HYDROLOGIC AND HYDRAULIC ENGINEERING STUDY

PIQUA WATER SYSTEM
FRANZ POND, ECHO LAKE AND SWIFT RUN LAKE

PREPARED FOR:

CITY OF PIQUA
OHIO

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Environment / Energy / Infrastructure

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1.0 INTRODUCTION

This study, prepared by Hull & Associates, Inc. (Hull), was commissioned by the City of Piqua in response to Ohio Department of Natural Resources (ODNR) required Engineer Repairs and Investigation measures identified in ODNR Inspection Reports for Franz Pond, Echo Lake and Swift Run Lake Dams. The ODNR inspections were performed on October 23, 2014 and reports received by the City of Piqua in September 2016. These measures from the ODNR Reports are summarized below.

1. "The dam's discharge/storage capacity must be sufficient to safely pass the required design flood without overtopping the embankment. Prepare plans and specifications as necessary to increase the discharge/storage capacity to pass the required design flood. In accordance with OAC Rule 1501:21-13-02, the minimum design flood for Class I dams is 100% of the Probable Maximum Flood or the critical flood. See the Flood Capacity section for additional information." (Franz, Echo, Swift)

2. "The embankment crest alignment must be uniform. Investigate the variable vertical alignment of the crest of the dam and canal and, as necessary, prepare plans and specifications for the correction of any problems. This item should be completed in coordination with Item 1 above. (See Discussion Item A of this section for additional information.)" (Franz, Echo, Swift)

3. "This dam must have a device to permit draining of the reservoir within a reasonable period of time in accordance with OAC Rule 1501:21-13-06. Investigate the ability of the valve at the canal spillway to adequately lower the water level in Franz Pond/Echo Lake and document in an Operation, Maintenance, and Inspection Manual for the dam. Or, prepare plans and specifications for the installation of such a device. See the "Lake Drains" fact sheet for additional information. (The owner must complete this item and implement all engineered plans for improvement within 5 years.)" (Franz, Echo)

4. "The erosion on the upstream slope of the embankment must be repaired and the upstream slope must be protected from erosion. Prepare plans and specifications for repairing the erosion and installing erosion protection. The erosion must be monitored quarterly until repairs can be made. See the "Upstream Slope Protection" fact sheet for additional information." (Swift)

1.1 Hydrologic and Hydraulic Study Objective and Project Alternatives

The objective of this report is to provide the City of Piqua with possible solutions to address the ODNR required Engineer Repairs as described in Section 1.0. A list of the alternatives explored in this report are summarized below and described in greater detail in the following sections of this report. Note that some combination of alternatives may be required to bring the entire network of dams into compliance with ODNR Dam Safety regulations. Some alternatives are likely not feasible, but included for completeness.

- Alternative 1 – Widen Existing Spillways
- Alternative 2 – Add Auxiliary Spillway at Swift Run Lake
- Alternative 3 – Labyrinth Spillway at Swift Run Lake
- Alternative 4 – Convert Franz Pond and Echo Lake into Dry Detention Storage Areas
- Alternative 5 – Raised Embankment using Parapet Wall
- Alternative 6 – Lower Dam Classification

1.2 Piqua Water Supply Background Information

Piqua is a city in Miami County, Ohio, officially incorporated in 1807. The city grew out of a 1747 settlement called Fort Pickawillany, which was located northeast of the present city at the confluence of the Great Miami River and Loramie Creek. The City occupies the broad western terrace of the Great Miami River at approximately 40°8′51″N, 84°14′53″W. The mapped 100-year floodplain is largely confined to the river channel, although base flood elevations have not been determined. Most of the City is mapped as an area of minimal flood hazard.

The City's municipal water treatment plant was constructed in 1925 and expanded in 1961. The water treatment plant is situated adjacent to the hydraulic canal and the spillway at the southeast corner of Swift Run Lake. The city recently completed construction of a new water treatment plant approximately one mile north of the existing facility along S.R. 66, replacing the existing facility. The water treatment plant draws from the lake and hydraulic canal system, but it can also draw raw water via pump directly from the Great Miami River and from an abandoned gravel quarry located on the east bank of the Great Miami River. The water treatment plant may draw from each of these three sources as needed to minimize the amount of treatment required and to optimize drinking water quality.

The Piqua water supply system was constructed in 1874 to supply drinking water to the growing city. The raw water supply was created by construction of an earthen dike along the base of the natural bluff that defines the western edge of the central city and the Great Miami River terrace on which the City sits. The dike was designed to intercept and dam the flow of several stream tributaries to the Great Miami River, creating a series of three lakes or upland reservoirs, known as Franz Pond, Echo Lake and Swift Run Lake. The dike was constructed using material dug from a canal which connects all three lakes, known as the hydraulic canal. The three lakes and the hydraulic canal connecting them created a single raw water supply for the City of Piqua which supplies the City's water needs via gravity flow.

1.3 Existing Dam Characteristics

The Ohio Department of Natural Resources (ODNR) Division of Soil & Water Resources – Dam Safety Program inspected the City of Piqua's dams on October 23, 2014 and issued inspection reports, dated September 15, 2016, detailing their findings. The ODNR Dam Inventory Sheets, which were updated in 2016, for these dams list the structures as Class I dams. The dams were constructed in 1876. The Franz Pond and Echo Lake dam spillways outlet into a canal that is a tributary to Swift Run Lake, which then discharges into Swift Run. The dams do not have open-channel emergency spillways. The Swift Run Lake dam has a lake drain that consists of a 24-inch diameter sluice gate, 36-inch diameter pipe and 24-inch diameter water line. The normal pool is regulated by concrete weirs. The listed characteristics of the dams are shown in Table 1 below.

Table 1. Existing Dams Characteristics*

	Franz	Echo	Swift	Canal
Class	I	I	I	N/A
Height (ft)	20.6	14.2	39.4	11
Normal Pool Elev.	N/A	N/A	902.6	902.6
Normal Pool Surface Area (ac)	6.1	16.5	38.0	N/A
Emergency Spillway Elev.	N/A	N/A	N/A	N/A
Top of Dam Elev.	909.9	907.2	906.2	906-908.9
Maximum Pool Storage (ac-ft)	92	142	629	N/A

* according to Table 3.1 in current Emergency Action Plan.

As a Class I structure, the dams must be able to safely pass the design storm of 100% of the Probable Maximum Flood (PMF). The ODNR Dam Inventory sheet states that the dams each have a flood capacity of 12% of the PMF. The Class I status for these dam is based on downstream hazard. There are residential areas downstream of all three dams.

1.4 Previous Studies Consulted

Hull visited the ODNR office and consulted with Dam Safety to obtain and review previous studies performed by others. The following list of documents and electronic files was reviewed in the preparation of this report.

- Concrete Repair at Water Treatment Plant and Water Impoundment Spillways Contract Drawings. Brundage, Baker & Stauffer, Limited, 1980.

- Phase I Inspection Report, Nation Program of Inspection of Non-Federal Dams. Ohio Division of Natural Resources Division of Water, July, 1981.
- Channel Embankment Leak Repair Engineering Design Report. BBC&M Engineering Inc., January, 2001.
- Piqua Canal Improvements As-Built Drawings. BBC&M Engineering, Inc., November, 2001.
- Hydrology and Hydraulic Study for the Piqua Hydraulic Reservoir. Bowser Morner, June, 2004.
- Piqua Hydraulic Reservoir Hydrology and Hydraulics Study Responses to Comments from the ODNR, Division of Water (August 31, 2004 Letter). Bowser Morner, February, 2005.
- Evaluation of Swift Run Dam as a Class II Dam for the City of Piqua, Ohio. Bowser Morner, August, 2006.
- Raw Water Engineering Study. Hull & Associates, Inc., May, 2009.
- Swift Run Lake, Echo Lake and Franz Pond Dams Hydraulic Canal Levee Emergency Action Plan. DLZ, December, 2014.
- Various ODNR Hydrologic and Hydraulic Calculations for Franz Pond, Swift Run, Echo Lake, and the Canal.

2.0 HYDROLOGIC AND HYDRAULIC STUDY

Hull used Autodesk Storm and Sanitary Analysis (SSA) to develop a preliminary model to study the alternatives included in this report. The modelling was performed using the SCS TR-55 hydrology method with a user defined time of concentration and weighted runoff curve number for each drainage area. Hydraulic routing was performed using the hydrodynamic link routing method to allow for backwater effects between ponds and along the canal during each simulation. Primary existing spillways 1, 2 and 3 were included in the model as well as broad-crested weirs at each dam to simulate dam overtopping.

Due to the selected hydrologic routing method, only one single rainfall time series was allowed. For this reason, the Swift Run Lake PMP depth was selected and applied to the ODNR required rainfall distribution for two reasons. First, the Swift Run Lake drainage area was the largest of all four. Second, the smaller canal drainage area and Franz Pond drainage area resulted in higher PMP depths that would artificially overestimate the total runoff within the Swift Run Lake watershed.

Table 2. Model Parameters

	Drainage Area (AC)	Weighted Runoff CN	Time of Concentration (min)
Franz Pond	617.6	85	164.2
Echo Lake	1,288.7	82	191.8
Swift Run Lake	4,659.5	81	42.1
Hydraulic Canal	224.1	81	197.3

Selection of modeling parameters is discussed in more detail in the sections below.

2.1 Drainage Area

The drainage areas for each of the ponds and lakes and canal were delineated using LiDAR data obtained from the Ohio Geographically Referenced Information Program (OGRIP).

2.2 SCS Runoff Curve Number

The SCS method was used to estimate runoff losses using a runoff curve number as described in the TR-55. The estimated weighted curve number for each drainage area represents the intersection of two datasets using ARCGIS software – The NLCD Land Use Database and the SSURGO Soil Database. Each soil type area was assigned a land use value and hydrologic soil group designation, verified using recent aerial imagery, and tabulated to determine the final weighted average. Figures 2 and 3 show land use and soil data overlaid on current aerial imagery.

2.3 Time of Concentration

Time of concentration was determined using the SCS method for Watershed Lag from the National Engineering Handbook Section 630.1502(a).

2.4 Probable Maximum Precipitation

The Probable Maximum Precipitation (PMP) was based on revised rainfall depth estimates for the state of Ohio from a statewide PMP study released by ODNR in 2013. Specifically, the 2013 guidelines require the evaluation of two separate distributions: an SCS Type II distribution commonly used in the Midwest but modified slightly by ONDR; and a dimensionless distribution provided by ODNR developed from the HMR-52. The time step of both distributions is defined by ODNR. The more conservative event (the higher peak water surface) was used in the hydraulic analyses. PMP charts representing the appropriate duration and drainage area were used to interpolate a rainfall depth estimate for the corresponding distribution.

2.5 50-year rainfall

50-year precipitation depth was obtained from the NOAA point precipitation frequency estimates database from a point location located near the Swift Run lake embankment. Hull used a traditional SCS type-II rainfall distribution for the 50-year 24-hour event.

2.6 Elevation Stage Storage and Spillway Hydraulics

The elevation stage-storage for Franz Pond, Echo Lake, Swift Run Lake and the Hydraulic Canal was obtained from previous analyses performed by ODNR. Existing Spillway Hydraulics were estimated using SSA sharp crested weir calculations and generally verified using previous analyses performed by ODNR and others.

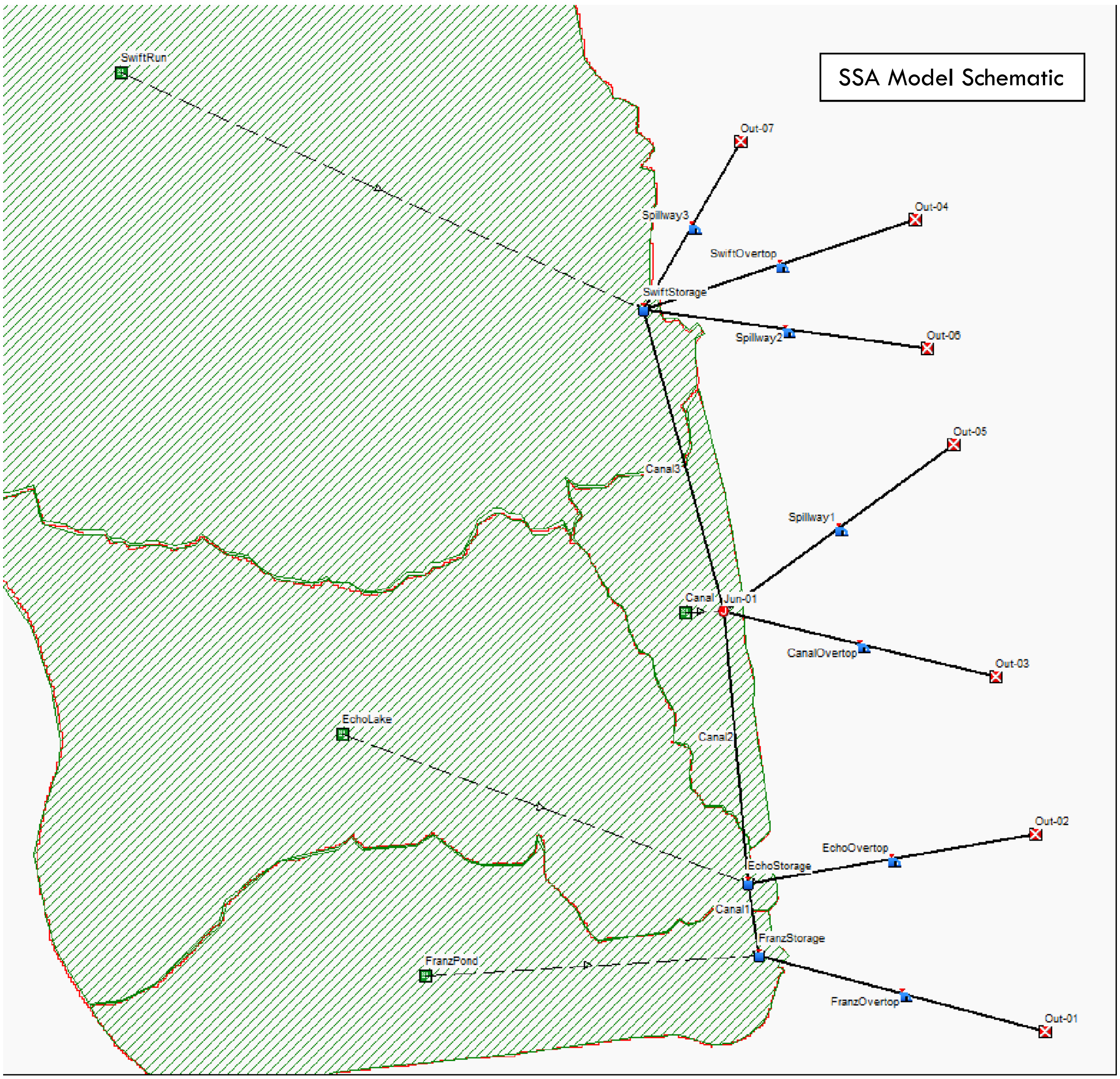
2.7 Hydrologic Study Results

Hull compared results from SSA representing the existing network of impoundments to historical studies performed by others to generally verify input parameters. The following table describes the result of Hull's existing conditions model that was used as a basis for development of the alternatives discussed in this report. Note that previous studies may reflect slightly different assumptions or hydrologic methodologies but are shown here for comparison.

Table 3 – Hydrologic Study Results Comparison to Previous Studies

Impoundment	Embankment Elevation	Peak WSEL (1)	Peak WSEL (2)	Peak WSEL (3)
Franz Pond	909.9	910.3	910.4	913
Echo Lake	907.2	909	910.6	913.1
Swift Run	906.2	908.5	909.1	910

(1) Results from 2018 Hull Hydrologic Study.
(2) Results from 2004 Bowser Morner H&H Study.
(3) Results from 2006 Bowser Morner Evaluation of Swift Run as a Class II Dam.



3.0 ALTERNATIVES

Hull considered multiple alternatives to address each of the ODNR engineering items on the most recent Inspection Report. Some of the alternatives address all three impoundments and others were found to only impact some of the impoundments. Some combination of these alternatives may be required to address all items listed in Section 1.0 of this report. Hull has described each of the alternatives in greater detail below including advantages and disadvantages and an opinion of probable cost range to implement each one. Note that the estimated costs included for each of these alternatives is highly variable at a preliminary level and may require revision if a final comprehensive solution combines multiple alternatives or other costs not anticipated as part of this study.

3.1 Widen Existing Concrete Spillways

Three spillways currently handle storm water discharge for all three impoundments and the hydraulic canal. Spillway 1, 2 and 3 are all concrete weir stepped or drop spillways, with crest lengths of 93 feet, 75 feet and 73 feet respectively. Hull considered widening each of the spillways to pass the PMF event. A spillway widening would require a substantial excavation and construction of a large concrete structure that would extend the length of each of the spillways. The primary objective of this alternative is to determine the required spillway width that eliminates overtopping at all three embankments and along the hydraulic canal. The following table describes the results of the study for this alternative.

Table 4 – Estimated Spillway Width Required

Spillway	Location	Existing Width (ft)	Required Width @ NP(ft)	Required Width with 2-ft pool drop (ft)	Required Width with 4-ft pool drop (ft)
Spillway 1	Hydraulic Canal	93	300	110	93
Spillway 2	Swift Run Lake	75	385	200	125
Spillway 3	Swift Run Lake	73	385	200	125

3.1.1 Franz Pond and Echo Lake

The modeling suggests that widening Spillway 1 has a negligible effect on Franz Pond and Echo Lake due to two primary factors. First, Echo Lake discharges to the hydraulic canal via an open channel that crosses under Echo Lake Drive limiting the discharge capacity. Second, Spillway 1 is so far downstream that the changes made to Spillway 1 have negligible effects on the performance of the outlet from Echo Lake at Echo Lake Drive.

3.1.2 Swift Run Lake

Swift Run Lake can safely pass the design storm event when each of the three spillways are widened to the approximate lengths shown in the table above. Only Spillway 1 was widened as required to keep the widening at Spillways 2 and 3 at a minimum because Spillway 1 had a lesser impact on the hydraulic performance of the other two spillways. Note that making these improvements will only address the discharge capacity of Swift Run Lake Dam and the Hydraulic Canal.

3.1.3 Advantages

Widening each of the three spillways will provide sufficient discharge capacity to allow Swift Run Lake Dam to safely pass the PMF. Additionally, all three spillways currently discharge to an established outlet channel that eventually discharges to the Great Miami River. Having an established discharge route is a big advantage.

3.1.4 Disadvantages

This alternative only addresses the discharge capacity of Swift Run Lake because Spillway 1 has a relatively negligible effect on the Echo Lake discharge point under Echo Lake Drive. Swift Run Lake would likely need to be lowered substantially during construction which could potentially affect the available water resources for the City. There does not appear to be enough space along the existing Swift Run embankment to widen Spillways 2 and 3 which would require that the spillways extend farther to the south and discharge near the old water plant facility. Finally, the cost of this alternative could be relatively high due to the large quantity of concrete and earthwork required to construct widened spillways.

3.1.5 Opinion of Probable Cost

The estimated costs for this alternative are preliminary and are provided as a range from 50% - 200% of the estimated cost to implement this alternative. This estimated cost assumes demolition of Spillways 1, 2 and 3 and removal or stockpiling of embankment materials, construction of new concrete spillways and catwalks and minor improvements to downstream outlet protection. This cost does not consider costs associated with lowering the normal operating pool and does not include costs associated with other alternatives constructed in combination with this alternative.

$750,000 -$3,000,000

3.2 Auxiliary Spillway at Swift Run Lake

Another alternative to increase discharge capacity at Swift Run Lake is the construction of an auxiliary spillway. The auxiliary spillway would be an open channel constructed along the northern groin of the embankment near SR 66. This alternative requires that discharge through the auxiliary spillway must travel south along SR 66 to reconnect with the discharge from Spillways 2 and 3. For a Class I dam an auxiliary spillway can only become activated during a 50-year storm event which has a big impact on the required length of the proposed spillway. At the current normal pool elevation this spillway is not feasible. However, if the City considers lowering the normal pool elevation of all three impoundments the required spillway size begins to decrease. The following table shows the relationship between drop in pool elevation and required auxiliary spillway size. Note that this relationship will change is this alternative is constructed in conjunction with another alternative like widening Spillways 2 and 3 or construction of a labyrinth weir.

Table 5 – Estimated Auxiliary Spillway Width Required

Normal Pool Incremental Drop	Required Crest Width (ft)	Depth (ft)
1 foot	2100	1.6
2 feet	850	2.5
3 feet	415	3.5
4 feet	240	4.5

3.2.1 Advantages

Construction of an auxiliary spillway increases discharge capacity at Swift Run lake and potentially reduces the scope of other improvements when combined with another alternative from this report.

3.2.2 Disadvantages

The auxiliary spillway does not appear to be feasible as a stand-alone solution for Swift Run Lake due to the required crest length to pass the design storm. This alternative requires that discharge through the auxiliary spillway must travel south along SR 66 to reconnect with the discharge from Spillways 2 and 3. Thus, the City must own the property between the embankment and SR66. Additionally, it is our understanding that this area along SR 66 carries underground water line infrastructure that would need to be relocated to make room for a relatively large open channel conveyance. Finally, this alternative will only address safely passing the design storm at Swift Run Lake.

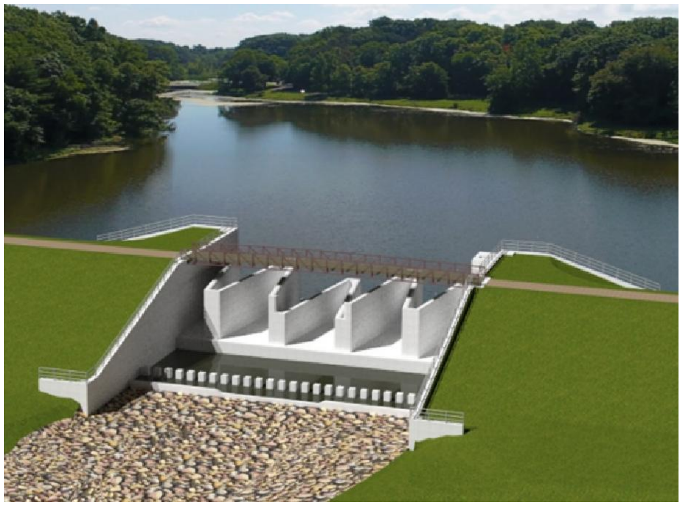
3.2.3 Opinion of Probable Cost

The estimated costs for this alternative are preliminary and are provided as a range from 50% - 200% of the estimated cost to implement this alternative.

$500,000 - $2,000,000

3.3 Labyrinth Spillway at Swift Run Lake

A popular alternative to conventional weir spillways is to consider a labyrinth structure that provides the benefits of weir crest length without the large footprint. Hull utilized the Tullis method to perform a preliminary labyrinth spillway design. An example taken from the Ohio Dam Safety Organization 2017 Newsletter is shown below to illustrate an isometric rendering of a spillway that was recently constructed at Mt. Gilead State Park, in Marion County, Ohio.



The footprint of the proposed spillway would vary depending on the normal pool elevation within Swift Run lake post construction. Should the normal pool elevation remain the same, the labyrinth will likely fill the entire length of the embankment from Spillway 2 to Spillway 3. If the City can drop the normal pool elevation at Swift Run lake the proposed footprint will decrease.

3.3.1 Advantages

The primary advantage is that Swift Run Lake Dam will comply with Dam Safety regulations and safely pass the PMF. Spillways 2 and 3 currently discharge to an established outlet channel that eventually discharges to the Great Miami River. Having an established discharge route is a big advantage considering the spillway could pass as much as 18,000 cfs during the PMF.

3.3.2 Disadvantages

The complexity and quantity of concrete can be costly for a labyrinth spillway in addition to the earthwork requirements and demolition of Spillways 2 and 3. Additionally, Swift Run Lake would likely need to be lowered substantially during construction which could potentially affect the available water resources for the City. Finally, this alternative does not address the discharge capacity at Franz Pond or Echo Lake.

3.3.3 Opinion of Probable Cost

The estimated costs for this alternative are preliminary and are provided as a range from 50% - 200% of the estimated cost to implement this alternative. This estimated cost assumes demolition of Spillways 2 and 3 and removal or stockpiling of embankment materials, the labyrinth spillway and minor imporovements to downstream outlet protection. This cost does not consider costs associated with lowering the normal operating pool and does not include costs associated with other alternatives constructed in combination with this alternative.

$1,000,000 - $4,000,000

3.4 Convert Franz Pond and Echo Lake to Dry Storage

The lakes that are part of the raw water supply system have become the focus of house development. Lakeside homeowners enjoy a view of the lakes, and historically the lakes and hydraulic canal have been used for recreational boating. Many of the lakeside landowners have constructed docks for boating access, but many of the docks are no longer useable due to lake shallowing and aquatic plant growth.

In recent years the City has become concerned about several aspects of the raw water supply system. The system captures sediment, nutrients and other contaminants that flow in from the subwatersheds for each lake. This phenomenon has led to significant lake shallowing concentrated at the points where the free-flowing streams have their confluence with the lakes, but extending throughout the lake system. Shallow-water conditions and a rich supply of light and nutrients have led to establishment of wetland areas dominated by various plant species and growth forms of wetland plants. In addition, open water areas of the lakes are subject to elevated concentrations of green algae. Ongoing lake shallowing and dominance by wetland plant species and algae are cause for concern to the City of Piqua because of its responsibility to maintain a safe, efficient and reliable public water supply, and to lake homeowners for mainly aesthetic reasons.

An alternative was considered consisting of removing the hydraulic connection between Swift Run Lake and the Hydraulic Canal. Franz Pond will remain connected to Echo Lake via the existing canal between the two impoundments. The outlet from Echo Lake beneath Echo Lake Drive will remain in its current configuration. Spillway 1 will be fully or partially removed to the lowest elevation of the hydraulic canal to allow Echo Lake to completely drain between storm events. Franz Pond will only drain to approximately elevation 894.4 leaving approximately 6 feet of water within the pond.

This alternative prevents Franz Pond from overtopping but the modeling suggests that Echo Lake will still overtop by as much as a foot. Additionally, this alternative assumes that measures are taken upstream to attenuate storm water runoff. A few examples of such measures include:

- The City may consider diverting a large portion of the watershed away from Franz Pond. Diverting a minimum of 35% of the existing watershed appears to be enough to bring Franz Pond into compliance with ODNR requirements and greatly improves the performance of Echo Lake.
- The time of concentration was doubled for each watershed to simulate various detention or slow release devices that could result in a much slower time of concentration.

3.4.1 Advantages

This alternative will prevent overtopping along the Franz Pond embankment. Another potential advantage not specifically included as part of this study could be restoration of the upstream areas that would feed the dry basins and installation of various forms of treatment to help mitigate for sediment transport that appears to be an issue for the City. This alternative will create a more efficient hydraulic connection between the ponds and the discharge point at Spillway 1.

3.4.2 Disadvantages

This alternative will eliminate standing water within Echo Lake and most of the current lake in Franz Pond. It is our understanding that Echo Lake has been used for recreation in the past before sedimentation became an issue. Recreation will no longer be an option in either impoundment and the primary storage area will likely be off-limits for recreation due to the potential for flash flooding during storm events. Additionally, Echo Lake will require overtopping protection for the PMF event that will include a wall or barrier that will protect the house built into the existing embankment.

3.4.3 Opinion of Probable Cost

The estimated costs for this alternative are preliminary and are provided as a range from 50% - 200% of the estimated cost to implement this alternative. This estimated cost includes demolition of Spillway 1, cohesive fill within the existing canal north of Spillway 1 to cut off the canal from Swift Run Lake, and site restoration at Franz Pond and Echo Lake. This cost does not include the potential cost of other alternatives construction in combination with this alternative to address Swift Run Lake Dam or Spillways 2 and 3.

$250,000 - $1,000,000

3.5 Raised Embankment using Concrete Parapet Walls

This alternative considers the installation of a concrete parapet wall, or free-standing levee wall, to raise the top of dam elevation. This would result in a larger storage capacity.

Table 6 – Estimated Parapet Wall Height

Spillway	Embankment Elevation	Wall Height Required (Normal Pool)	Wall Height Required (2 foot drop)	Wall Height Required (4 foot drop)
Franz Pond	909.9	N/A	N/A	N/A
Echo Lake	907.2	N/A	N/A	N/A
Hydraulic Canal	906 – 908.9	1.2-4.1 ft	0-2.5 ft	0 ft
Swift Run Lake	906.2	5 ft	4.5	3 ft

3.5.1 Franz Pond and Echo Lake

Raising the dam embankment of Franz Pond or Echo Lake with this alternative does not appear to be feasible. The calculated parapet wall height to contain the design storm appears to exceed 5 vertical feet above the existing embankment elevations.

3.5.2 Swift Run Lake

With no change to the normal pool elevation Swift Run Lake requires a minimum 5-foot-tall parapet wall. As the normal pool elevation is incrementally lowered, the minimum parapet wall height appears to drop to about 3 feet tall.

3.5.3 Hydraulic Canal

Like Swift Run Lake, the normal pool elevation has a large influence on the minimum parapet wall height requirement. The minimum wall height ranges from as much as 4.1 feet high to as low as no wall requirement assuming the normal pool is lowered by at least 4 feet.

3.5.4 Advantages

Construction of a parapet wall along the Swift Run Lake Dam embankment and the hydraulic canal can potentially allow Swift Run Lake to safely discharge the full PMF. This alternative could possibly be used in conjunction with other alternatives discussed in this report to reduce the minimum wall height requirements listed above.

3.5.5 Disadvantages

This alternative is not a feasible solution for Franz Pond and Echo Lake. A 4-foot to 5-foot-high parapet wall would be required along the entire length of the Swift Run Lake Dam embankment as well as the full length of the hydraulic canal. Additionally, the condition of the canal embankment is unknown to support these walls along the canal and deeper foundations may be required. Alternatively, a lower normal pool elevation across all three impoundments could eliminate the need for a wall along the hydraulic canal but may not be a feasible option for the City water supply.

3.5.6 Opinion of Probable Cost

The estimated costs for this alternative are preliminary and are provided as a range from 50% - 200% of the estimated cost to implement this alternative. The estimated cost assumes a 5-foot-high parapet wall along Swift Run Lake Dam and the northern portion of the hydraulic Canal to Spillway 1.
,;This assumes no changes to the normal operating pool and does not include the potential cost of other alternatives construction in combination with this alternative.

$750,000 - $3,000,000

3.6 Lower ODNR Dam Classification

Franz Pond, Echo Lake and Swift Run Lake are all considered Class I dams due primarily to downstream hazard. Class I Dams are required to safely pass the full PMF storm event and the existing dam spillways at Swift Run Lake and along the Canal are inadequately sized to pass the PMF. Each of the criteria listed in Ohio Revised Code (ORC) 1501:23-13 was considered to determine if a lower dam safety classification is possible, in order to lower the design storm requirement. The following table represents the dam classification guidelines as described in the ORC.

Table 7 – ODNR Dam Classification Guidelines

Guideline	Class I	Class II	Class III	Class IV
Height	>60 FT	>40 FT	>25 FT	<25 FT
Storage	>5000 Ac-FT	>500 Ac-FT	>50 Ac-FT	<50 Ac-FT
Hazard	Probable loss of human life, or structural collapse of residence or business.	Loss of water supply or waste treatment facility, flooding of structures or high value property, Disruption of major roads, damage do railroads or public utilities, and/or damage to downstream dams.	Property losses not included in higher classifications and/or disruption of local roads.	Property losses restricted to mainly the dam and rural lands, and no probable loss of human life.

The following table lists the existing dam classification for Franz Pond, Echo Lake and Swift Run Lake dams.

Table 8 – ODNR Classifications for Piqua Dams

Dam	Height Class	Storage Class	Hazard Class
Franz Pond	IV	III	I
Echo lake	IV	III	I
Swift Run lake	III	II	I

3.6.1 Franz Pond

Franz Pond is only a Class I dam due to downstream hazard. Multiple homes along Fisher Drive and a large neighborhood east of Washington Avenue create a probable loss of human life in the event of an embankment failure at Franz Pond. A large commercial building sits along the toe of the Franz Pond embankment. Hard armoring along the Franz Pond embankment could potentially pass the overtopping runoff from the design event but there is no space for a diversion channel to avoid the development downstream. For these reasons we do not consider this a feasible alternative for Franz Pond.

3.6.2 Echo Lake

Echo Lake is also a Class I Dam due to downstream hazard. A single-family residence is built into the toe of the embankment and a large neighborhood is located immediately downstream of the embankment, east of Forest Avenue. Hard armoring along the Echo Lake embankment could potentially pass the overtopping runoff from the design event but there is no space for a diversion channel to avoid the development downstream. For these reasons we do not consider this a feasible alternative for Echo Lake.

3.6.3 Swift Run Lake

Swift Run Lake is the largest of the three impoundments. The old water plant is located downstream and slightly south of the primary embankment and a single-family residence is located immediately downstream. After reviewing inundation mapping prepared for the EAP and the Bowser Morner 2006 report on potentially reclassifying the Swift Run Lake Dam as a Class II structure there appears to be a few additional single-family residences that would also be affected by breach flows during a dam failure event.

To lower the classification to a Class II dam, each of the following steps would need to be taken to reduce the likelihood of loss of life in downstream areas.

1. The old water plant facility must remain vacant; OR, a diversion berm is required along the western and northern end of the facility to divert flows from a dam failure or overtopping event.
2. The single-family residence immediately downstream of the dam embankment will need to be purchased by the City and removed or condemned.
3. A revised inundation mapping study, in conjunction with one or more of the other alternatives discussed in this report, may reduce the downstream impacts of breach flows during a dam failure event and could possibly remove the likelihood of loss of life in downstream areas.

3.6.4 Advantages

The primary advantage to pursuing this alternative is the potential to lower the classification of Swift Run lake which would lower the design storm requirement from 100% PMF to a 50% PMF. A lower classification can be paired with other alternatives and potentially result in major cost savings for construction efforts required to bring each impoundment into dam safety compliance.

3.6.5 Disadvantages

The cost of engineering fees to perform a new inundation mapping study are relatively negligible compared to the potential cost savings from required spillway modifications to pass the 50% PMF design storm event. However, the City would also have to purchase the property immediately downstream of the embankment and either maintain a vacant water plant facility or build a large diversion berm to shield the existing facility from potential breach flows.

3.6.6 Opinion of Probable Cost

The estimated costs for this alternative are preliminary and are provided as a range from 50% - 200% of the estimated cost to implement this alternative. The estimated cost assumes purchase of the property adjacent to the embankment, engineering fees for revised H&H analysis and construction of a diversion berm or diversion wall to prevent breach waters from inundating the old water plant facility. This cost assumes that Swift Run Lake Dam can be successfully reclassified as a Class II Dam; Otherwise, the cost may increase with the addition of spillway improvements or overtopping protection to meet the discharge requirements for a class I Dam.

$250,000 - $1,000,000

4.0 DISCUSSION AND RECOMMENDATIONS

The following sections describe each of the ODNR required Engineer Items from Section 1.0 and how the alternatives discussed in this report can potentially address each of these items.

1. *The dam's discharge/storage capacity must be sufficient to safely pass the required design flood without overtopping the embankment.*

All six alternatives included in this study were considered because they could potentially address this first ODNR Item. Due to the Class I classification of these impoundments, each is required to pass the full PMF event. Considering the complexity of the entire network of impoundments it may be necessary to consider improvements to Swift Run Lake separate from improvements to Echo Lake and Franz Pond.

Only one alternative, lowering the normal operating pool within Franz Pond and treating Echo Lake as dry detention, can potentially address the discharge capacity at these two impoundments. All other alternatives were not determined to be feasible options at these locations. Both watersheds will require some modification to help attenuate storm water runoff before entering the impoundments and Echo Lake would subsequently require overtopping protection.

For Swift Run Lake, there are potentially many alternatives or combinations of alternatives that can improve the discharge capacity of the lake. Whichever alternative or combination of alternatives is chosen, the City may see substantial cost reductions if a lower normal operating pool can be maintained across the entire network. Although it's not required to find a solution for Swift Run Lake, many of the alternatives are not feasible due to the limited freeboard between the current normal operating pool and the crest elevation of the embankment. The following alternatives are considered feasible at the current operating pool for Swift Run lake:

- Labyrinth Spillway;
- Take steps toward lowering the classification of Swift Run Lake as described in this report and in accordance with requirements from ODNR; Or
- Some combination of modifying the normal pool elevation and multiple alternatives.

2. *The embankment crest alignment must be uniform. Investigate the variable vertical alignment of the crest of the dam and canal.*

A professional ground survey was not performed as part of this study. However, based on previous reports and available LiDAR information the entire network does appear to have a variable embankment height. As shown in Table 1 in Section 1.3 of this report the crest elevation of each pond is different and the hydraulic canal embankment varies between Spillway 1 and Swift Run Lake. From a hydraulic standpoint, the embankment crest elevation appears to follow the natural contour of the ground surface and the hydraulic limitation of the entire network appears to be with the geometry of the hydraulic canal and the capacity of all three spillways. Recommendations for vertical modifications to the existing crest alignment should be made in conjunction with the selected alternative(s) and comprehensive solution to address these Engineer Items.

3. *This dam must have a device to permit draining of the reservoir within a reasonable period of time in accordance with OAC Rule 1501:21-13-06.*

It is our understanding that all three spillways have operable lake drain pipes. Additionally, the old water plant has existing infrastructure connected to the hydraulic canal that can increase the drawdown capacity near Swift Run Lake. Considering how far Spillway 1 is located from Franz Pond and Echo Lake, drawdown from these ponds is slow. The bridge opening at Echo Lake Drive controls flow in both directions between the hydraulic canal and Echo Lake. The City should consider a pipe connection to existing storm water infrastructure downstream of Franz Pond and Echo Lake. During an emergency condition, these new lake drain structures could discharge directly to a nearby manhole and through the existing storm water network through the City of Piqua.

4. *The erosion on the upstream slope of the embankment must be repaired and the upstream slope must be protected from erosion.*

Erosion along the upstream slope of each impoundment should continue to be monitored in accordance with the existing OMI. Improvements to upstream slopes should be performed as part of a larger and comprehensive solution for the entire network of impoundments and in conjunction with other items discussed in this report. However, if monitoring indicates a worsening condition these areas should be repaired as necessary to prevent embankment instability or further erosion. In some cases stronger vegetation reinforcement is likely sufficient but harder armoring solutions such as riprap stone may be required where wave action or higher velocities may be present.

5.0 CONCLUSIONS

The objective of this report is to provide the City of Piqua with possible solutions to address the ODNR required Engineer Repairs as described in Section 1.0. The results of this study are preliminary. A final hydrologic and hydraulic analysis and final design of any selected alternatives will need to be performed and submitted to ODNR for review and approval prior to modifications or improvements.

6.0 REFERENCES

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Tullis, J. P., Nosratollah, A., and Waldron, D., (1995). "Design of Labyrinth Spillways." Journal of Hydraulic Engineering. ASCE. 121(3), 247-255.

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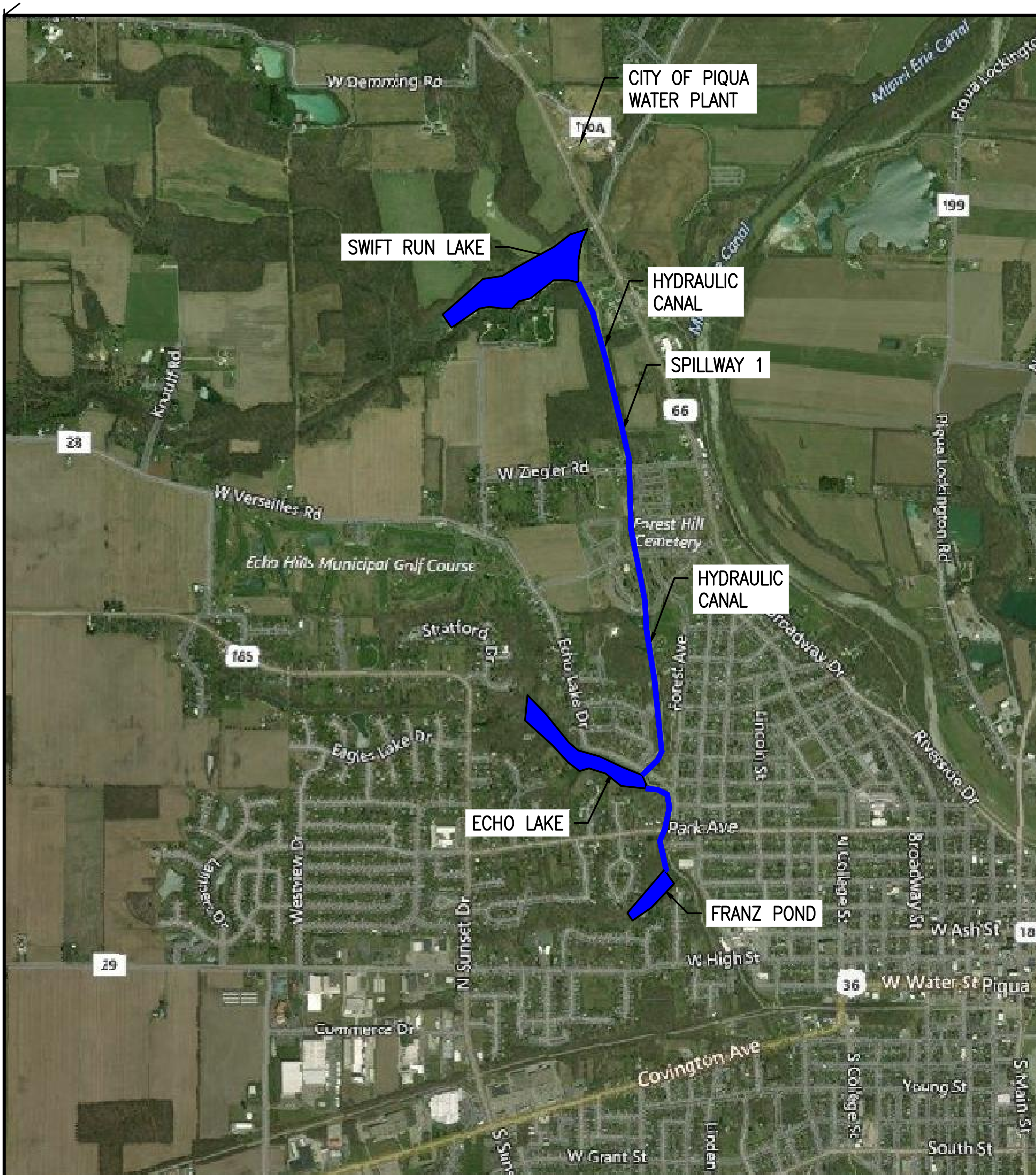
ATTACHMENT A

Vicinity Map
Drainage Area Map
Land Use Map



AERIAL IMAGE SOURCE: BING MAPS FROM AUTODESK CIVIL 3D.

LAYOUT BY: MRM	PROJECT NO. PIQ016
CHECKED BY: MRM	
DRAWN BY: MRM	SHEET NO. A.1
DATE: 5/29/2018	

HYDROLOGIC AND HYDRAULIC ENGINEERING STUDY
CITY OF PIQUA, OHIO

MIAMI COUNTY
OHIO

VICINITY MAP

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Notes:
The aerial photo was acquired through the ESRI Imagery web service. Aerial photography dated 2015.

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May 2018

Engineering Study

Figure

Aerial Map

A.2

City of Piqua, Ohio

Produced using ArcGIS 10.5

File Name: PIQ016_01_FigA2_Aerial.mxd

Edited: 5/11/2018 By: mopel

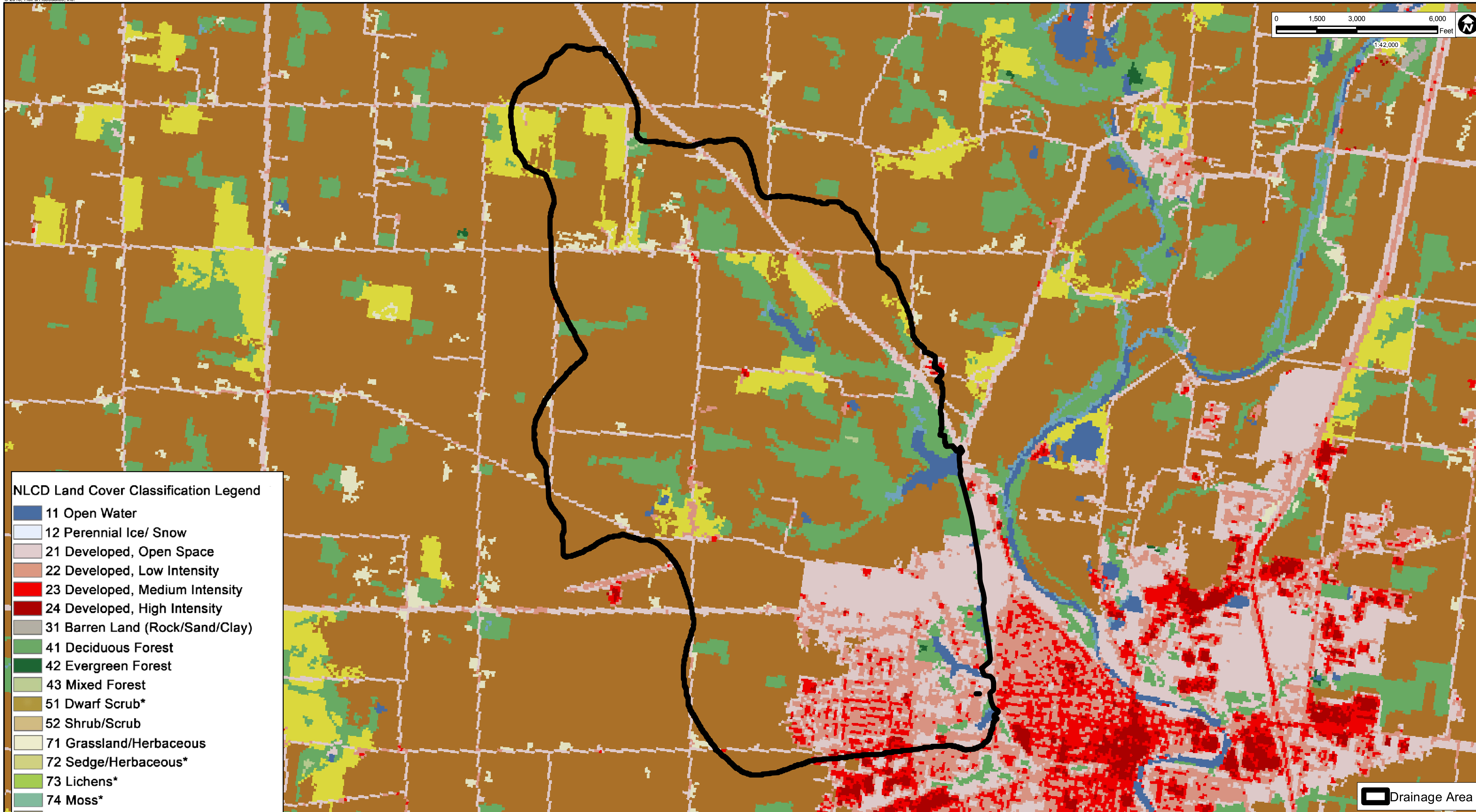

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Figure

Land Use Map

A.3

City of Piqua, Ohio

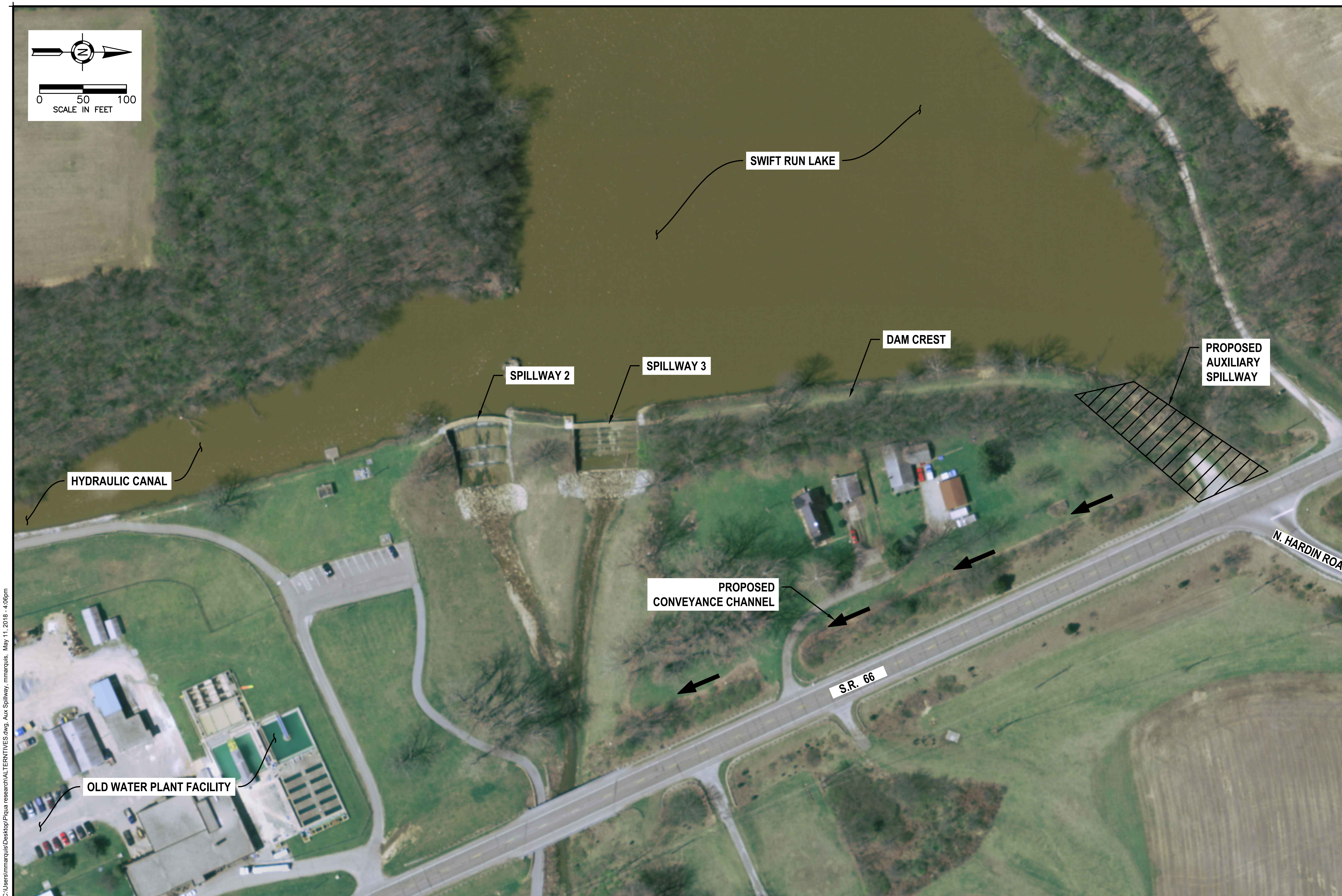
Produced using ArcGIS 10.5

File Name: PIQ016_01_FigA3_LandUse.mxd

Edited: 5/11/2018 By: mopel

ATTACHMENT B

Alternatives



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ALTERNATIVE 3.2
AUXILIARY SPILLWAY

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CITY OF PIQUA, OHIO

LAYOUT BY: MRM
CHECKED BY: MRM
DRAWN BY: MRM
DATE: 05/11/2018
PROJECT NO. PIQ016
SHEET NO. B.2

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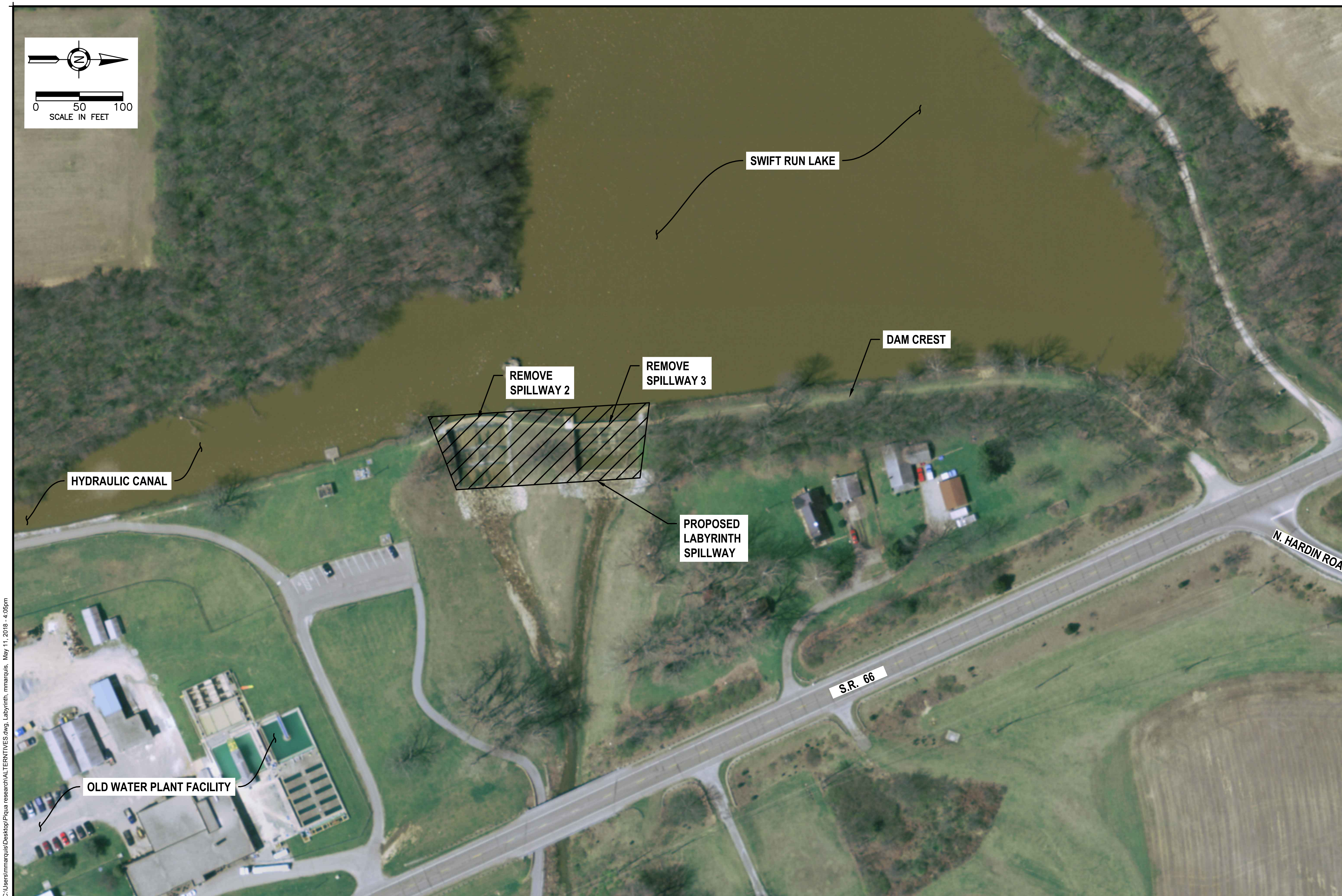

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ALTERNATIVE 3.3
LABYRINTH SPILLWAY

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CITY OF PIQUA, OHIO

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ALTERNATIVE 3.4
CONVERT FRANZ POND AND ECHO LAKE

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CITY OF PIQUA, OHIO

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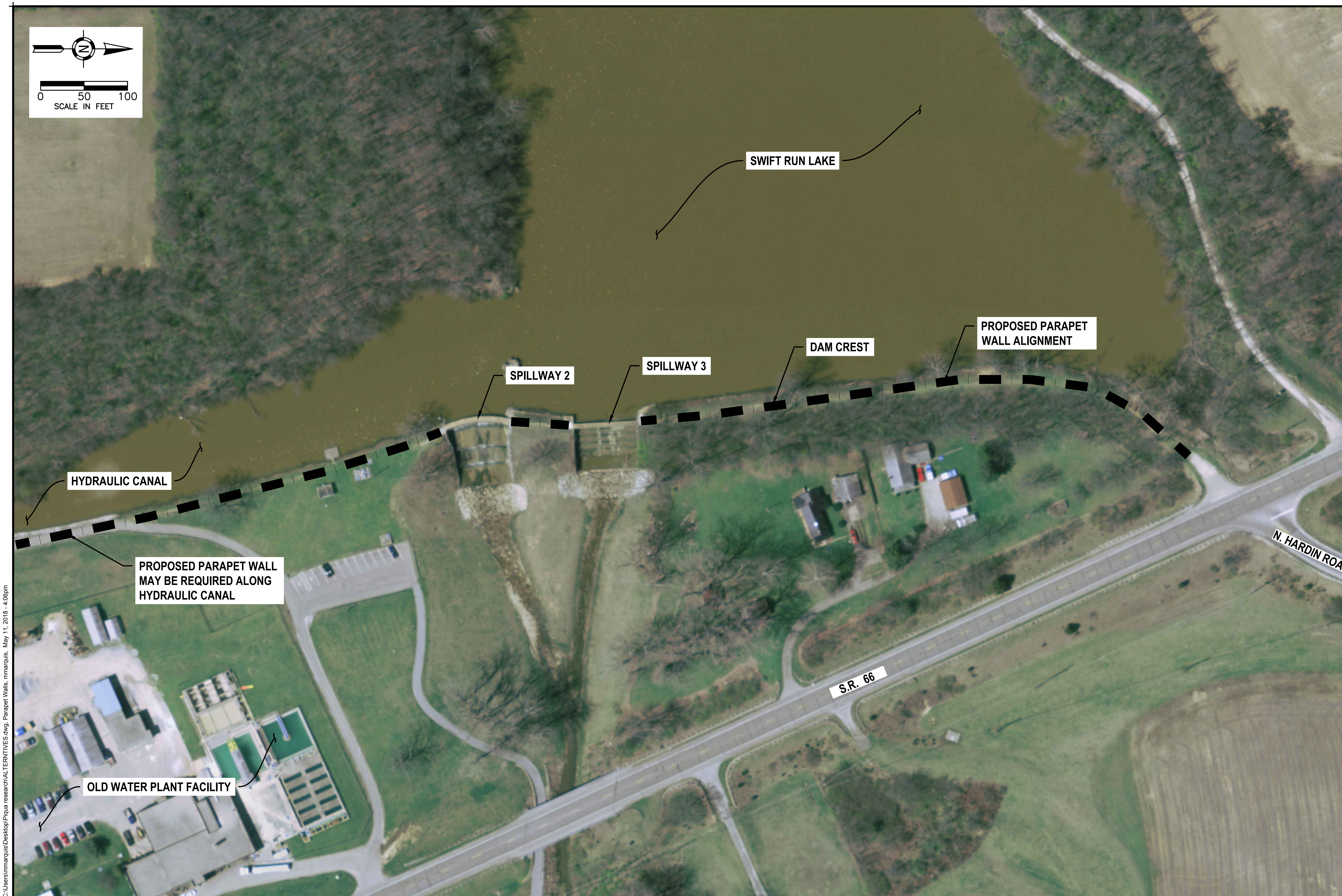

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ALTERNATIVE 3.5
RAISED EMBANKMENT WITH CONCRETE PARAPET WALLS

HYDROLOGIC AND HYDRAULIC ENGINEERING STUDY
CITY OF PIQUA, OHIO

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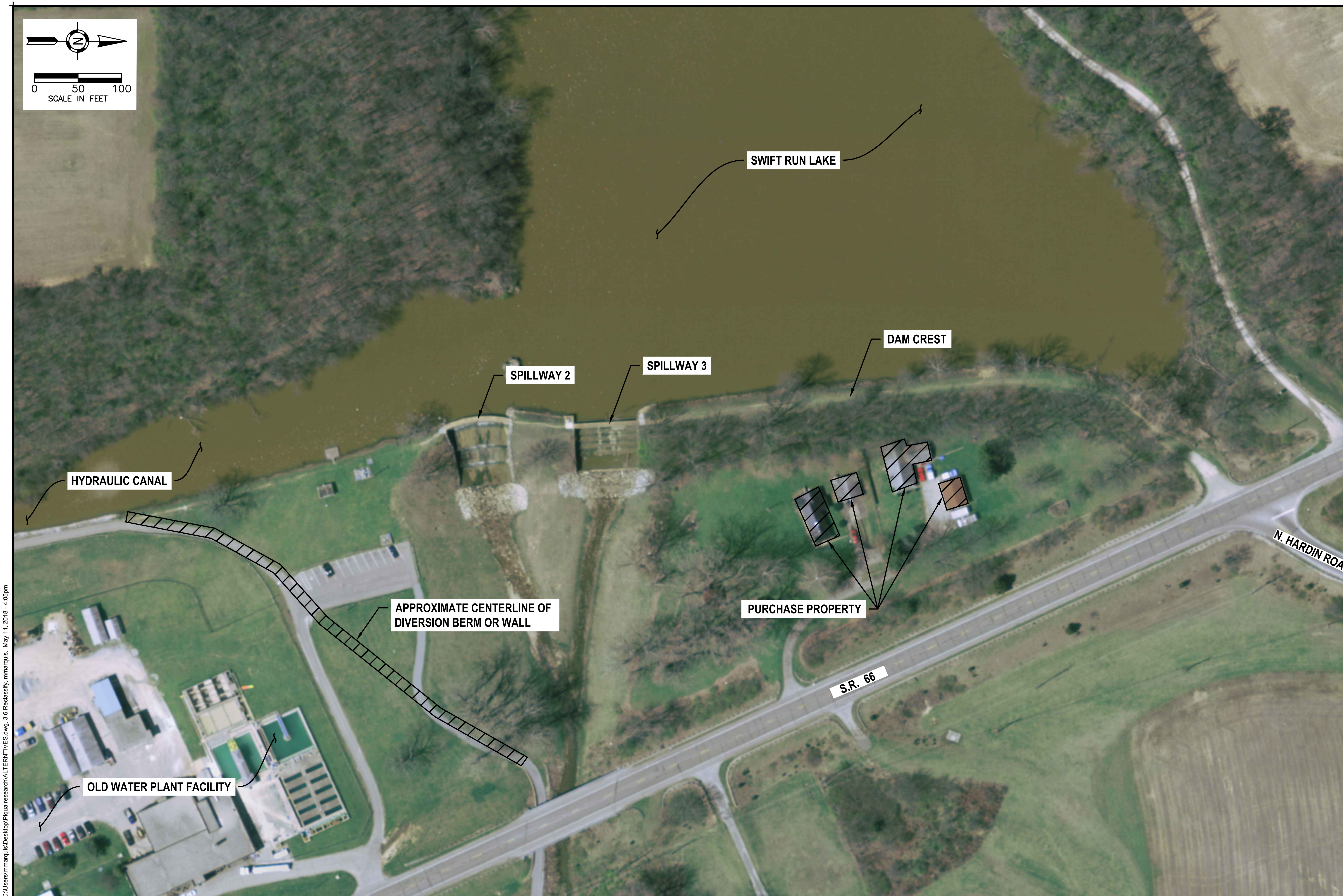

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ALTERNATIVE 3.6
LOWER DAM CLASSIFICATION

HYDROLOGIC AND HYDRAULIC
ENGINEERING STUDY
CITY OF PIQUA, OHIO

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PROJECT NO. PIQ016
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