Chapter 2 – Overview
The Portage Lakes in the Landscape

This chapter discusses the lakes, watershed, and the canal that connects the lakes across the drainage divide between the Ohio River and Lake Erie basin. Lake levels are managed by dams for flood control, and some flow is diverted north across the drainage divide. Understanding how water is controlled and moves into and through the lakes is important in determining how to manage them.

- Originally a collection of kettle lakes, the Portage lakes were modified and enlarged as a water supply for the Ohio and Erie Canal. Similar to the ancient portage, the canal crosses the Lake Erie-Ohio River drainage divide.
- The Portage Lakes are within the Upper Tuscarawas watershed, receiving water and influenced by 74 square miles of communities within the watershed.
- With dams and the canal, the lakes are used for flood control and for diverting flow from the Ohio River Basin north to the Lake Erie basin. A small staff maintains lake levels and flow into the canal by manipulating lake drains and gates and removing obstructions.
- The highest of the lakes and southernmost, Nimisila Reservoir, mostly flows south but occasionally is released to Turkeyfoot Lake to partially refill the other Portage Lakes.
- North of Nimisila, the other lakes descend to Long Lake, beginning with Turkeyfoot Lake and the other "Main Chain" lakes, which are connected by channels. The other lakes are lower than the Main Chain, separated by dams.
- Long Lake, the northernmost and lowest in elevation, discharges to the Tuscarawas River and the Ohio and Erie Canal, where the water is moved north to the Lake Erie Basin at Lock 1 in Akron.

Chapter Organization

2. The Portage Lakes in the Landscape

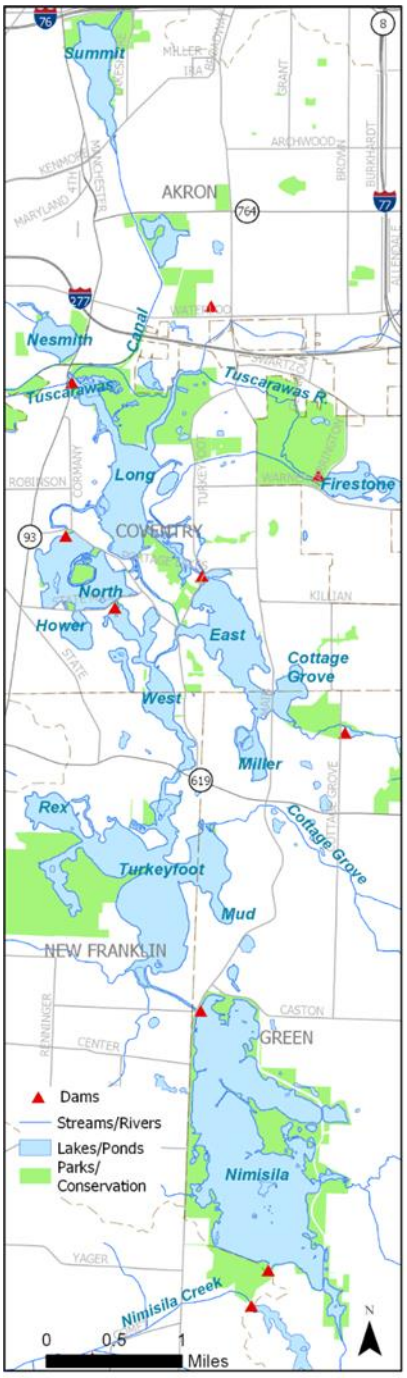
The Portage Lakes – Location

The Portage Lakes is a series of connected lakes in Akron, Coventry Township, the Village of New Franklin, and the City of Green in southern Summit County, Ohio (See Maps 2.1 and 2.2).[1] The lakes are part of the Portage Lakes State Park. Two parks on the lakes are managed by Summit County Metro Parks.

The Portage Lakes are an unusual combination of natural lakes, dams, canals, reservoirs, and an intensely managed waterway. The reservoirs were originally built to provide water for the nearby Ohio and Erie Canal. Today, the dams, augmented by lake drains, are used for flood control and regulating flow between the Ohio River basin (the Tuscarawas River) and the Lake Erie basin (the Cuyahoga River).

Map 2.2 Portage Lakes Location

Map 2.1 – The Portage Lakes



NEFCO, 2020. Map Sources Maps 2.1, 2.2: ODNR GIS; Summit County GIS; National Hydrologic Database (NHD) 2016; AMATS; Western Reserve Land Conservancy.

The Lakes and the Divide

Map 2.4 Canal and Drainage Divide

Map Sources Maps 2.3, 2.4: ODNR GIS; National Hydrologic Database (NHD) 2016

Map 2.3 Tuscarawas River Watershed

The Portage Lakes are in the upper Tuscarawas River watershed just south of the Lake Erie-Ohio River drainage divide (Map 2.3).[2] Water north of the divide naturally flows to Lake Erie, while water south of the divide flows to the Ohio River. Water from the lakes enters the Tuscarawas River from Long Lake in the north and from the Nimisila Reservoir (via Nimisila Creek) at the southern end, then flows south to the Ohio River via the Muskingum River.

Ohio & Erie Canal and the Portage Lakes

The Portage Lakes are unusual, because they have been connected to both Ohio and Erie drainage areas by the Ohio Canal (Map 2.4). Water from the Portage Lakes mostly flows south to the Ohio River, but some is diverted north to Lake Erie. Canal construction and operation shaped the lakes today.

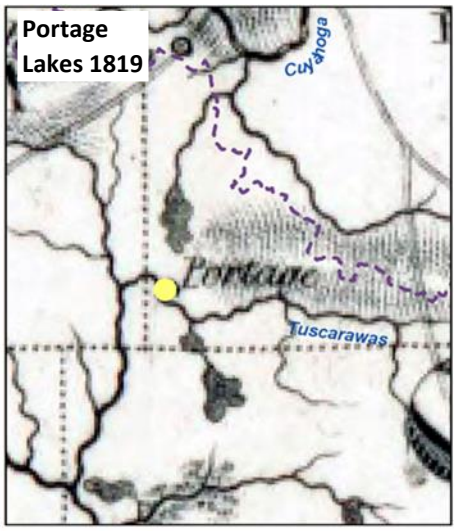
Early inhabitants of this area portaged between the Lake Erie and Ohio River basins south of where Akron is now. Settlers and surveyors (including George Washington) noted the importance of a potential trade route connecting the Ohio River/Mississippi drainage to Lake Erie. Following development of the Erie Canal, the Ohio and Erie Canal was begun in 1825 and finished in 1832, spanning the divide and creating a transportation system between the Great Lakes and the Gulf of Mexico.

Fig. 2.1 Shape of the Lakes[3]

Before the Canal was built

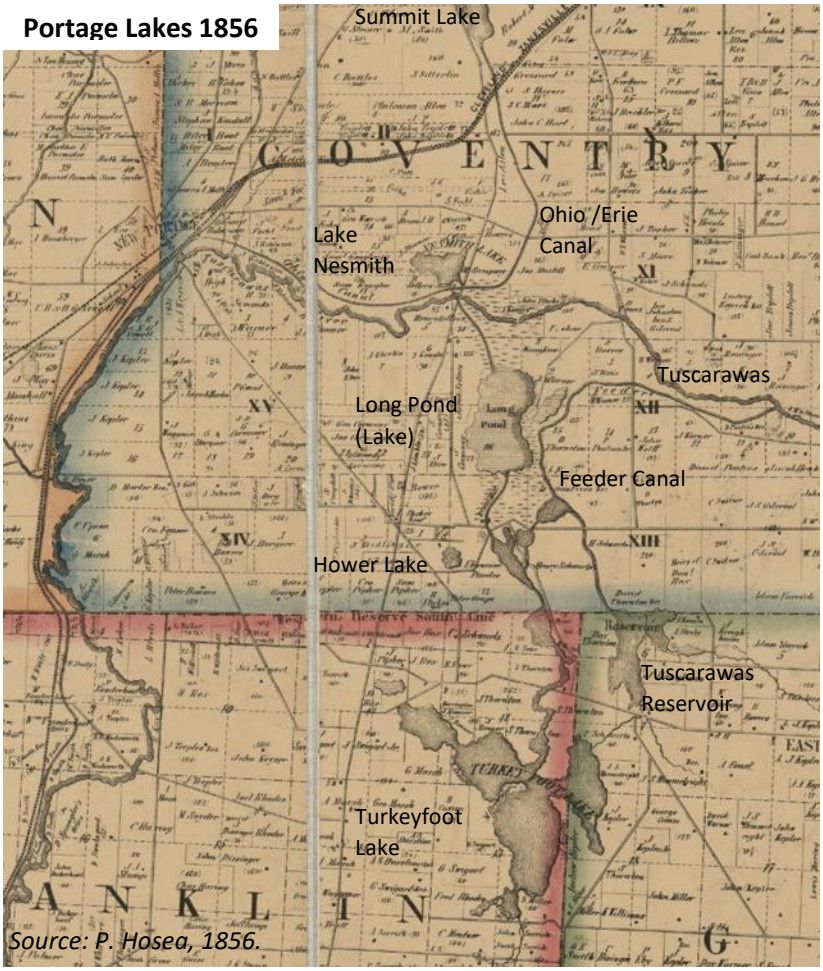
Early maps show small lakes south of the drainage divide (added to map on right) that were precursors to the Portage Lakes, and the close proximity of the Cuyahoga and Tuscarawas Rivers. Portage (yellow dot) is on the Tuscarawas, south of the drainage divide and present-day Akron.

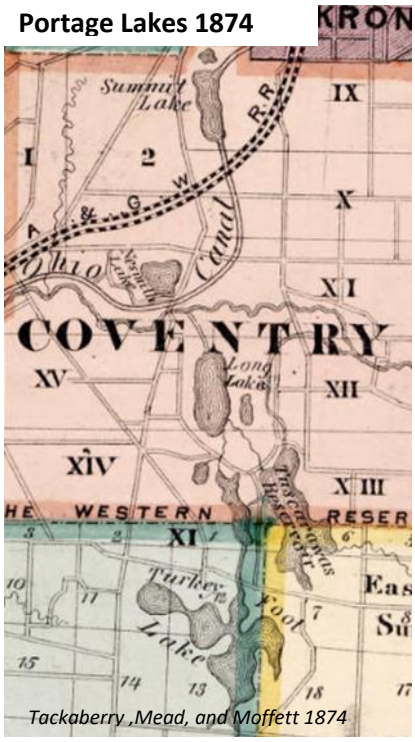
Source: R. Putnam, T. Wightman, T. Harris, 1805



Lake Erie-Ohio River Drainage Divide (approx.) Map Source: R. Tanner, 1819

After the Canal was built. *The Tuscarawas (East and West) Reservoir was built in 1840 to supply canal water, fed by a feeder canal. Turkeyfoot and Long Lakes were deepened. Hower Lake existed, likely as a natural kettle lake. New Reservoir (North Res.) was built in 1909, and Nimisila Reservoir was built in the 1930 to augment the industrial water supply in the canal.*



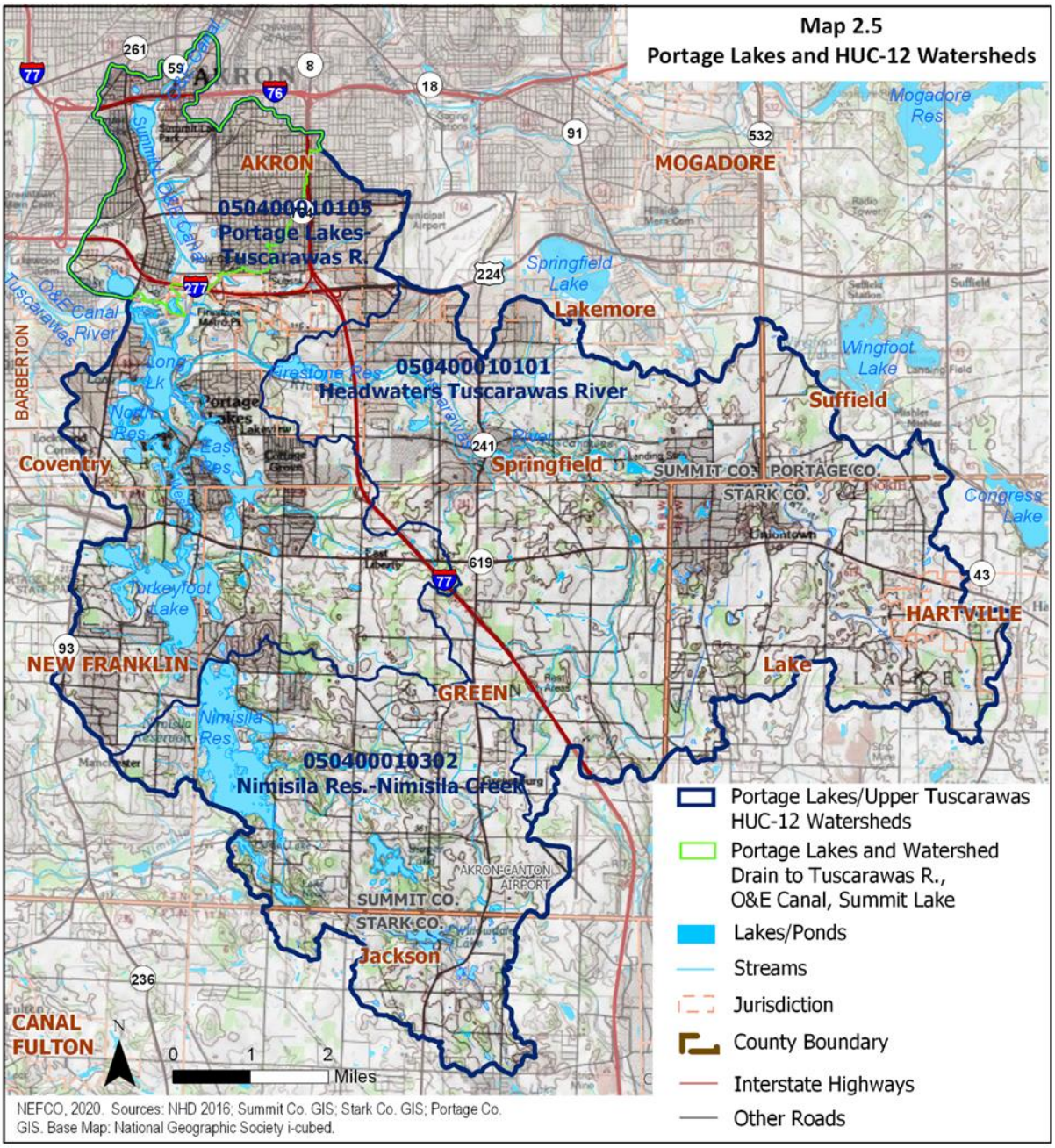


These 1856 and 1874 maps show the Tuscarawas (East and West) Reservoirs taking shape, fed by a feeder canal from the Tuscarawas River, which flows to a canal north of Long Pond. The Nimisila and North Reservoirs had not been built.

Water Flows Downhill…Portage Lakes and Upper Tuscarawas Watersheds[4]

The land that drains to the Portage Lakes, its watershed, is part of the three HUC-12 designated watersheds of the Upper Tuscarawas River (See Map 2.5).

Watersheds are designated by nested Hydrologic Unit Codes (HUCs). The HUCS of the largest watersheds have the fewest digits. HUCs of smaller subdivisions have more digits. The Ohio River basin, HUC 0504, contains many smaller watersheds, including the 12-digit HUC watersheds draining to the Portage Lakes, e.g., 050400010105.



Water flows downhill across the landscape of the watershed (See Map 2.6), entering the lakes through streams, ditches, storm drains, and as stormwater runoff from the land. About 74 square miles of the 80-square mile Upper Tuscarawas watershed feeds the Portage Lakes, through three sub-watersheds and portions of nine communities. Each subwatershed affects specific lake areas: Long Lake and Tuscarawas River; Turkeyfoot Lake to North Reservoir; and Nimisila Reservoir.

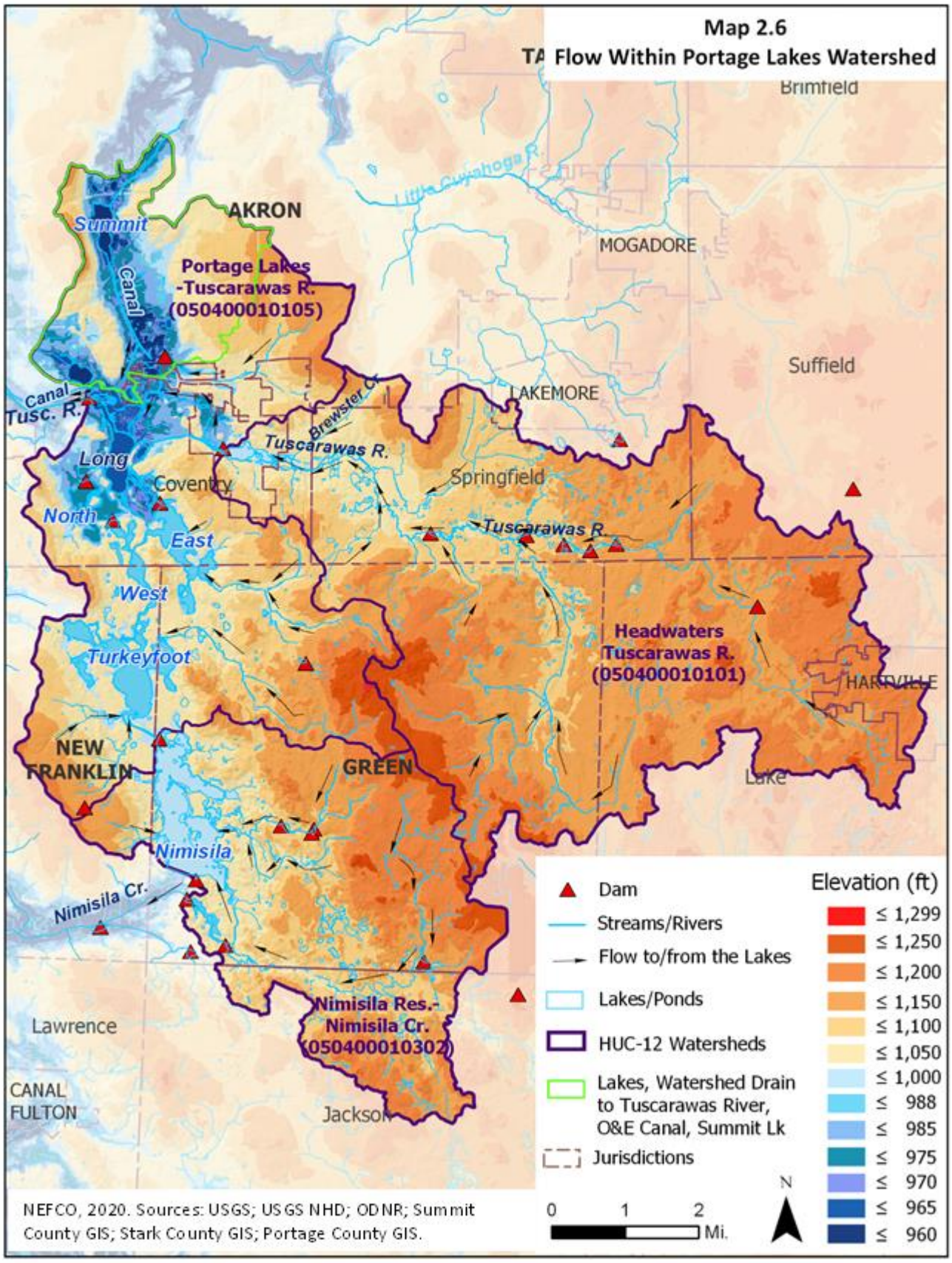
As shown on Map 2.6, the Portage Lakes are on a high area between river valleys, with the Tuscarawas River at both north and south ends of the lakes. Long Lake, the lowest of the lakes and one of the original, natural lakes, is at the end of a lowland that extends north, which contains Summit Lake and connects with the Cuyahoga River valley. This lowland, with its lakes and streams, is the location of the ancient portage and the present-day Ohio and Erie Canal.

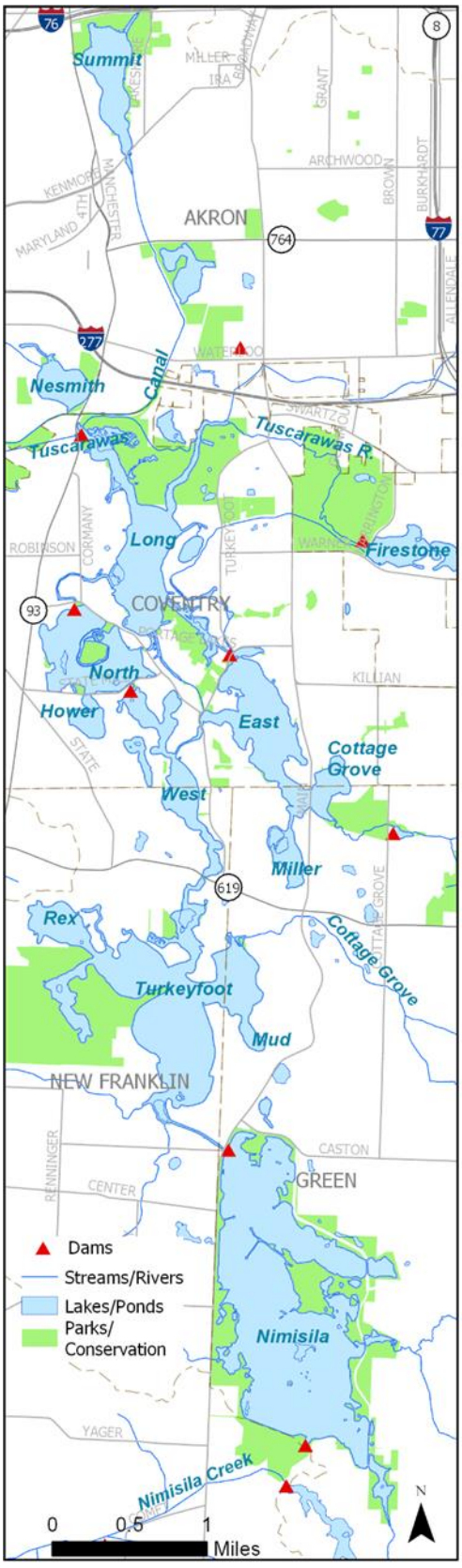
Watersheds Affecting the Portage Lakes and Waterways

The sub-watersheds of the Portage Lakes (Maps 2.5 and 2.6) drain to the Tuscarawas River and Portage Lakes. The size and landscape of the watersheds affects the amount and quality of water entering the lakes.

The canal-lakes system is bounded by Firestone Reservoir, Lock 1 north of Summit Lake, the Canal at Wolf Creek, and Nimisila Reservoir. Flow in this system is managed with dams, flow-control gates, channels, and the canal. (J. Garretson, pers. commun., 2020)

- Nimisila Reservoir is fed by the Nimisila Creek/ Reservoir subwatershed (…0302). It empties to Nimisila Creek south of the lakes and also is used to recharge the other lakes occasionally.
- The “Main Chain” (Turkeyfoot Lake, East and West Reservoir, and their associated lakes) are fed by the upstream (southern) 13.5 square miles of the Portage Lakes watershed (…0105).
- Small areas of the Portage Lakes watershed feed Hower Lake and North Reservoir (0.7 and 1.1 square miles, respectively), which also receive flow from the Main Chain lakes.
- Long Lake receives water from the other Portage Lakes, Brewster Creek, the southeastern 17.3 square miles of HUC …0105, the Tuscarawas River, and its 37 square mile watershed (HUC …0101).
- The Tuscarawas River west of Long Lake receives water from the entire Tuscarawas Headwaters and Portage Lakes watersheds (…0105 and …0101) as well as occasional recharge from Nimisila Reservoir via the other lakes.
- The Ohio and Erie Canal receives discharge from Long Lake and thus, the Tuscarawas and other lakes. Some flows south to the Tuscarawas River at Barberton, some is directed north to the Cuyahoga River and Lake Erie basin.


Map 2.6
TA Flow Within Portage Lakes Watershed
Brimfield
AKRON
Summit
Canal
Portage Lakes
-Tuscarawas R.
(050400010105)
MOGADORE
Suffield
LAKEMORE
Canal
Tusc. R.
Brewster Ck
Tuscarawas R.
Long
Coventry
Springfield
North
East
Tuscarawas R.
West
Headwaters
Tuscarawas R.
(050400010101)
Turkeyfoot
HARTVILLE
NEW
FRANKLIN
GREEN
Lake
Nimisila
Nimisila Cr.
Nimisila Res.-
Nimisila Cr.
(050400010302)
Lawrence
CANAL
FULTON
Jackson
Dam
Streams/Rivers
Flow to/from the Lakes
Lakes/Ponds
HUC-12 Watersheds
Lakes, Watershed Drain
to Tuscarawas River,
O&E Canal, Summit Lk
Jurisdictions
Elevation (ft)
≤ 1,299
≤ 1,250
≤ 1,200
≤ 1,150
≤ 1,100
≤ 1,050
≤ 1,000
≤ 988
≤ 985
≤ 975
≤ 970
≤ 965
≤ 960
N
0 1 2
Mi.
NEFCO, 2020. Sources: USGS; USGS NHD; ODNR; Summit
County GIS; Stark County GIS; Portage County GIS.



Managing the Water

Staff from The Ohio Department of Natural Resources (ODNR) Division of Parks and Watercraft, O&E Canal Lands and Reservoirs, manages water level and flow in the canal-lakes system. ODNR generally maintains the water in the lakes at nearly constant levels, to provide adequate water for boaters and waterways, minimize flooding on nearby roads, and prevent flooding Akron from the Portage Lakes during high flow. ODNR also maintains flow into the canal and Tuscarawas River and diverts water into the Lake Erie Basin.[5]

The dams, lakes and canal are part of a complex system of flood control structures, in an area of historical flooding:

- Water from the lakes inundated Akron in 1913 after the dams at East and North Reservoirs failed.
- Akron experienced flooding for decades before the Firestone Reservoir was impounded.

The Main Chain lakes feed into North Reservoir and Long Lake. The dam spillways control flow by elevation and size. Designed in the 1800s and early 1900s, the spillways in East and West Reservoirs are inadequate to handle storm flow. A rise of four inches in water elevation in East or West Reservoirs causes flooding.

The historical spillway design cannot be enlarged. Flow release at the dams has been augmented by lake drains and gates, which are manually adjusted to alter flow. A small ODNR staff monitors water elevations remotely, then manually adjusts gates or removes obstructions to ensure safe water levels during storms. The period before, during, and after storms involves intense activity throughout the system to maintain safe water levels.

In addition to flood control, ODNR is responsible for diverting water from the Ohio River basin to the Great Lakes basin to balance out the water diverted across the divide for water or sewer service. The federal Water Resources Development Act of 1986 was enacted to protect the Great Lakes Basin from export of water. The Governors Accord

of the Great Lakes approved Akron's Water Diversion Plan in 1998. The first of its kind, it allowed water to be sold and diverted outside of the Great Lakes Basin. This allowed water supplies and wastewater treatment to operate across the divide, if an equal amount of water is returned to the Great Lakes basin. The Canal and feeder reservoirs are the mechanism to provide fresh water into the Great Lakes basin to offset water that Akron sells outside of the basin. ODNR discharges 17 to 21 cubic feet per second (cfs) to the Ohio and Erie Canal. This pushes 6-13 million gallons per day (mgd) to Lock 1 north of Summit Lake, which is released north to the Lake Erie Basin. The rest waters the canal.

Every two years in autumn, the ODNR draws down the Main Chain lakes by about 18 inches partially refilling them from Nimisila Reservoir. This allows maintenance of docks and boats. The ODNR Wingfoot Lakes and Portage Lakes park manager coordinates dredging and repairs/improvements to shoreline structures.

ODNR Dam Safety staff inspects and maintains the dams, which were built from 1840 to 1930. Recent reconstructions include:

- West Reservoir, 2011
- Tuscarawas Diversion Dam (Firestone) 2014-2018
- Long Lake and East Reservoir, 2018-2019
- North Reservoir – the northern embankment failed in the 1913 flood and is being reconstructed, 2020
- Nimisila Reservoir - risk reduction study scheduled, 2020-2021
- The Portage Lakes canal-lakes system will be evaluated in 2021.

East Reservoir dam, 2020

Elevation of the Lakes and Associated Waterways

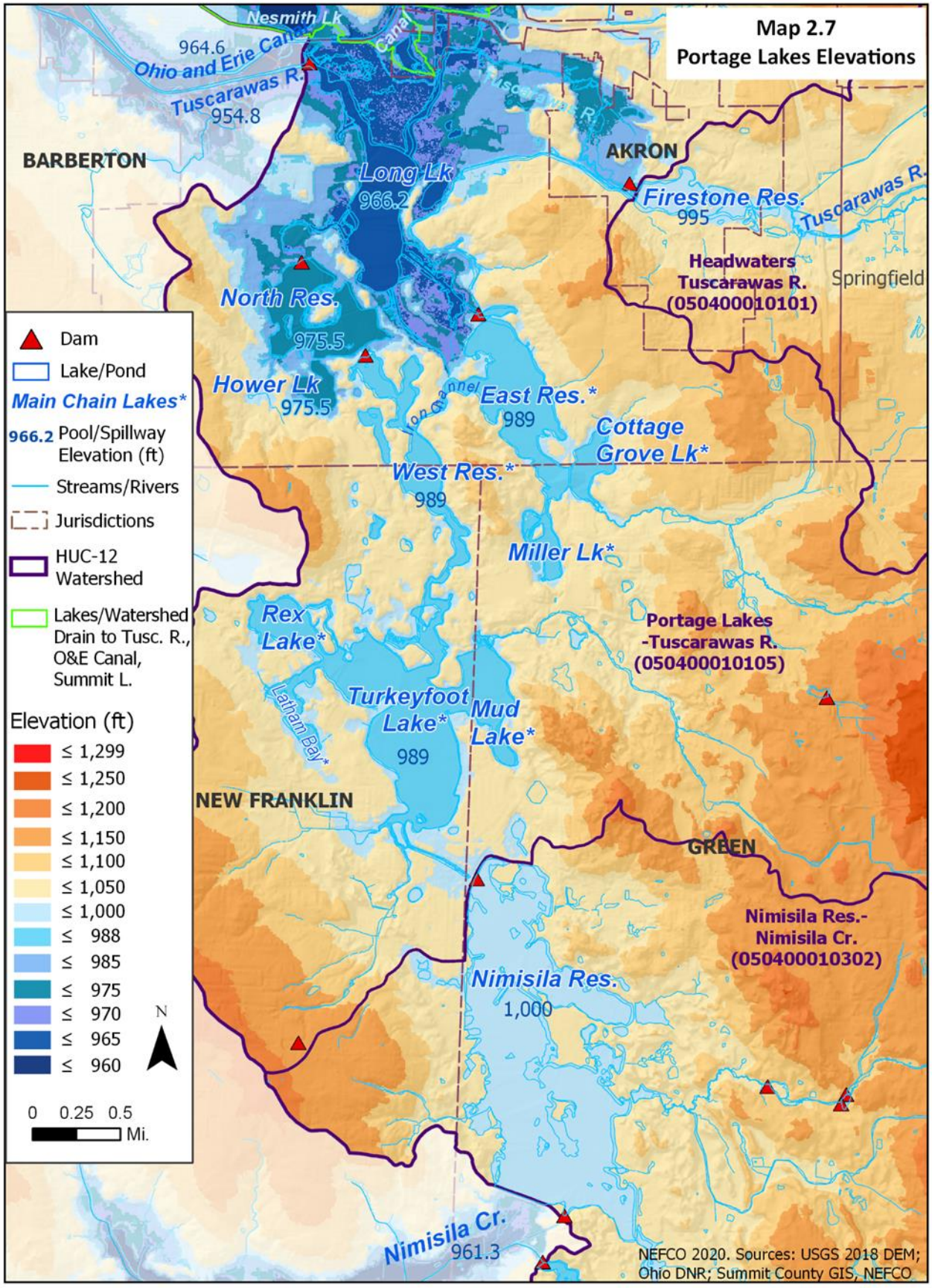
As shown on Table 2.1 and Map 2.7, the lakes descend from Nimisila Reservoir to Long Lake.

- Nimisila has the highest elevation of the Portage Lakes.
- Turkeyfoot, East, and West Reservoirs, and their associated lakes, known as the "Main Chain" are all at the same elevation and are connected by channels, allowing water and boats to travel between the lakes.
- North Reservoir and Hower Lake are at the same elevation and connected by a culvert. Both lakes are lower than the "Main Chain."
- Long Lake is lower than North Reservoir, Hower Lake, and the Main Chain.
- Summit Lake and the canal are lower than Long Lake. The Tuscarawas River north of the lakes, and Nimisila Creek at the southern end, are lower than the lakes.

East Reservoir, one of the "Main Chain lakes. Looking toward the Iron Channel, which connects East and West Reservoirs. View is from the East Reservoir dam, which separates East Reservoir from Long Lake.

Table 2.1 Portage Lakes Elevations and Watershed Information

Lake/River	Elev. (ft)[6]	Water Flows	Watershed 05040001-
Nimisila Cr.	961.3	to Tuscarawas	Fed by -0302, Green
Nimisila Res. spillway	1,000	Mostly to Nimisila Cr. over dam. Occasionally released to Turkeyfoot	-0302 – 17.4 sq mi. Green
Main Chain			-0105 – 17.3 sq mi affects Portage Lakes upstream of Long Lake, from Green, New Franklin, Coventry. Feeder canal diverts minimal flow to East Res. The lakes are occasionally recharged from Nimisila Res., -0302 via Turkeyfoot.
Turkeyfoot Lk	989	To/from East Res. through a channel	
East Res.		To/from West Res. by Iron Channel Main outflow to Long Lake	
West Res.		Flows into East Res. by Iron Channel Some flow to North Res. over dam	
Hower Lake	975.5	To North Res., through culvert	
North Res.		To Long Lake over dam	
Long Lake	966.2	To Tusc. River over dam; some diverted to Ohio and Erie Canal	Receives water from 56.9 sq. mi of -0101, -0105, plus recharge from -0302.
Firestone Reservoir	995	Diversion dam directs flow to Tusc. R, small amounts to Feeder Canal	-0101 - 35.8 sq mi
Tuscarawas R.	954.8	Muskingum River, then Ohio River	Receives water from -0105 and -0101 (63.6 sq. mi); occasional recharge from -0302 via the lakes (17.4 sq mi)
Canal, Summit Lk	964.8	N to Lake Erie or S to Ohio River	Cuyahoga, Tuscarawas watersheds.
Nesmith Lake	964.8	Canal to Tuscarawas at Wolf Cr.	Watered by canal


Map 2.7
Portage Lakes Elevations
Nesmith Lk
964.6
Ohio and Erie Canal
Tuscarawas R.
954.8
BARBERTON
AKRON
Long Lk
966.2
Firestone Res.
995
Tuscarawas R.
Headwaters
Tuscarawas R.
(050400010101)
Springfield
North Res.
975.5
Hower Lk
975.5
East Res.*
989
Cottage
Grove Lk*
West Res.*
989
Miller Lk*
Rex
Lake*
Portage Lakes
-Tuscarawas R.
(050400010105)
Turkeyfoot
Lake*
Mud
Lake*
989
Latham Bay*
NEW FRANKLIN
GREEN
Nimisila Res.-
Nimisila Cr.
(050400010302)
Nimisila Res.
1,000
Nimisila Cr.
961.3
Dam
Lake/Pond
Main Chain Lakes*
966.2 Pool/Spillway Elevation (ft)
Streams/Rivers
Jurisdictions
HUC-12 Watershed
Lakes/Watershed Drain to Tusc. R., O&E Canal, Summit L.
Elevation (ft)
≤ 1,299
≤ 1,250
≤ 1,200
≤ 1,150
≤ 1,100
≤ 1,050
≤ 1,000
≤ 988
≤ 985
≤ 975
≤ 970
≤ 965
≤ 960
N
0 0.25 0.5
Mi.
NEFCO 2020. Sources: USGS 2018 DEM; Ohio DNR; Summit County GIS, NEFCO

Tour of the Lakes

This management plan focuses on the lakes south of the Tuscarawas River. Figs. 2.2-2.5 is a tour of how water moves through the lakes, from highest (Nimisila) to lowest (Long Lake). Map 2.8 shows flow through the lake system.

Nimisila Reservoir - the highest of the lakes in this plan, was created in 1930 to augment the canal as an industrial water supply. Dams at both ends control flow. Most water leaves the reservoir at the southern dam, falling about 39 feet to Nimisila Creek and then the Tuscarawas River. Occasionally, water is released to Turkeyfoot Lake through gates at the northern end, to replenish the other lakes. A past practice was also to pump water into the reservoir for storage.

Turkeyfoot Lake - the one of the original, natural lakes. Latham Bay was dredged out. Turkeyfoot Lake, one of the three "Main Chain" lakes, is connected to West Reservoir by a channel.

West Reservoir - the middle of the three "Main Chain" lakes, was impounded by dams, along with East Reservoir in 1840 to provide canal water. The two reservoirs were known as the Tuscarawas Reservoir. West Reservoir is connected to Turkeyfoot Lake and East Reservoir by channels. At the northern end of West Reservoir, a dam with gates controls flow to the North Reservoir, discharging small amounts.

East Reservoir - East Reservoir is the third of the "Main Chain" lakes, impounded with West Reservoir in 1840 as the "Tuscarawas Reservoir" to supply canal water. Water and boats move between West and East Reservoirs through the Iron Channel. Water enters from West Reservoir, minimal inflow from the Feeder Race, and as runoff and streams from Coventry and Green. The East Reservoir is the primary lakes feeder to Long Lake. Flow out of the East Reservoir to Long Lake, 23 feet below, is controlled by a dam and gates. A spillway relieves excess flow. The dam and spillway were recently reconstructed. "Cat Swamp" is where the 1913 flood breached, causing Long Lake to overflow and flood Akron.

Hower Lake and North Reservoir - Hower Lake, one of the smallest lakes, is one of the original kettle lakes. It is connected to North Reservoir by a culvert under State Mill Road. North Reservoir was built in 1909 as "New Reservoir." It is isolated from all other lakes, controlled by a dam on the northern side (Long Lake). Water enters from Coventry, Green and New Franklin.

Long Lake - shown on early maps is the southern terminus of the ancient portage. The dam built in 1936 impounded and altered the lake as an industrial water supply for the canal. It is the lowest of the Portage Lakes, receiving inflow from all the other Portage Lakes and the Tuscarawas River. Its watershed is 74.3 square miles. It is critical for flood control. If it overflows during the severe rain events it could flood Akron, which occurred in 1913.

The Tuscarawas enters at the northeast, and the lake discharges to the Tuscarawas and canal at the northwest, Long Lakes Feeder. Water from Long Lake drops ten feet to the Tuscarawas River through flood gates in a newly reconstructed dam. Under international agreement, the ODNR diverts 6-13 million gallons of water per day to the Lake Erie basin via the canal to offset wastewater that leaves the Lake Erie basin for treatment south of the divide.

Figure 2.2 Nimisila Reservoir Flow

1. Water enters from a portion of Green and New Franklin via streams and runoff.
2. *Most* water flows over southern dam, drops 35 feet to Nimisila Creek, (and then enters the Tusc.)
3, 4, 5, 6 Occasionally, water from the reservoir is released into Turkeyfoot Lake.
3. Water is released from Nimisila Reservoir at the control structure by the berm.
4. Water enters the channel via a control structure. Berm (background) hides view of reservoir.
5. Water flows northwest through the channel to Turkeyfoot Lake.

Turkeyfoot Lake

6. Water enters Turkeyfoot Lake. Photos show channel and outlet into Turkeyfoot Lake.
7. Streams/runoff enter from Green, New Franklin. ***Photos:*** 7a Cottage Grove Cr.; 7b Mud Lk near Cottage Grove Cr.
8. Water flows between Turkeyfoot Lake and West Reservoir via the channel. ***Photo*****: L**ooking north toward West Res. from Rte 619.

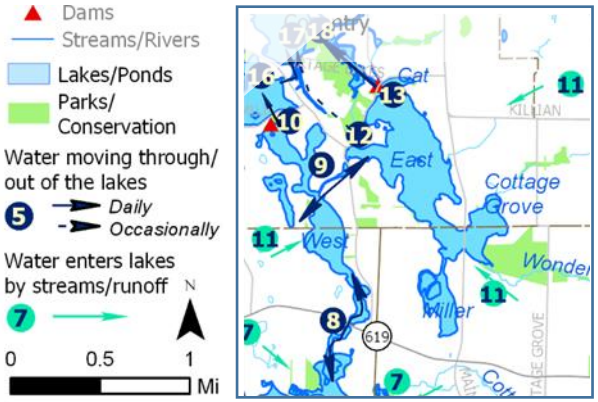


Figure 2.3 West and East Reservoir Flow

8. Water and boats move between West Reservoir and Turkeyfoot Lake through a channel.

9. Water flows between West and Easts Reservoirs through the Iron Channel. ***Photos:*** Views of the Iron Channel. 9a looking toward East Reservoir; 9b looking into Iron Channel from East Reservoir.

10. Dam/gates at north end of West Reservoir releases low volumes into North Reservoir, 13.5 feet lower.

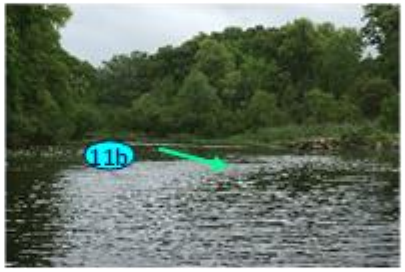
11. Water enters the reservoirs from Coventry, New Franklin, and Green via runoff and streams.

Photos: 11a Wonder Lake Creek; 11b view of Wonder Lake Creek where it enters Cottage Grove Lake.

12. Secondary spillway (el. 989.1) E. Reservoir is a high-water release to Long Lake, 23 feet below.

13. Water primarily leaves East Res. at a recently reconstructed dam with gates, falling 23 feet to Long Lk.

Photos: 13a Upstream (E. Res.), 13b downstream (Snakey River/Heimz Ditch) of dam outlet; 13c Cat Swamp.



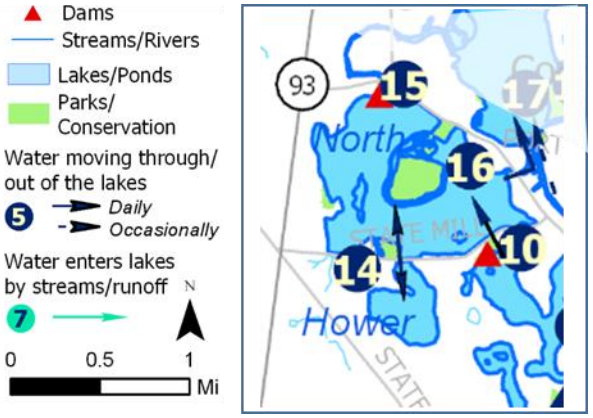


Figure 2.4 Hower Lake and North Reservoir Flow

10. Small volumes enter North Reservoir from dam/gates on West Reservoir via a stilling basin. Photos: 10a enters stilling basin from W. Reservoir 10b enters North Res. from stilling basin.

14. Hower Lake and North Reservoir are connected by a culvert under State Mill Rd.
Photo: View of culvert under State Mill Rd. from North Reservoir

15. The North Reservoir embankment, which failed in 1913, is being reconstructed.
Photo: 15 North Reservoir embankment.

16. Water leaves North Reservoir through a spillway, dropping 11 feet to the Long Lake channel.

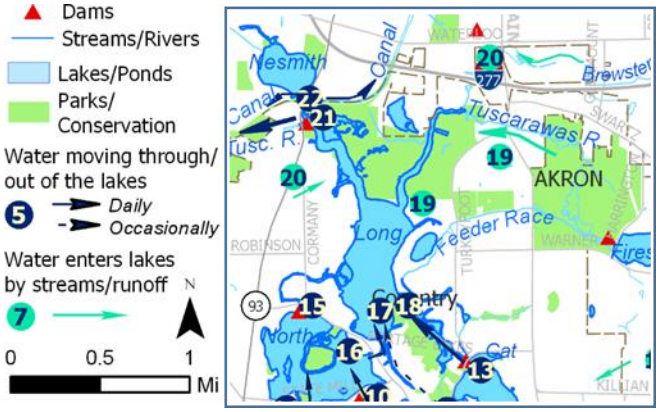


Figure 2.5 Long Lake Flow

17. Water enters from E. Res. secondary spillway and North Res. ***Photo***: Inflow from E. and North Res.

18. Water enters from the East Res. dam/gates. ***Photo:*** Long Lk, inflow from East Res. dam.

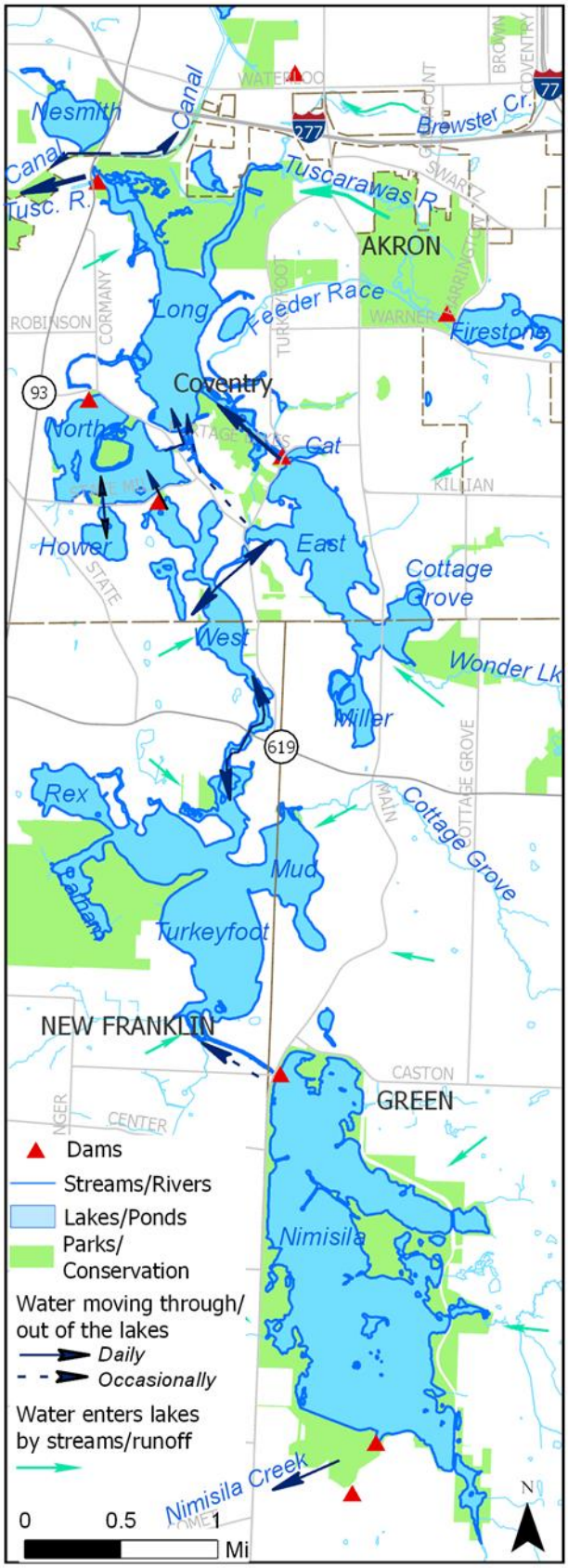
19. The Tuscarawas River enters Long Lake. ***Photos:*** 19a Tuscarawas River at S. Main St. looking east. 19b The Tuscarawas River enters Long Lake through the channel joining the body of the lake here.

20. Water enters Long Lake via streams and runoff. ***Photo:*** Brewster Creek at S. Main St, view north.

21. Water flows through gates to the Tuscarawas River, dropping 7 feet to the river. ***Photos:*** 21a Dam (foreground) and outlet to canal (background) from Long Lake; 21b dam viewed from Tuscarawas R.

22. A flow control structure directs flow to the canal and the Lake Erie Basin. ***Photo:*** Outlet to canal.

Map 2.8 Flow in Portage Lakes



Key Considerations

The Portage Lakes began as a few small kettle lakes left by glaciers. The lakes were transformed during the 1800s and early 1900s into an interconnected system controlled by dams, supplying the canal water for transportation and industrial water supply.

Today, the lakes:

- Support thriving communities, and a regional recreational and economic resource
- Are crucial for flood control
- Are used to comply with requirements to maintain water levels in the Great Lakes
- Receive water from 67 miles of developed

Managing – and protecting – the lakes for multiple uses will require understanding where the water comes from that enters the lakes, how it moves through the system, and how it is controlled.

Watershed – The watershed affects the quantity and quality of the water entering the lakes. Protecting water quality requires understanding which areas contribute to each lake and taking care of the upstream lands of the watershed that feed the lakes. Best management practices, reducing non-point source pollution and protecting or restoring certain landscape features helps reduce the amount of runoff and the pollutants, and improves the quality of the water entering the lakes. This is discussed further in Chapters 5 and 6.

Dams – The dams and their control structures provide flood control, are necessary for maintaining flow to the Great Lakes Basin, and are used to change lake levels. Dams are engineered and maintained for safety and longevity. Most have been or will be reconstructed. Certain uses may not be allowed on the dams for safety, e.g., structures or trees.

A small ODNR staff maintains lake levels and flow as required. This critical, labor-intensive task involves monitoring water levels, adjusting gates, and clearing vegetation and debris from waterways and drains.

Management Concerns - Later chapters of this plan recommend additional management measures in the lakes to better understand current and changing conditions, manage aquatic plants in a balanced way with residents' and visitors' concerns, and protect the lakes from further eutrophication. The current small, dedicated staff that manages the waterways does what they can to also manage the aquatic plant growth and provide for navigation. However, they lack the time, technical resources, staff, and funding to adequately take on the complex task of managing the lakes as a multi-use resource and ecosystem. Protecting the lakes and accommodating the uses will require a coordinated, concerted effort, consistent management, and adequate resources.

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[1] Map Sources Maps 2.1, 2.2: NEFCO, 2020. Map Sources Maps 2.1, 2.2: ODNR GIS Ohio Dams database, https://gis.ohiodnr.gov/arcgis/rest/services/DSW_Services/Ohio_Dams/MapServer; Summit County GIS roads, streams, jurisdictions, parcels databases, retrieved from https://data-summitgis.opendata.arcgis.com/ 2018-2020.

National Hydrologic Database (NHD) 2016, retrieved from nationalmap.gov Jan. 2017. Parks data layers from AMATS; Western Reserve Land Conservancy, parcel data.

[2] Map Sources Maps 2.3, 2.4: ODNR GIS 2017; NHD 2016 ibid.

[3] Map Sources Fig. 2.1 All historic maps retrieved April, 2020.

Friend, N.; Smith, C.L.; Hunter, Thomas;, 1874. 1874 Combined Atlas of Summit County. Tackaberry, Mead, and Moffett, Philadelphia, PA. Obtained from Summit Memory Online Map Room. https://www.summitmemory.org/digital/collection/new-maproom/id/625/rec/5; Paul, Hosea. *Map of Summit Co., Ohio*. Philada.: Matthews & Taintor, 1856. Map. https://www.loc.gov/item/2012592394/.; Putnam, Rufus, Thomas Wightman, and Thaddeus Mason Harris. *Map of the state of Ohio*. [Boston: Printed by Manning & Loring, 1804] Map. https://www.loc.gov/item/90682167/.Tanner, Henry Schenck. *Ohio and Indiana*. [Philadelphia: Tanner, Vallance, Kearny & Co, 1819] Map. https://www.loc.gov/item/2011585893/.;

J. Garretson 2020. Parks and Watercraft, Canal Lands and Reservoirs, pers. commun. 2020;

Carolyn Vogenitz 1999. Portage Lakes Then and Now. Waterside Publishing, Akron, OH.

[4] Map sources Map 2.5: NHD 2016; Summit Co. GIS; Portage Co. GIS; Stark Co. GIS. ESRI base map: National Geographic I-cubed. Maps 2.6 and 2.7 USGS, 2018. The National Map. U.S. Geological Survey, 20180212, USGS 13 arc-second n41w082 1 x 1 degree; n42w082 1 x 1 degree.: U.S. Geological Survey. Retrieved from thenationalmap.gov April, 2020.

[5] The discussions of water elevation, flow, dams, connections, and managing the reservoir system relies heavily on communication with Josh Garretson, ODNR Parks and Watercraft, Canal Lands office, from 2017-2021.

[6] Spillway elevations from J. Garretson, 2020; other elevations from USGS, 2018, ibid. digital elevation model data.