Department of Planning, Design and Natural Resources
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Department of Parks
Division of Outdoor Education
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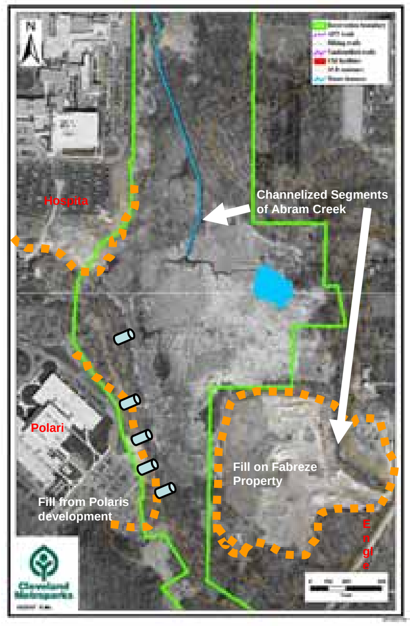
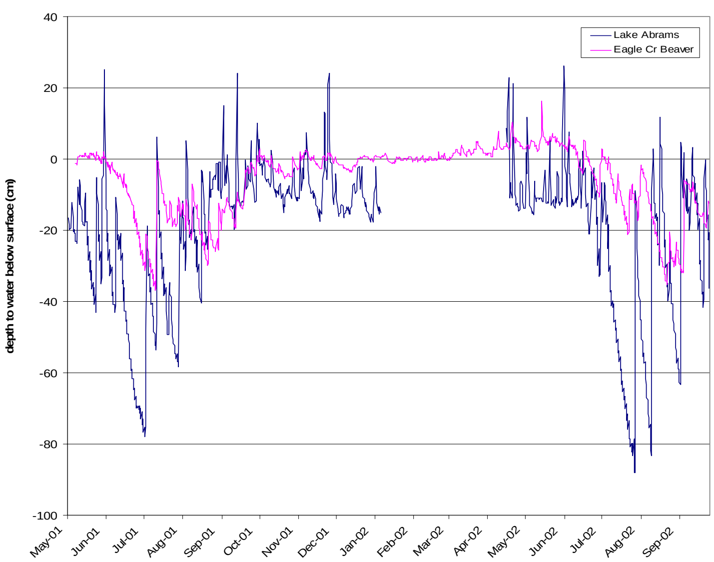
Ecosystem Management Plan for the Lake-to-Lake Trail, Berea, Brook Park and Middleburg Heights, Big Creek Reservation, Rocky River Watershed Version 0 (Discussion Draft)

Cleveland Metroparks Technical Report 2008/NR-03





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The highest function of ecology is understanding consequences.

Pardot Kynes, Planetary Ecologist, Arrakis

EXECUTIVE SUMMARY

While nearly self-apparent from the perspective of ecology (i.e. healthy, functioning ecosystems provide the services for a healthy, functioning human society), this paradigm is not intuitively apparent in human-dominated landscapes where issues related to the day-to-day repair and maintenance of the engineered infrastructure (e.g. water, wastewater, transportation, energy, habitation) that supports our present society) appear largely divorced from natural ecosystem processes. Natural ecosystems in good (sustainable) condition provide free (or relatively low-cost) infrastructure to support human activities in the ecosystem. Replacing natural infrastructure with human engineered infrastructure requires a large initial development investment and perpetual repair and replacement costs from human society. Conserving and restoring natural ecosystem structure and function represents a cost-effective way to maintain and improve the benefits humans derive from the ecosystems they inhabit. This Ecosystem Management Plan (EMP) represents the first step in implementing the "ecosystem approach" for the Lake-to-Lake Trail ecosystem, which includes the Lake Abram and Fowles Road Wetlands and surrounding upland habitats. This ecosystem is located in the cities of Berea, Brook Park, Cleveland and Middleburg Heights. With projected population declines in all of these communities by 2020, implementation of this plan is expected to lead to increased property values and economic benefits from environmental tourism (e.g. bird watching, cycling, hiking) as well as maintaining and improving the existing natural resource infrastructure for water storage, detention and improvement. Implementation of this plan is also expected to benefit the biological, chemical and physical quality of the lower Abram Creek and mainstem Rocky River watershed. This document is intended to be a living document that is regularly amended and updated as new data becomes available and management activities are implemented and evaluated to restore the condition and services of this ecosystem. It is expected that topic or project specific plans will be developed as the ecosystem approach is implemented for the Lake-to-Lake Ecosystem. These more specific can be included as appendices to this document or as stand-alone documents. The ecosystem approach and this plan have as a major goal

the maintenance and improvement of benefits to human society. Conserving and restoring ecosystem function and structure is a primary way to accomplish this goal. The rest of this section outlines present condition and services, threats to condition and services, and monitoring and assessment to evaluate the improvement of condition and services.

1.0 BACKGROUND

1.1 Climate, Regional Landscape, Geology and Post-glacial development

The Lake-to-Lake Trail ecosystem is located in the Erie-Ontario Drift and Lake Plains Ecoregion in the Erie Lake Plain subregion (Woods et al. 1998). The Erie Lake Plain is "...a nearly level coastal strip of lacustrine deposits punctuated by beach ridges and swales...[with a] lake-modified climate [that] sets it apart from other nearby ecoregions and [an] annual growing season [that] is often several weeks longer than inland areas" (Woods et al. 1998).

Climate in the area of the ecosystem is continental and humid with warm summers and cold winters and precipitation relatively evenly distributed throughout the year. Temperature and Precipitation averages for 1996-2006 from the nearby Cleveland-Hopkins International Airport are summarized in Table 1. Average rainfall and snowfall was 38.5 in and 71.4 in, respectively, during this period with total precipitation (converting snow to rainfall equivalent) of 45.6 in.

Table 1. Temperature and precipitation averages from 1996 to 2006 from Cleveland-Hopkins International Airport (NOAA 2007). Total = precip + snow/10.

	Avg Max (F)	Avg Min (F)	Avg Temp (F)	Avg Precip (in)	Avg Snow (in)	Avg Total (in)
1996	57.2	40.9	49.5	46.8	105.0	57.3
1997	57.6	41.1	49.6	35.7	18.8	37.5
1998	61.9	45.3	53.8	33.1	8.0	33.9
1999	60.8	42.7	52.0	32.2	63.2	38.5
2000	58.4	41.3	50.1	40.8	84.0	49.2
2001	60.0	43.5	51.9	34.7	41.8	38.9
2002	60.5	43.7	52.3	36.6	88.7	45.5
2003	58.4	41.8	50.4	42.8	102.8	53.1
2004	58.7	42.1	50.6	39.7	105.9	50.3
2005	59.3	42.7	51.2	40.2	116.4	51.8
2006	60.2	44.3	52.5	40.9	50.5	46.0
Average	59.3	42.7	51.3	38.5	71.4	45.6
Maximum	61.9	45.3	53.8	46.8	116.4	57.3
Minimum	57.2	40.9	49.5	32.2	8.0	33.9

The bedrock geology of the Abram Creek watershed is comprised of shales and sandstones deposited during the Paleozoic Era (544-250 million years ago) including the Chagrin shale, the Ohio shale (usually divided into the Huron and Cleveland shale), the Bedford shale, and the Berea sandstone (Prosser 1912, Banks and Feldman 1970). Three of these formations have significant outcrops within the Abram Creek watershed: the Ohio (Cleveland) shale, the Bedford shale and the Berea sandstone (Prosser 1912). The Cleveland shale was deposited during the middle to late Devonian (408 to 360 million years ago) and in the area of Abram Creek watershed is approximately 500 feet of black shale interspersed with thin layers of sandstone and siltstone. The Bedford formation (about 100 feet of shales and siltstones) was deposited in the late Devonian and the disconformity between the Bedford formation and the Berea sandstone is considered to be the Devonian-Carboniferous[1] boundary (360 million years ago) (Prosser 1912). Finally, the Berea sandstone is approximately 50 feet thick and represents deposition during the Mississippian period (360 to 323 million years ago) of the Carboniferous (Banks and Feldman 1970).

Outcrops of the Cleveland Shale, Bedford formation and Berea sandstone are mostly not visible within the Lake-to-Lake Trail ecosystem as nearly the entire area is located within a buried river valley of the pre-Wisconsin glaciation Rocky River (Figure 1). Soils in the Abram Creek watershed are part of the Urban Land-Mahoning association (SCS 1980). Within the Lake-to-Lake ecosystem, the center of the wetland areas are dominated by Carlisle silty clay loam with Condit silty clay loam and Canadice silty clay loam along margins and watercourses[2] (Figure 2). Upland areas are mostly Mahoning silt loam with local inclusions of Ellsworth, Fitchville, Glenford and Loudonville silt loams, and Chili and Haskins loams[3] (SCS 1980) (Figure 2). The genesis of the wetlands from glacial lakes is readily apparent from the configuration of the soil units. The much larger extent of the lake system can be seen from the Canadice units mapped between Lake Abram and the Fowles Road wetland (Figure 2). A complex of slope (ground water drive) wetlands is present on a complex of Chili-Ellsworth-Haskin soils at the south end of the ecosystem (Figure 2) (Mack, personal observation).

1.2 Ecosystem development since the end of the last glaciation

The latest glaciation (Wisconsin) in a series of glaciations (Nebraskan, Kansan, Illinoisan) over the past 1.5 million years of the Pleistocene Epoch formed the entire

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[1] The Carboniferous (360 to 290 million years ago) is divided into the earlier Mississippian period (360 to 323 million years ago) and the later Pennsylvania period (323 to 290 million years ago).

[2] Carlisle soils are very poorly drained soils that formed in bogs and swales. Condit soils are poorly drained soils that formed in low lying depressional areas or at the heads of drainageways on ground moraines. Canadice soils are very poorly drained soils that formed in the basins of former glacial lakes.

[3] Mahoning soils are somewhat poorly drained soils that formed in broad areas on till plains and higher parts of the lake plains. Ellsworth soils are moderately well drained soils that formed on knolls and side slopes at the heads of drainageways on ground and end moraines. Fitchville soils are somewhat poorly drained soils that formed on terraces and basins of former glacial lakes. Glenford soils are moderately well drained soils that formed on convex parts of knolls on lake plains and terraces. Loudonville soils are well drained soils that formed on side slopes and ridgetops. Chili loams are well drained soils that formed on outwash terraces. Haskins soils are somewhat poorly drained soils that formed on terraces and beach ridges.

landscape of Northeast Ohio. Since the peak of the Wisconsin glaciation (Table 2), the vegetation in northeast Ohio has been reconstructed using fossil pollen data.[4]

Table 2. Geologic time in the late Quaternary south of the glacial margin in eastern North America. Adapted from Delacourt and Delacourt (1981).

Age	Subage	Interval	years before present (BP)
Holocene		Late	0 to 4,000 BP
		Middle	4,000 to 8,000 BP
		Early	8,000 to 12,500 BP
Wisconsinin	Woodfordian	Late Glacial	12,500 to 16,500 BP
		Full Glacial	16,500 to 23,000 BP
	Farmdalian		23,000 to 28,000 BP
	Altonian		28,000 to >75,000 BP

18,000 PB - Peak of the Woodfordian Subage Full Glacial Interval. The Woodfordian Subage full glacial interval extended from 23,000-16,500 BP. At 18,000 BP, the Wisconsin glaciation reached its maximum extent in Ohio (Delacourt and Delacourt 1981). A spruce (*Picea*) and jack pine (*Pinus banksiana*) forest was well-developed as the dominant vegetation in Ohio south of the ice front. Tundra or tundra-like vegetation probably existed in a band parallel to the ice front for 60-100 km (Delacourt and Delacourt 1981). The area of the Lake-to-Lake Trail ecosystem was completely ice-covered at 18,000 BP and the earlier Rocky River Valley was buried with clay and till.

Ice Retreat to 13,500 BP - Woodfordian Subage Late Glacial Interval. The Woodfordian Subage late glacial interval extended from 16,500-12,500 BP. Climate amelioration during this period marked the initial retreat of the Wisconsin ice. A spruce dominated forest developed throughout Ohio (Delacourt and Delacourt 1981). By 14,000 BP, Ohio was completely ice free except for stranded ice blocks in incipient kettle lakes and other similar isolated ice fragments, the glacier having retreated from most of the state between 18,000-16,000 BP (Ogden 1966; Delacourt and Delacourt 1981; Shane 1987). As the ice blocks melted, deep clear lakes developed at the present locations of Lake Abram, the Fowles Road wetland, and Lake Isaac. From the period of ice-retreat to 13,500 BP, the lakes were briefly surrounded by tundra or tundra-like vegetation which quickly succeeded to closed spruce forest (Shane 1987).

[4] Reconstruction of vegetation in Ohio during the Holocene based on the summary in Mack (2001) following papers by Wright (1968), Geis and Boggess (1968), Delacourt and Delacourt (1981), Webb et al. (1983), Davis (1983), Shane (1987, 1993), COHMAP (1988), Kutzbach and Webb (1991).

12,500 - 8,00 YBP - Early Holocene Age. Conditions in northeast Ohio remained relatively stable during the Early Holocene. The region was dominated by a spruce woodland until the migration of jack, red, and white pine with hemlock into the region around 10,400 BP.[5] The forest that replaced spruce forest was without a modern pollen profile analogue (Webb et al. 1983) and consisted of elm (*Ulmus*), ash (*Fraxinus*) and oak (*Quercus*) as well as some spruce and pine (*Pinus banksiana*, *P. resinosa*) and later white pine (*Pinus strobus*).[6] By the end of this period, the lakes in the Lake Abram/Lake Isaac corridor would have developed marginal bogs similar to those still present at Lake Kelso/Fern Lake Bog (Burton Wetlands) in Geauga County (Mack, personal observation) with a mixture of deciduous forest and pine species occupying upland areas around the wetlands.

8,000 - 4,000 BP - Middle Holocene Age. The Allegheny Plateau and the Till Plains were dominated by a diverse deciduous forest composed of oak, elm, hickory, ash, ironwood, maple, and other deciduous tree species. American beech became a major component of this forest around 7,000 BP (Shane 1987; Odgen 1966). Delacourt and Delacourt (1981) map Ohio as mixed northern hardwood forest in the northern third, and mixed hardwood or oak-hickory in the southern third. It was during this period that prairie, savannah and xeric oak woodland developed in western Ohio during the development of the Prairie Peninsula (Webb et al. 1983). A more boreal flora clung to the lake margins of the Lake Abram/Lake Isaac corridor. *Sphagnum* moss slowly grew and deposited peat in a bog mat into lake waters of kettle lakes in the Lake-to-Lake ecosystem.

4,000-500 BP - Late Holocene. With the gradual reassertion of moist Gulf air and the return of humid summer conditions, prairie and savannah retreated from western Ohio. Ohio pollen profiles show a resurgence of mesic tree pollen percentages and an overall gradual decline of oak and hickory pollen during this period. Overall, the forests of northeast Ohio were moving to the mesic (beech, maple) climax forest. By 500 BP, vegetation in Ohio was likely very close to conditions mapped by Gordon (1966). The Lake Abram/Lake Isaac corridor had become a refugia for a boreal flora similar to that observed at Lake Kelso/Fern Lake Bog in Geauga County (Mack, personal observation). The glacial lakes in the Lake Abram-Lake Isaac corridor had largely filled with peat and muck accumulated over the last 10,000 years and the lakes were shallower with floating wetland plants (pondweeds, water lilies) in open water areas and bog and marsh vegetation in shallower zones. Peripheral areas had become forested with mesic and wetland tree species.

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[5] From 14,000-11,000 BP, the spruce forest was in decline everywhere in Ohio except the glaciated Allegheny Plateau. In the Till Plains, there was brief resurgence in spruce dominance, and a decline in deciduous tree pollen, with the readvance of the ice front in the Two Creeks interval (11,000-10,400 BP) followed by the migration of the pine species (Webb et al. 1983; Shane 1987). Shane (1987) interprets the increase in spruce as a regional temperature reversal in the Till Plains from warmer to cooler and perhaps also moister conditions. In estimating the change in temperature represented by these shifts in vegetation assemblages Shane (1987) states "...an increase from 10% to 30% spruce would represent a cooling of 2 to 3^{o} for July mean temperatures. On the Allegheny Plateau, this proposed temperature decrease allowed maintenance of the spruce populations and the expansion of fir."

[6] Delacourt and Delacourt (1981) map most of Ohio as a "mixed northern hardwoods" assemblage.

1.3 Human interaction with Lake Abram ecosystem

Humans have been interacting with the lakes and wetlands of the Lake-to-Lake Trail ecosystem for thousands of years. Except in the romantic sensibilities of the early landscape painters, there was never any "wilderness" in any historical sense. The first humans to arrive here would have been able to see and hunt the diverse and abundant Pleistocene megafauna of mastodon, mammoth, horse, bison, and camel. The early human cultures managed this landscape, first with fire to encourage oaks and hickories and the valuable protein from acorn and hickory nuts, and then, with the advent of agriculture in North America, by farming the lowland valleys with beans, squash, and corn, exported north, a village at a time, from cultures of Central America and Mexico (Williams 2006).

By 400 years ago, the wetlands in the Lake Abram-Lake Isaac corridor were shallow kettle lakes surrounded by bog vegetation, with wild cranberry, poison sumac, wild blueberry, and perhaps even wild rice in the deeper water. Native Americans would have come here in the fall to harvest these abundant natural foods. Fire management for hunting, gathering, and agriculture by native American peoples during this period has long been suspected as having at least moderate if not strong impacts on the vegetation in eastern North America first observed by Europeans. Recent observed shifts from oak-hickory to maple forests in Ohio and other parts of eastern North America has been attributed to the removal of frequent, low-intensity burning by fire suppression (Delacourt and Delacourt 1997).

The first European explorers and missionaries begin to penetrate the region in the 1600s (Parkman 1999). The lands around Middleburg Township were originally part of the Erie tribal lands but the Five Nations (Mohawk, Oneida, Onondaga, Cayuga, Seneca) destroyed the Erie tribe during the French and Indian Wars (Shaw 1936). Shaw (1936) noted the presence of at least two native American Villages in Middleburg Township with one located at the present location of Berea High School. In 1795, land survey crews led by Seth Pease surveyed Middleburg Township and the Lake Abram area (Township 6, Range 14) (Holzworth 1970) (Figure 3). They observed a large lake surrounded by hundreds of acres of bog, marsh, and swamp forest, and rated the land as low quality because of these characteristics. Holzworth (1970) described the immediate Lake Abram area as,

> …shallow, almost inaccessible…normally covering about 50 to 60 acres, [Lake Abram] lay like a huge saucer without banks when Township 6 Range 14 was surveyed in 1795…the marsh lands surrounding it, a haven for wild fowl, infested with wolves and wild cats…

Holzworth described most of the present day Lake Abram watershed as follows:

> The central and northern portion was flat, low and poorly drained. From its southern line at Strongsville, where marshes and duck ponds existed in the muck lands, then northerly across Fowles Road and Bagley Road, then through Lake Abram and its marshes, [then] following the general direction of the Big Four

> [Conrail] Railroad through Podunk Swamp[7] [present day Holland to Smith Roads in Brook Park] and then into Rock Port Township…was all part of a great swale…

(Figure 4).

In 1805, native Americans give up all claims to land in Middleburg Township (west bank of Cuyahoga River to western boundary of Connecticut Western Reserve lands) in Treaty of Fort Industry, July 4, 1805. Gideon Granger, former postmaster general to Thomas Jefferson, purchased the entire 14,194 acres of Township 6, Range 14 for $26,037 in 1807 (Holzworth 1973). The first settlers followed shortly thereafter. In 1809, Jared Hickox became the first settler on 50 acres north of Bagley Road and southeast of Lake Abram (which was named after his uncle, Abram Hickox (Coates 1924; Holzworth 1970, 1973). Shortly after, Abram Meeks settled on Sheldon Road at the location of the former Middleburg Heights wastewater treatment plant, followed by the Vaughn and Beckett families in 1810 in area of downtown Berea and by Abram and John Fowles in 1811 near present-day Woodvale Cemetery on Fowles Road (Coates 1924). The War of 1812 interrupted settlement for several years, but after the victories of Matthew Perry in Lake Erie and William Henry Harrison in northwest Ohio, settlement resumed and the Scott, Meeker, Lathrop, Watrous and Gardner families settled over the next few years (Coates 1924, Holzworth 1970). By 1815, Coates (1924, p. 123) described the area as follows:

> Near the river [Rocky River] the surface is broken, the balance level. When opened for settlement it was covered with a forest of beech, maple, oak and elm. *About the swamp northeast of [Berea] were groves of hemlock and larch* [probably tamarack, *Larix laricina*]. Into this swamp wolves, panthers, bears, etc., retreated from the rifles of the woodsmen.

Early anthropogenic disturbances would have included clearing of the old growth forest for farmland and establishing roads. Most of the main roads in use today (Bagley, Sheldon, Eastland, Fowles, Pearl were developed very early. One of the first roads in the township was cut diagonally across the section (i.e. across the Lake Abram wetland complex) from Eastland to Sheldon and Engle Roads, but was soon abandoned because of difficulties in crossing the Lake Abram wetlands (Holzworth 1970).

As early as1843, Francis Granger, son of Gideon Granger, had the outlet of Lake Abram deepened. Holzworth (1970, p. 81) states,

> The lake had a shallow outlet leading to the north. In 1843, Francis Granger…had this outlet dug deeper and extended *westward across Eastland Road to lead into a gully or ravine leading to Rocky River*. This reduced the extent of the water coverage and exposed the muck land to aeration and sunshine…What become known as the Lake Abram outlet flowed through a

[7] This large swamp complex (at least as large as the present day Lake Abram complex has been completely filled and drained. It was located northeast of Lake Abram in present day Brook Park from Holland to Smith Roads and parallel to and on either side of Conrail line (former Big Four Railroad) (Figure 4).

> culvert of the L.S. & M.S. Railroad, then through a place called Waddups Gully, *across Grayton and Cedar Point Roads, to empty into Rocky River at the location of the present administration building of the N.A.S.A.*…This was the most beautiful and picturesque little valley in all of Middleburg Township, a countryside full of walnut, butternut, hickory, beech, oak and hemlock trees. In spring, wild flowers bloomed everywhere on the banks. In the freshets of spring time, the river and Lake Abram teemed with fish. But all that has disappeared. *The leveling of the land by the Cleveland Hopkins Airport has filled it in, making that section of Lake Abram outlet a drainage system of culverts*.

(emphasis added). In the same year as the first draining of Lake Abram, W. H. Berwick started the first onion farm in Lake Abram on 51 acres he purchased for $14/acre (Holzworth 1970). Onion farming and land prices for muck lands in Lake Abram and the Podunk swamp area rapidly increased during and after the Civil War (Holzworth 1970). But complaints about flooding began to occur at the same time. The culvert built by the Big Four (Conrail) Railroad across Abram Creek in 1849 was never considered adequate by upstream landowners (Holzworth 1970). In 1875, The County Surveyor and County Commissioners approved the construction of 1.2 miles of main channel (16 feet wide) and 3 miles of lateral channels with the goal of reducing water levels at Lake Abram by 4.5 feet at a cost of $11,000 in order to "...bring considerable valuable land under cultivation which is now useless" (Figure 5).[8] This work was completed in 1876 and "benefited" (drained) 578 acres of land in Lake Abram and the Podunk Swamp area (Holzworth 1970) (Figure 6). By 1878, over 80 acres of land around Lake Abram was devoted to onion and celery farming (Holzworth 1970). However, this was just the beginning of nearly 40 years of complaints and litigation about flooding and improper drainage between farmers, landowners, the railroad and the county that was not resolved until 1915 (Holzworth 1970).

The resolution of this litigation was short lived as the Works Project Administration installed storm sewers in Middleburg Heights in 1935 that discharged to Lake Abram and again exacerbated the flooding of the Lake Abram lowlands (Holzworth 1970). By 1930, onion farming was in decline, muck from Lake Abram was being sold as topsoil (Holzworth 1970) and filling of wetlands to accommodate development and to dispose of municipal waste, foundry sand and other debris began to commence in earnest (Holzworth 1970).

1.4 Recent efforts to preserve the Lake-to-Lake Trail ecosystem

With the decline of farming activities[9] and slow failure of the ditches draining Lake Abram, the wetland character of the Lake-to-Lake Trail ecosystem reasserted itself

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[8] It appears that much of this work was done north of Lake Abram and not in and through Lake Abram as the subsequent litigation and complaints largely focused on the Podunk Swamp area in Brook Park and the restrictions in drainage caused by the Big Four (Conrail) Railroad culvert north of Lake Abram proper (see Holzworth 1970).

[9] The last onion farm run by Henry Grospitch on 15 acres land at 6777 Eastland Road was abandoned in 1971 (Thursday 28 October 1971, The News Sun).

(Figures 7 and 8). Efforts to preserve or protect Lake Abram began in the late 1950s.[10] Efforts accelerated in the 1970s with the establishment of the Lake Abram Advisory Committee and the Citizens for the Conservation of Lake Abram and the involvement of Cleveland Metroparks staff.[11] In 1978, the Middleburg Heights City Council passed a resolution favoring cooperation with Cleveland Metroparks in the preservation of Lake Abram.[12] Baseline scientific information of ecosystem condition began to be collected with Baldwin-Wallace professors leading this effort.[13] Acquisition of Lake Abram began in 1980 when Baldwin-Wallace College acquired 70 acres of land. In 1994, the Board of Commissioners for Cleveland Metroparks approved initial acquisition of the 70 acre tract at Lake Abram from Baldwin-Wallace College[14] with acquisitions continuing north and south of Bagley Road until 2008, when Cleveland Metroparks acquired the northernmost part of Lake Abram (former Middleburg Heights Wastewater treatment plant property) south of Sheldon Road.

1.5 Current and projected population in communities of the ecosystem

The Lake-to-Lake Trail ecosystemis located in the cities of Berea, Brook Park and Middleburg Heights with most of its area in Middleburg Heights and Berea. Total population in all three communities in 1990 was 56,618 with population in Berea, Brook Park and Middleburg Heights 19,051, 22,865 and 14,072, respectively (NOACA 2006). Population in all three communities is expected to decline by 2020 by an average of 13%.[15]

1.6 Existing watershed, TMDL and stormwater management plans

Three existing planning efforts encompass the Abram Creek watershed and the Lake-to-Lake Trail ecosystem: *The Rocky River Watershed Action Plan* (NOACA 2006) (Watershed Plan); *Total Maximum Daily Loads [TMDL] for the Rocky River Basin* (OEPA 2001, 2005) (Rocky River TMDL); and the *Regional Intercommunity Drainage Evaluation (RIDE) Study* (NEORSD 2004) (RIDE Study). Results from the RIDE Study are discussed in Section 3.0 and Results from the Rocky River TMDL are discussed in Section 4.0. The Rocky River Watershed Plan is mostly silent with regards to the upper

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10 In 1958, Harold Wallin, Park Naturalist investigates property owners around Lake Abram for Dr. Myron Owen Davies. Dr. Myron Owen Davies writes Dr. Thomas Surrarrer (Baldwin-Wallace College) and urges him to take on the task of finding public and private funding to preserve Lake Abram. In 1968, Dr. Surrarrer contacts America the Beautiful Fund of the Natural Areas Council for funding to preserve Lake Abram. In 1971, Harold Wallin, Chief Naturalist, to Dr. Thomas Surrarrer indicating that prospects for public ownership of Lake Abram have not improved and enclosied a report on birds recorded in Lake Abram area (unpublished letters in Cleveland Metropark files).

11 Harold Schick, Executive Director, Steven Coles, Chief of Planning, John Kason, Wildlife Manager.

12 From FACT SHEET - April 10, 1978 from Citizens for the Conservation of Lake Abram, in Cleveland Metroparks files.

13 Preliminary Report on Some Ecological Parameters of the Lake Isaac/Lake Abram Areas by Glenn Peterjohn. Unpublished report in Cleveland Metroparks files.

14 Agenda Board of Park Commissioners of the Cleveland Metropolitan Park District, 21 July 1994.

15 Population in 2020: Berea = 18,700 (-2%); Brook Park 17,900 (-22%); Middleburg Heights 12,500 (-15%) (NOACA 2006).

portions of the Abram Creek watershed addressed here. It specifies three main goals for the Rocky River watershed: 1) protect[16] and restore the riparian corridor of the Rocky River mainstem, tributaries and headwater streams[17]; 2) reduce instream bacterial levels[18] to meet state water quality standards and reduce nutrient loadings[19] to meet TMDL targets; and 3) increase public awareness and involvement in the stewardship of the Rocky River (NOACA 2006). Although the Watershed Plan lists multiple problems with the lower (below RM 3.4 at Sheldon Road) portion of the Abram Creek watershed[20], it is largely silent[21] with regards to the areas in the Lake-to-Lake Trail ecosystem except for some general statements

2.0 THE "ECOSYSTEM APPROACH"

The ecosystem concept has been one of the most resilient and useful concepts in the field of ecology (MEA 2006). In general terms, an "ecosystem" can be considered an interconnected community of living things, including humans, and the physical environment in which they interact. More technically, the Millennium Ecosystem Assessment Project (MEA 2006) and Convention on Biodiversity (COB 2000) have defined "ecosystem" as "…a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit" that can vary enormously in size from a small woodland vernal pool to the Great Lakes with humans being integral parts of most ecosystems. In contrast, "ecosystem services" are

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16 Permanently protect mainstem of the East Branch downstream of Hinckley Lake and the entire West Branch of Rocky River and protect all existing vegetated areas through setback requirements.

17 "Maintenance of functioning riparian corridors...is the single most important action that can be taken to maintain water quality...and minimize problems from future development. The goal is to replant or otherwise restore one half of the [disturbed riparian corridor]...and to prevent any additional loss wherever possible and to provide for remediation of any future disturbances that are considered necessary." (NOACA 2006, p. 2)

18 The Plan states (without citation) that "Human contamination is recognized as the most pronounced source of fecal contamination in the Rocky River watershed." The Watershed Plan then states that, although the number of failing septic systems cannot be quantified, the plan adopts a 50% reduction of this unknown number of failing septic systems as an interim target. It also lists a goal of implementing 60 waste management plans at horse farms and livestock facilities.

19 The Watershed Plan adopts the N and P reductions of 468 and 12 tons (English) per year, respectively, specified in the Rocky River TMDL (OEPA 2001)

20 The Rocky River Watershed Action Plan lists the following:
(A) water resource use impairments: 1) fish taste (slightly impaired); fish tumors (not impaired) health fish/wildlife populations (impaired); 2) eutrophication/algae (not impaired); 3) drinking water taste or odor problems (not impaired); 3) swimming/wading (impaired); 4) dredging of sediment (not impaired); 5) microbial flora and fauna (unknown); 6) diverse fish/wildlife habitats (impaired).
(B) Point/Nonpoint sources impairments: 1) point sources (impacted); 2) CSOs (absent); 3) agricultural runoff (not an issue); 4) urban runoff (major); 5) septic systems (moderate); 6) wildlife wastes (present).
(C) Water quality problem causes: 1) nitrogen loadings (high); 2) organic enrichment/DO (high); 3) habitat modifications (high); 4) bacteria/pathogens (moderate); 5) toxic chemicals (high).
(D) TMDL causes of concern: 1) nitrogen loadings; 2) organic enrichment/DO; 3) habitat modifications; 4) bacteria/pathogens; 5) toxic chemicals (NOACA 2006).

21 "Numerous large wetlands located within the confines of the Metropark systems in the watershed are well protected and are functioning well...Lake Abram has a long-standing problem with discharges from failing home sewage disposal systems, but that problem is being addressed..."

> …the benefits that people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits.

The concept of an ecosystem then provides a framework for making decisions that reorients the traditional boundaries (e.g. political, disciplinary (wildlife management, forestry), geographic, etc.) for making resource management decisions that take into account the entire system and not just some of the component parts. This ecosystem-based decision-making framework is called the "ecosystem approach" and is defined as

> …a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way…[that] is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions, and interactions among organisms and their environment…Humans, with their cultural diversity, are an integral component of many ecosystems.

In some respects, the ecosystem approach is similar to various "watershed approaches" to aquatic ecosystem conservation and restoration (e.g. USEPA 1995) but the ecosystem approach has a broader framework, better theoretical underpinnings in the literature of conservation biology and landscape and restoration ecology, does not distinguish between terrestrial and aquatic ecosystems and places human needs, choices and effects on natural ecosystems at the center of the approach.

The Convention on Biodiversity (COB 2000) outlines 12 principles when implementing an ecosystem-level approach: 1) the objectives of management of land, water and living resources are a matter of societal choice; 2) management should be decentralized to the lowest appropriate level; 3) ecosystem managers should consider the effects (actual and potential) of their activities on adjacent and other ecosystems; 4) ecosystem management and understanding needs to occur within an economic context in order to reduce market distortions that adversely affect biodiversity, align incentives to promote biodiversity and internalize costs and benefits; 5) conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach; 6) ecosystems must be managed within the limits of their functioning; 7) the ecosystem approach should be undertaken at the appropriate spatial and temporal scales; 8) recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term; 9) management must recognize that change is inevitable; 10) the ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity; 11) the ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices; and 12) the ecosystem approach should involve all relevant sectors of society and scientific disciplines.

In addition to these general principles, the COB (2000) proposed operational guidance for implementing an ecosystem approach. First, focus on the functional relationships and processes with ecosystems (the movement of water, energy, and nutrients as mediated by the living biota) but recognize that ecosystem management may need to be carried out with insufficient or incomplete understanding of these processes. Second, maintain and restore the benefits humans derive from the ecosystems in which they live. Third, because of their complexity and variability, ecosystem management must involve a learning process. Management programs should be flexible and designed to adjust to the unexpected. Fourth, management actions should be undertaken at the scale appropriate for the issue being addressed with decentralization to and empowerment of the relevant stakeholders to assume responsibility and taken action for the decision.

Although landscape ecology, conservation biology and restoration ecology have produced a large body literature, much of this ecological knowledge never gets translated to on-the-ground management decisions (Lindenmayer et al. 2007; Dale et al. 2000). Recent efforts to place the concepts, principles and results from these disciplines into a practical decision-making framework have identified several broad ecological themes that should be considered.[22] Lindenmayer et al. (2007, p. 8) provide a non-prescriptive "...checklist factors to be considered by people managing landscapes for conservation...[which can be] formulated as a set of hypotheses more specific to a particular set of circumstances." Their checklist is summarized below (Lindenmayer et al. 2007, pgs. 9-11):

1. *Develop long-term shared visions and quantifiable objectives*. "Much conservation is undertaken without consideration of goals or whether goals are achievable given ecological, social and economic constraints. Ecologists and resource managers have been poor at problem definition and objective setting. Clear objectives need to be derived from a broad vision of what people want from landscapes in the future..."

2. *Manage the entire mosaic, not just the pieces*. "Patch-based management is still the norm, but this approach ignores flows of biota, water and nutrients as well as interactions among elements of the mosaic. A single patch can be subject to state-of-the-art conservation, but that management can fail if the surrounding landscape continues to degrade...Hence patches need to be assessed and managed within the context of landscape mosaics and the entire landscape."

3. *Consider both the amount and configuration of habitat and particular land cover types*. "...the amount of habitat remaining in an area is often the most important factor determining persistence of biota in many (but certainly not all) landscapes. It also can influence ecological processes such as erosion rates and nutrient losses. Habitat configuration is often less important until levels become low...threshold effects and

[22] Lindenmayer et al. (2007) list six broad, interrelated themes in landscape ecology, conservation biology and restoration ecology: landscape classification; habitat amount, amount of land cover, patch sizes and mosaics; structure and condition; connectivity; the significance of edges; disturbance, resilience and recovery.

regime shifts are also hypothesized to be more likely [when habitat amounts become low]."

4. *Identify disproportionately important species, processes and landscape elements.* "Some landscape elements may be disproportionately important because of their provision of key resources...or for their spatial context in enhancing connectivity and gene flow. Researchers need to develop approaches to better identify key landscape elements and species and assist with their proactive management."

5. *Integrate aquatic and terrestrial environments.* "Terrestrial and aquatic elements of landscapes are closely interlinked, although management practices and institutional arrangements rarely reflect this interconnectedness...Catchment or watershed-level management will usually be essential to better integrate the conservation of aquatic and terrestrial environments."

6. *Use a landscape classification and conceptual models appropriate to objectives*. "Landscape classification is critical because it can significantly affect where and what conservation or other investments are made. This, together with interrelationships between landscape classification, landscape models and other themes means the selection of a landscape model for addressing a particular objective or problem needs much deeper thought than is widely recognized."

7. *Maintain the capability of the landscapes to recover from disturbance*. "It is important to maintain the potential for a landscape to recover from disturbance. This includes maintaining processes and flows and the ability of biota in a landscape to cope with extreme events (e.g. floods and droughts)....An objective should be to quantify differences between natural and human disturbance regimes and, in turn, to find ways of creating human disturbance regimes more similar (rather than identical)to naturally occurring ones."

8. *Manage for change*. ",,,conservation often aims at stasis and assumes an equilibrium state for natural systems [even though] landscapes are dynamic and may become more so with future climate variability...Failure to acknowledge the dynamic nature of systems will inevitably result in unexpected change and unachieved conservation goals...[land managers] should plan to accommodate successional dynamics, spatial and temporal mosaics, colonization and processes, and likely shifts associated with climate change. Developing this capacity is complicated by the institutional tendency to ignore potential problems until they become critical, only then instigating crisis management. There is there a need to develop a capacity to embrace preventative management."

9. *Time lags between events and consequences are inevitable*. [The existence of time lags between events and consequences]...applies to attempts to restore damaged systems as well as to the adverse effects of human activities...[We] need to develop approaches to better predict time lags and anticipate circumstances where they might be

appropriate...[and]...methods to reduce time lags (e.g. creative thinning of replanted forests to promote structural diversity of vegetation cover..."

10. *Manage in an experimental framework*. "Because of contingency, lack of knowledge of biotic responses and complex system dynamics, there is always significant uncertainty associated with landscape management...It is crucial not to do the same thing everywhere so that we can limit the risk of making the same mistake everywhere. If we treat the variety of management options as adaptive management experiments, we can continuously improve ecosystem understanding. This involves careful consideration of experimental design and the implementation of monitoring programmes to ensure that the power of the results is maximized."

11. *Manage both species and ecosystems*. Single-species and ecosystem conservation are not competing approaches. Rather, a range of conservation strategies will nearly always be required: some focused on individual species, others on suites of species and yet others on entire landscapes or ecosystems..."

12. *Manage at multiple scales*. "...there is no single or 'right' or 'sufficient' scale for conservation and resource management. A single strategy adopted at a single scale will meet only a limited number of goals....Multiple management scales are needed because there are multiple ecological scales, not only for different ecological processes and different species, but also for the same species..."

13. *Allow for contingency*. "Broad considerations are contingent and must be considered in the context of conservation goals, landscape type and spatial and temporarly scale. No single set of 'rules' applies everywhere. Instead there is a set of contingent (specific) principles that depend on context, conditions, species assemblages, processes and other factors. They will be most useful when coupled with a deep knowledge and understanding of a given landscape. There is an increasing number of examples where checklists and other approaches have facilitated the translation of broad considerations into useful on-the-ground management."

3.0 KEY DEFINITIONS

Several terms are commonly used in this plan. These terms have specialized meanings that can differ from common understandings:

Condition. In this plan, the term "condition" is frequently used in phrases like "The condition of the ecosystem is..." or "The ecological condition of the wetlands are..." etc. Condition is used in the sense of the state of an ecosystem being in good or poor ecological condition, i.e. ecological health or biological integrity. To the extent, the resource is a wetland or stream the concept relates to the aquatic life use designations, e.g. "good" condition is equivalent to a stream/wetland capable of supporting and maintaining a balanced, integrated, adaptive community of flora or fauna with a species composition, diversity and functional organization comparable to a similarly situated natural system.

Ecosystem. The term ecosystem is defined as a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit that can vary enormously in size from a small woodland vernal pool to the Great Lakes. Human beings are integral parts of ecosystems (MEA 2006).

Disturbance. Events (natural or human-induced) which cause a perturbation in pre-existing ecosystem structure or function. Disturbances which exceed the capacity of the ecosystem to recover from them are often termed stressors, threats, exogeneous disturbances, anthropogenic disturbances, etc.

Function. Although loaded with divergent uses, as used in this plan "function" refers value-neutral ecosystem processes like evapotranspiration or N mineralization. Function refers to relatively short term ecosystem *processes* (transformations, flows, etc.), as opposed to more fixed or stable ecosystem components like the trees in a forest (*See* structure).

Management. Intentional human activities for the purpose of changing ecosystem structure or function to benefit human society, or a natural ecosystem, or both.

Scale. A concept in ecology (and other natural science disciplines) that relates to moving from the very small to the small to the medium to the large to the very large in relation to time (e.g. years, decades, millennia) or size (length, area, volume). Ecosystem processes can occur at multiple temporal and physical scales simultaneously.

Services (*also referred to as "ecosystem services" or "ecological services").* Services are the benefits that people obtain from ecosystems and include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits (MEA 2007).

Structure. Generally is the converse of "function;" structure refers to relatively stable (physically, temporally) biological or physical features of an ecosystem, that often can be repeatedly measured for the purpose of deriving or calculating indices of biotic integrity.

4.0 ABRAM CREEK WATERSHED CHARACTERISTICS

4.1 Watershed Description

The Lake Abram watershed is 10.6 mi^2 (6,787 acres) in size and is the lowermost major tributary to Rocky River[23]. The mainstem of Abram Creek is 7.4 miles long. Topographically, it is a relatively steep watershed with an average slope of 1.9% (29.4 ft/mile). The maximum elevation in the watershed is 872 ft (at its southeast end in Middleburg Heights); the minimum elevation is 642 ft (at confluence with Rocky River in Cleveland) (NEORSD 2004) (Figure 8). Soils in the watershed are relatively low infiltration C (slowly drained clay loam, sandy loams) and D (poorly drained clays) soils (27% C soils, 71% D soils) (NEORSD 2004).[24] The Regional Intercommunity Drainage Evaluate (RIDE) Study (NEORSD 2004) divided the watershed into 5 main segments. The Main Branch of Abram Creek extends south from its confluence with Rocky River through Cleveland and Brook Park to Sheldon Road, then to Bagley Road, then to Engle Road, then across Interstate 71, then north along Big Creek Parkway (Figure 9). The upper part of the Main Branch (east and north of Engle Road) is characterized by moderately sloping terrain (NEORSD 2004). The middle reach of the Main Branch is a series of wetland areas (Lake Abram and Fowles Road wetland complex) with very low topographic relief (Figure 9). North of Sheldon Road, Abram Creek becomes a more typical stream again with the depth and slope of the stream banks gradually increasing until the creek is located in a deep gorge when it enters Rocky River (NEORSD 2004).

Other than the East Branch, the "branches" of Abram Creek area relatively short (Figure 9). The East Branch includes the former “Poudunk Swamp” area. This former wetland area has been completely filled and water courses in this are mostly culverted. The East Branch enters the Abram Creek Main Branch south of Leslie Drive, a little north of Sheldon Road (Figure 9)[25]. The North Branch is a short section of open channel in Brook Park located north of Holland Road that enters the Abram Creek Main Branch near the Hayes Industrial Park (Figure 9). The Southwest Branch is as short section of open channel and culvert located mostly between Old Oak Boulevard and Bagley Road that enters the Main Branch north of Bagley Road (Figure 9). The south branch is a short section of open channel and culver located north of Sheldon and east of Grayton Roads (Figure 9). Finally, the West Branch is a section of open channel that drains areas west of Eastland Road in the First Avenue area of Middleburg Heights and Brook Park (Figure 9).

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[23] The Rocky River watershed (294 mi^2) is located between the Cuyahoga and Black River watersheds. The headwaters for the Rocky River are located in Medina and Summit Counties, in East and West Branches. Average discharge from Rocky River is 285 ft^3/second, with a maximum measured flow of 21,400 ft^3/second in 1959 and minimum flow of 0.2 ft^3/second in 1932 (OEPA 1999). Average flow from July-October 1997 was 484 ft^3/second.

[24] "C" soils have maximum (dry or initial) infiltration of 2 in/hr and minimum (wet or final) infiltration of 0.1 in/hr; "D" soils have maximum (dry or initial infiltration of 1 in/hr and minimum (wet or final) infiltration of 0.05 in/hr.

[25] The East Branch upstream of Smith Road in Middleburg Heights as an open channel. As flow enters Brook Park it enters a culvert at Smith and Sheldon Roads where it is conveyed through a series of storm sewers along Edgehurst and Birchcroft Drives and Frye and Holland Roads until it empties into an open channel west of Claudia drive.

4.2 Watershed Development

More than three-fourths of the watershed is developed (76%), with 44% of developed area "medium-intensity residential (NEORSD 2004)[26]. The remaining developed area (32%) is commercial, industrial or institutional development with over one-third of this area associated with the Cleveland-Hopkins Airport/IX Center area (NEORSD 2004). Of the undeveloped area, 14% is classified as forest, 2% as agriculture, 6% as grassland/open space and 1% wetland (NEORSD 2004). Although clearly not pristine in character prior to 1950, most of the intensification of development in the watershed has occurred since 1950 (Figure 10).

4.3 Sewersheds of Abram Creek Watershed

According to the Ride Study, the Abram Creek Watershed provides intercommunity storm water drainage[27] to Berea, Brook Park, Cleveland and Middleburg Heights, although the majority of the watershed lies within Brook Park and Middleburg Heights (NEORSD 2004) (Figure 11). Of the 12.2 miles of total intercommunity drainage area in the watershed, 8.1 miles (70%) is in open channels with the remainder culverted[28] (NEORSD 2004). Most of the sewer system is "separate trench" without detention (76%) with the remainder "separate trench with detention" (NEORSD 2004).[29] The Ride Study mapped 45 subcatchment "sewersheds" of 300 acres or less in the Abram Creek Watershed (Figure 11).

5.0 IMPLEMENTING THE ECOSYSTEM APPROACH

The ecosystem approach to management and restoration (MEA 2007, COB 2000, IEMT 1995) stresses the central, if not pivotal, role that the human species has played, and is playing, in world ecosystems. The Lake-to-Lake Trail ecosystem presents an excellent opportunity to evaluate the relationship between the utilization of ecosystem services (functions and values) and the maintenance and restoration of ecosystem health. This will entail putting the concepts outlined in Lindenmayer et al. (2007), the Convention of Biodiversity (COB 2000) and the Millennium Ecosystem Assessment (MEA 2007) onto-the-ground in a long-term ecosystem management program. Synthesizing the key principles from Lindenmayer et al. (2007) and COB (2000), an ecosystem approach for the Lake-to-Lake Trail ecosystem should:

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[26] Land cover percentages were based on 2001 Landsat 7 imagery and orthophotographs from Cuyahoga County (NEORSD 2004).

[27] “Intercommunity drainage” is drainage that crosses between two communities. The RIDE study also evaluates “intracommunity drainage” to some extent.

[28] About one-third of the culverted mileage is associated with the culvert installed as part of the Cleveland-Hopkins airport runway extension.

[29] Storm water sewers and sanitary sewers not connected and located in separate trenches. Separate sewers in the same trench or combined sewers are nearly absent from the watershed.

1. Develop long-term shared goals and quantifiable objectives. These goals and objectives for the management of land, water and living resources are a matter of societal choice and should seek the appropriate balance between conservation and use of biological diversity (Section 5.1).

2. Be undertaken at spatial and temporal scales appropriate for the issue(s) being addressed (Section 5.2).

3. Identify disproportionately important species, processes and landscape elements (Section 5.3).

4. Maintain and improve the benefits humans derive from the ecosystems in which they live by conserving and restoring ecosystem structure and function (Section 5.4).

5. Be a learning process because of the complexity and variability of ecosystems. This involves careful consideration of experimental design and the implementation of monitoring programs to ensure that the power of the results is maximized (Section 5.5).

6. Recognize that ecosystem management needs to be data-driven but also may need to be carried out with insufficient or incomplete understanding of functional relationships and processes within the ecosystem (Section 6.1).

8. Integrate aquatic and terrestrial ecosystems, manage both species and ecosystems, and manage the entire system, not just pieces of the system (Section 6.2).

9. Recognize that time lags between events and consequences are inevitable. Therefore, management should expect the unexpected, be flexible and be set for the long term (Section 6.3).

10. Be decentralized to the lowest appropriate level and should involve all relevant sectors of society and scientific disciplines (Section 6.4).

11. Have quantitative measures of success (performance) to determine whether the goals and objectives are being attained (Section 7.1).

12. Occur within an economic context in order to reduce market distortions that adversely affect biodiversity, align incentives to promote biodiversity and internalize costs and benefits (Section 8.0).

These principles are used in the rest of this plan as an operational framework for implementing ecosystem-level improvement of conditions and services.

5.1 The ecosystem approach should develop long-term shared goals and quantifiable objectives. These goals and objectives for the management of land, water and *living resources are a matter of societal choice and should seek the appropriate balance between conservation and use of biological diversity*

This plan proposes several long-term goals for the Lake-to-Lake Trail Ecosystem: 1) restore the extent of lake areas characteristic of the ecosystem ca 1840, 2) increase bird habitat for wetland-dependent bird species and neotropical songbirds, 3) restore a hydrologic regime characteristic of good quality headwater wetlands, 4) maintain of flood storage/detention and water quality improvement services, and 5) restore overall wetland ecological condition to good levels. Adoption and subsequent implementation of these goals will require discussion and evaluation and ultimately commitment from the communities and organizations with a stake in the decisions and changes in the watershed.

This development of "shared goals" that "are a matter of societal" is at least or more complicated than any of the scientific issues presented in this version of the Ecosystem Management Plan. While there a some management activities that can be undertaken by Cleveland Metroparks in its role as land manager of its holdings in the Lake-to-Lake Trail Ecosystem, to realize the larger goals of this plan will require the involvement and commitment of the citizenry and communities of the Lake-to-Lake Trail ecosystem.

5.2 The ecosystem approach should be decentralized to the lowest appropriate level(s) and should involve all relevant sectors of society and scientific disciplines

Finalization and implementation of this plan will require coordination with and involvement of multiple governmental entities and organizations. Because Cleveland Metroparks is the owner of the core of the remaining wetland areas in the ecosystem, and because most of the ecosystem boundary is located within the City of Middleburg Heights it is expected that implementation of this plan will require commitment and coordination from both entities. Other organizations with a substantial stake in ecosystem approach for the Lake-to-Lake Trail ecosystem are the Northeast Ohio Regional Sewer District, the Cities of Berea, Cleveland, and Brookpark, the Cuyahoga Planning Commmission, Soil and Water Conservation District and Board of Health, the Rocky River Watershed Council, and the Ohio Environmental Protection Agency.

5.3 The ecosystem approach should be undertaken at spatial and temporal scales appropriate for the issue(s) being addressed

The ecosystem boundary for this plan was determined by landscape and pragmatic considerations: upper Abram Creek is dominated by wetlands, whereas lower Abram is dominated by a stream ecosystem; the geology, soils and glacial genesis and primary ecological forcing factors are similar throughout the ecosystem boundary; most of the ecosystem is located within a single political jurisdiction (Middleburg Heights); the core of the remaining natural part of the ecosystem is owned by Cleveland Metroparks (although additional natural lands could be preserved); and the size of the ecosystem presents a manageable area within which to undertake ecosystem management activities.

For the purposes of this plan, the ecosystem boundary of the Lake-to-Lake Trail Ecosystem is defined as the 22 sewersheds mapped by the RIDE study (Table 3; Figure 12). This is the southern (primarily wetland) part of the Abram Creek watershed and is approximately bounded by the railroad line east of I71, Eastland Road/Old Oak Road to the west, Sheldon Road to the north, Fowles Road to the south, and areas along Big Creek Parkway (Figure 12). The ecosystem includes the Lake Abram wetland as well as what is often termed the Fowles Road Wetland south of Bagley Road (Figure 12). Total acreage is 3,111 acres (4.86 mi^2) or 45.8% of the entire Abram Creek watershed.[30] The mean, minimum, and maximum sewershed size is 147, 63, and 578 acres, respectively, with 50% of the sewersheds between 85 and 179 acres in size (NEORSD 2004). Land use within these sewersheds is 76.0% developed, 20% forest, 0.5% wetland, 2.6% agriculture and 0.9% other (Table 3). These are nearly the same as land use percentages for the entire watershed. However, the wetland estimate in NEORSD (2004) is a gross underestimate. Circa 1980, there was nearly 300 acres of mapped hydric soils and nearly 200 acres of that was still present in 2008 (Table 4; Figure 13).

5.4 The ecosystem approach should identify disproportionately important species, processes and landscape elements

The following elements of the Lake-to-Lake Trail ecosystem are identified as being disproportionately important relative to other ecosystem elements:

5.4.1 Wetlands

The wetland complex associated with Lake Abram, north and south of Bagley Road, is the largest remaining contiguous wetland in Cuyahoga County and the only remaining example of the type of bog/kettle lake/headwater riverine wetland complexes that can still be observed in counties with less urban development to the east. The wetlands in the ecosystem, and their associated upland forests, also represent the largest contiguous block of natural habitat remaining in the ecosystem (Figure 13).

Because of its size, the wetland complex has significant flood storage and detention services that it provides to the surrounding communities. Circa 1980, there were approximately 297 acres of mapped hydric soils in the ecosystem. By 2008, approximately 182 acres remains (Table 3; Figure 13). Gamble et al. (2007) estimated that riverine wetlands have an average depth of 2.6 feet, can hold approximately 246,472 gallons per acre of wetland, and turn over this amount of water 4.1 times per year, primarily due to evapotranspirative removal of water from the hydrologic network. Flood storage/detention capacity ca1980 was approximatey 300 million gallons; ca 2008 capacity was approximate 180 million gallons or an approximately 40% reduction in wetland flood storage/detention service (Table3).

Preserving the present and future worth of this natural storm water infrastructure is critical. In addition, as the largest contiguous green space, in the nearby communities,

[30] The area of Abram Creek north of Sheldon Road is excluded since Abram Creek changes from a predominately wetland ecosystem to a predominately stream ecosystem at this point; the East Branch area is excluded because the Poudunk Swamp wetlands have been completely destroyed, most of the East Branch is culverted.

Table 3. Sewershed size and land use percentages for 22 sewersheds within the Lake-to-Lake Trail ecosystem boundary (3,111 acres, 4.86 mi^2. Data from NEORSD (2004). Refer to Figure 12 for sewershed map.

sub-catchment	acres	residential	commercial industrial institutional	agri-culture	forest	wetland	other
SB-210	66	6	89	0	2	4	0
SB-220	96	27	70	0	3	0	0
SB-250	86	19	43	4	34	0	0
SB-260	103	8	18	0	65	7	8
SB-265	91	43	44	0	12	0	0
SB-270	117	21	53	0	25	0	0
SB-280	143	76	5	15	2	0	1
SB-290	92	69	3	6	22	0	0
SB-300	182	59	9	8	24	0	0
SB-310	102	6	40	0	55	0	0
SB-320	117	15	60	0	23	0	2
SB-330	78	29	52	0	17	0	2
SB-340	244	70	14	0	15	1	0
SB-350	578	76	22	0	2	0	0
SB-360	299	55	17	11	15	0	0
SB-370	69	15	76	0	9	0	0
SB-380	80	17	57	0	26	0	0
SB-390	210	23	19	4	54	0	0
SB-410	63	39	14	10	30	0	7
SB-420	178	86	9	0	5	0	0
SB-425	117	79	20	0	0	0	0
new150	115	65	36	0	0	0	0
average	146.6	41.0%	35.0%	2.6%	20.0%	0.5%	0.9%

Table 4. Mapped hydric soil units in ecosystem boundary (SWS 1980). Units are numbered on Figure 13. * based on visual estimates of aerial photos.

no.	mapped hydric soil unit	acres of hydric soils ca1980	location	status ca2008	% remaining*	acres of hydric soils ca2008
1	Condit	5.44	Poudunk swamp (Brook Park) area	filled	0%	0.00
2	Condit	7.27	Lake Abram area	partially filled	90%	6.54
3	Carlisle	7.4	Lake Abram area	filled	20%	1.48
4	Condit	2.5	Lake Abram area	filled	0%	0.00
5	Canadice	16.65	Lake Abram area	partially filled	60%	9.99
6	Water	5.77	Lake Abram area	present	100%	5.77
7	Carlisle	107.47	Lake Abram area	partially filled	85%	91.35
8	Canadice	37.53	Lake Abram area	partially filled	40%	15.01
9	Sebring	8.08	Lake Abram area	partially filled	40%	3.23
10	Carlisle	4.12	Fowles wetland	filled	0%	0.00
11	Carlisle	3.94	Fowles wetland	partially filled	90%	3.55
12	Carlisle	29.05	Fowles wetland	present	100%	29.05
13	Sebring	26.47	Fowles wetland	partially filled	10%	2.65
14	Condit	22.86	upper watershed	partially filled	40%	9.14
15	Condit	4.88	upper watershed	partially filled	50%	2.44
16	Condit	5.85	upper watershed	partially filled	30%	1.76
17	Condit	1.83	upper watershed	filled	0%	0.00
	TOTAL	297				182
	average depth*	2.6				
	average gals/acre*	246,472				
	flood detention	73,202,184				44,857,904
	average turnover*	4.1				
	annual storage (gals)	300,128,954				183,917,406
	%loss	39%				

the wetland complex and its associated forests could with the completion of the Lake-to-Lake Trail begin to provide significant recreational-health-aesthetic services.

5.4.2 Hydrologic processes

Given the high urbanization and its associated storm water and nonpoint source pollution effects on the aquatic resource, and the dominant place wetlands hold in the ecosystem, hydrologic processes are a, if not the, primary ecological forcing factor on the condition, services, and long term health and survival of the ecosystem. Understanding, quantifying and restoring a positive hydrodynamics to the ecosystem will be necessary effect most of the goals and objectives outlined in this plan. Restoring the "lake" part of the Lake Abram wetland complex will essentially be a problem of hydrologic restoration.

5.4.3 Birds

The Lake Abram wetland complex could become a birding mecca. Grame (1984) documented numerous resident and migratory birds species at Lake Abram. With the re-creation of the lakes that were once present, hydrologic restoration, control of invasive plants and restoration of a native, diverse wetland plant community, the bird viewing opportunities from the Lake-to-Lake Trail would be spectacular. Waterfowl and wading bird habitats, habitats for wetland songbirds and migratory resting and feeding in the woodlands around the complex by neotropical songbirds will all by significantly improved the activities outlined in this plan. Recreational activities like bird watching have a significant, documented economic impact on the surrounding communities (e.g. La Rouche 2001).

5.4.4 Invasive plants

Upland and wetland invasive plants constitute the most obvious biological threat to condition and services of the ecosystem. The dominant presence of invasive plant species in the ecosystem is attributable to the cumulative effects of 150 years of exploitive land uses and neglect. In addition, other more subtle problems may be masked until invasive plants are controlled. Invasive plants affect the existing and future services and economic benefits that could be derived from the ecosystem. Narrow-leaved cattail and *Phragmites* stands restrict wildlife viewing and reduce the habitat quality and diversity to bird habitats. Invasive plants alter ecosystem processes in upland and wetland habitats and cause changes or declines to native fauna and flora.

5.4.5 Deer

Deer were largely extirpated from Ohio ca1900 (ODNR 2004). Reintroduction efforts were undertaken by the Ohio Department of Natural Resources (Ohio DNR) in the 1920 and 1930s. Current population estimates of white-tailed deer (*Odocoileus virginiana*) are approximately 600,000 deer statewide (ODNR 2006). Human beings in the form of hunters and deer-vehicle collisions are the main population control, other than density-dependent factors like starvation, parasites and disease (DeNicola et al. 2000).

While a natural part of the fauna of pre-settlement Ohio landscapes, landscape fragmentation and lack of natural predators has resulted in a explosion of deer populations in Ohio. There is an extensive network of deer trails between Sheldon and Fowles Road and casual encounters with multiple deer during day light hours are common (Mack, personal observation). Upland forest habitats appear to be heavily impacted by deer-browse throughout the ecosystem. Economic losses from deer-vehicle collisions and from deer browse of urban landscaping are likely moderate to high. Restoration of good condition upland forest habitats with active reproduction of tree species, the presence of subcanopy and herbaceous plant assemblages characteristic of healthy forests, and the micro- and macro-faunal assemblages they support is likely to require active management of deer in the ecosystem.

5.6 Maintain and improve the benefits humans derive from the ecosystems in which they live (services) by conserving and restoring ecosystem structure and function

Natural ecosystems in good (sustainable) condition provide free (or relatively low-cost) infrastructure to support human activities in the ecosystem. Replacing natural infrastructure with human engineered infrastructure requires a large initial development investment and perpetual repair and replacement costs from human society. Conserving and restoring natural ecosystem structure and function represents a cost-effective way to maintain and improve the benefits humans derive from the ecosystems they inhabit.

While nearly self-apparent from the perspective of ecology (i.e. healthy, functioning ecosystems provide the services for a healthy, functioning human society), this paradigm is not intuitively apparent in human-dominated landscapes where issues related to the day-to-day repair and maintenance of the engineered infrastructure (e.g. water, wastewater, transportation, energy, habitation) that supports our present society) appear largely divorced from natural ecosystem processes.

The ecosystem approach and this plan have as a major goal the maintenance and improvement of benefits to human society. Conserving and restoring ecosystem function and structure is a primary way to accomplish this goal. The rest of this section outlines present condition and services, threats to condition and services, and monitoring and assessment to evaluate the improvement of condition and services.

5.5.1 Present condition of the ecosystem

In 1809, when Jared Hickox arrived at his 50 acres on Hepburn Road, the Lake-to-Lake Trail ecosystem was a predominately old growth deciduous forest with a large kettle lake wetland complex embedded in its center (Gordon 1966, 1969). It is clearly not the goal or objective of this plan to somehow regain this pre-settlement landscape. The decisions or needs which resulted in the use, inhabitation or development of this landscape since 1809 may be questioned but in many respects cannot be undone.

The present extent (quantity of wetlands in the ecosystem can be approximated by evaluating the acreage of mapped hydric soils. Of the 3,111 acres in the ecosystem, 297 acres (9.5%) are presently mapped as hydric soils (SCS 1980) (Table 4; Figure 13). Somewhat poorly drained Mahoning soils dominate the rest of the ecosystem area (Figure 2). Mahoning map units include small areas of Condit soils (hydric) and Haskins and

Mitiwanga soils (non-hydric), and these inclusions can make up 15% of mapped Mahoning units (SCS 1980 It is clear that large areas of hydric soils were filled or drained prior to completing the soil survey for the county and the areas of mapped soils would be doubled or more (Figure 13). A conservative estimate of wetland area ca 1800 would be 500-1000 acres or 15 to 30 percent of the ecosystem area. In 2008, proportions of natural upland versus natural wetland habitats have reversed, with the core of the ecosystem wetland complex surviving and upland forests present as discontinuous fragmented stands of trees constituting no more than 20% of the ecosystem (NEORSD 2004), with the largest forests occupying the margins of the Lake Abram/Fowles Road Wetlands.

Inventory and evaluation of stream habitats within the Lake-to-Lake Trail ecosystem is more problematic than evaluating wetland habitats. Mainstem stream habitats characterized by riffles and pools were probably absent *south* of Sheldon Road ca 1840.[31] Other wetland complexes in similar headwater landscape positions in Northeast Ohio are characterized by braided, beaver-influenced "wetland" streams (Mack, personal observation). Inspection of the earlier topographic maps (Figure 10), shows what appear to be primary headwater streams flowing into the area of the wetland complexes north and south of Bagley Road. Since settlement, "stream" segments of Abram Creek along Big Creek Parkway, east and west of Engle Road, and north and south of Bagley have developed due to channelization activities and increased flows and are probably not "natural" riffle-pool streams. All of these segments have been filled, moved, channelized or culverted,. Use of fish and invertebrate IBIs (Index of Biotic Integrity) calibrated to mainstem streams to assess these short channels is questionable, since channels would not be here absent human activities in the past 200 years.

All of the stream studies in Abram Creek conducted by the Ohio Environmental Protection Agency (Ohio EPA) have occurred downstream (north) of Sheldon Road and outside of the Lake-to-Lake Trail ecosystem boundary. All of these studies have documented serious aquatic ecosystem degradation (OEPA 1993, 1999, 2001). Ohio EPA considers Abram Creek "…the most degraded tributary to the Rocky River [due to] habitat modifications, urban stormwater impacts, septic system discharges, and point source discharges of pollutants…" (OEPA 2001, p. 32)[32]. But, these assessments have

[31] North of Sheldon Road, Abram Creek loses its wetland character and becomes a more typical "stream" with bedrock (shale) substrates.

[32] From River Mile 0.0 to River Mile 3.4 (~Sheldon Road), Abram Creek is listed as nonattainment using both fish IBI and invertebrate ICI (Invertebrate Community Index), although habitat assessments indicate Warmwater Habitat could be attained (OEPA 1993, 1999, 2001). Fish community results were very poor with IBI scores of 12 to 16 between River Miles 0.6 to 3.4; invertebrate community results were 18 to 26 (fair condition) over the same reach (OEPA 1999).[32] Retirement of Brook Park and Middleburg Heights wastewater treatment plants that discharged to Abram Creek in 1993 was expected to result in significant improvements in water quality and stream biology (OEPA 1993), but these discharges were subsequently determined to be masking significant nitrogen, glycol and stormwater inputs from Cleveland Hopkins Airport that were entering Rocky River and Abram via outfalls from the NASA Lewis Research Center (OEPA 1999). Control of these discharges, especially extremely elevated N (from urea in de-icing operations), has been the subject of several state and federal administrative and judicial orders since 1987 (OEPA 1999). Approximately 5400 ft of lower Abram Creek was buried in a 10 ft culvert to accommodate the expansion of Cleveland Hopkins Airport. Elevated levels (3200-18000) of fecal coliform bacteria in Abram Creek (RM 3.91 to 0.84) were also observed by Ohio EPA (OEPA 1999). There are 529 home sewage disposal systems (HSTs) in Abram Creek Watershed: Berea (19), Middleburg Heights (320) and

focused on the stream ecosystems of lower Abram Creek. The upper (wetland) portion of the watershed was first mentioned in Ohio EPA's 2001 TMDL Report (OEPA 2001). It recognized that "…ecologically important wetland areas continue to exist, such as the wetland complex surrounding Lake Abram…" (OEPA 2001, p. 32). That report concluded that the stream segments in the lower portion of Abram Creek watershed[33] (below Sheldon Road) had higher restoration potential than segments upstream of Sheldon Road (OEPA 1999). These reports did not assess the restorability of the wetland ecosystems that predominate in the upper part of the watershed.

The only wetland studies performed by Ohio EPA upstream of Sheldon Road were performed in 2001-2002, when hydrology, vegetation, macroinvertebrates and amphibians in the Lake Abram wetland were assessed as part of a larger study of natural and mitigation wetlands (Fennessy et al. 2004). An automated water level recorder was installed near the south end of the present Lake Abram open water area in 2001-2002 and documented an extremely flashy hydrological clearly influenced by storm water inputs (Figure 14). Lake Abram had the greatest single day change in water levels (79.2 cm) and the highest flashiness index score (4.2) of any natural wetland site in the study (Fennessy et al. 2004). Amphibians and macroinvertebrates were sampled on 26 May and 3 July 2001 by deploying funnel (activity) traps for 24 periods around the perimeter of open water areas at Lake Abram. No frogs or salamanders were collected on either date and virtually no macroinvertebrates were collected in funnel traps or with qualitative dip net sweeps (Fennessy et al. 2004; unpublished Ohio EPA data).

Vegetation was sampled in 0.1 ha plots located north and south of the open water areas of Lake Abram in 2001 and 2002 using standard methods for calculating the Vegetation Index of Biotic Integrity (VIBI) for Ohio Wetlands (Mack 2007). Quality of wetland plant communities was poor to localized areas of fair (Table 5). Large areas of the remaining wetlands are dominated by narrow-leaved cattail (*Typha angustifolia*), Phragmites (*Phragmites autralis* subsp. *australis*) reed canary grass (*Phalaris*

Brook Park (190) (NOACA 2006). Prior Ohio EPA sampling locations and parameters (OEPA 1999) for Abram Creek:

RM0.2	Invertebrates	41 24 57/81 52 07	West Area Road
RM0.6	Fish	41 24 37/81 52 10	
RM0.8	Water Chemistry , Fecal Coliform	41 24 27/81 52 11	Cedar Point Road
RM1.9	Fish, Invertebrates, Water Chemistry, Fecal Coliform	41 23 43/81 51 57	Grayton Road
RM2.8	Fish	41 23 34/81 51 05	
RM3.2	Fish	41 23 32/81 50 38	Eastland Road
RM3.4	Invertebrates	41 23 31/81 50 34	Eastland (upstrm)
RM3.9	Water Chemistry, Fecal Coliform	41 23 21/81 50 05	Sheldon Road

33 "Overall condition of the channel and intact riparian corridor throughout much of this lower segment is *indicative of a stream with the potential to support* well balanced warm water biological communities of macroinvertebrates and fish, which has been confirmed through water quality surveys conducted in 1992…and 1997, and through a study conducted for [Cleveland Hopkins Airport] in 1995…Therefore, the use designation of warm water habitat [WWH]…has been assigned to Abram Creek…and the restoration potential for this lower segment can be classified as moderate to high…Non-attainment of the WWH biological water quality criteria within the lower segment of Abram Creek can partly be attributed to uncontrolled hydromodifications within the upper watershed, Cleveland-Hopkins…and NASA…which have increased peak flows and reduced base flows in the stream" (OEPA 1999, p. 33).

arundinacea), although native elements persist within and at the margins of this non-native assemblage.[34] Limited surface water sampling during the wetland assessmenet showed multiple parameters with concentrations higher than the 75th percentile of typical ranges for headwater marshes in Ohio and the extremely high value for chloride indicated a strong stormwater influence (Table 6).

5.5.2 Current services provided to human society by the ecosystem

Although wetlands are often called the "kidneys of the landscape", it is less recognized that wetlands can also experience kidney "disease" and kidney "failure." It is clear that the wetlands in the ecosystem are in relatively poor condition, but certain ecosystem services, e.g. detaining and treating storm water, are still being provided at relatively high levels. As the largest remaining single wetland complex remaining in Cuyahoga County, the ecosystem is or could be providing substantial ecological services to the local community, the Rocky River watershed and the region (Table 7).

Economically valuing the existing (e.g. storm water detention) and potential (e.g. recreational bird watching) services and there impact on local and regional economies represents a significant baseline data needed to evaluate the effect of implementing this plan. Assuming present levels of preservation, storm water input, the opening of the Lake-to-Lake Trail, etc. are maintained, ecosystem services that are being provided are not expected to continue unchanged (Table 8). Most services are expected to decline over time as the limits of the various ecosystem processes that support the service are exceeded. Other reductions in service are attributable to lost opportunities (Table 8).

5.5.3 Threats to Ecosystem Condition and Services

There are multiple current threats to the services and ecological condition of the Lake Abram ecosystem including filling, storm water nonpoint source pollution and invasive plants. In addition, to these current threats, the system has been subjected to historical disturbances (see Section 1.3). In some instances it has largely recovered from these past disturbances. For example, wetland hydrology has largely been reestablished everywhere in the system after the draining and farming between 1840 and 1930. In other ways, the system has recovered to a point, but has not been able to return itself to conditions characteristic of good ecosystem condition or function. The location of what are considered to the be most serious past or on-going disturbances are summarized in Figure 14.

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[34] For example, wheat sedge (*Carex atherodes*), a potentially threatened species, was collected in the wetland complex south of Bagley Road by Dr. George Wilder (Mack, personal communication).

Table 5. Summary of Vegetation IBI Scores at Lake Abram. Refer to Mack (2006) for Wetland Tiered Aquatic Life Uses (WTALUs) for Riverine Headwater Wetlands in Erie-Ontario Drift and Lake Plains ecoregion.

plot sampling date plot location	25 July 2001 41.78111, 81.83694	16 July 2002 41.38472, 81.83639
VIBI Score	33	64
Wetland Tiered Aquatic Life	Restorable Wetland Habitat (RWLH), Riverine Headwater Marsh	Wetland Habitat (WLH), Riverine Headwater Wet Meadow
No. of *Carex* species	1	1
No. of dicotyledon species	12	27
No. of native wetland shrub species	4	4
No. of Hydrophyte species	19	26
Annual/Perennial species ratio	0.067	0.207
FQAI score	12.5	12.2
%sensitive species	0.0134	0.000
%tolerant species	0.6795	0.1744
%invasive graminoid species	0.6693	0.0236
average standing biomass (g/m^2)	413	171

Table 6. Water chemistry at Lake Abram.

Parameter	unit	24 May 2001	18 July 2001	Greater than 75th or less than 25th percentile for riverine headwater marshes
pH	S.U	---	7.9	EXCEEDS Q3 = 7.3
TSS	mg/l	25	177	EXCEEDS Q3 = 68
TS	mg/l	687	645	EXCEEDS Q3 = 361
TOC	%	---	8.6	Q1 = 8
Al	µg/l	618	2320	EXCEEDS Q3 = 623
Ba	µg/l	40	62	less than Q3 = 66
Ca	mg/l	59	74	EXCEEDS Q3 = 51
hardness	---	193	255	EXCEEDS Q3 = 199
Fe	µg/l	1600	4550	less than Q3 = 7390
Mg	mg/l	11	17	Q3 = 17
Mn	µg/l	232	247	Q3 = 997
K	mg/l	8	12	EXCEEDS Q3 = 4
Na	mg/l	128	111	EXCEEDS Q3 = 18
turbidity	n.t.u.	---	89.1	Q3 = 89.6
CL^-	mg/l	235	216	EXCEEDS Q3 = 23.5
TKN	mg/l	---	0.63	Q3 = 2.58
P total	mg/l	---	0.081	Q3 = 0.51

Table 7. Existing and potential ecological services of Lake-to-Lake Trail ecosystem.

Services	description of service	Degree service presently?	Restoration activities proposed (includes LtoL trail construction)	Potential to provide after restoration
Flood storage, detention or removal	Store, remove from the local hydro-logic cycle via evapotranspiration or temporarily detain storm water	high	Restore integrity of hydrologic to maintain long-term ability to remove, store, or detain storm water	very high
Bird habitat	Breeding, non-breeding and migratory habitat for birds	medium-low	Increase wetland bird habitat by restoring former lake area and improving vegetative quality	high to very high
Economic enhancement	Provision of natural resource infrastructure and ecotourism	medium-low	Increase value of natural resource and ecotourism infrastructure	high to very high
Water quality improvement	Store or transform sediment, N, P or other contaminants	high	Maintain long-term ability to store or transform contaminants	very high
Landscape services to Rocky River watershed	Provide improved water quality of hydrologic condition to lower Rocky River watershed	low	Increase and maintain long-term ability to remove-store-detain water, store or transform contaminants	medium to high
Aesthetics	Provide aesthetic or religious experience of nature	medium	Increase aesthetic experience by restoring lake areas, improving vegetative-visual quality	very high
Recreation	Bird watching, ecotourism, walking, cycling, hiking	low	Increase recreation by restoring former lake areas and improving vegetative and visual quality	very high
Education and Interpretation	Primary, secondary, college education, park interpretation	low	Increase educational experience by restoring former lake areas, vegetative and visual quality	high
Direct Human health	Primary contact with water in wetlands and streams	low	Reduce *E. coli* concentrations	medium
Green infrastructure	Green space in ecosystem	medium	No change unless additional properties acquired or preserved	medium
Urban refugia for flora and fauna	Provision of urban habitat for flora and fauna	medium-low	Increase habitat for flora and fauna in urban ecosystems	high

Table 8. Expected ecological services of Lake-to-Lake Trail ecosystem with no restoration activities. Table assumes the construction of the Lake-to-Lake Trail.

	Services	Degree of service provided presently	Expected degree of service without restoration
1	Water storage, detention or removal	High	Medium
2	Water quality improvement	High	Low
3	Landscape services to Rocky River watershed	Low	Low
4	Aesthetics (Connection to Nature)	Medium	Low
5	Recreation	Medium	Medium
6	Education and Interpretation	Low	Medium
7	Direct Human health	Low	Low
8	Green infrastructure	Medium	Medium
9	Bird habitat	Low to medium	Low to medium
10	Economic enhancement	Low	Low
11	Urban refugia for flora and fauna	Medium-low	Low

5.5.3.1 Water Quantity (increases in total and peak flows)

Peak and total volumes moving through the hydrologic network of the Lake-to-Lake Trail ecosystem have been significantly affected by human activities. According to the RIDE Study, directly-connected impervious area (DCIA) is the

> …most important hydrologic characteristic affecting storm water runoff [from] land surface that does not allow infiltration of runoff into the soil and is directly connected to the drainage system. Imperviousness correlates well with land cover and drainage system type. Highly urbanized areas, where much of the land surface has been either paved or covered with buildings, are highly impervious. Rural areas tend to have low imperviousness, in which case runoff response is almost entirely a function of soil type.

(NEORSD 2004, p. 4-11). Hydrologic loadings to the Lake Abram part of the complex are known to be extremely flashy, at least towards the northern end of the complex in the area of the residual Lake Abram "lake" (Figure 15). The main storm water inputs to the core wetland areas of the Lake-to-Lake ecosystem are shown on Figure 16 A, B and C. The primary inputs appear to be 1) ditches that discharge to northern Lake Abram from industrial and residential development between Engle Road and Lake Abram (including areas to the railroad tracks to the east), 2) commercial development around Abram Creek at north and south of Bagley Road, 3) storm water inputs from the Southwest General Hospital/Polaris Campus area, and 4) inputs upstream of Engle Road from Big Creek Parkway areas in Middleburg Heights (see storm water sheds for ecosystem in Figure 12).

Hydrology in the Lake-to-Lake ecosystem portion of the Abram Creek watershed was modeled using the procedures outlined in Sherwood (1994).[35] Peak discharges ranged from 4800 gal/sec (2 year storm) to 23000 gal/sec (100 year storm) (Table 9; Figure 17). Flood volume estimates for a short duration (3.55 hour) storm ranged from 29 to 140 million gallons (2 to 100 year storms) (Table 11). Volume:Frequency:Duration estimates for 2 to 32 hour duration storms of 2 to 100 frequency had total volumes for a long duration (32 hour) storm ranging from 66 to 273 million gallons (Table 10; Figure 17). These figures should be considered useful for the applied purposes of this plan but not valid until evaluated with empirical hydrologic data collected in the watershed. However, the RIDE Study estimated that approximately 260 million gallons of dry detention storage was needed in upper Abram Creek watershed area to detain storm water runoff (Figure 18), which is approximately the volume estimate for a 100 year 32 hour duration storm (Table 11). By setting the Basin Development Factor to "0" (relatively undeveloped) verus "12" (high developed) in the Sherwood (1994) model, some estimate of pre-development versus post-development watershed peak discharges and volume can be obtained. Peak discharges estimates ca2008 (nearly built-out watershed) are 55-59% greater than pre-development estimates.

5.5.3.2 Pollutants (Sediment, nutrients, chloride, toxic pollutants)

The data from stream (OEPA 1993, 1999, 2001) and wetland (Fennessy et al. 2001; Ohio EPA, unpublished data) suggests that water quality in the Lake-to-Lake Trail ecosystem is highly degraded (Table 6). Given that there are no known minor or major National Pollutant Elimination System (NPDES) dischargers or combined sewer overflows (CSOs) to the portion of the Abram Creek watershed in the Lake-to-Lake Trail ecosystem (NOACA 2006), water quality impairments are presumed to be due to nonpoint source pollutant inputs.

5.5.3.3 Pathogens

Although there is limited available data on presence of human pathogens, in particular *E. coli*, it is expected that levels in water of Abram Creek and the open water areas of the Lake-to-Lake Trail ecosystem wetlands, especially during periods of high flows, exceed safe levels. Elevated *E. coli* has been measured in the lower reaches of Abram Creek (OEPA 2005). Levels may also be high within shallowly inundated wetland areas of Lake Abram and Fowles Wetland. There are 19 septic systems in Berea, 320 in Middleburg Heights, and 190 in Brook Park; of these 529 systems, 218 are in the Abram Creek watershed ecosystem (NOACA 2006, OEPA 2005). Of the septic systems

[35] The watershed upstream of Sheldon Road is 4.6 square miles slightly above the recommended model limits (4.1 mi^2). Of more concern is the storage capacity represented by the Fowles Road and Lake Abram wetland areas. The model for urban streams in Sherwood (1994) assumes minimal storage capacity in the modeled streams. The large wetland areas in this portion of the watershed could reduce peak discharges and potentially total volumes moving through the system. Empirical data collected during implementation of this plan will evaluate the accuracy of this model. Parameters used in the model include: basin development factor = 10, basin area = 4.86 mi^2, annual precipitation = 36 in, main channel length = 4 miles, main channel slope = 25 in, basin lagtime = 1.649 hours.

Table 9. Peak discharge estimates for Lake-to-Lake Trail ecosystem based on Sherwood (1994).

Recurrence Interval	std error of prediction (%)	Peak Discharge (cfs)	upper limit (cfs)	lower limit (cfs)	Peak Discharge (gal/s)	lower limit (gal/s)	upper limit (gal/s)
Q2	0.343	642	220	1,064	4,806	1,648	7,963
Q5	0.348	1,172	408	1,936	8,767	3,051	14,483
Q10	0.360	1,584	570	2,597	11,846	4,264	19,427
Q25	0.376	2,132	802	3,463	15,952	5,998	25,906
Q50	0.388	2,578	1,000	4,156	19,288	7,484	31,092
Q100	0.401	3,041	1,219	4,862	22,745	9,121	36,370

Table 10. Volume:Frequency:Duration estimates (gallons) for Lake-to-Lake Trail ecosystem based on Sherwood (1994).

Recurrence interval	**2 year**	**5 year**	**10 year**	**25 year**	**50 year**	**100 year**
Duration (hour)	**V2**	**V5**	**V10**	**V25**	**V50**	**V100**
1	14,618,763	23,656,370	30,574,743	39,540,346	46,781,755	54,322,467
2	23,037,579	35,336,576	46,692,542	60,812,919	71,602,308	81,410,300
4	32,137,955	51,566,764	65,117,516	85,051,218	100,822,305	118,283,151
8	42,827,027	71,682,403	93,216,050	123,265,960	149,023,027	175,523,040
16	55,440,976	93,047,005	120,861,404	161,678,874	194,667,597	231,167,771
32	66,163,278	110,141,814	145,864,198	192,689,476	234,522,757	273,097,490

Table 11. Flood volume estimates for 2, 5, 10, 25, 50 and 100 year storms for 3.55 hour storm for Lake-to-Lake Trail ecosystem based on Sherwood (1994).

interval t2 hours	2 year Q2 gal/sec	5 year Q5 gal/sec	10 year Q10 gal/sec	25 year Q25 gal/sec	50 year Q50 gal/sec	100 year Q100 gal/sec
0.41	577	1,052	1,421	1,914	2,314	2,729
0.49	769	1,403	1,895	2,552	3,086	3,639
0.58	1,009	1,841	2,487	3,350	4,050	4,776
0.66	1,249	2,279	3,080	4,147	5,014	5,913
0.74	1,586	2,893	3,909	5,264	6,364	7,505
0.82	1,922	3,506	4,738	6,380	7,715	9,097
0.91	2,355	4,295	5,804	7,816	9,450	11,144
0.99	2,787	5,084	6,870	9,252	11,186	13,191
1.07	3,220	5,873	7,936	10,687	12,922	15,238
1.15	3,652	6,662	9,002	12,123	14,658	17,285
1.24	4,036	7,363	9,950	13,399	16,201	19,105
1.32	4,325	7,889	10,660	14,356	17,358	20,469
1.40	4,565	8,328	11,253	15,153	18,322	21,606
1.48	4,709	8,591	11,608	15,632	18,901	22,289
1.57	4,805	8,766	11,845	15,951	19,286	22,744
1.65	4,757	8,678	11,726	15,792	19,093	22,516
1.73	4,613	8,415	11,371	15,313	18,515	21,834
1.81	4,421	8,065	10,897	14,675	17,743	20,924
1.90	4,133	7,539	10,187	13,718	16,586	19,560
1.98	3,844	7,013	9,476	12,761	15,429	18,195
2.06	3,556	6,487	8,765	11,804	14,272	16,830
2.14	3,268	5,961	8,055	10,847	13,115	15,466
2.23	2,979	5,435	7,344	9,890	11,958	14,101
2.31	2,691	4,909	6,633	8,933	10,800	12,736
2.39	2,451	4,471	6,041	8,135	9,836	11,599
2.47	2,258	4,120	5,567	7,497	9,065	10,690
2.56	2,066	3,769	5,093	6,859	8,293	9,780
2.64	1,874	3,419	4,620	6,221	7,522	8,870
2.72	1,730	3,156	4,264	5,742	6,943	8,188
2.80	1,586	2,893	3,909	5,264	6,364	7,505
2.89	1,442	2,630	3,553	4,785	5,786	6,823
2.97	1,345	2,454	3,317	4,466	5,400	6,368
3.05	1,249	2,279	3,080	4,147	5,014	5,913
3.13	1,153	2,104	2,843	3,828	4,629	5,458
3.22	1,057	1,929	2,606	3,509	4,243	5,004
3.30	961	1,753	2,369	3,190	3,857	4,549
3.38	913	1,666	2,251	3,031	3,664	4,321
3.46	817	1,490	2,014	2,712	3,279	3,866
3.55	769	1,403	1,895	2,552	3,086	3,639
3.63	721	1,315	1,777	2,393	2,893	3,412
3.71	673	1,227	1,658	2,233	2,700	3,184
3.79	625	1,140	1,540	2,074	2,507	2,957
3.88	577	1,052	1,421	1,914	2,314	2,729
3.96	529	964	1,303	1,755	2,121	2,502
TOTAL	29,709,199	54,197,317	73,232,766	98,619,266	119,240,383	140,615,574

in the Abram Creek watershed, approximately 80 are projected to be failing (NOACA 2006).

5.5.3.4 Physical Disturbances (Filling, Channelization, Culverting, etc.)

There are numerous physical disturbances in the ecosystem. With the exception of a short stretch between Engle Road and I71, no part of Abram Creek stream south of Sheldon Road is a natural stream channel. From Engle Road to Sheldon Road Abram Creek exists in artificial channels, culverts, or relocated stream beds (e.g. Figures 2, 16 A, B, C). There are also numerous locations where parts of the Lake Abram wetland complex have been filled in the past or fairly recently (Figures 2, Figure 16, A, B, C). Since 1980, approximately 40% of the hydric soil acreage has been filled or drained (Table 3; Figure 13).

5.5.3.5 Invasive plants

A substantial portion of the remaining wetland areas in the ecosystem are dominated by invasive plants especially narrow-leaved cattail (*Typha angustifolia*) and reed canary grass (*Phalaris arundinacea*) with localized infestations of giant reed (*Phragmites australis* subsp. *australis*). However, native wetland plants and plant communities are also embedded or remain in local refugia throughout the wetland complex (Mack personal observation, Table 5). Some upland forests have significant infestations of nonnative honeysuckles (*Lonicera* spp.) and garlic mustard (*Alliaria petiolata*).

5.5.3.7 ATV impacts

The north end of the ecosystem (south of Sheldon Road to ca 2008 Cleveland Metroparks property boundary) has been heavily disturbed from off-road vehicle usage (Mack, personal observation) in recent years.

5.4.3.8 Waste disposal

Active construction/demolition debris and waste disposal in the ecosystem, while common pre-1990, has largely ceased within the ecosystem boundary except for the Fabreze disposal area southeast of Sheldon and Eastland Roads. Residual impacts from leachate or loss of wetland area from past disposal are expected to occur at low to moderate levels.

6.0 ECOSYSTEM GOALS AND MEASURES OF SUCCESS

6.1 Integrate aquatic and terrestrial ecosystems, manage both species and ecosystems, and manage the entire system, not just pieces of the system

An important step forward taken in this plan is to consider the entire ecosystem both, human and natural, terrestrial and aquatic. Most upland habitats are now highly managed, human-occupied areas, although there are undeveloped woodlots embedded in developed upland areas (see Figure 19). Residual, undeveloped upland areas are closely associated with the core of the aquatic (primarily wetland) ecosystem areas. Improvement and restoration of aquatic and terrestrial ecosystem areas will necessarily involve management activities in existing (upland) commercial, industrial and residential areas within the ecosystem. This will involve significant prior involvement, evaluation, and ultimately commitment from the private, municipal and commercial interests that are potentially affected. Given the imperative that human individuals and institutions need to accept the goals and activities outlined in this plan (or they need to be modified), management of the entire system and integration of aquatic and terrestrial ecosystems will necessarily be an organic process driven by data and opportunity.

6.2 Recognize that time lags between events and consequences are inevitable. Therefore, management should expect the unexpected, be flexible and be set for the long term

The initial time scale for implementation and evaluation of this plan is expected to be in the range of 5-10 years. Given that whole ecosystem restoration of urban ecosystems has rarely been attempted (e.g. Shuster et al. 2008, Schueler et al. 2007, Schueler and Kitchell 2007), full ecosystem restoration may require longer than 5-10 years. This plan should be, and is expected to be, revised and updated on a regular basis as new data is obtained and management activities are initiated, completed and evaluated.

6.3 Have quantitative measures of success (performance) to determine whether the goals and objectives are being attained)

Critical to the success of the ecosystem approach is a commitment to monitoring of the effect of restoration and a clear enunciation of quantitative targets of success. If the state of knowledge is not sufficient to specify quantitative targets, the data gap should be closed as part of the monitoring and assessment being performed. Monitoring to collect data necessary for determining whether a performance standard has been met is outlined in Section 7.0, below.

6.2 Specific ecosystem goals and measures of success

Because of the strong inter-relationship between ecosystem condition and services, the following goals are expected to maintain and increase services and condition, whether or not the relationship is direct or indirect. Economic valuation (See e.g. Costanza et al. 1997) of the current and future ecosystem services represents a significant knowledge gap in ecosystem planning. For the purposes of this version of the Lake-to-Lake Trail ecosystem plan, it is assumed that the quantified improvements to ecosystem condition will result in an positive economic impact that will ultimately translate into an increased tax base and standard of living for persons living within and around the ecosystem boundary.

6.2.1 Water quantity and water quality

A substantial reduction in peak flows and total volume moving through the ecosystem will be needed to improve condition and maintain and increase ecosystem services. While the exact amount will be more precisely quantified after hydrologic monitoring is initiated, several estimates from existing data and models provide estimates within the same order of magnitude. Using the model of Sherwood (1994), current conditions represent an approximately 60% increase in peak discharge from pre-development conditions. The RIDE Study (NEORSD 2004) recommended approximately 260 million gallons of dry storage within the ecosystem to address peak discharge and total volume (Figure 18). Estimates from the Sherwood (1994) model were within the same order of magnitude (140 to 270 million gallons) (Tables 10 and 11). *The Initial goal for maintenance and restoration of ecosystem services and condition is a reduction in peak discharge of 50% and total volume by 150 to 300 million gallons.* This goal will be refined and modified as more accurate hydrologic data is obtained for the ecosystem.

Given that there are no major or minor NPDES discharges into the ecosystem area, it is assumed that all water quality problems are directly associated with nonpoint sources associated with excess storm water inputs. *Meeting peak and total volume water quantity is assumed to address water quality problems except, possibly for human pathogens.* There are approximately 200 home sewage treatment systems in the Abram Creek watershed with an estimated 80 failing systems (NOACA 2006). *An additional goal is to remove or replace all failing HSTs in the ecosystem.*

Achievement of this goal will be determined by the following:

1. Empirical measurements of peak discharge and total volume from the hydrologic monitoring network outlined in Section 7.0, below, based on baseline (pre-implemention) and post-restoration monitoring data.
2. The flashiness of the hydrographs for the Lake Abram and Fowles Wetland will be reduced and a hydrologic regime comparable to other non-storm water impacted riverine headwater marshes (e.g. Figure 15) will be achieved with a flashiness index score of 3.0 or less (Fennessey et al. 2004).
3. An increase in the Amphian IBI score (Micacchion 2004) to >10.[36]
4. Determining the percentage of failed HSTs that are removed or replaced.

6.2.2 Restoration of "lake" habitats

Based on historical accounts and soil types and genesis, it is relatively well established that "lake" or deep-water marsh habitats were substantially greater ca 1840 in the Lake Abram/Fowles Wetland areas than at present. Historical accounts refer to 50-60 acres of "lake" at Lake Abram with extensive wetland area surrounding the lake (Holzworth 1970). Circa 2008 there is approximately 5 acres of open water (lake/deepwater marsh) at Lake Abram and virtually no open water (lake/deepwater

[36] No amphibians were collected in Lake Abram in 2004 after three 24 trapping periods. Improvements in hydrology and water quality should result in improvements in the amphibian assemblage.

marsh) in the Fowles Wetland. *The goal is to create approximately 30 acres of lake/deepwater marsh habitat at Lake Abram and approximately 10 acres of lake/deepwater marsh habitat in the Fowles Wetland*. This will have ancillary effects in increase in bird habitat and flood storage detention services. Achievement of this goal will be determined by measuring the surface area of restored lake habitats using aerial photographs.

6.2.3 Wetland vegetation restoration

Wetland areas in the ecosystem have high percentages of several invasive plants including *Phalaris arundinacea* (reed canary grass), *Phragmites australis* subsp. *australis* (Phragmites), and *Typha angustifolia* narrow-leaved cattail). Vegetation community quality is poor to fair (Table 5), although remnant native vegetation and better quality community elements persist in localized areas (Mack, personal observation). The ecosystem goal is to eradicate invasive wetland species. *The initial goal is restore the Lake Abram and Fowles Wetland plant communities to conditions characteristic of good quality riverine headwater marshes in Northeast Ohio.*

Achievement of this goal will be determined by the following:

1. Reduction of the areal coverage of invasive wetland plants[37] to less than 5% and an increase in area of coverage of perennial native hydrophytic (FACW, OBL) plants to >80%.

2. Achieve an average Vegetation IBI score of 57 or greater[38] based on the average of scores from focused (0.1 ha) plots and aggregated random plots (See vegetation monitoring network in Section 7.0, below).

6.2.4 Recreational bird watching.

The improvements to hydrology, lake habitat, and vegetation are all expected to result in substantial improvements in migratory and resident bird usage and in recreational bird watching. *Quantifying recreational bird watching and economic improvements resulting from it represents a significant data gap in this plan*.

Achievement of this goal will initially be determined by empirical measurements of migratory and resident bird usage pre-implementation and post-implementation, i.e. a statistically significant ($p < 0.05$) increase in breeding and migratory waterfowl usage of complex from baseline conditions.

6.2.4 Terrestrial habitats

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[37] *Butomus umbellatus, Lythrum salicaria, Myriophyllum spicatum, Najas minor, Phalaris arundinacea, Phragmites australis* subsp. *australis, Potamogeton crispus, Ranunculus ficaria, Rhamnus frangula, Typha angustifolia, T.* x *glauca.*

[38] A VIBI score of 57 the minimum score for riverine headwater wetlands in the Erir-Ontario Drift and Lake Plains ecoregion that is equivalent to Wetland Habitat (WLH) Tiered Aquatic Life Use (Category 2), i.e. "good" ecologic condition (Mack and Micacchion, 2006; Mack et al. 2006).

The proportion of intact terrestrial to wetland habitats in the ecosystem has been reversed, with most terrestrial (upland) habitats developed and remaining undeveloped habitats predominately wetland in character (But see Figure 19). Most remaining upland habitats in the ecosystem have been developed or formerly developed for residential, commercial or industrial uses. Some residual upland forests remain around the perimeters of the Lake Abram and Fowles Wetland or scattered in woodlots embedded in residential or commercial developments in Berea, Brook Park and Middleburg Heights. A few of these stands have relatively intact, mature canopies (Mack, personal observation). A major data gap is a comprehensive inventory and assessment of upland (forest, meadow, shrub) habitats within the ecosystem, although several residual areas have been noted but not quantitatively assessed (Figure 19).

The following initial terrestrial habitat goals are established within lands controlled by Cleveland Metroparks: *1) Reduction of deer populations to <10 per square mile; 2) reduction of upland forest invasive plant species*[39] *to <5% areal coverage, 3) Removal of ATV vehicle impacts, and 4) restoration of good quality herb, shrub and canopy layer forest vegetation characteristic of beech-maple forests in the glaciated Allegheny Plateau.*

6.2.5 Preservation of undeveloped lands

A relatively small amount of land is available for preservation in the ecosystem. Remaining substantial areas which could be preserved are noted in Figure 19. However, relatively discrete (in terms of acreage) areas along water courses or embedded with mostly built-out areas of the ecosystem could be preserved or managed in ways that could, in the aggregate, have positive effects on ecosystem services or condition.

7.0 MONITORING TO DETERMINE SUCCESS AND EVALUATE MANAGEMENT EFFORTS

7.1 Recognize that ecosystem management needs to be data-driven but also may need to be carried out with insufficient or incomplete understanding of functional relationships and processes within the ecosystem

The goals and management steps in this report represent a first approximation in the steps needed to maintain and improve condition and services in the Lake-to-Lake Trail ecosystem. They represent the state of knowledge outlined in this plan which is obviously incomplete. *But, understanding of functional relationships and processes in the ecosystem is judged to be sufficiently understood to initiate management activities, in conjunction with a monitoring network and data-driven adaptive management strategy*.

7.2 The ecosystem approach should be a learning process because of the complexity and variability of ecosystems. This involves careful consideration of experimental

[39] *Alliaria petiolata, Elaeagnus* spp. (*E. angustifolia, E. umbellata), Lonicera* spp. (*L. japonica, L. maackii,L. morrowii, L. tatarica*), *Polygonum cuspidatum, Rhamnus cathartica, Rosa multiflora*.

design and the implementation of monitoring programs to ensure that the power of the results is maximized

7.2.1 Data gaps

Several gaps in available information exist that must be addressed to effect the restoration of the condition and services provided by the Lake Abram ecosystem: the hydrology of the ecosystem must be quantified including current hydroregime and location and amounts of storm water inputs; water quality data is limited or missing especially concentrations and loadings of nutrients, sediment, human pathogens, and screening for toxic contaminants; baseline ecological condition especially condition of upland and wetland plant communities and avifauna is missing or limited; maps of major invasive plant infestations are lacking; economic valuation of present and future the natural resource infrastructure that the Lake-to-Lake Trail ecosystem is and could be providing; and direct measurement of recreation including recreational bird watching and economic impact on local communities and region.

7.2.2 Monitoring Network

In order to make effective management decisions and to make necessary changes to those decisions, an effective monitoring and assessment system must be established. Although research partners with local universities are expected, the goal of the monitoring network is to avoid highly organized research and emphasize small scale experiments with 1) regular interchange of data for between research projects and groups in order to develop data sets for management interventions and 2) to conduct run-through tests to put difficulties into perspective. In addition, the monitoring network will collect data to determine whether performance targets are being reached.

7.3 Hydrologic and water quality monitoring network

The purpose of hydrology monitoring is to quantify the volume of water moving through the Lake-to-Lake Trail ecosystem, focusing on anthropogenically induced changes that are causing decreases in ecosystem condition and services. The ecosystem goal is to restore hydrologic condition to levels necessary to maintain increase condition and services to levels associated with long-term sustainability and ecosystem health. This plan provides the broad outline with some detail of the hydrologic monitoring network. It is expected that more detailed work plans will be prepared as this plan is implemented.

Figure 19 shows the expected hydrologic monitoring locations. Key upstream and downstream location are at Engle Road and Sheldon Road. Monitoring at Engle Road (Station 2) will allow the contribution of areas in Middleburg Heights along Big Creek parkway to be estimated. Sheldon Road (Station 14) is the approximate outlet for all surface water leaving the ecosystem area. Monitoring at Stations 3 5, 6, 7, 9, 11, and 12 will provide data to estimate the contribution of the expected largest storm water contributions. The location, expected sewershed, purpose and type of monitoring is summarized in Table 12. Short duration (<15 minute) hydrologic data and continuous water chemistry with multiparameter sondes at monitoring stations. Precipitation data will be collected at Engle and Sheldon Roads and data from the National Weather Service station at Cleveland-Hopkins International Airport will also be used. Continuous hydrologic and water chemistry monitoring will be supplemented by collecting grab or composite samples of water as necessary. The hydrologic monitoring network is

Table 12. Initial hydrologic and water quality monitoring network. Water quality data will be collected at all hydrologic monitoring locations.

Station	priority	deployment sequence	expected equipment	location	purpose	sewersheds (Fig 12) addressed by station	duration
1	low	2009	ISCO 2150, YSI sonde	downstream side of culvert at RR tunnel	to quantify inputs from upper watershed	upper parts of SB-390	< 2 years
2	high	2009	ISCO 2150, YSI sonde	on upstream side of Engle Road on Abram Creek mainstem	to quantify upper sewersheds in Middleburg Heights, track changes and improvements	SB-350, 410, 420, 425, new 150 and possibly SB-340 east of RR	long term
3	low	2009	ISCO 2150, YSI sonde	multiple culverts associated with Polaris development	to quantify storm water inputs from Polaris, development west of Fowles Rd wetlands	SB-390	<2 year each
4	high	2008	Ecotone wells, YSI Sonde	Fowles Rd Wetland Proper	to monitor water quality and hydroperiod of Lake Abram	SB-390, possibly SB-360	long term
5	high	2009	ISCO 2110 with weir, YSI sonde	at outlet of Fowles Rd Wetland	to quantify inputs between Station 2 and Station 4	SB-380, 390 and possibly part of SB-360	long term
6	low	2010	ISCO 2150	upstream end of culvert at Bagley Rd draining Old Oak Road area	to quantify part of sewershed associated with Old Oak Road arewa	SB-360	<2 years
7	high	2010	ISCO 2150 or ISCO 2110	at Abram Cr culvert west of Hepburn Rd or at trail bridge	to quantify storm water,track changes/improvements from between Stations 4 and 7	SB-370	long term
8	low	2010	ISCO 2150 or ISCO 2110	possible inputs from residential development around Robin Dr	to quantify possible storm water inputs to south Lake Abram wetlands	SB-300	<2 years
9	medium (?)	(?)	ISCO 2150 or ISCO 2110	downstream of Hepburn Rd before creek enters wetlands	to quantify all inputs upstream of Lake Abram wetlands	SB-310	?
10	high	2008	Ecotone wells, YSI Sonde	Lake Abram proper	to monitor water quality and hydroperiod of Lake Abram	all	long term
11	high	2010	ISCO 2110 with weir (?)	at outlet of south ditch from sewersheds east of Lake Abram	to quantify northeastern sewersheds and track changes and improvements	SB3-310, 330 and SB-340 west of RR tracks	2-4 years
12	high	2010	ISCO 2110 with weir (?)	at outlet of north ditch from sewersheds east of Lake Abram	to quantify northeastern sewersheds and track changes and improvements	SB-320, 260, 270, 280	2 -4years
13	low	(?)	ISCO 2150(?)	at culvert(s) along Eastland Rd	quantify inputs from develop-ments West of Eastland Rd	SB-290, 250, 210, 220	<2 years
14	high	2009	ISCO ADFM Pro20	at Sheldon Rd Bridge	boundary of ecosystem	all	long term

expected to be deployed in stages and for different durations depending on the monitoring purpose and relative importance of that location to overall ecosystem hydrodynamics (Table 12).

7.4 Biological Monitoring Network

The core taxa groups for biological monitoring will be vegetation, birds and amphibians. Project partners who may address macroinvertebrates, diatoms and pollen studies of the peat will be actively sought. The purpose of monitoring is to collect baseline data and track improvement or changes over time. Monitoring will initially focus on habitat owned by Cleveland Metroparks or continguous to Cleveland Metroparks property, especially wetland and adjacent upland forest habitats; but can be expanded over time to other upland and wetland habitats in the ecosystem.

In order to ensure data comparability, vegetation and amphibian sampling will follow established Ohio Environmental Protection Agency wetland assessment protocols as outlined in the following documents:

> *Standardized monitoring protocols, data analysis and reporting requirements for mitigation wetlands in Ohio, v. 1.0.* Ohio EPA Technical Report WET/2004-6
>
> *Integrated wetland assessment program. Part 9: field manual for the vegetation index of biotic integrity for wetlands v. 1.4.* Ohio EPA Technical Report WET/2007-6
>
> *An ecological assessment of Ohio mitigation banks: vegetation, amphibians, hydrology and soils.* Ohio EPA Technical Report WET/2006-1
>
> *Micacchion, M. 2004. Integrated wetland assessment program. Part 7: amphibian index of biotic integrity for Ohio wetlands.* Ohio EPA Technical Report WET/2004-7.

Vegetation sampling will include multiple permanent 0.1 ha plots as well as 20-40 random plots The same vegetation sampling protocol will be used in both wetland and upland habitats. Amphibian sampling will occur in shallow marsh areas of Lake Abram and Fowles Road Wetland. Bird sampling will follow Audobon Important Bird Area methods (INSERT CITATION) and/or other appropriate methods.[40] It is expected that

[40] From Mack et al. (2006): "Methods used by Porej (2004) for extensive studies of mitigation wetlands in Ohio are recommended as protocols for performing quantitative surveys of wetland birds. Sites should be surveyed three times during the spring breeding period (May 1 to June 30) although actual dates may vary depending on the region of the state and weather patterns for that year. Where multiple sites are being monitored in the same year, the date and time of site visits should be randomized within each survey period. Point-count (Ralph et al. 1993, 1995) and call-response (playback) methods (Gibbs and Melvin 1997; Ribie et al. 1999) are recommended to survey birds. Surveys should be conducted from sunrise to 10:00AM at an array of 5 points established at each site prior to the first survey. The same survey points should be used throughout the monitoring period. Survey points should be placed in the emergent zone or at the wetland's edge when emergent vegetation is absent. A 50m radius circle (7853 m^2 or 1.94 acres) is surveyed around each point unless the survey point is located near the edge of the wetland. All birds heard

more detailed work plans for monitoring will be prepared as needed during the implementation of this plan.

8.0 OPERATIONALIZING THE ECOSYSTEM MANAGEMENT PLAN

A major goal of this plan is to move beyond assessing the scope of the problem, and initiating activities with the goal of attempting whole ecosystem restoraion of services and ecological condition. The goals in this plan have been clearly enunciated with measurable standards of success and monitoring capable of collecting the data needed to measure success and determine when and if goal modification or adaptive management is necessary.

What follows in this section is an initial listing of steps and activities necessary to increase, restore and maintain ecosystem services of the Lake-to-Lake Trail ecosystem. These are arranged loosely by year and with the understanding that many activities can proceed in approximate parallel rather than in sequence. In addition, some activities can be initiated by Cleveland Metroparks by itself and others require extensive coordination and involvement of multiple levels of public and private entities. The approach taken here is to outline broad goals which will inform and direct specific management steps that will occur organically and opportunistically rather than to outline a highly prescriptive plan.

<u>Year 1</u>

- Internal and external review and discussion of goals for ecosystem
- Evaluate restoration of lake habitats and initiate necessary permit discussions
Finalize version 1.0 of plan
- Begin baseline hydrologic and water quality monitoring of key upstream, downstream, and stormwater input locations
- Initiate research and native plant propagation discussions with Polaris and Baldwin Wallace
- Explore and evaluate funding and urban mitigation bank options
- Evaluate sewer sheds with storm sewer maps from Middleburg Heights and Berea

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or seen within a 7-minute counting period at each survey point are recorded. During the middle 3-minutes, a tape player should be used to play back vocalizations of least bittern (*Ixobrychus exilis*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), common moorhen (*Gallinula chloropus*), American bittern (*Botaurus lentginosus*), and pied-billed grebe (*Podiceps nigricollis*). Birds are counted if the flight of a bird originates or terminates within the plot boundary, including birds flushed as the survey point is approached. For active species like swallows, only the highest number observed at any point along the survey route is recorded. Active nests, young, or proportions of records of at least one adult are used to determine breeding status. One adult must be present during at least two visits to be counted as a breeding species (Brown and Dinsmore 1986; Inman et al. 2002). Species nesting in colonies (e.g. herons, swallows) are also classified as "non-nesters" unless actual nesting colonies are observed at the site. Bird densities should be calculated as the average number of individuals recorded per site visit for each year, except for mallards, wood ducks and Canada geese. For mallards and wood ducks, the number of breeding pairs is used to estimate density (Dzubin 1969), and for Canada geese, the number of nests per site per year is used to estimate density. Individual counts are then averaged across five survey points for each study site for every bird species."

- Eradicate *Phragmites* infestations; map *Typha angustifolia* and *Phalaris arundinacea* infestations
- Begin baseline vegetation and bird community monitoring

Year 2

- Begin discussion and evaluation of flooding and storm water management upstream of - Engle Road along Big Creek Parkway
- Obtain and/or implement funding and/or mitigation banking options
- Begin primary and secondary education scientific efforts in ecosystem
- Initiate native plant propagation at Polaris and Baldin Wallace
- Initiate contacts with public and private entities of predominant stormwater inputs south of Bagley Road and east of Lake Abram
- Initiate baseline economic studies
- Continue and expand hydrologic, vegetation and bird community monitoring
- Evaluate aerial control of *Typha angustifolia* and *Phalaris arundinacea* infestations
- Initiate deer management

Year 3

- Begin storm water source control efforts in upper (upstream of Engle Road) portions of watershed and sewersheds north of Bagley and south of Sheldon
- Initiate aerial control of *Typha angustifolia* and *Phalaris arundinacea* infestations
- Continue deer management
- Initiate upland invasive plant control especially garlic mustard (*Alliaria petiolata*), lesser celandine (*Ranunculus ficaria*), privet (*Ligustrum vulgare*), multiflora rose (*Rosa multiflora*) and non-native honeysuckles (*Lonicera maackii, L. morrowii, L. tatarica*).
- Initiate native plant restoration in upland and wetland habitats
- Summarize and evaluate baseline hydrologic, water chemistry and biological data

Year 4

- Continue storm water source control efforts in upper (upstream of Engle Road) portions of watershed and sewersheds north of Bagley and south of Sheldon
- Continue control of *Typha angustifolia* and *Phalaris arundinacea* infestations
- Continue deer management
- Continue upland invasive plant control especially garlic mustard (*Alliaria petiolata*), lesser celandine (*Ranunculus ficaria*), privet (*Ligustrum vulgare*), multiflora rose (*Rosa multiflora*) and non-native honeysuckles (*Lonicera maackii, L. morrowii, L. tatarica*).
- Continue native plant restoration in upland and wetland habitats
- Summarize and evaluate baseline hydrologic, water chemistry and biological data
- Initiate appropriate plan revisions and adapative management

Year 5

- Continue storm water source control efforts in upper (upstream of Engle Road) portions of watershed and sewersheds north of Bagley and south of Sheldon

- Continue control of *Typha angustifolia* and *Phalaris arundinacea* infestations
- Continue deer management
- Continue upland invasive plant control especially garlic mustard (*Alliaria petiolata*), lesser celandine (*Ranunculus ficaria*), privet (*Ligustrum vulgare*), multiflora rose (*Rosa multiflora*) and non-native honeysuckles (*Lonicera maackii, L. morrowii, L. tatarica*).
- Continue native plant restoration in upland and wetland habitats
- Summarize and evaluate baseline hydrologic, water chemistry and biological data
- Initiate appropriate plan revisions and adapative management
- Evaluate economic impact of ecosystem activities

9.0 REFERENCES

Anderson, Dennis M. 1982. Plant Communities of Ohio: A preliminary classification and description. Division of Natural Areas and Preserves, Ohio Department of Natural Resources, Columbus, Ohio.

Banks, P. O. and R. M. Feldman. 1970. Guide to the geology of northeastern Ohio. Northern Ohio Geological Society.

Brown, S. C. and J. J. Dinsmore. 1986. Implications of marsh size and isolation for marsh bird management. Journal of Wildlife Management 50:392-397.

Coates, W. R. 1924. A history of Cuyahoga County and the City of Cleveland. Vol. 1. The American Historical Society, New York, New York.

COB. 2000. The Ecosystem Approach. Decision V/6, Nairobi, 15-6 May 2000. UNEP/CBD/COP/5/23. Decisions adopted by the conference of the parties to the Convention on Biological Diversity at its Fifth Meeting. http://www.cbd.int/convention/cop-5-dec.shtml?m=COP-05&id=7148&lg=0

COHMAP Members. 1988. Climatic changes of the last 18,000 years: Observations and model simulations. Science 241:1043-1052.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature 287:253-260.

Dale, V. H., S. Brown, R. A. Haeuber, N. T. Hobbs, N. Huntley, R. J. Naiman, W. E. Riebsame, M. G. Turner and T. J. Valone. 2000. Ecological principles and guidelines for managing the use of land. Ecological Applications 10:639-670.

Davis, Margaret Bryan. 1983. Holocene vegetational history of the eastern United States. *In* Late-Quaternary Environments of the United States. Ed. H. E. Wright, Jr. University of Minnesota Press, Minneapolis, Minnesota.

Delacourt, Hazel R. and Paul A. Delacourt. 1997. Pre-Columbian Native American Use of Fire on Southern Appalachian Landscapes. Conservation Biology 11(4):1010-1014.

Delacourt, Paul A. and Hazel R. Delacourt. 1981. Vegetation Maps for Eastern North America: 40,000 YR B.P. to the Present. *In* Geobotany II, pages 123-165, Ed. Robert C. Romans. Proceedings of the Geobotany Conference, March 1, 1980, Bowling Green State University, Bowling Green, Ohio. Plenum Press, New York and London 123-165.

DeNicola, A. J., K. C. VerCauteren, P. D. Curtis and S. E. Hygnstrom. 2000. Managing white-tailed deer in suburban environments. A technical guide. Cornell Cooperative

Extension, the Wildlife Society Wildlife Damage Management Working Group, and the Northeast Wildlife Damage Research and Outreach Cooperative, Ithaca, New York.

Dzubin, A. 1969. Assessing breeding populations of ducks by ground counts. Canadian Wildlife Service Report Series 6:178-230.

Fennessy, M. S., J. J. Mack, A. Rokosch, M. Knapp and M. Micacchion. 2004. Integrated Wetland Assessment Program. Part 5: biogeochemical and hydrological investigations of natural and mitigation wetlands. Ohio EPA Technical Report WET/2004-5. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Fennessy, M. S., J. J. Mack, E. Diemeke, M. T. Sullivan, J. Bishop, M. Cohen, and M. Micacchion and M. Knapp. 2007. Integrated Wetland Assessment Program. Part 5: biogeochemical and hydrological investigations of natural and mitigation wetlands. Ohio EPA Technical Report WET/2004-5. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Gamble, D., E. Grody, J. Undercoffer, J. J. Mack, and M. Micacchion. 2007. An ecological and functional assessment of urban wetlands in central Ohio. Volume 2: morphometric surveys, depth-area-volume relationships and flood storage function. Ohio EPA Technical Report WET/2007-3B. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

Geis, James W. and William R. Boggess. 1968. The Prairie Peninsula: its origin and significance in the vegetational history of Central Illinois. The Quaternary of Illinois. A Symposium in Observance of the Centennial of the University of Illinois. February 12-13, 1968. Ed. Robert E. Bergstrom. Illinois Geological Survey.

Gibbs, J. P. and S. M. Melvin. 1997. Power to detect trends in waterbird abundance with call-response surveys. Journal of Wildlife Management 61:1262-1267.

Goldthwait, Richard P., George W. White, Jane L. Forsyth. 1961. Glacial Map of Ohio. Miscellaneous Geologic Investigations map I-316. Ohio Division of Geological Survey, Ohio Department of Natural Resources, Columbus, Ohio.

Gordon, Robert B. 1969. Natural vegetation of Ohio at the time of the earliest land surveys. Ohio Biological Survey, Columbus, Ohio.

Grame, C. D. 1984. The Birds of Lake Abrams (1983-1984). Unpublished manuscript in files of Cleveland Metroparks.

Holzworth, W. F. 1970. Men of grit and greatness: a historical account of Middleburg Township, Berea, Brook Park, and Middleburg Heights. Berea, Ohio.

Holzworth, W. F. 1973. The spirit of independence.

IEMT. 1995. The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies. Volume I – Overview. Report of the Interagency ecosystem Management Task Force. Washington, DC.

Inman, R. L., H. H. Prince and D. B. Hayes. 2002. Avian communities in forested riparian wetlands of southern Michigan, USA. Wetlands 22:647-660.

Johnson, C. 1879. History of Cuyahoga County wit portraits and biographical sketches of its prominent men and pioneers. D. W. Ensign, Philedelphia, Pennsylvania.

Kutzbach, John E. and Thompson Webb III. 1991. Late Quaternary climatic and vegetational change in eastern North America: concepts, models, and data. *In* Quaternary Landscapes, Eds. Linda C. K. Shane and Edward J. Cushing. University of Minnesota Press, Minneapolis.

La Rouche, G. P. 2001. Birding in the United States: A Demographic and Economic Analysis. Report 2001-1. Division of Federal Aid, U.S. Fish & Wildlife Service, Washington, D.C.

Lindenmayer, D., R. J. Hobbs, R. Montague-Drake, J. Alexandra, A. Bennet, M. Burgman, P. Cale, A. Calhoun, V. Cramer, P. Cullen, D. Driscoll, L. Fahrig, J. Fischer, J. Franklin, Y. Haila, M. Hunter, P. Gibbons, S. Lake, G. Luck, C. MacGregor, S. McIntyre, R. M. Nally, A. Manning, J. Miller, H. Mooney, H. Possingham, D. Saunders, F. Schmiegelow, M. Scott, D. Simberloff, T. Sisk, G. Tabor, B. Walker, J. Wiens, J. Woinarski, and E. Zavaleta. 2007. A checklist fo ecological management of landscapes for conservation. Ecology Letters 10:1-14.

Mack, J. J. 2006. Landscape as a predictor of wetland condition: an evaluation of the landscape development index (LDI) with a large reference wetland dataset from Ohio. Environmental Monitoring and Assessment 120:221-241.

Mack, J. J. 2007. Developing a wetland IBI with statewide application after multiple testing iterations. Ecological Indicators 7:864-881.

Mack, J. J. 2004. M. S. Fennessy, M. Micacchion and D. Porej. 2004. Standardized monitoring protocols, data analysis and reporting requirements for mitigation wetlands in Ohio, v. 1.0. Ohio EPA Technical Report WET/2004-6. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

Mack, J. J. 2007. Integrated wetland assessment program. Part 9: field manual for the vegetation index of biotic integrity for wetlands v. 1.4. Ohio EPA Technical Report WET/2007-6. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

Mack, J. J. and M. Micacchion. 2006. An ecological assessment of Ohio mitigation banks: vegetation, amphibians, hydrology and soils. Ohio EPA Technical Report WET/2006-1. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

Mack, J. J. and M. Micacchion. 2006. Addendum to Integrated wetland assessment program. Parts 4: vegetation index of biotic integrity for Ohio wetlands and Part 7: amphibian index of biotic integrity for Ohio wetlands. Ohio EPA Technical Report WET/2006-2. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

Mack, J. J. and M. Micacchion. 2007. An ecological and functional assessment of urban wetlands in central Ohio. Volume 1: condition of urban wetlands using rapid (level 2) and intensive (level 3) assessment methods. Ohio EPA Technical Report WET/2007-3A. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

MEA. 2006. Ecosystems and Human Well-being: A framework for assessment. Millennium Ecosystem Project. Island Press. 212 p.

Micacchion, M. 2004. Integrated wetland assessment program. Part 7: amphibian index of biotic integrity for Ohio wetlands. Ohio EPA Technical Report WET/2004-7. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

NEORSD. 2004. Regional Intercommunity Drainage Evaluation (RIDE) Study. Rocky River Tributaries Drainage Area Report. Vol. 1. April 27, 2004. Northeast Ohio Regional Sewer District, Cleveland, Ohio.

NOAA. 2007. Climate summary data collected at Cleveland-Hopkins International Airport. downloaded from http://ols.nndc.noaa.gov on 20 December 2007.

NOACA. 2006. Rocky River Watershed Action Plan. Northeast Ohio Areawide Coordinating Agency, Cleveland, Ohio.

ODNR. 2004. Life History Notes White-Tailed Deer. Ohio Department of Natural Resources, Division of Wildlife, Columbus, Ohio.

ODNR. 2006. Wildlife Population Status and Hunting Forecast. Ohio Department of Natural Resources, Division of Wildlife, Columbus, Ohio.

OEPA. 1993. Biological and water quality study of the Rocky River and selected tributaries: Summit, Lorain, Medina and Cuyahoga Counties, Ohio. OEPA Technical Report EAS/1993-8-3. Ohio Environmental Protection Agency, Division of Water Quality Monitoring and Assessment, Ecological Assessment Section, Columbus, Ohio.

----------. 1999. Biological and water quality study of the Rocky River and selected tributaries: Summit, Lorain, Medina and Cuyahoga Counties, Ohio. OEPA Technical Report MAS/1998-12-3. Ohio Environmental Protection Agency, Division of Surface Water, Columbus, Ohio.

----------. 2001. Total maximum daily loads for the Rocky River basin. Final Report. Ohio Environmental Protection Agency, Division of Surface Water, Columbus, Ohio.

----------. 2005. Total maximum daily loads for bacteria in the Rocky River watershed. Final Report. Ohio Environmental Protection Agency, Division of Surface Water, Columbus, Ohio.

Ogden, J. Gordon, III. 1966. Forest history of Ohio. I. Radiocarbon dates and pollen stratigraphy of Silver Lake, Logan County, Ohio. Ohio Journal of Science 66(4):387-400.

Parkman, F. 1999. LaSalle and the Discovery of the Great West. The Modern Library, New York, New York.

Pavey, R. R., R. P. Goldthwait, C. S. Brockman, D. N. Hull, E. M. Swinford and RG. Van Horn. 1999. Quaternary Geology of Ohio. Map No. 2. Ohio Division of Geological Survey, Department of Natural Resources, Columbus, Ohio.

Peet, Robert K., Thomas R. Wentworth, and Peter S. White. 1998. A Flexible, multipurpose method for recording vegetation composition and structure. Castanea 63(3):262-274.

Prosser, C. S. 1912. The Devonian and Mississippian formations of Northeastern Ohio. Geological Survey of Ohio, Fourth Series, Bulletin 15. Columbus, Ohio.

Ralph, C. J., J. R. Sauer and S. Droege. 1995. Monitoring bird populations by point counts. PSW-GTR-149. U.S. Forest Service, Pacific Research Station, Albany, California.

Ribie, C. A., S. J. Lewis, S. Melvin, J. Bart and B. Peterjohn. 1999. Proceedings of the marsh bird monitoring workshop. U.S. Fish and Wildlife Service, Patuxent Research Refuge, Laurel, Maryland.

SCS. 1980. Soil survey of Cuyahoga County. Soil Conservation Service, U.S. Department of the Interior and Ohio Department of Natural Resources, Columbus, Ohio.

Schmida, A. 1984. Whittaker's plant diversity sampling method. Israel Journal of Botany 33:41-46.

Schueler T. and A. Kitchell. 2005. Urban Subwatershed Restoration Manual No. 2. Methods to develop restoration plans for small urban watersheds Version 2.0. Center for Watershed Protection, Ellicott City, Maryland.

Schueler, T., D. Hirschman, M. Novotney and J. Zielinkski. 2007. Urban Subwatershed Restoration Manual No. 3. Urban stormwater retrofit practices Version 1.0. Center for Watershed Protection, Ellicott City, Maryland.

Shane, Linda C.K. 1987. Late-glacial vegetational and climatic history of the Allegheny Plateau and the Till Plains of Ohio and Indiana, U.S.A. Boreas 16:1-20.

Shane, Linda C.K. and Katherine H. Anderson. 1993. Intensity, gradients and reversals in late glacial environmental change in east-central North America. Quaternary Science Reviews 12:307-320.

Shaw, W. H. 1936. Historical facts concerning Berea and Middleburgh Township. Berea Centennial, 1836-1936. Mohler Printing Company, Berea, Ohio

Sherwood, J. M. 1994. Estimation of peak-frequency relations, flood hydrographs, and volume-duration-frequency relations of ungaged small urban streams in Ohio. U.S. Geological Survey Water-Supply Paper 2432. U. S. Geological Survey, Columbus, Ohio.

Shuster, W., J. Beauleiu and A. Roy. 2008. The Shepherd Creek Project - A multidisciplinary approach to management of storm water runoff in a small, midwestern USA watershed. downloaded 31 March 2008 from http://www.epa.gov/nrmrl/std/seb/research/hlut.htm

USEPA. 1995. Watershed protection: a statewide approach. EPA 841-R-95-004. U.S. Environmental Protection Agency, Office of Water, Washington, D. C.

Wagner, A. C. 1921. Wagner's new complete large scale map of Cleveland and suburbs. The A. C. Wagner Company, Cincinnati, Ohio.

Webb, T. III, E. J. Cushing, and H. E. Wright, Jr. 1983. Holocene Changes in the Vegetation of the Midwest. *In* Late-Quaternary Environments of the United States. Ed. H. E. Wright, Jr. University of Minnesota Press, Minneapolis, Minnesota.

Whittlesey, C. Early history of Cleveland, Ohio: including original papers and other matter relating to the adjacent county with biographical notices of the pioneers and surveyors. Fairbanks, Benedict & Company, Cleveland, Ohio.

Williams, A. B. 1949. The native forests of Cuyahoga County, Ohio. Cleveland Museum of Natural History, Cleveland, Ohio.

Williams, M. 2006. Deforesting the Earth, from Prehistory to Global Crisis, an Abridgment. University of Chicago Press, Chicago, Illinois.

Woods, A. J., J. M. Omernik, C. S. Brockman, T. D. Gerber, W. D. Hosteter, and S. H. Azevedo, 1998. Ecoregions of Indiana and Ohio (Map) and Supplementary text.

Wright, H.E., Jr. 1968. History of the Prairie Peninsula. The Quaternary of Illinois. A Symposium in Observance of the Centennial of the University of Illinois. February 12-13, 1968. Ed. Robert E. Bergstrom. Illinois Geological Survey.

APPENDICES

Appendix A – Work Plan for Management Activities

Appendix B - Work Plan for Monitoring and Assessment Activities

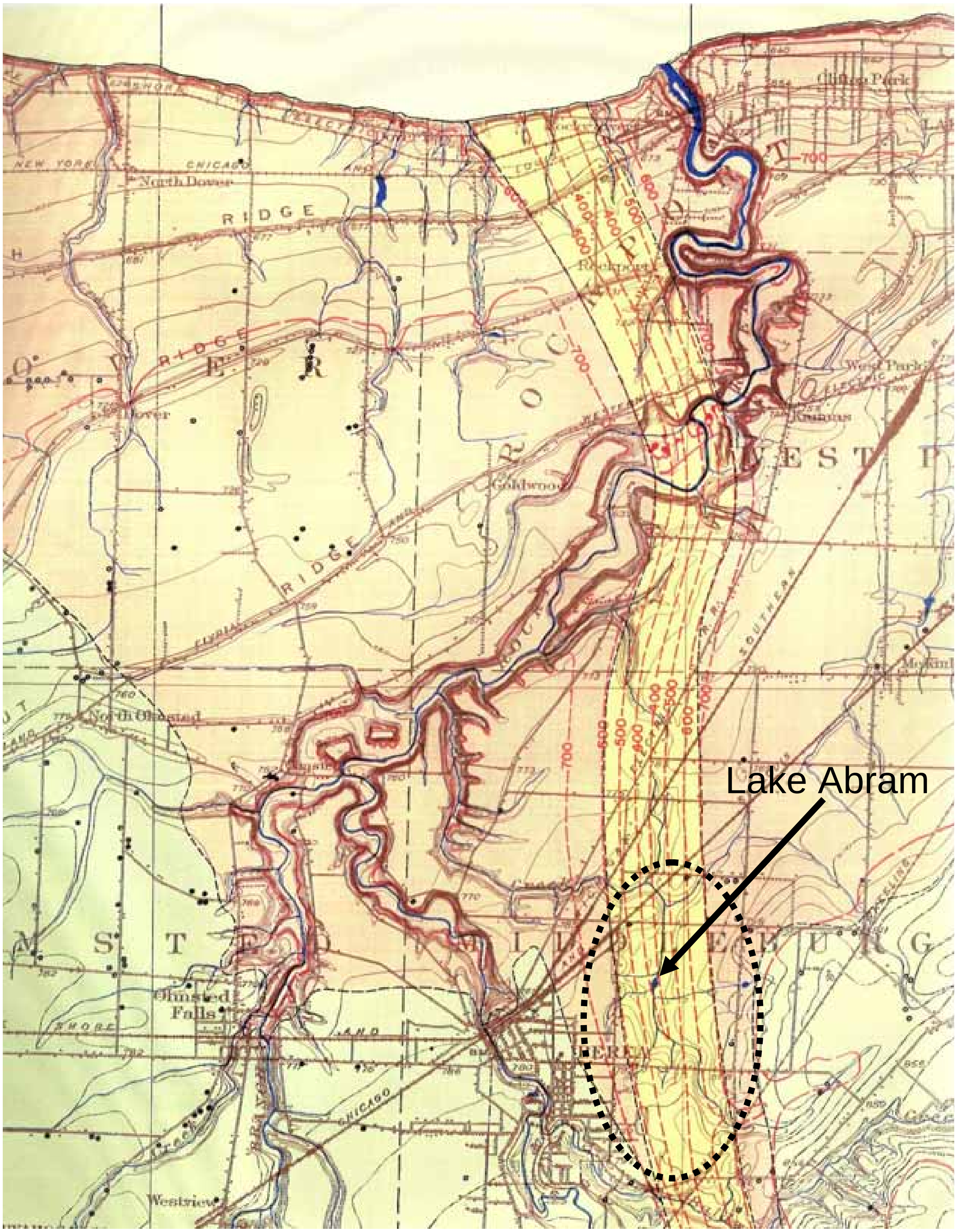


Figure 1. 1952 ground water resources map for Ohio. Ohio Department of Natural Resources, Division of Water in cooperation with the U.S. Geological Survey. Note buried river valley of former Rocky River and location of Lake Abram wetland complex. Yellow = excellent source of ground water, unconsolidated deposits, Light Red = poor source of ground water, unconsolidated deposits, Light Green = good source of ground water, bedrock. Dashed oval indicates main ecosystem area

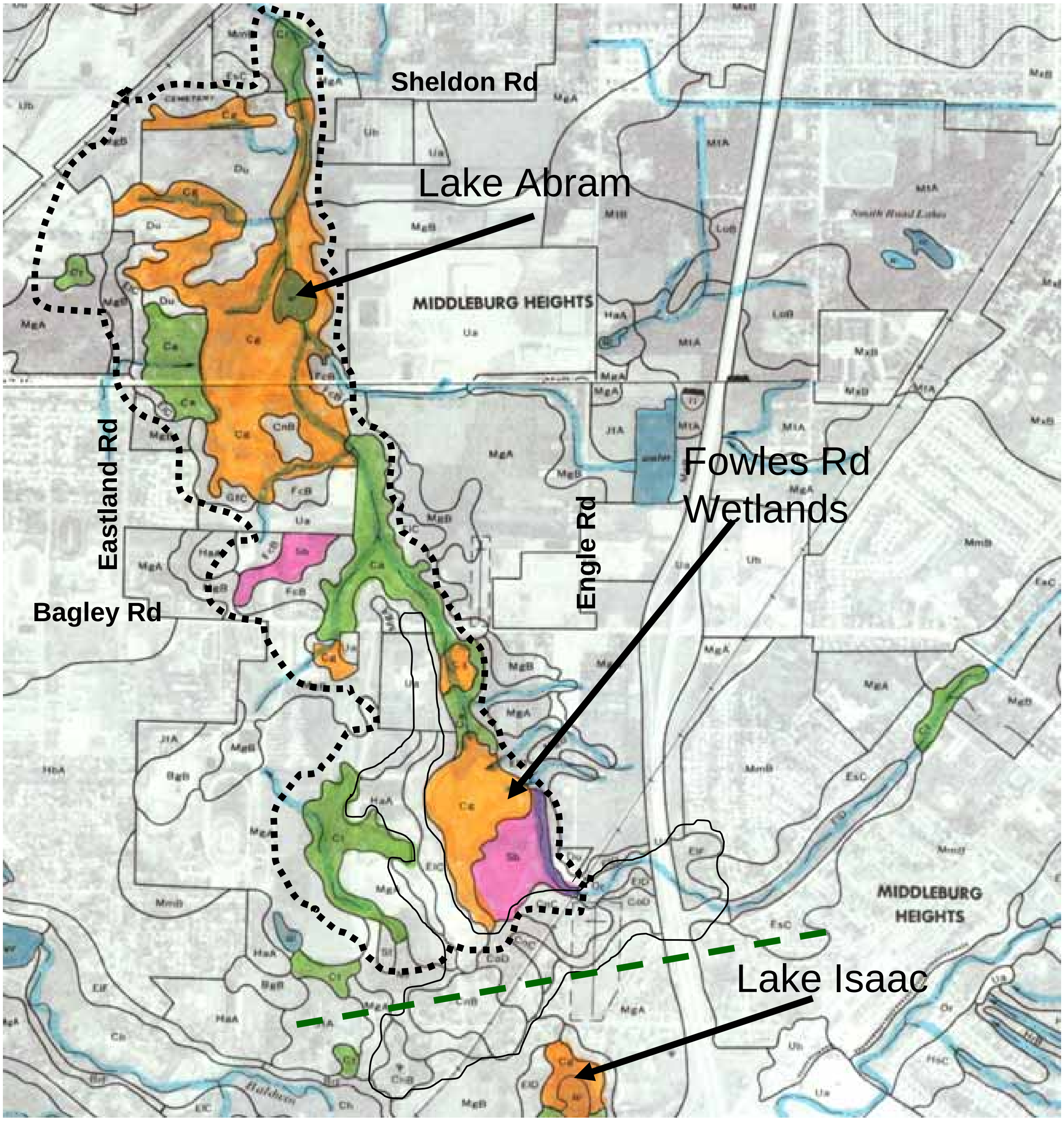


Figure 2. Hydric soils mapped in the LtL ecosystem ca1980. Orange = Carlisle silty clay loam, Green = Condit silty clay loam or Canadice silty clay loam, Pink = Sebring silt loam, Blue = watercourses. Dotted black line = approximate historical extent of LtL ecosystem wetland complex. Dashed green line = divide between Lake Isaac (Baldwin Creek) watershed. Blue shaded area shows Chili-Ellsworth-Haskins loams on side slopes with strong ground water expression at south end LtL ecosystem.

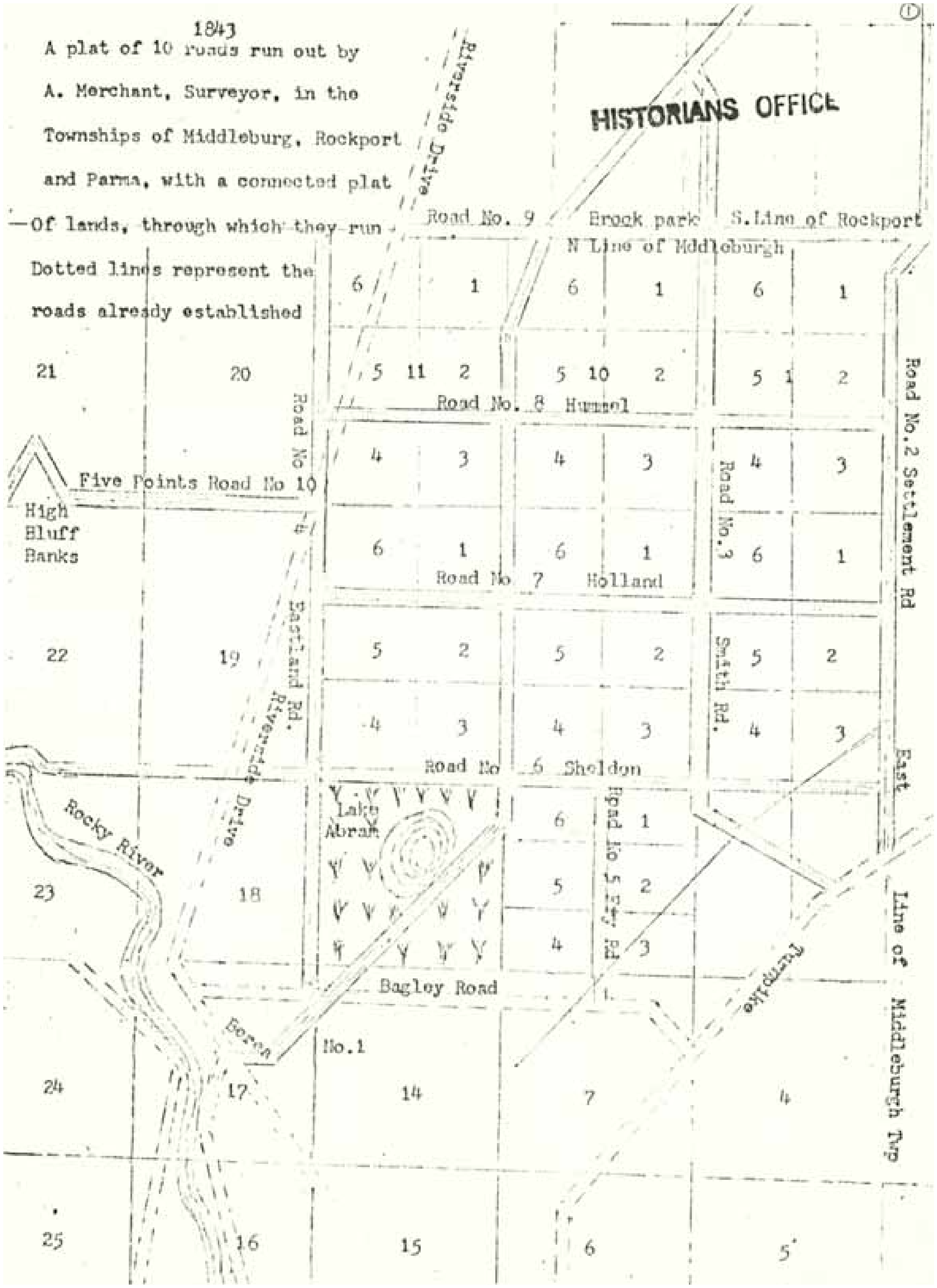


Figure 3. 1843 map of platted rounds in Middleburg Township showing Lake Abram area. Note abandoned diagonal road.

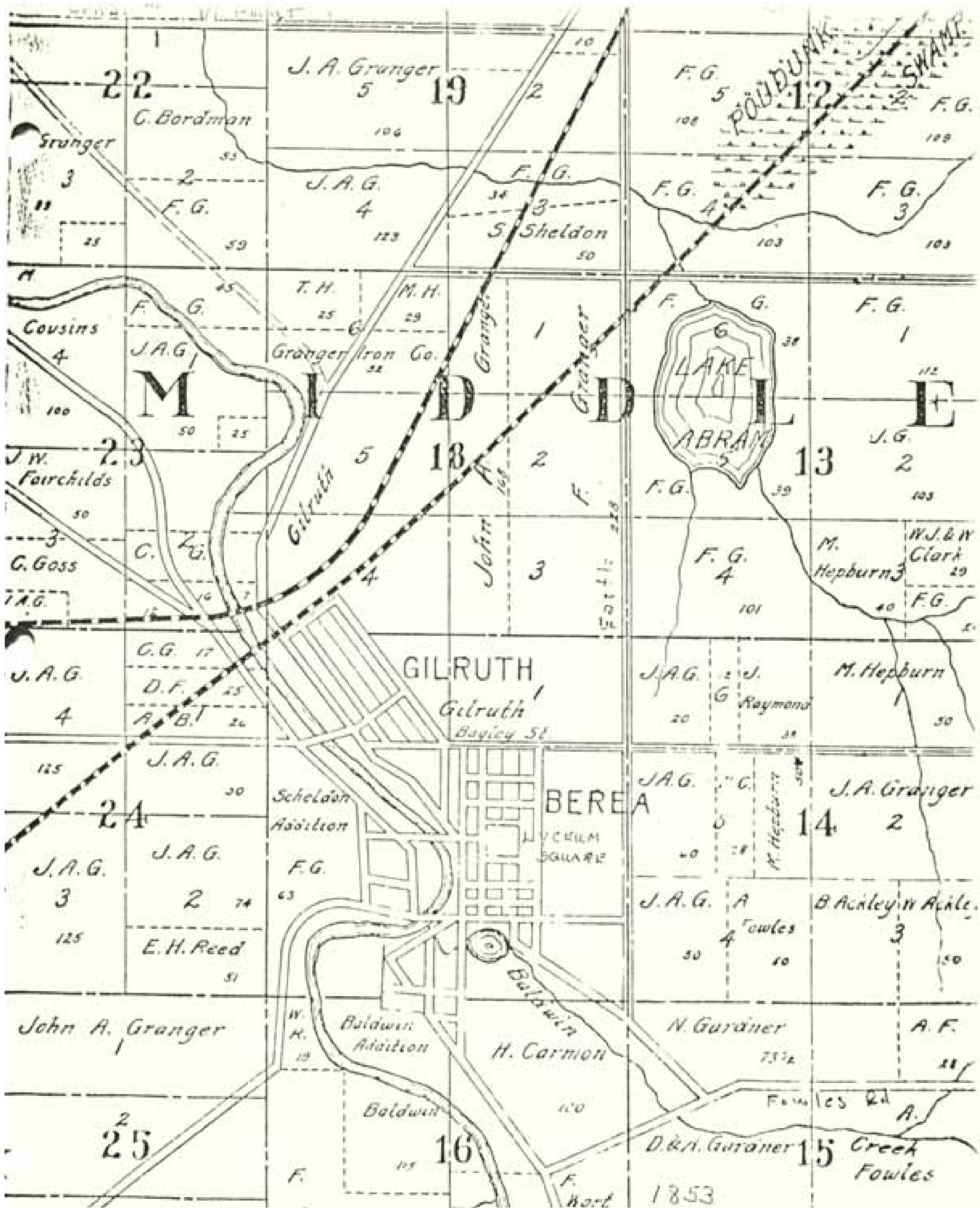
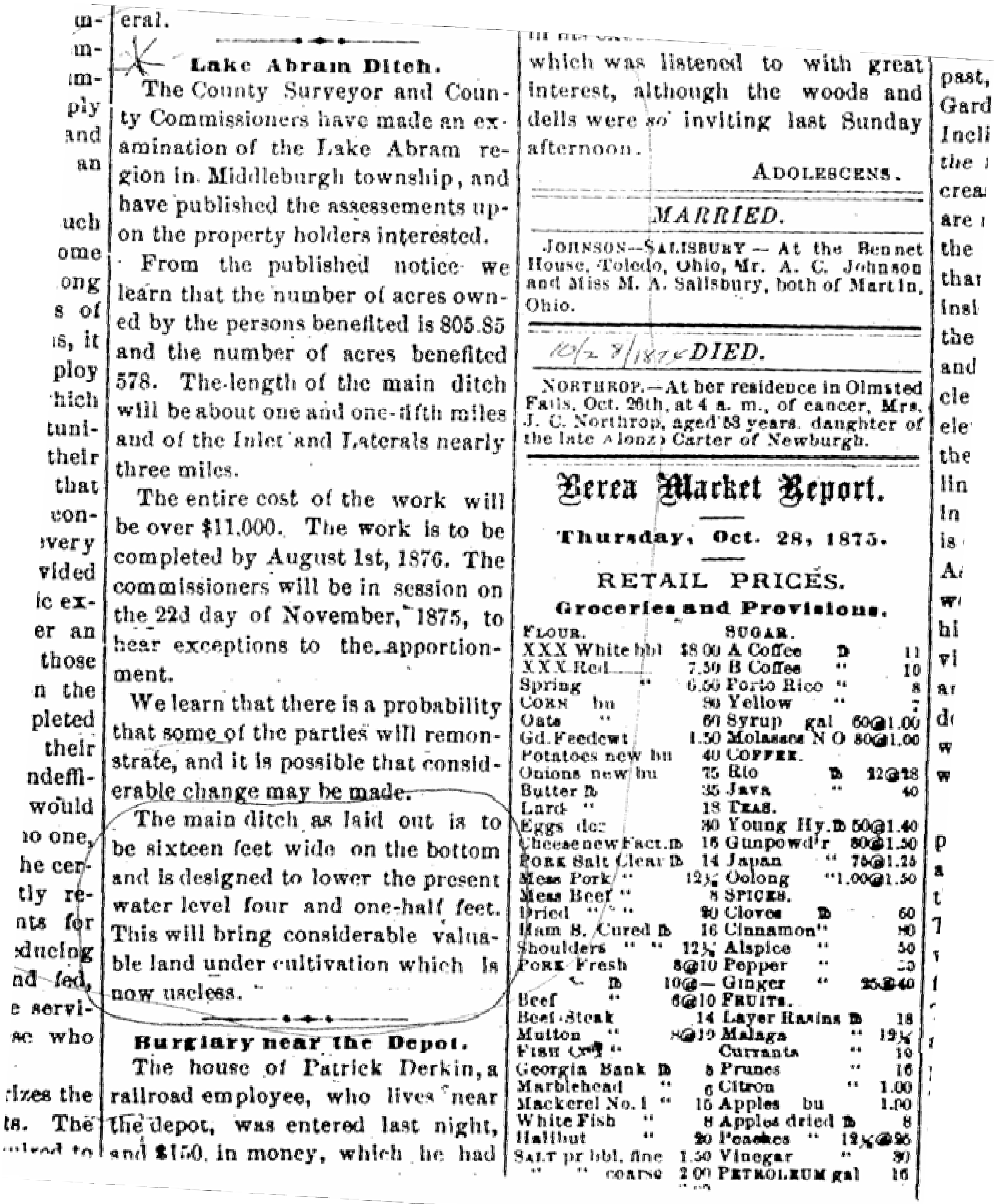


Figure 4. Lake Abram, Abram Creek, and the former Poudunk Swamp ca 1853 with property owners, source unknown.



eral.

Lake Abram Ditch.

The County Surveyor and County Commissioners have made an examination of the Lake Abram region in Middleburgh township, and have published the assessements upon the property holders interested.

From the published notice we learn that the number of acres owned by the persons benefited is 805.85 and the number of acres benefited 578. The length of the main ditch will be about one and one-fifth miles and of the Inlet and Laterals nearly three miles.

The entire cost of the work will be over $11,000. The work is to be completed by August 1st, 1876. The commissioners will be in session on the 22d day of November, 1875, to hear exceptions to the apportionment.

We learn that there is a probability that some of the parties will remonstrate, and it is possible that considerable change may be made.

The main ditch as laid out is to be sixteen feet wide on the bottom and is designed to lower the present water level four and one-half feet. This will bring considerable valuable land under cultivation which is now useless.

Burglary near the Depot.

The house of Patrick Derkin, a railroad employee, who lives near the depot, was entered last night, and $150 in money, which he had

which was listened to with great interest, although the woods and dells were so inviting last Sunday afternoon.

ADOLESCENS.

MARRIED.

JOHNSON—SALISBURY.—At the Bennet House, Toledo, Ohio, Mr. A. C. Johnson and Miss M. A. Salisbury, both of Martin, Ohio.

10/28/1875 *DIED.*

NORTHROP.—At her residence in Olmsted Falls, Oct. 26th, at 4 a. m., of cancer, Mrs. J. C. Northrop, aged 83 years, daughter of the late Alonzo Carter of Newburgh.

Berea Market Report.

Thursday, Oct. 28, 1875.

RETAIL PRICES.

Groceries and Provisions.

FLOUR.		SUGAR.	
XXX White bbl	$8 00	A Coffee lb	11
XXX Red	7.50	B Coffee "	10
Spring "	6.50	Porto Rico "	8
CORN bu	80	Yellow "	7
Oats "	60	Syrup gal	60@1.00
Gd. Feed cwt	1.50	Molasses N O	80@1.00
Potatoes new bu	40	COFFEE.	
Onions new bu	75	Rio lb	22@28
Butter lb	35	Java "	40
Lard "	18	TEAS.	
Eggs doz	30	Young Hy. lb	50@1.40
Cheese new Fact. lb	16	Gunpowd'r	80@1.50
PORK Salt Clear lb	14	Japan "	75@1.25
Mess Pork "	12½	Oolong "	1.00@1.50
Mess Beef "	8	SPICES.	
Dried " "	20	Cloves lb	60
Ham S. Cured lb	16	Cinnamon "	80
Shoulders " "	12½	Alspice "	30
PORK Fresh	8@10	Pepper "	30
" lb	10@—	Ginger "	25@40
Beef "	6@10	FRUITS.	
Beef-Steak	14	Layer Rasins lb	18
Mutton "	8@10	Malaga "	12½
FISH Cod "		Currants "	10
Georgia Bank lb	5	Prunes "	16
Marblehead "	6	Citron "	1.00
Mackerel No. 1 "	15	Apples bu	1.00
White Fish "	8	Apples dried lb	8
Halibut "	20	Peaches "	12½@25
SALT pr bbl. fine	1.50	Vinegar "	30
" " coarse	2 00	PETROLEUM gal	16

Figure 5. Public notice of installation of ditch in Lake Abram area, 28 October 1875.

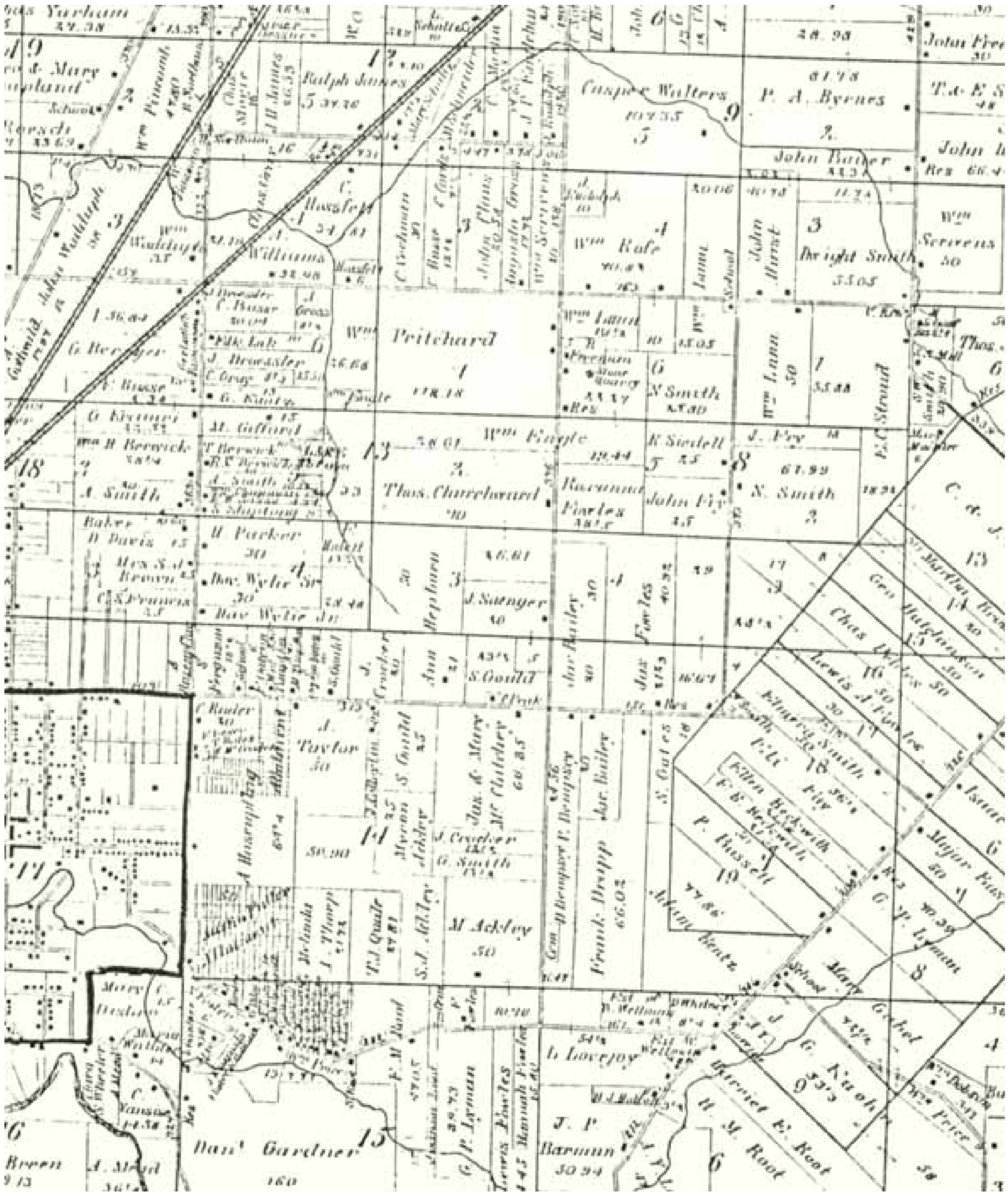


Figure 6. Property owners and map of Lake Abram from 1874 Atlas of Middleburg Township, T6R14.

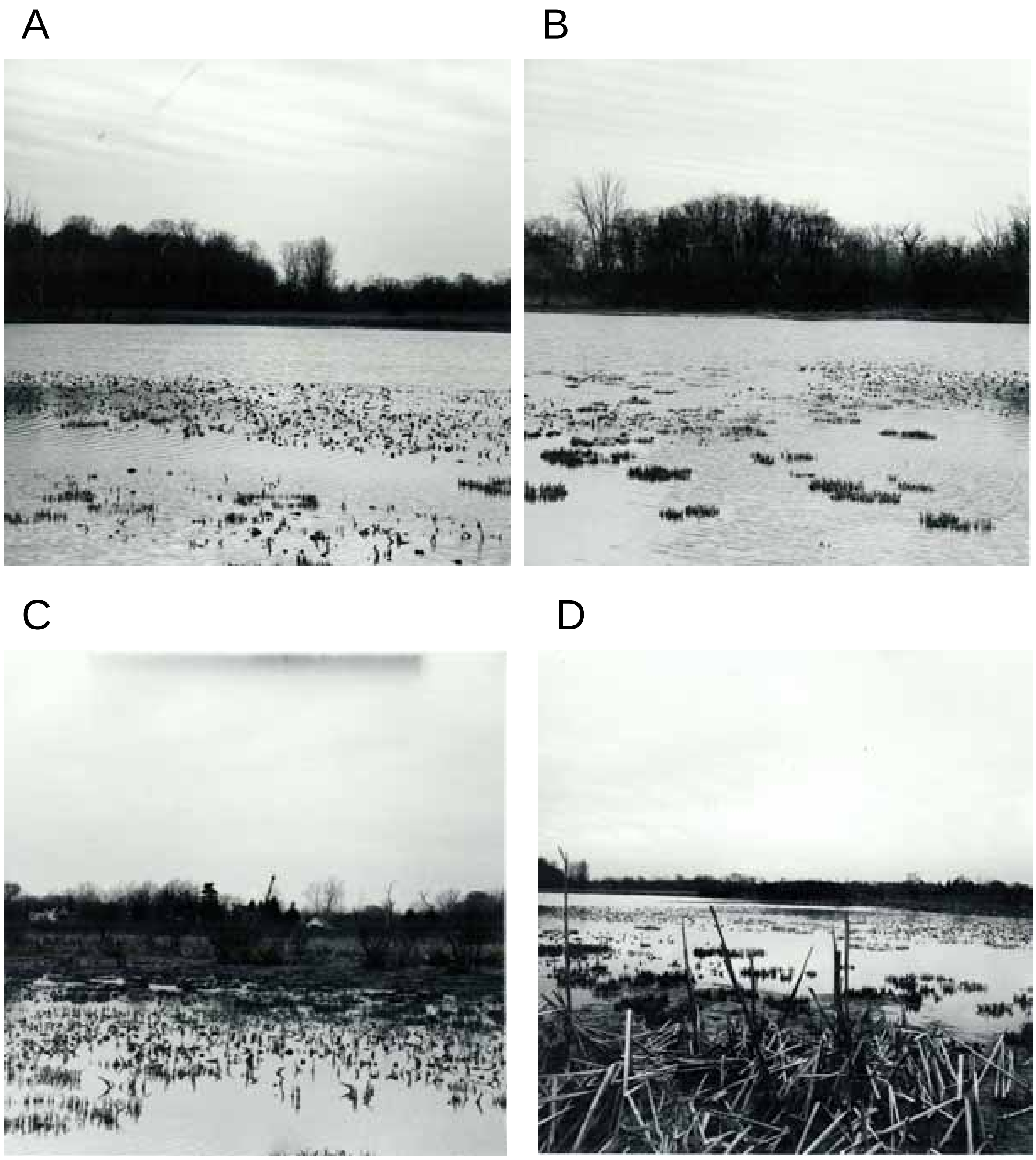


Figure 7. Photographs of Lake Abram from March 1976. A and B: looking south across open water area of Lake Abram. C: Looking southwest towards Eastland Road across open water.

D

E

F

G

Figure 7. Photographs of Lake Abram from March 1976. A and B: looking west towards early stages of fill across lake. C and D: Looking north, northwest towards Eastland/Sheldon Roads.

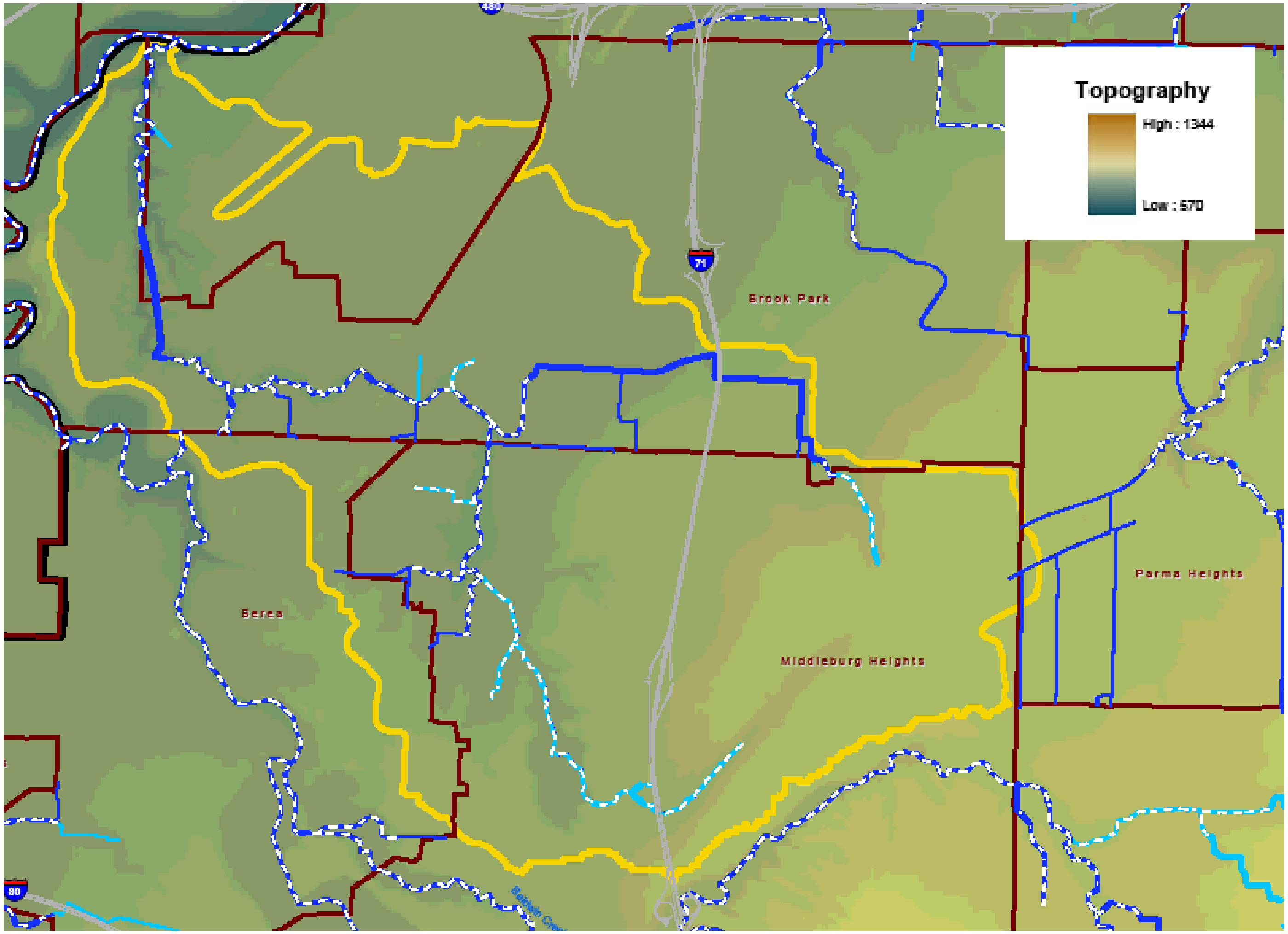


Figure 8. Topography of the Abram Creek Watershed. Scan of Figure 4-3 (RIDE 2004). Dark blue segments are culverted. Dashed segments are open channels. Lighter blue = intracommunity drainage, dark blue = intercommunity drainage. Yellow line in Abram Creek watershed boundary.

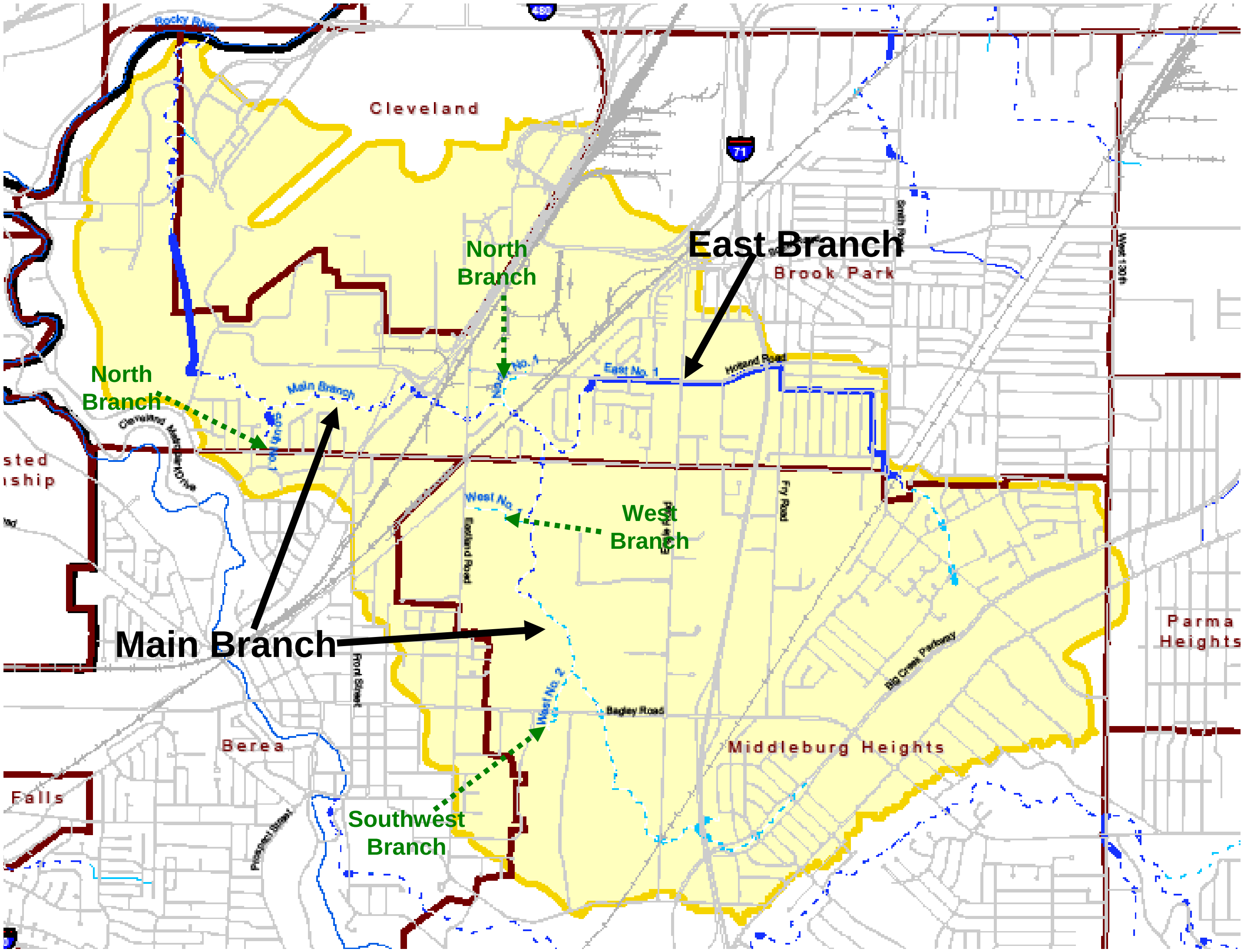


Figure 9. Stream Segments of the Abram Creek watershed. Scan of figure 4-2 (RIDE 2004). Dark blue segments are culverted. Dashed segments are open channels. Lighter blue = intracommunity drainage, dark blue = intercommunity drainage. Yellow line in Abram Creek watershed boundary.

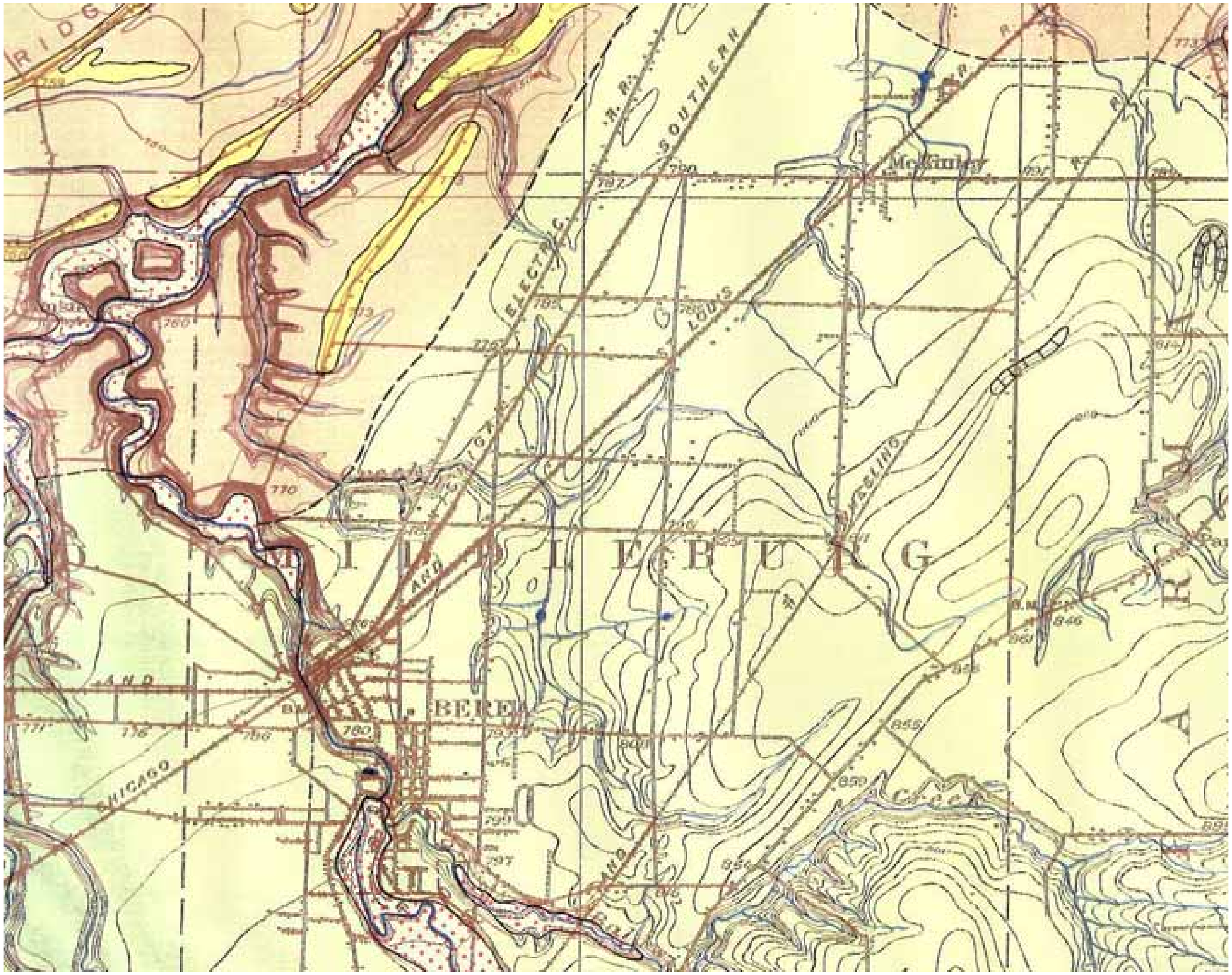


Figure 10. 1952 Topographic and surficial geology map showing lack of urbanization ca 1950 in the Abram Creek watershed.

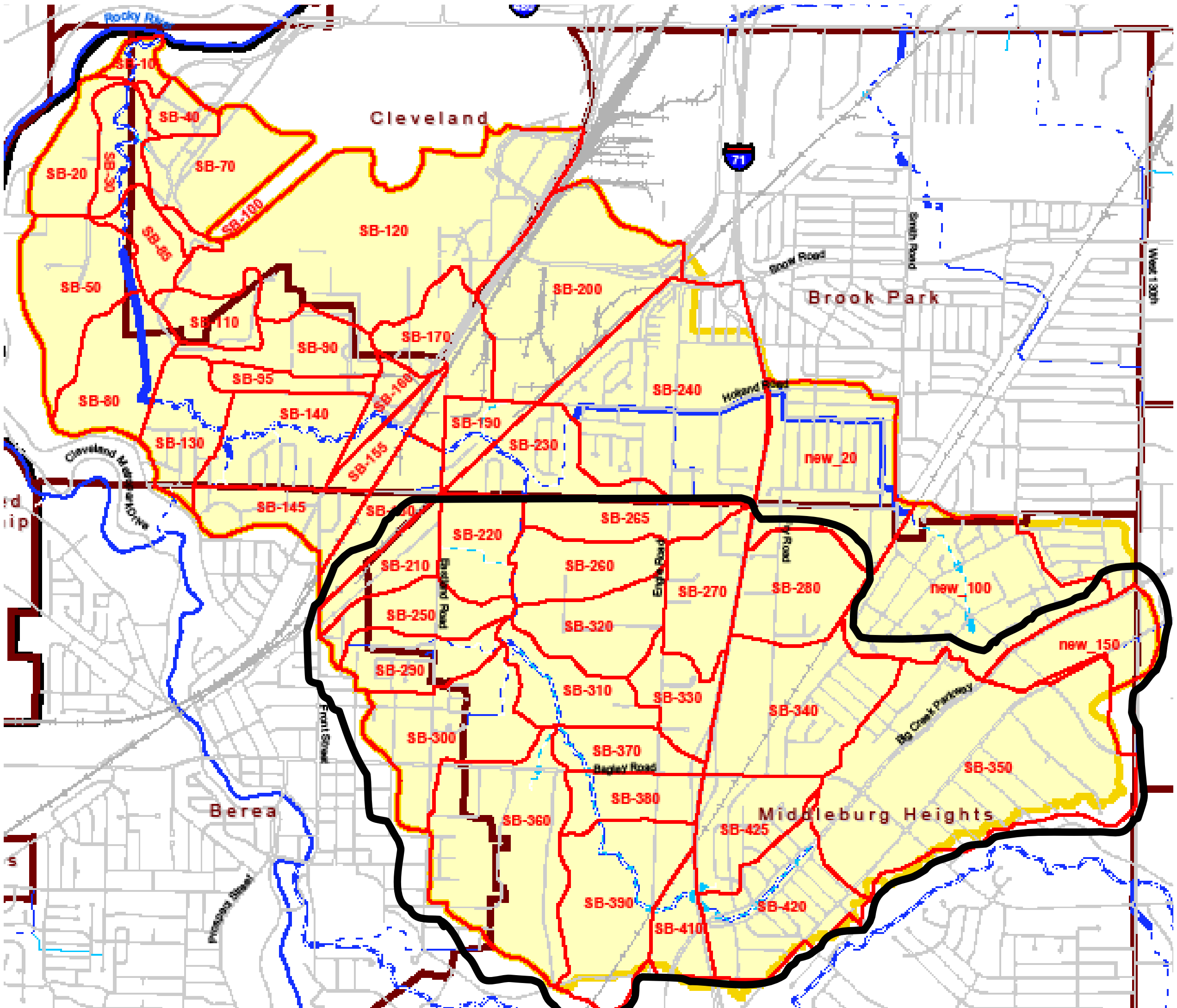


Figure 11. Sewersheds of the Abram Creek Watershed. Outlined area are sewersheds within Lake-to-Lake Trail ecosystem boundary. Scan of Figure 4-4 (RIDE 2004).

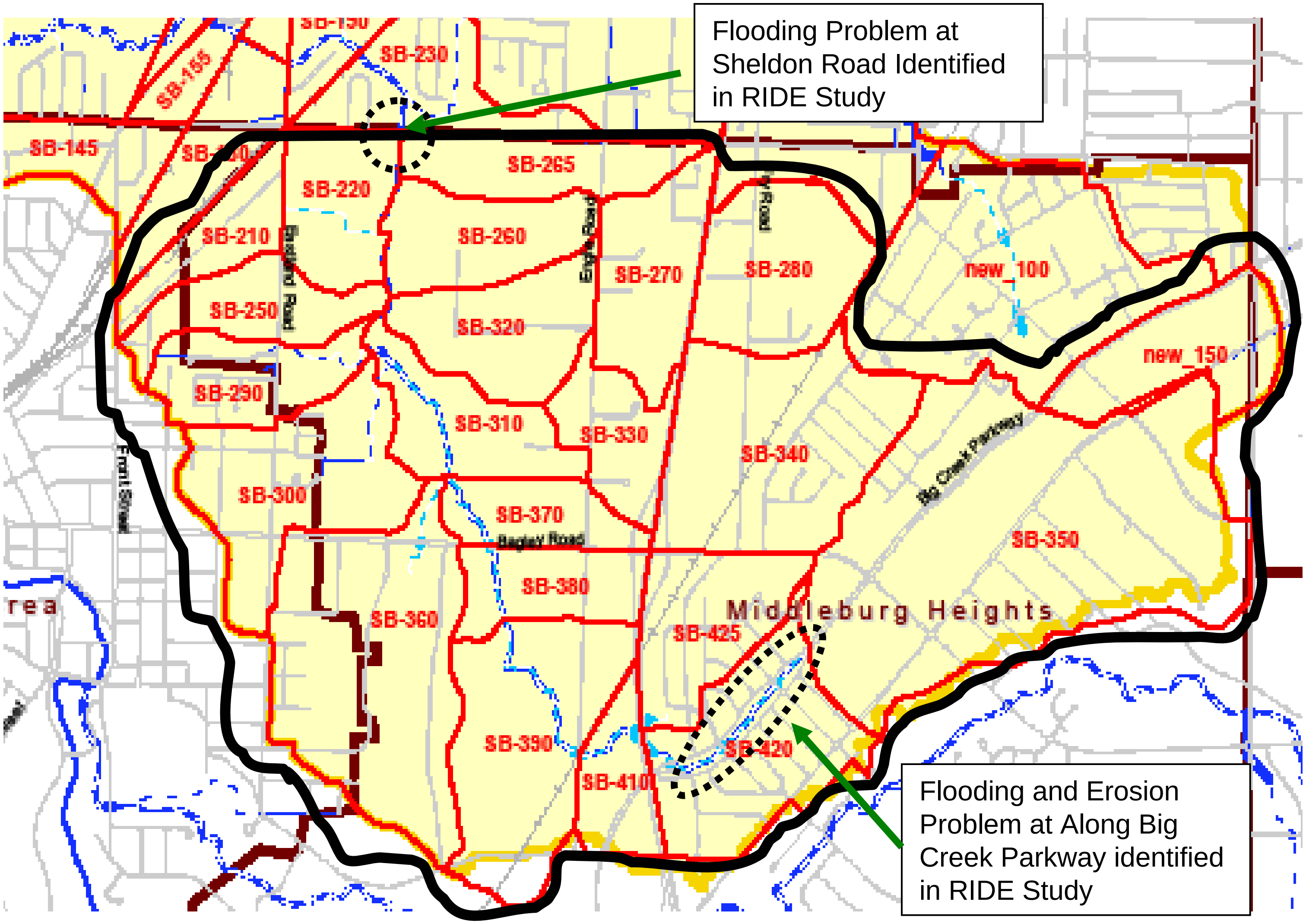


Figure 12. Sewersheds within the Lake-to-Lake Trail ecosystem boundary. Scan of Figure 4-4 (RIDE 2004).

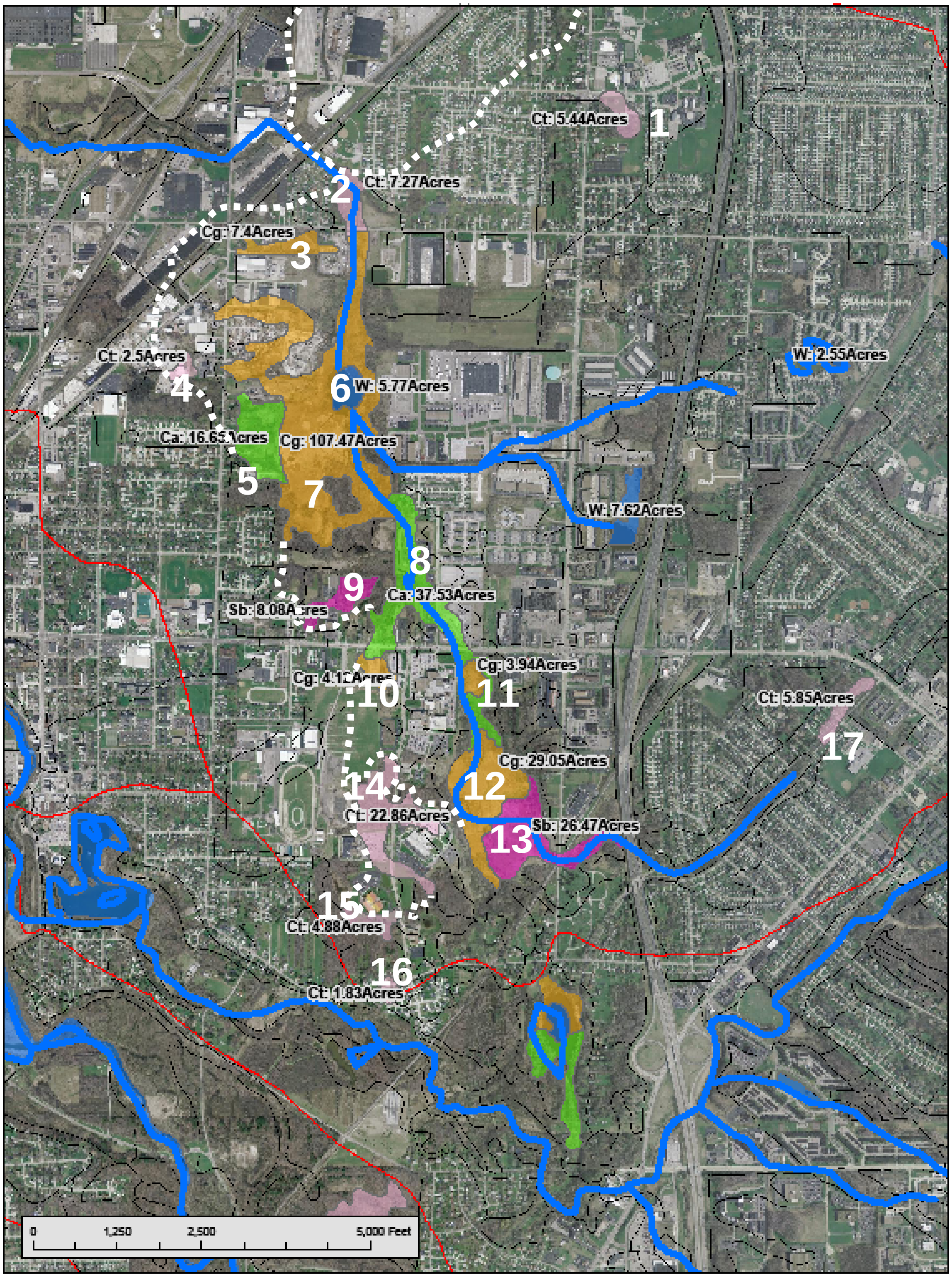


Figure 13. Mapped hydric soil units (SWS 1980) in Lake-to-Lake Trail ecosystem. Dashed line shows probable former extent of hydric soils and wetlands that were filled prior to 1980 when soil map produced. Red line is watershed boundary. Blue lines are streams and open water areas.

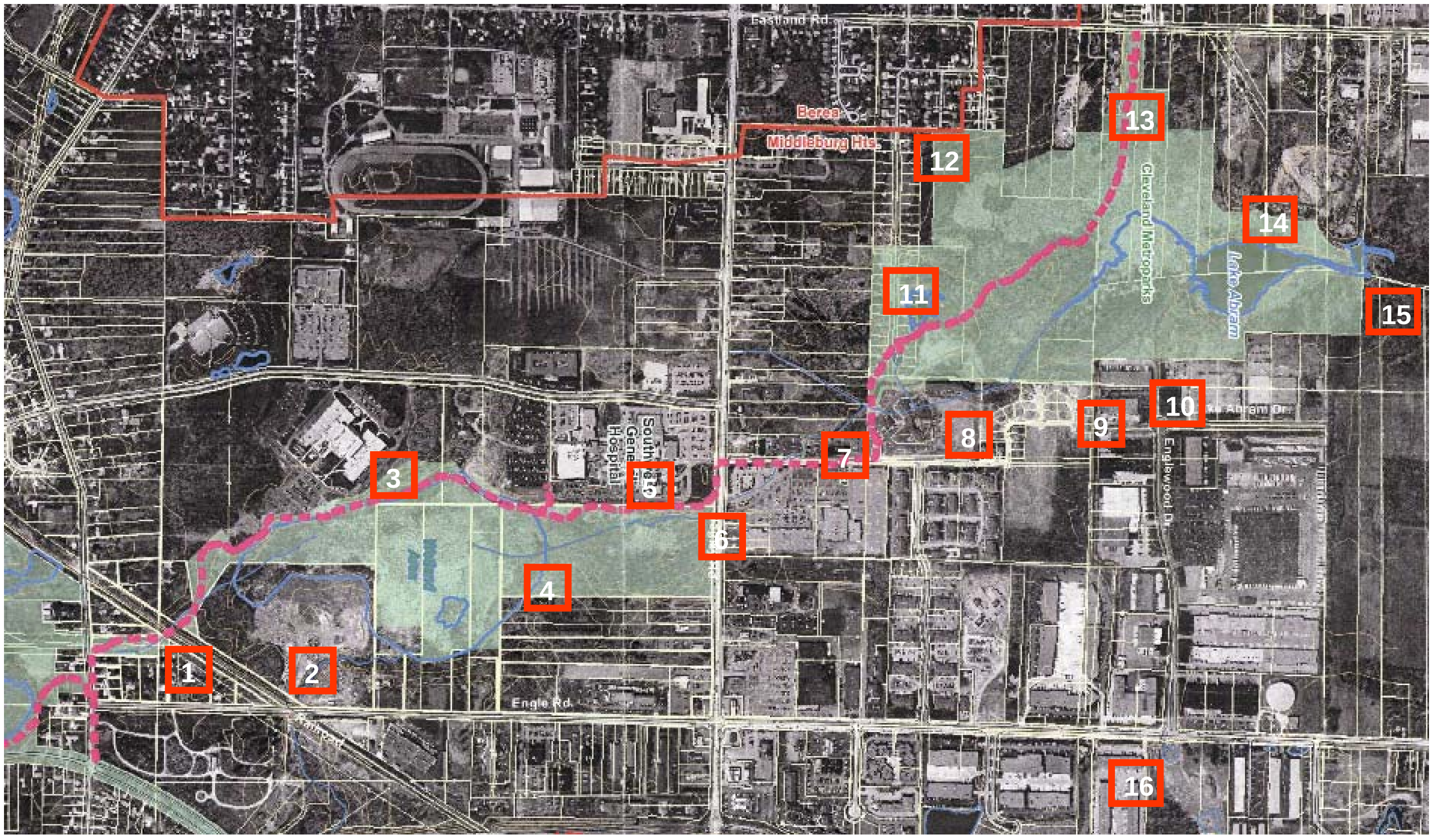


Figure 14. Major stressors on Lake-to-Lake Trail ecosystem services and condition. (1) Water quantity and quality influences upstream of Engle Road on Abram Creek, (2) Filling in Fowles Road Wetland, (3) Storm water input from Polaris Center, (4) Channelization and lowering of lake level in Fowles Road Wetland, (5), Filling and storm water inputs from Southwest General Hospital, (6) Culverting Abram Creek and filling of wetland in Hepburn Road area, (7) Storm water inputs from Oak Grove Road area, (8) Filling, waste disposal and relocation of Abram Creek, (9) Storm water inputs from development west of Engle Road (South Ditch), (10) Storm water input from Engle Road industrial complex (North Ditch), (11) Filling at south end of Lake Abram complex, (12) Storm water from Robin Drive subdivision, (13) Filling and storm water from Eastland/First Avenue Road areas, (14) Filling at Fabreze and Eastland Road industrial areas, (15) Filling, channelization and storm water at north end of Lake Abram complex, (16) Storm water inputs from east of Engle Road (see sewer sheds in Figure 12).

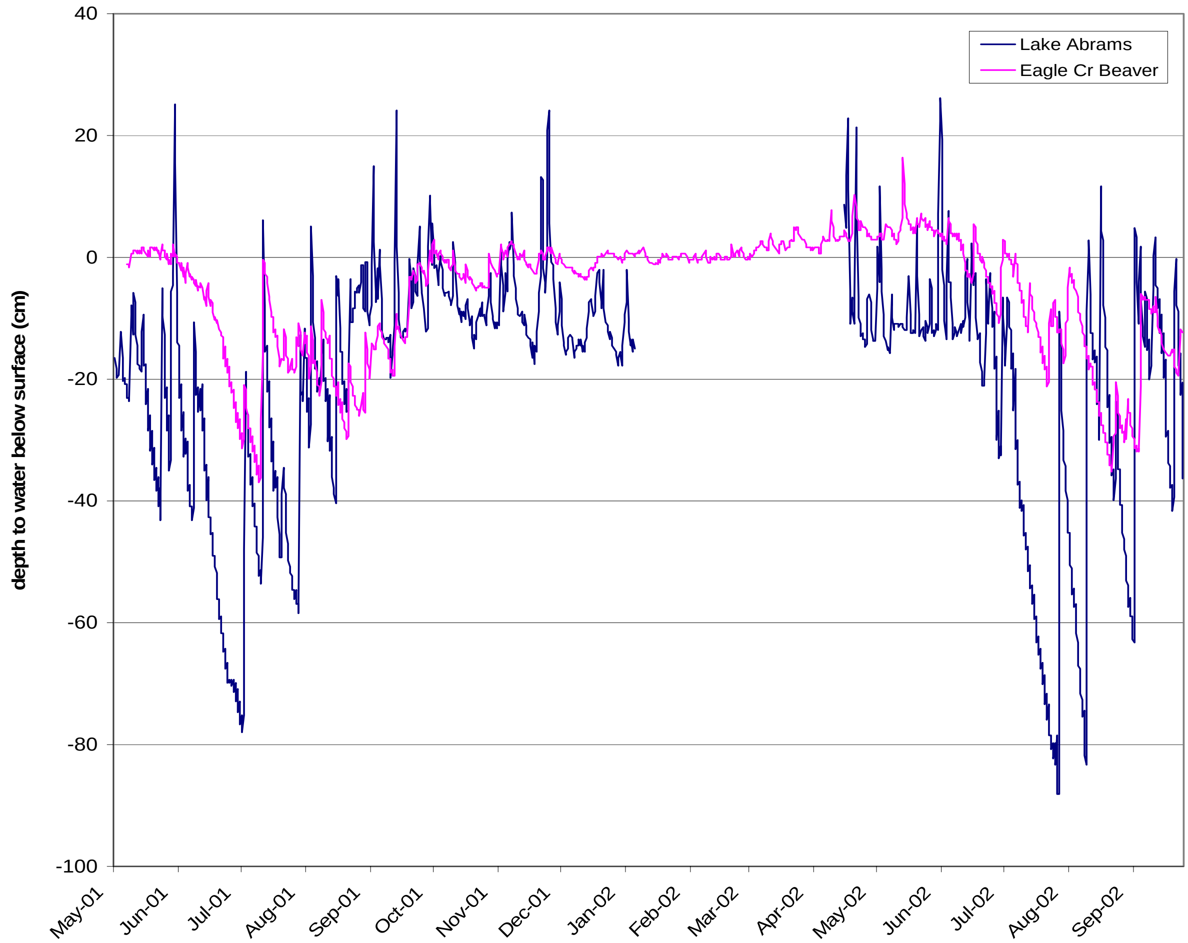


Figure 15. Hydrograph for Lake Abram showing flashy storm water influenced hydrology and Eagle Creek Beaver a hydrologically undisturbed wetland in Portage Co. showing, stability of hydrograph. From data from Fennessy et al. (2004).

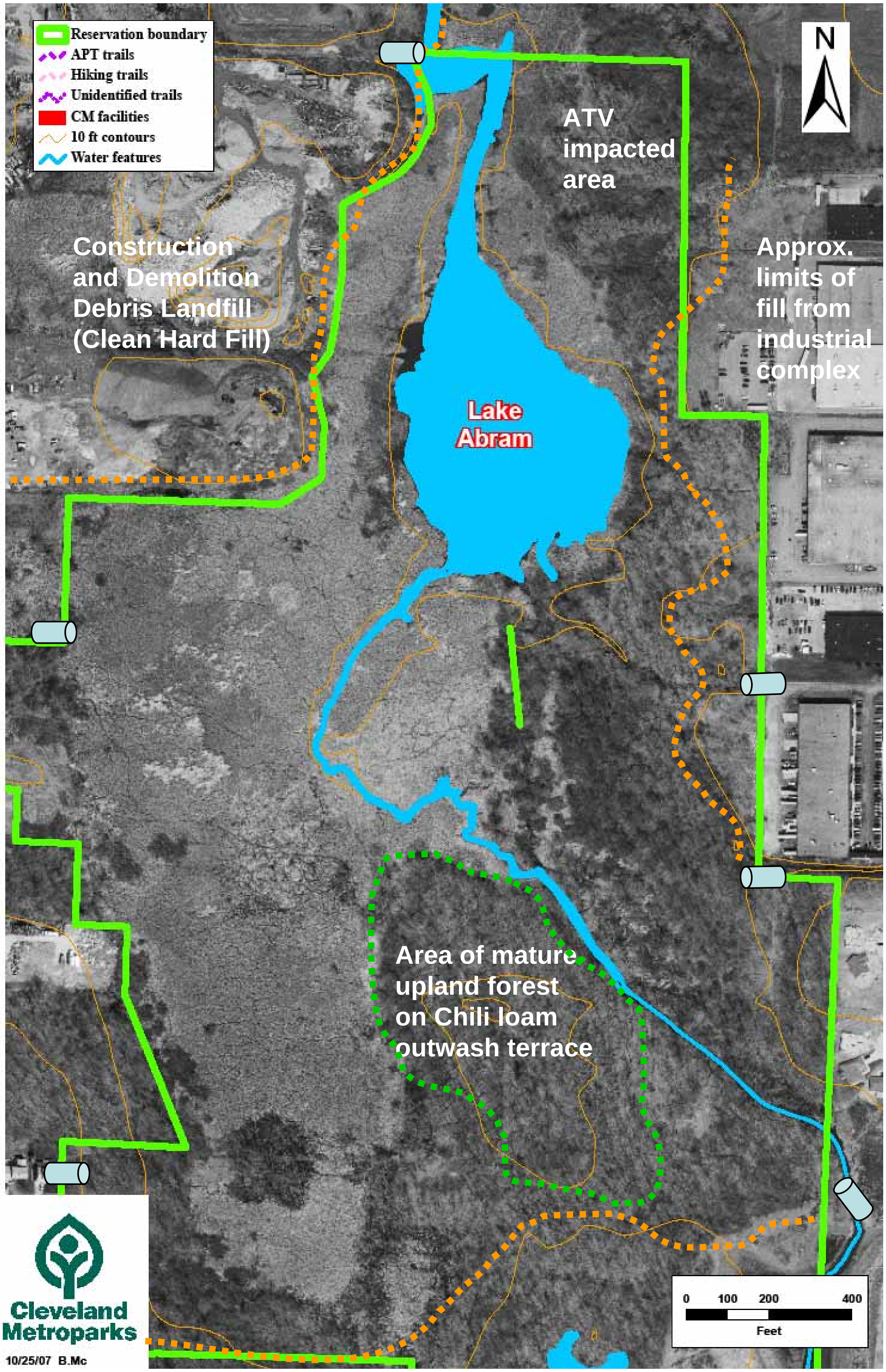


Figure 16A. Upper area of Lake Abram ecosystem showing areas of fill, channelization, and storm water inputs. (storm water input symbol) = known or suspected storm water input location.

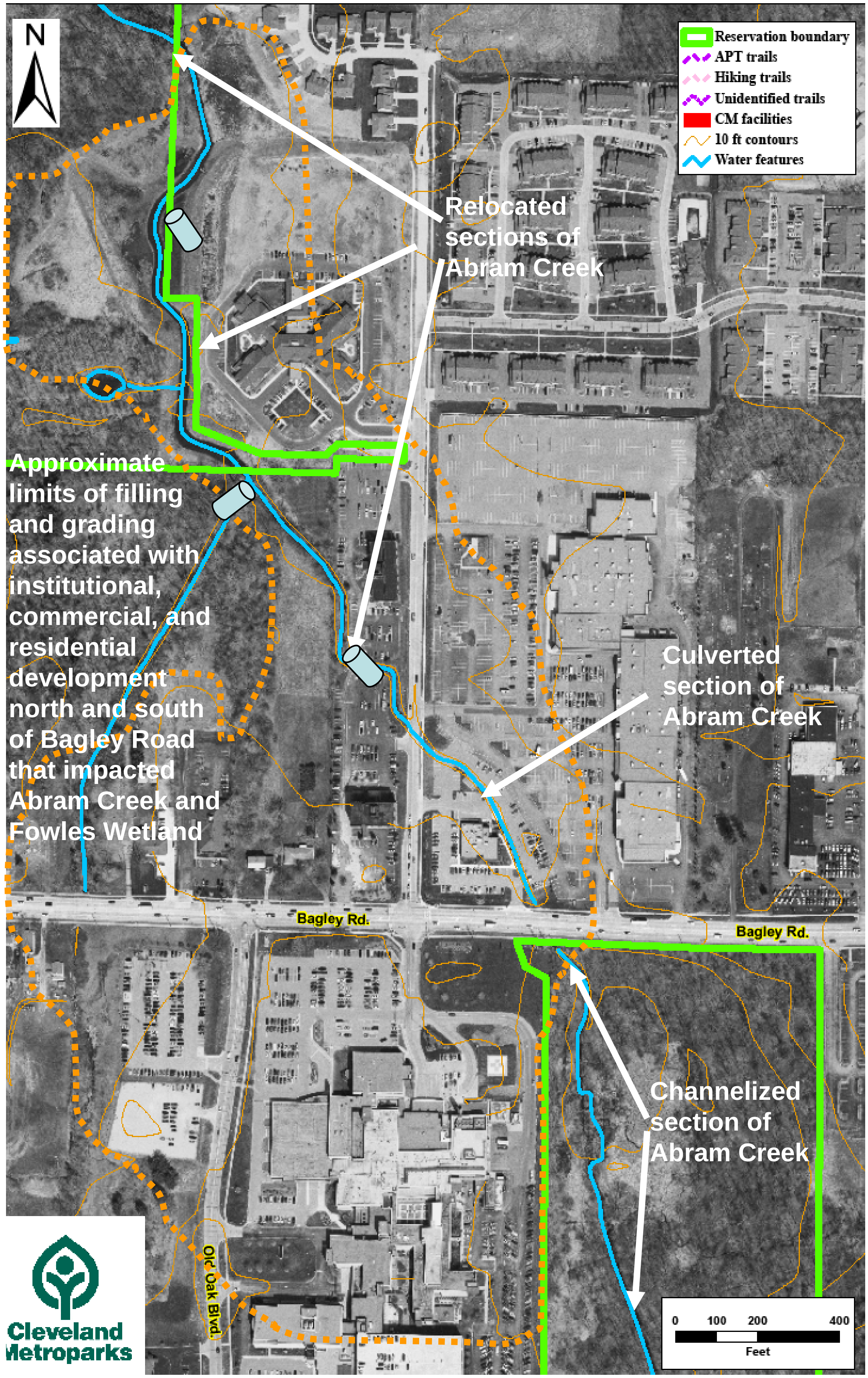


Figure 16B. Middle area of Lake Abram ecosystem showing areas of fill, channelization, culverting, and relocation of Abram Creek. (culvert symbol) = known or suspected storm water input location

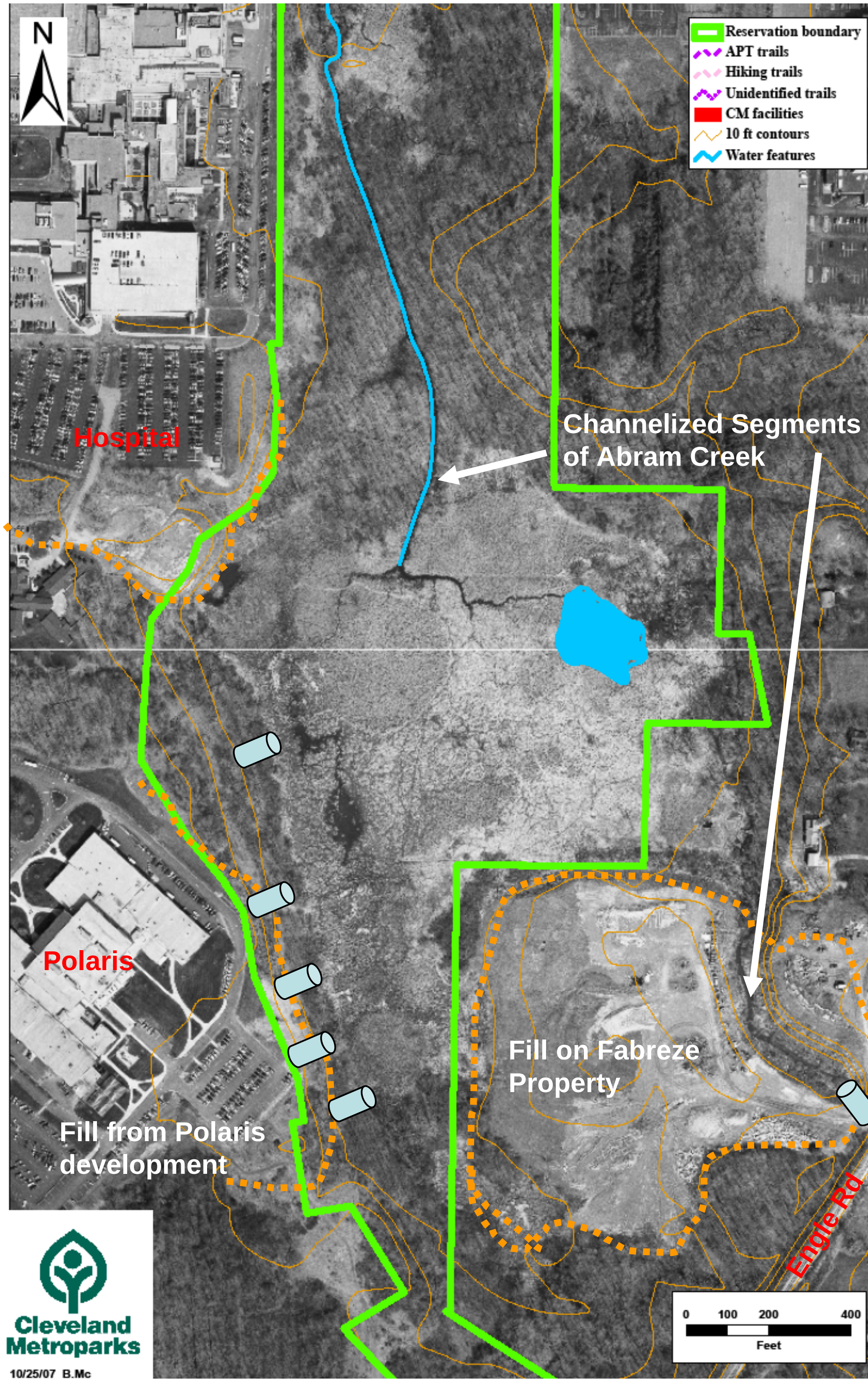
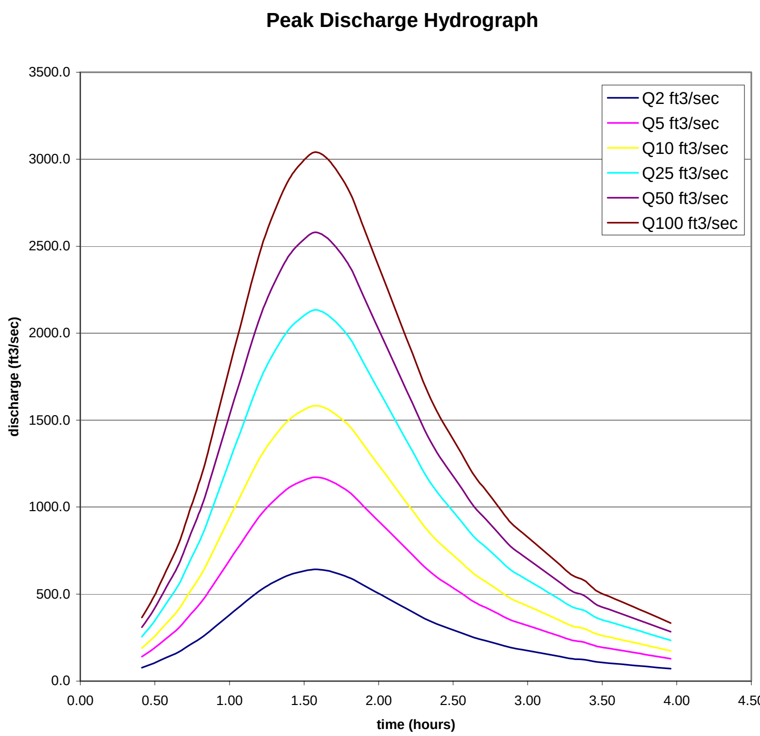


Figure 16C. Southern end of Lake Abram ecosystem showing Fowles Wetland area and areas of fill, stream channelization, development, and known stormwater inputs. [cylinder symbol] = known or suspected storm water input location.



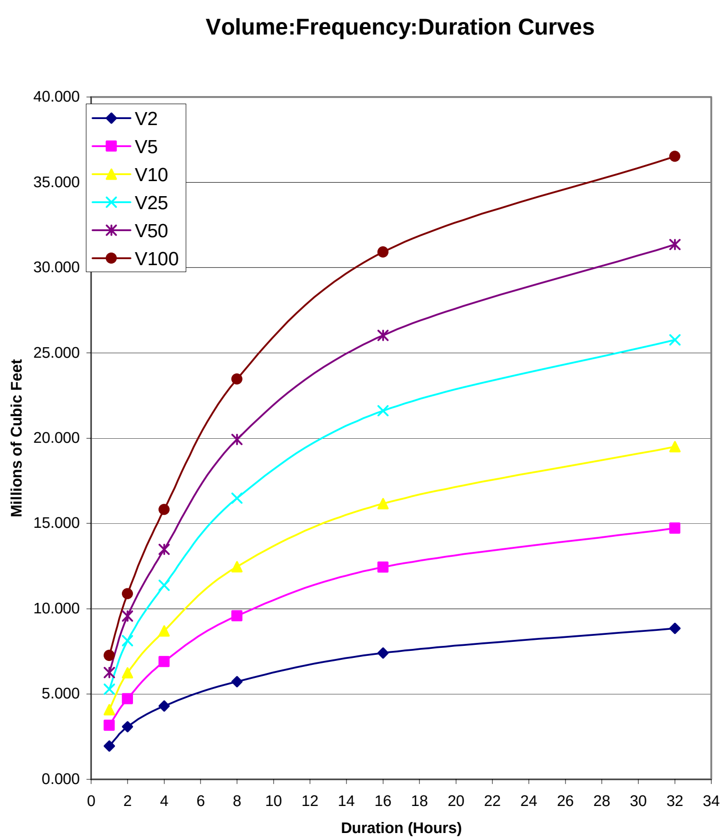
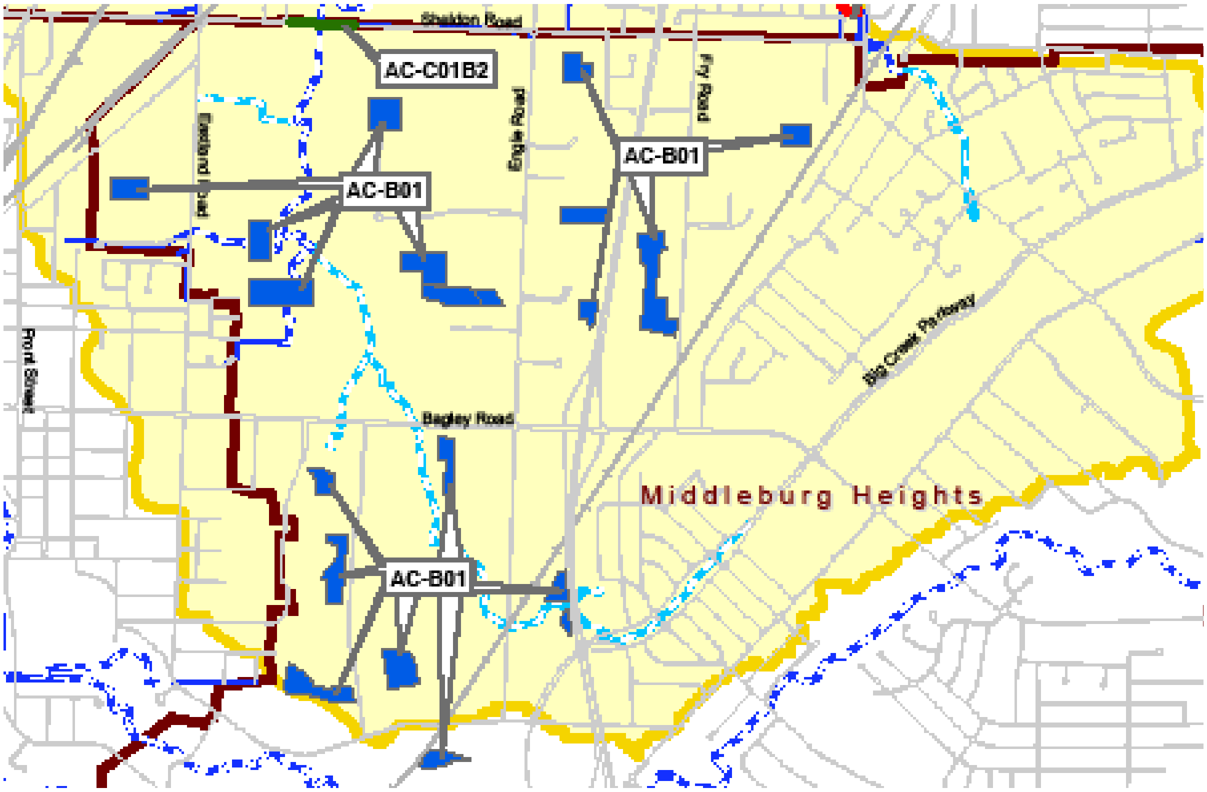


Figure 17. Peak discharge and Volume:Frequency:Duration curves for Lake-to-Lake Trail ecosystem following Sherwood (1994).



Improvement Option ID	Description of Improvement Option	Cost $
AC-A03	Install 728 LF sewer.	$252,000
AC-B01	Construct 258.86 MG dry detention basin, including 13.75 MG extended detention for water quality.	$30,516,000
AC-B02	Construct 20.40 MG dry detention basin, including 3.15 MG extended detention for water quality.	$2,579,000
AC-C01B2	13,685 SF roadway raising.	$123,000
Total Design, Construction, and Land Acquisition Cost:		$33,470,000

Figure 18. Storm water detention facilities recommended in the RIDE Study for Abram Creek watershed (NEORSD 2004).

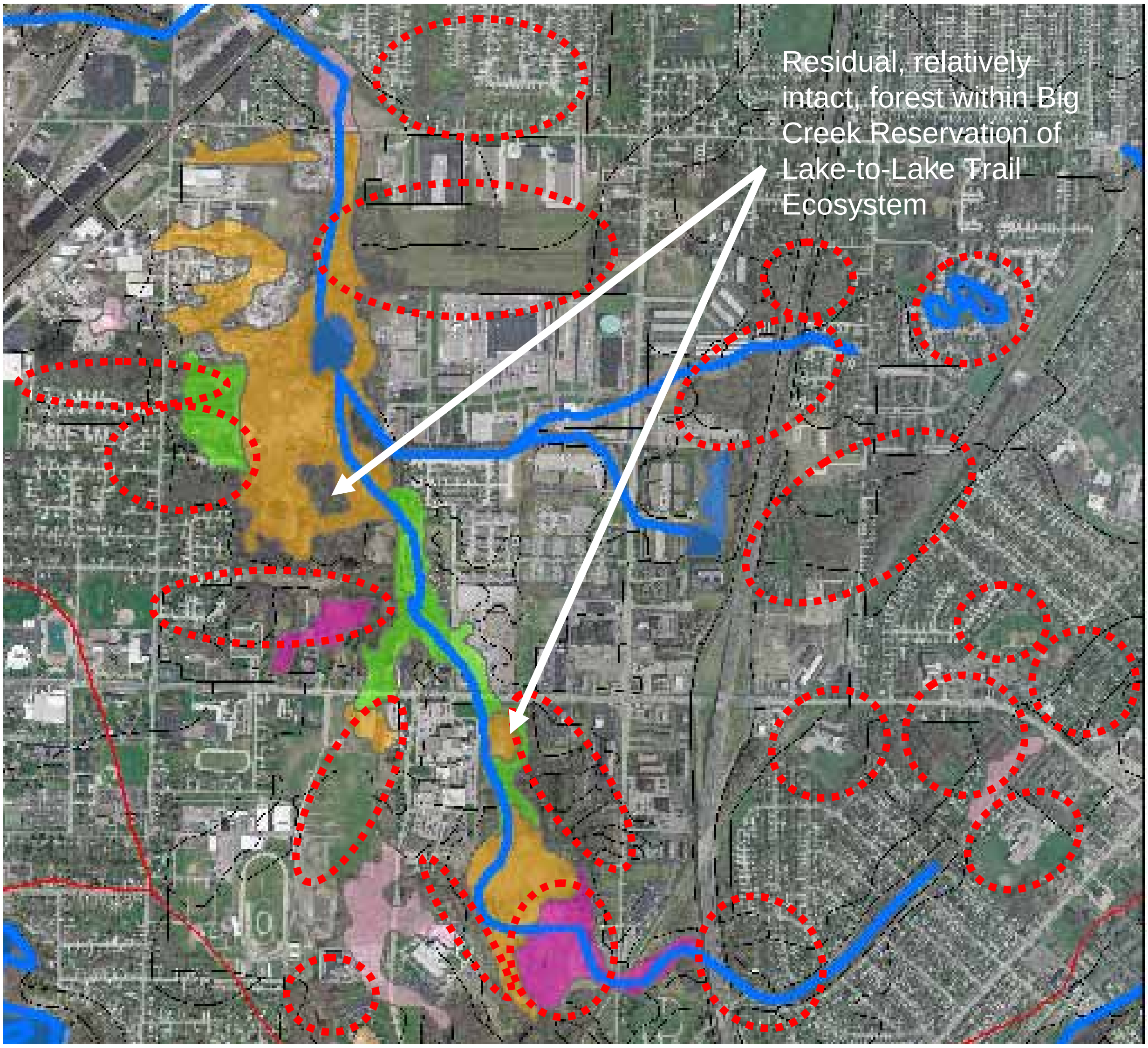


Figure 19. Initial, potential upland (mostly forest) restoration and preservation areas noted within the ecosystem area (Mack personal observation).

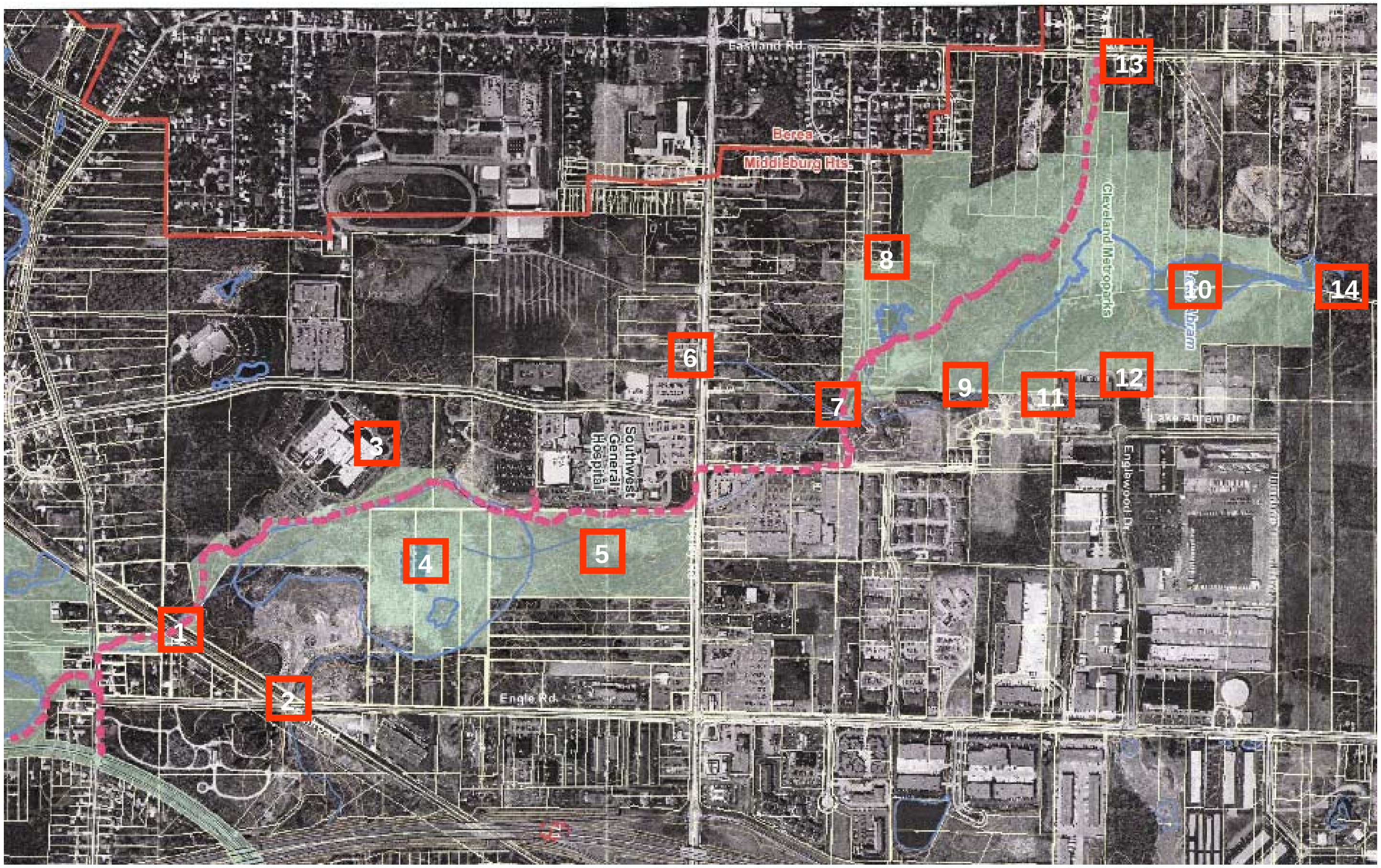


Figure 20. Water Quantity and Quality Monitoring Locations for Lake-to-Lake Trail ecosystem. Locations in yellow circles are considered key locations (1) Ground water inputs at railroad embankment, (2) Abram Creek where it crosses Engle Road, (3) Multiple storm water culverts from Polaris Center, (4) Fowles Road Wetland proper, (5) Abram Creek at outlet of Fowles Rd Wetland and/or as it passes into culvert under Bagley Road, (6) Southwest Segment upstream of Bagley Road culvert, (7) Southwest segment upstream of confluence with mainstem Abram Creek, (8) Potential Inputs from Robin Drive subdivision streets, (9) Abram downstream of Hepburn Road developments and inputs, (10) Lake Abram proper, (11) South Ditch, (12) North Ditch, (13) West of Engle Development, (14) Abram Creek at Sheldon Road.