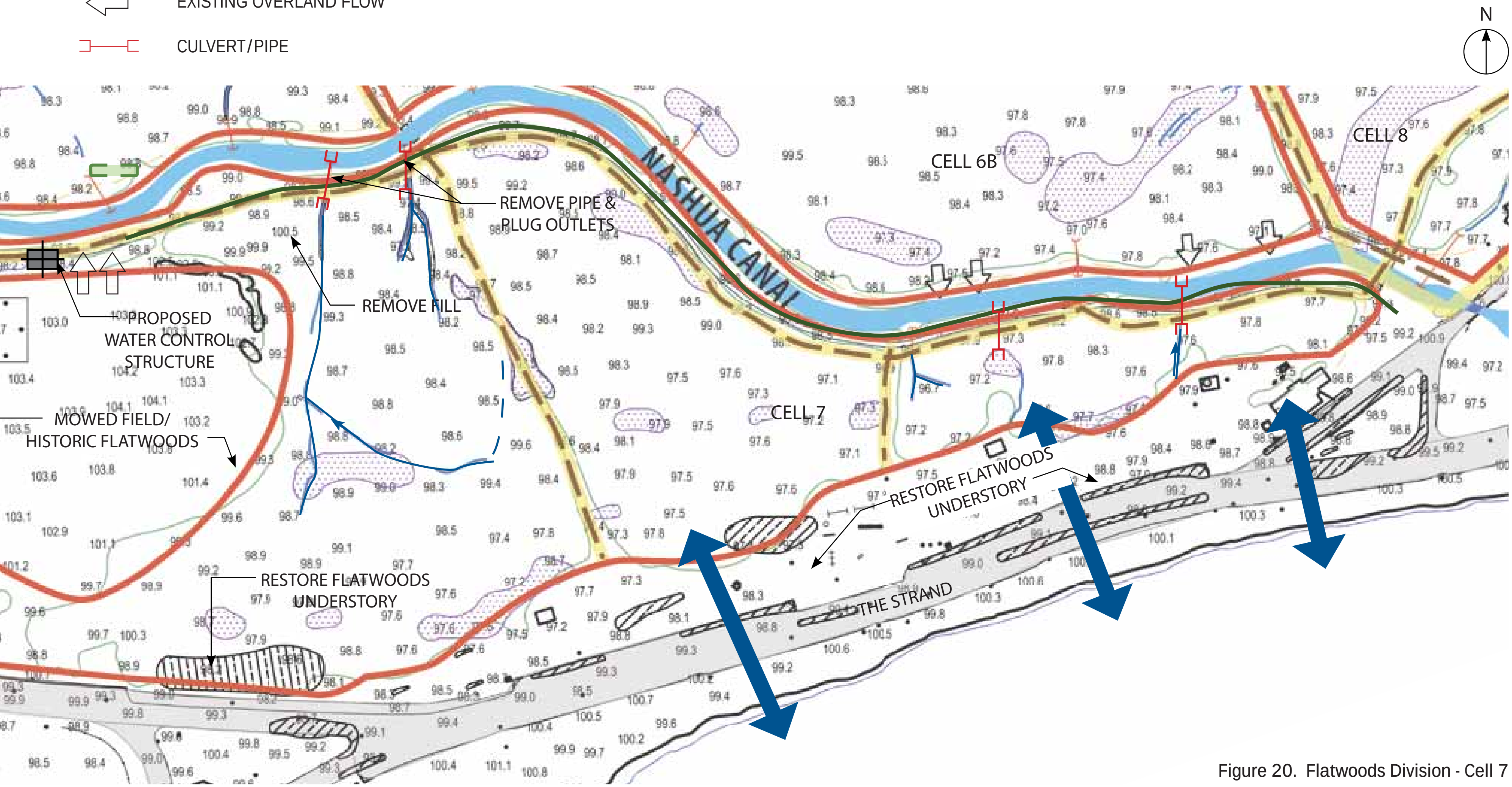


Figure 20. Flatwoods Division - Cell 7

CELL 8 ANALYSIS

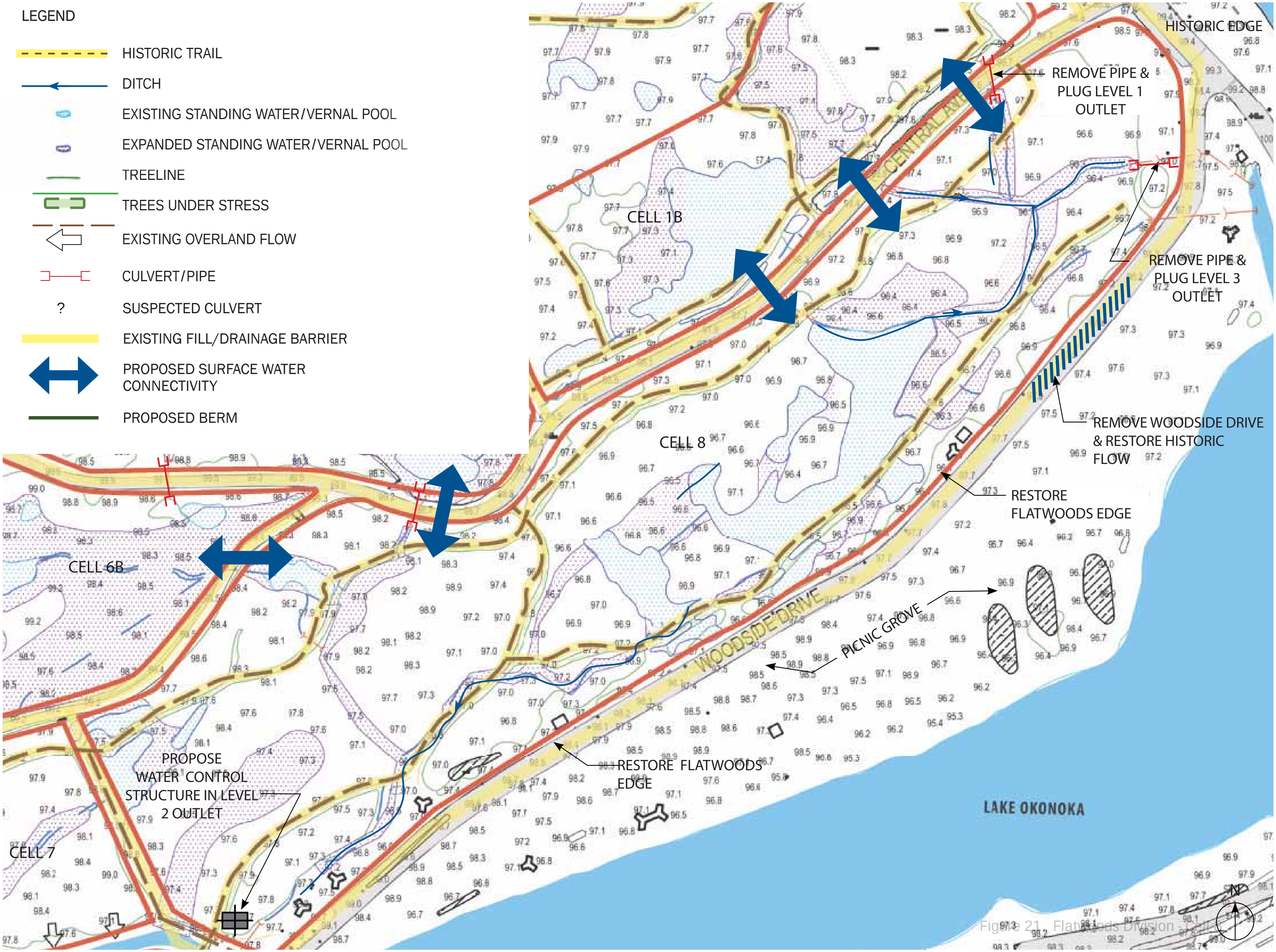
Defined by Central Avenue, Tanglewood Drive (abandoned), the asphalt path adjoining Cell 6B, the lower reach of Nashua Canal, Woodside Drive and Riverside Drive, Cell 8 encompasses +/- 35 acres (Figure 21). With the exception of the small lawn area adjacent to Riverside Drive (east side of cell), the flatwoods boundary closely aligns with its historical boundary.

Cell 7 represents the lowest area in the flatwoods and receives surface discharges from parts of Cells 1B, 3 and 5. Historically, the surface water discharged into the coastal wetland complex that is now occupied by a picnic area and Lake Okonoka. The picnic area was historically wetland but has been cut off from the hydrologic connection to the cell due to Woodside Drive fill and, for the most part, is now seasonally dry enough to mow.

Internally, drainage patterns have been significantly altered due to the extensive ditching and fill associated with the original bridle trails. A level 1 ditch and outlet exists at the southeast corner of the cell and discharges into Lake Okonoka via a subsurface drainage system. The ditching system is wide and deep and has significant impacts on the adjacent surface hydrology and the absence of standing water of any size and abundance (except within the ditches themselves) is evidence. It appears that a secondary purpose of the braided ditching is to assist in relief of the excessively wet conditions that exists in Cell 1B. The proposed plans for Lake Okonoka identify this outlet as a structure to be removed, allowing the cell to surface flow to Lake Okonoka. In the center of the cell, ditching impacts are less apparent, and pool development is good and extensive. This is due in-part to fallen ash trees that litter the ground and partially block the main ditch that extends into the pool area. By late summer, this pool is significantly reduced in size. A level 2 ditch discharges into the Nashua Canal in the southwest corner of the cell via a galvanized steel culvert pipe below the asphalt path. It could also be categorized as a level 1 ditch, since it extends approximately half way into the cell, but its influence on pool hydrology is less of an impact due primarily to the blockage of several of the equalizer pipes and fallen trees, and the ditch is not as deep or wide. At the west end of the cell, two medium size pools extend to the edge of the asphalt path and Cell 6B; however, there does not appear to be any connectivity between them. The northern most pool is the deepest and by late summer, is reduced in size but still contains standing water. The absence of understory vegetation and flared root collars on the large oak trees suggest a normal pool. The second pool is shallow and is completely dry by late summer. The remainder of pipes and ditches are level 3 or equalizer pipes. As described under Cells 1B, 3 and 5 analysis, five equalizer pipes connect these cells below Central Avenue and Tanglewood Drive but are mostly or completely non-functional except during spring conditions. The internal bridle paths are extensive and all abandoned. Numerous equalizer pipes were found and are associated with trail crossings over the level 2 ditch or to span shallow depressions that originally or currently convey seasonally high water across the paths.

The southern edge between the treeline and Woodside Drive is a problematic area due to fallen ash trees, blockages in the ditching system, abandoned picnic facilities and seasonally mowed lawn that stays wet for extensive periods of time. Woodside Drive is elevated approximately 1 foot above existing grades on both sides, drains to this strip of land and effectively blocks historic surface flows. A level 3 ditch and outlet at the east end helps remove some of the water but is mostly ineffective except during the summer when standing water is too low to drain to this structure.

Tree conditions are generally good, but canopy cover and species diversity vary based on its location within the cell. The east third is comprised of mostly maple species with limited large diameter trees. The loss of ash trees in this area is clearly noticeable creating a semi-open tree canopy. Dense colonies of small trees are taking hold in response to the additional light penetrating to the ground plain. The central and western portion of the cell contains a mix of oak and maple, with oak being more predominant in the western end.


LEGEND
HISTORIC TRAIL
DITCH
EXISTING STANDING WATER/VERNAL POOL
EXPANDED STANDING WATER/VERNAL POOL
TREELINE
TREES UNDER STRESS
EXISTING OVERLAND FLOW
CULVERT/PIPE
? SUSPECTED CULVERT
EXISTING FILL/DRAINAGE BARRIER
PROPOSED SURFACE WATER CONNECTIVITY
PROPOSED BERM
HISTORIC EDGE
REMOVE PIPE & PLUG LEVEL 1 OUTLET
CENTRAL AVE
CELL 1B
REMOVE PIPE & PLUG LEVEL 3 OUTLET
REMOVE WOODSIDE DRIVE & RESTORE HISTORIC FLOW
CELL 8
RESTORE FLATWOODS EDGE
CELL 6B
WOODSIDE DRIVE
PICNIC GROVE
PROPOSE WATER CONTROL STRUCTURE IN LEVEL 2 OUTLET
RESTORE FLATWOODS EDGE
LAKE OKONOKA
CELL 7
N

The canopy ranges from semi-dense to closed due to the absence of significant amounts of ash trees. Honeysuckle is abundant throughout this cell and occurs extensively in the fill areas associated with the internal bridle trails.

Cell 8 Restoration Strategies:

- Reduce the footprint of Central Avenue to a single-lane or shared-use path including all shoulder fill (above contour elevation 98.0). Refer to Cell 1B and 3 recommendations for decisions on the road equalizer pipes.
- Remove Tanglewood Drive fill and reconnect surface flows to Cell 5. Connectivity to Cell 8 is extremely important for restoring historic drainage to Lake Okonoka, and road removal should extend below elevation +/- 98.5. Construct a boardwalk in this section if trail access is to remain.
- Remove all internal foot path fill and equalizer pipes and restore grades to match existing adjacent elevations.
- Plug the level 1 drainage structure inlet as part of the Habitat Restoration project and fill all related ditches.
- Plug the level 3 drainage structure inlet and fill its connecting ditch.
- Remove the asphalt path between cells 6B and 8 and restore surface water connectivity. Boardwalk section(s) will be required if the intention is to maintain a trail.
- Install a water control structure in the level 2 outlet to Nashua Canal since the historical surface flow to the Lake Okonoka area will not be possible at this time without making alterations to Woodside Drive and the exsiting picnic area.
- Remove surplus fill, turf and abandoned picnic structures on the north edge of Woodside Drive and restore to flatwoods.

SUMMARY OF FINDINGS

The Flatwoods Enlargements – Analysis and Restoration Strategies presented above divides the flatwoods into eight cells. The restoration strategies brought forward under this section focus on flatwoods-wide restoration strategies in more specific terms since the application of these recommendations have similar but subtle differences based on the location within the flatwoods.

One of the current unknowns as it relates to the approach of restoring site hydrology while protecting the large diameter trees, is the competing recreational uses and demands placed upon this unique system that may require compromise from both sides of the spectrum. A common theme brought forward under each cell's restoration strategy deals with the restoration of surface water hydrology through the removal of fill, the plugging of ditches and the return of surface flows that attempts to follow historical patterns while leaving open the opportunity to continue to provide recreation venues (trails, roads, parking, picnic and boating). These restoration strategies do not reflect an either-or scenario and leaves the MDNR managers with decisions that need to be made based on how true to full restoration can be advanced. If compromise is required and trails, roads and their associated cut and fill are to remain in-part or in-full, the guidelines address this by providing connectivity between cells. This adds complexity to the restoration requiring greater scientific validation to identify the most accurate locations and elevations at which these connections would be made. While this report attempts to do this, it is presented with the understanding that the primary focus of these guidelines is to establish the framework for the next phase of studies that can now be taken with a much higher level of certainty that builds upon this report.

NEXT STEPS

When the Task 1 Hydrologic Analysis grant application was written, it was done so knowing that there would be at least two additional phases of work that would follow and the outcome of this report allows for the advancement of the next phase referred to as the preliminary design followed by final design and implementation.

Under the heading preliminary design:

- A greater understanding on the relationship between pools fluctuations and adjacent large diameter trees will be taken to the next level. Required studies include additional and more precise topographic and bathymetric surveys that relate to specific tree species and other natural features that require consideration.

- Locations where cut and fill is recommended will be finalized. Additional geotechnical investigations will be required to identify the amounts of fill placed over existing soils.

- Resolution of locations and cross sections of trails, roads and parking to remain or be added.

- The interactions between plants and animals occupying this unique habitat currently not part of this initial study will be completed including more accurate inventories of invasive species (primarily honeysuckle), colonizing trees, herpetofauna and bird inventories and continued monitoring of pool hydrology effecting the health of large diameter trees.

4 | BIBLIOGRAPHY

Belle Isle Canal Rehabilitation; Johnson Johnson & Roy/Inc; January 1993

Belle Ilse Conservancy, Park History; http://www.belleisleconservancy.org/belle-isle-park-history; Belle Isle Conservancy, Accessed 8-15- 2016

Belle Isle Lake and Canal Long-Term Management Program; JJR Incorporated, October 1999

Belle Isle Master Plan Technical Assessment Report, Part 1; Hamilton Anderson Associates; 2005

Ecological Management Plan – Belle Isle Forest; CardnoJFNew; Justin Heslinga, Andrew McDowell; November 14, 2013

Field Observation Report; Lake Okonoka; SmithgropuJJR; Carol Schulte; July 16, 2015

Field Observations; SmithgroupJJR; Paul Evanoff, Bernie Fekete, Carol Schulte, Nichole Heil; April 14, 2015; April 6, 14, 15, 29, 2015; May 21, 2015 ; June 16, 2015; July 16, 2015; September 3, 2015

Fish Collections in the vicinity of Lake Okonoka, Belle Ilse, Michigan; Dr. James S. Diana, June 29, 2015

Fish Survey of Belle Isle Lakes; Jeffrey Braunscheidel; MDNR; October 31, 2014

Geotechnical & Environmental Data Report; Lake Okonoka And South Shore Habitat Restoration; Somat Engineering; June 30, 2015

Lake Okonoka Habitat Restoration; Herpetological Monitoring Report; Herpetological Resources and Management, LLC; August 2015

Lake Okonoka Habitat Restoration in the Detroit River Area of Concern Quality Assurance Project Plan; SmithgroupJJR; April 8, 2015

Michigan Natural Communities, Wet-mesic flatwoods; http://mnfi.anr.msu.edu/communities/community.cfm?id=19009; Michigan state University Extension; Page updated on 11-26-2014, Accessed 8-15-2016

National Flood Insurance Program; Flood Insurance Rate Map, City of Detroit; Panel 35 of 45; July 2, 1981

National Register of Historic Places Registration Form, Belle Isle Park; MDNR, 2015

Numerous Historic Engineering Drawings for Utilities and roads; Provided from City of Detroit and MDNR; 2015

Project Narrative; Detroit River AOC – Lake Okonoka Habitat Restoration Design; Friends of Detroit River; February, 2014

Tree Survey and Plant Lists of the Woods of Belle Ilse Park; King & MacGregor Environmental, Inc.; September, 2002