Appendix D

Aquatic Habitat Assessment Study

Aquatic Habitat Assessment Study

Mongaup River Hydroelectric Projects:
Swinging Bridge Hydroelectric Project (No. 10482)
Mongaup Falls Hydroelectric Project (No. 10481)
Rio Hydroelectric Project (No. 9690)

February 2020

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List of Acronyms

Alpine	Alpine Ocean Seismic Survey, Inc.
BR	bedrock
CFR	Code of Federal Regulations
cfs	cubic feet per second
CNA	Centrarchid nesting area
DEM	digital elevation model
DGPS	Differential Global Positioning System
EAV	emergent aquatic vegetation
F	fine
FERC or Commission	Federal Energy Regulatory Commission
G	gravel
GIS	geographic information system
GPS	global positioning system
GRC	gravel, rubble, cobble
ILP	Integrated Licensing Process
IS	invasive aquatic plant species
LWD	large woody debris
MBS	multi-beam sonar
mm	millimeter
mph	miles-per-hour
NGVD29	National Geodetic Vertical Datum of 1929
NYSDEC	New York State Department of Environmental Conservation
Projects	Mongaup River Hydroelectric Projects
RB	rocky boulder
RF	rocky fine
RRAS	riprap/artificial shore
RSP	Revised Study Plan
SAV	submerged aquatic vegetation
SLS	sandy/silt-loam-soil complex
SPD	Study Plan Determination
SSS	side-scan sonar
USGS	U.S. Geological Survey

1.0 Introduction and Background

Eagle Creek Hydro Power, LLC; Eagle Creek Water Resources, LLC; and Eagle Creek Land Resources, LLC (collectively and hereinafter "Eagle Creek") are the Licensees of the Swinging Bridge Hydroelectric Project (FERC No. 10482), the Mongaup Falls Hydroelectric Project (FERC No. 10481), and the Rio Hydroelectric Project (FERC No. 9690) (collectively "Mongaup River Projects" or "Projects"). Collectively, the Projects are located on Black Lake Creek, Black Brook, and the Mongaup River in Sullivan and Orange Counties, New York.

On April 14, 1992, the Federal Energy Regulatory Commission ("FERC" or "Commission") issued three original and separate licenses for the operation of the Projects in accordance with the Commission's delegated authority under the Federal Power Act. Each Project's original license was issued for a term of 30 years and expires on March 31, 2022. Consequently, Eagle Creek is pursuing new licenses for the Projects and has opted to use the Commission's Integrated Licensing Process (ILP), as detailed at 18 Code of Federal Regulations (CFR) Part 5 of the Commission's regulations.

In accordance with 18 CFR §5.15, Eagle Creek conducted studies pursuant to Eagle Creek's January 10, 2018 Revised Study Plan (RSP) as modified in the Commission's February 9, 2018 Study Plan Determination (SPD). This report describes the methods and results of the Aquatic Habitat Assessment Study conducted in support of obtaining new licenses for the Projects.

2.0 Goals and Objectives

The goal of this study is to identify the aquatic habitat within the normal fluctuation zones (i.e., the area within the reservoir elevation operating ranges) of each of the five reservoirs associated with the Mongaup River Projects and identify potential effects that Project operations may have on these habitats. The specific objectives of this study are as follows:

- Conduct a combination of field surveys and desktop analyses to identify and map the aquatic habitats within the reservoirs' fluctuation zones;
- Identify aquatic invasive plant species within the fluctuation zones;
- Document unique attributes such as fish spawning beds and mussel beds or shell materials observed during aquatic habitat mapping;
- Document observed erosion areas within the fluctuation zones; and
- Describe the potential influences of the Projects' operations on aquatic habitats within the impoundments.

3.0 Study Area

The study area included the Projects' five reservoirs (Toronto, Cliff Lake, Swinging Bridge, Mongaup Falls, and Rio reservoirs). Survey data collection was generally limited to the area located within the fluctuation zone for each reservoir (Table 3-1). Each reservoir's maximum elevation operating range was separated into different zones for this study as indicated in Table 3-2. All elevations in this report are expressed in National Geodetic Vertical Datum 1929 (NGVD29), unless otherwise indicated. Maps of each reservoir delineating the extent of the areas surveyed are provided in Attachment 1.

TABLE 3-1
FULL, NORMAL UPPER/LOWER TARGET, AND LOW ELEVATIONS FOR THE PROJECTS' RESERVOIRS

	Toronto	Cliff Lake	Swinging Bridge	Mongaup Falls	Rio
Full Reservoir (Max.)	1,220 (top of flashboards)	1,071.1 (top of flashboards)	1,070 (top of Obermeyer gate/rubber dam)	935 (top of flashboards)	815 (top of flashboards)
Normal Upper Target[1]	1,218	1,068	1,068	935	815
Normal Lower Target[1]	1,200	1,049	1,049	929	808
Low Reservoir (Min.)	1,170	1,048	1,048	910	805
Reservoir Maximum Elevation Operating Range	50 feet	23.1 feet	22 feet	25 feet	10 feet

[1]The target elevations do not necessarily represent the minimum or maximum reservoir operating elevations.

TABLE 3-2
STUDY FLUCTUATION ZONES FOR THE PROJECTS' RESERVOIRS

	Toronto	Cliff Lake	Swinging Bridge	Mongaup Falls	Rio
Zone 1	1,220 - 1,218	1,071.1 - 1,068	1,070 - 1,068	NA[1]	NA[1]
Zone 2	1,218 - 1,200	1,068 - 1,049	1,068 - 1,049	935 – 929	815 - 808
Zone 3	1,200 - 1,170	1,049 - 1,048	1,049 - 1,048	929 - 910	808 – 805

[1]Zone 1 was not applicable for Mongaup Falls and Rio reservoirs because the full reservoir elevation is the same as the normal upper target elevation.

4.0 Methodology

4.1 Sonar Survey

In support of identifying and mapping the aquatic habitat present within the Projects' reservoirs fluctuation zones, the zones were surveyed by Alpine Ocean Seismic Survey, Inc. (Alpine) using a boat equipped with side-scan sonar (SSS) and multi-beam sonar (MBS) survey equipment between June 19 and July 3, 2018 (Table 4-1). In general, this sonar survey equipment consisted of a 22-foot survey vessel, Applanix™ POS MV[1] using Differential Global Positioning System (DGPS), hydrographic positioning and acquisition software, an Edgetech™ 6205 Multibeam Echo Sounder System with Side Scan Sonar, and an Applied Microsystems Sound Velocity Profiler (Alpine 2018). The initial transect line of each reservoir was performed running approximately 50 feet from the shoreline. Additional transect lines were run both closer to and further from the shore in order to achieve the required survey coverage. Consistent with the approved study plan, the sonar data was processed to evaluate the shoreline at 2-foot contours within the normal operating range of the reservoirs and at 5-foot contours thereafter.

[1] POS MV is a user-friendly, turnkey system designed and built to provide accurate position, heading, attitude, heave, and velocity data of marine vessel and remote sensing equipment.

TABLE 4-1
MULTI-BEAM AND SIDE-SCAN SONAR SURVEY DATES AND RESERVOIR ELEVATIONS

Reservoir	Survey Date(s)	Reservoir Elevation during Survey	Reservoir Elevation at Full Pond	Full Pond Surface Area (acres)
Toronto	June 19 – 23, 2018	1,217.7	1,220	860
Cliff Lake	June 30 – July 1, 2018	1,068.4	1,071.1	190
Swinging Bridge	June 24 – 26, 2018	1,068.4	1,070	1,000
Mongaup Falls	June 29, 2018	934.5	935	120
Rio	July 2 – 3, 2018	814.3	815	460

Source: Alpine 2018

Because the sonar surveys were performed slightly below full pond elevation within the reservoirs, digital elevation model (DEM) data in U.S. Geological Survey (USGS) format was converted to a raster dataset and utilized for elevations above those captured by the sonar surveys.

4.2 Field Verification Survey

To evaluate substrate classification accuracy and to further assess the aquatic habitat in the reservoirs' fluctuation zones, verification of the substrate mapping in the fluctuation zones was performed via boat and/or shoreline visual observations. The verification surveys occurred the weeks of May 13, 2019 and September 9, 2019 (Table 4-2).

TABLE 4-2
FIELD VERIFICATION SURVEY DATES AND RESERVOIR ELEVATIONS

Reservoir	Survey Date(s)	Reservoir Elevation
Toronto	September 9-12, 2019	1,214
Cliff Lake	May 15 & 16, 2019	1,061-1,062
Swinging Bridge	May 13-15, 2019	1,058-1,061
Mongaup Falls	September 11, 2019	929
Rio	May 17, 2019	814

Verification surveys were conducted at mapped substrate polygons in the Projects' reservoirs. During the verification surveys, the boat operator navigated to mapped polygons using an EOS Positioning Systems Arrow 100™ GNSS receiver linked to an iPad™ Air 2 or Android device operating Collector for ArcGIS™. The crew anchored/held the boat in position over the point and observed the substrate through visual inspection and/or lowered a submersible Eyoyo Portable 9 inch LCD Monitor Fish Finder HD 1000TVL Fishing Camera (with infrared lights) to inspect substrate near the point. The camera was connected to a television, which enabled the crew to visually assess and classify the actual substrate present at each verification site. The drop camera was deployed off the side of the boat and panned to provide a view of the substrate. Wherever possible, the crew used a long metal pole to prod and scrape the substrate beneath the boat.

Where appropriate, additional features of habitats were recorded, including dominant and subdominant substrates, cover type and relative abundance, estimated bank slope, and the presence of aquatic vegetation. Biological characteristics were also recorded during verification surveys, including readily observable aquatic fauna and invasive plant species. Fish spawning beds and mussel beds or evidence of shell material observed during the aquatic habitat surveys were also documented and their location recorded using the global positioning system (GPS). Representative photographs were taken of mapped substrates and cover types as appropriate.

The shorelines of the Projects' reservoirs were also inventoried for active erosion sites concurrently with the aquatic habitat mapping verification surveys conducted the weeks of May 13, 2019 and September 9, 2019. The inventory was conducted by boat and on foot. Each site with evidence of erosion was photo-documented.

Active erosion sites were defined as sites having exposed bare soil, usually slightly above and/or near the normal high water mark of each reservoir because of obvious alterations of the topography caused by disturbance, compared with surrounding areas. These sites generally exhibited signs of recent erosion, such as fresh breaks in the soil profile, exposed roots of vegetation, and chunks of sloughed-off soil at the base of the slope (occasionally with intact vegetation in the topsoil). Generally, the erosion assessment did not include an inventory of historic erosion sites. Historic erosion sites are defined as those sites where the soil had slumped or otherwise eroded in the past, compared with surrounding topography, and where vegetation had recolonized (revegetated) the majority of the site. Some sites that were inventoried contained segments of historic erosion intermixed with active erosion. These were mapped as continuous sites and noted as containing both active and historic components.

4.3 Sonar and Field Verification Data Assessment

As described above and below, a combination of sonar survey data interpretation and field verification mapping of individual habitat units was used to assess the data and develop aquatic habitat maps for the Projects' reservoirs.

The approximate locations of substrate and cover type boundaries were manually digitized around areas of uniform sonar signature by visual interpretation of the sonar imagery for each impoundment. Digitized lines were converted to polygons and assigned a substrate and/or a cover type class. The substrate classification scheme included eight predominant, surficial substrate classes: fine (F), gravel (G), gravel, rubble, cobble (GRC), rocky fine (RF), rocky boulder (RB), bedrock (BR), sandy/silt-loam-soil complex (SLS), and riprap/artificial shore (RRAS) (Table 4-3). These classes were defined on the basis of material composition and particle size. Sonar data was interpreted using texture, tone, shape, pattern, and association to distinguish and classify substrate and cover type polygons (Figures 4-1 through 4-4). Habitat units were also differentiated based on general slope characteristics within each reservoir. In each reservoir, habitat units were generally identified as segments of the shorelines/fluctuation zones with relatively uniform habitat characteristics (e.g., substrate, slope, cover, wetland development).

Dominant cover types were based on the categories of: Centrarchid nesting area (CNA), submerged aquatic vegetation (SAV), aquatic invasive plant species (IS), and large woody debris (LWD). Large woody debris consisted of roots, stumps, logs (cut or naturally fallen), fallen trees, deposition areas (i.e., associated with backwater areas, coves, shorelines), and beaver dams/lodges. Cover type categories are further detailed in Table 4-4 below.

TABLE 4-3
CLASSIFICATION SCHEME AND ASSOCIATED DEFINITIONS DEVELOPED FOR THE PROJECTS' AQUATIC HABITAT MAPS

Substrate Class	Acronym	Definition
Fine	F	Area composed of particles <2.0 millimeter (mm) diameter (sand, silt, clay or fine organic detritus)
Gravel	G	Area composed of particles 2.0 mm – 32 mm (1.26 ")
Gravel, Rubble, Cobble	GRC	An area predominantly composed of a conglomeration of gravel, rubble, and cobble at varying densities from 2.0 mm – 256 mm (10.08"). Cobblestone and platy rock types are included. Any area meeting these criteria, regardless of underlying substrate, is classified GRC
Rocky fine	RF	An area predominantly composed of small and medium boulders 256 mm (10.08") – 1,024 mm (40.31") in diameter across the widest side. Any area meeting these criteria, regardless of underlying substrate, is classified RF
Rocky boulder	RB	An area predominantly composed of boulders 1,024 mm (40.31") or larger in diameter across the widest side. Any area meeting these criteria, regardless of underlying substrate, is classified RB
Bedrock	BR	An area predominated by mostly solid bedrock
Sandy/Silt-loam-soil complex	SLS	Any area of land located within the maximum reservoir elevation predominantly composed of terrestrial habitat (e.g., upland)
Riprap/artificial shore	RRAS	A reservoir shore, or stream/river shore area, that is covered/protected with concrete, coarse stones, cobbles, concrete slabs, gabions, etc., placed primarily for erosion control

TABLE 4-4
COVER TYPES BY CATEGORY AND DESCRIPTION

Category	Acronym	Definition
Centrarchid Nesting Area	CNA	Includes observed Centrarchid nests; saucer-shaped nests observed along the shorelines of the reservoirs. These nests usually consist of a circular depression in silt, sand, or gravel that is lighter in color than the surrounding substrate because an adult male has consistently scraped silt, algae, or other organic material from accumulating within the nest area.
Submerged Aquatic Vegetation	SAV	Includes submerged vegetation and includes the dominant genus' of *Vallsineria, Elodea*, *Hydrilla*, *Najas, Potamogetan,* and *Ceratophyllum.*
Large Woody Debris	LWD	Includes stumps, logs, branches, fallen trees, beaver lodges, and any other woody-type materials.
Invasive Aquatic Plant Species	IS	Includes common invasive species such as purple loosestrife (*Lythrum salicaria*) and Phragmites (*Phragmites australis*).

FIGURE 4-1
SONAR IMAGE OF ROCKY BOULDER/ROCKY FINE IN TORONTO RESERVOIR

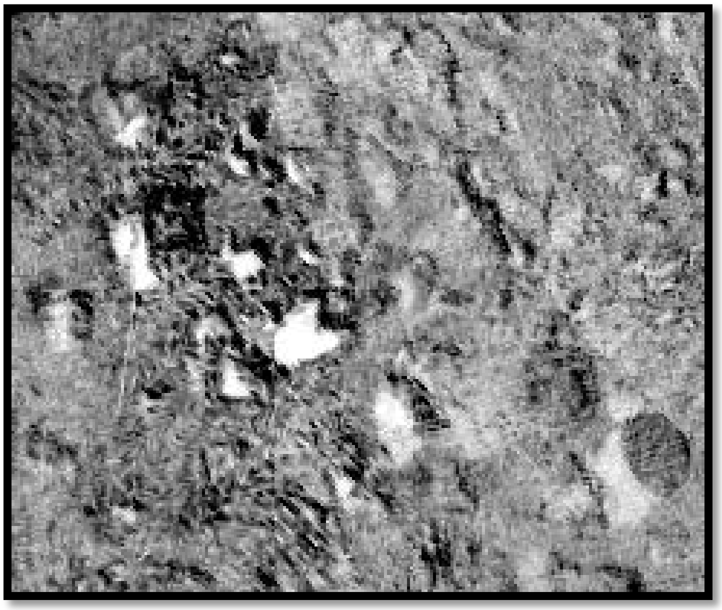


FIGURE 4-2
SONAR IMAGE OF FINE SUBSTRATE IN THE RIO RESERVOIR

FIGURE 4-3
SONAR IMAGE OF GRAVEL, RUBBLE, COBBLE SUBSTRATE IN CLIFF LAKE RESERVOIR SHOWING RIPPLES AT LEFT EDGE OF PHOTO

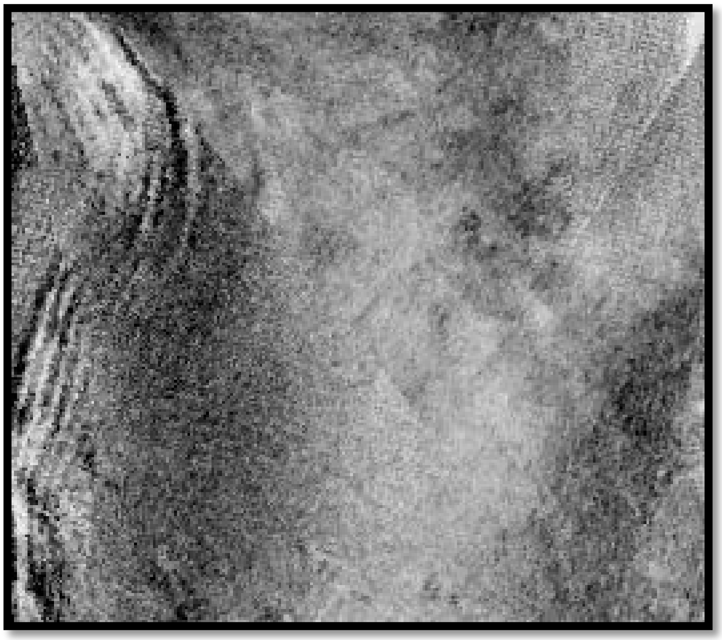


FIGURE 4-4
SONAR IMAGE OF LARGE WOODY DEBRIS IN TORONTO RESERVOIR IN CENTER OF PHOTO

5.0 Results

5.1 Shoreline Slope

Shoreline slope was visually estimated along the littoral zones of each of the Projects' reservoirs and confirmed via geographic information system (GIS) processing. Distinct changes in slope were not always discernible and were observed to be transitional in some mapped areas. Each slope category may include a partial transition zone to the adjacent slope category. Gradual and moderate slopes inherently occupy larger surface areas while steep and vertical slopes occupy much smaller surface areas when mapped aerially.

For this study, slope categories were defined as Gradual (0-15 degrees), Moderate (16-30 degrees), Steep (31-50 degrees), Very Steep (51-75 degrees) and Vertical (76-90 degrees). Representative photographs of the different slope categories are provided in Attachment 2. Slope is also visually represented as a width of exposed area along some of the Projects' reservoirs on the maps provided in Attachment 1. The total acreage of each slope category within each of the reservoirs' fluctuation zones is provided in Table 5-1.

Zone 1 of the Toronto, Cliff Lake and Swinging Bridge reservoirs is comprised of approximately 69 percent of gradual sloped areas, 28 percent of moderately sloped areas, and 3 percent of steep sloped areas (although, no steep sloped areas were identified at Cliff Lake Reservoir). Zone 2 of the Toronto, Cliff Lake and Swinging Bridge reservoirs is comprised of approximately 69 percent of gradual sloped areas, 26 percent of moderately sloped areas, and 5 percent steep sloped areas. Zone 3 of the Toronto, Cliff Lake and Swinging Bridge reservoirs is comprised primarily (95%) of gradual sloped areas.

Zones 2 and 3 of the Mongaup Falls and Rio reservoirs are largely comprised of gradual sloped areas (65% at Mongaup Falls Reservoir and 55% at Rio Reservoir) with moderately sloped areas occupying approximately 32 percent at Mongaup Falls and 29 percent at Rio and steep sloped areas occupying approximately 16 percent at Rio. Isolated areas of very steep or vertical sloped areas were also identified at Mongaup Falls and Rio reservoirs.

5.2 Substrate

The dominant substrate was mapped/verified simultaneously with the slope and cover types for the reservoirs' fluctuation zones, which are shown on the maps provided in Attachment 1 and in the representative photographs provided in Attachment 2. Total acreage of substrate types mapped/verified within each of the three fluctuation zones is provided in Table 5-2 and briefly summarized below.

The majority of the reservoirs' fluctuation zones are dominated by fine substrates followed by rocky fine substrate and gravel, rubble, cobble. Specifically, fine substrate dominates approximately 61 percent of Zones 1, 2, and 3 within the Projects' reservoirs, while rocky fine substrate represents approximately 23 percent of Zones 1, 2, and 3 within the Projects' reservoirs.

TABLE 5-1
SLOPE CATEGORIES FOR THE RESERVOIRS' FLUCTUATION ZONES

Zone (reservoir elevation)	Slope Category (acres)					Total Area (acres)
	Gradual	Moderate	Steep	Very Steep	Vertical	
	0-15°	16-30°	31-50°	51-75°	76-90°	
Toronto Reservoir						
Zone 1 (1,220 - 1,218)	15.20	5.79	0.43	--	0.02	21.44
Zone 2 (1,218 - 1,200)	176.10	44.18	9.83	--	0.03	230.14
Zone 3 (1,200 - 1,170)	428.38	17.76	0.98	--	--	447.12
Total Area (acres)	**619.68**	**67.73**	**11.24**	**--**	**0.05**	**698.70**
Cliff Lake Reservoir						
Zone 1 (1,071.1 - 1,068)	15.44	3.49	--	--	--	18.93
Zone 2 (1,068 - 1,049)	83.76	20.26	--	--	--	104.02
Zone 3 (1,049 - 1,048)	2.98	0.33	--	--	--	3.31
Total Area (acres)	**102.18**	**24.08**	**--**	**--**	**--**	**126.26**
Swinging Bridge Reservoir						
Zone 1 (1,070 - 1,068)	19.41	10.58	1.84	--	--	31.83
Zone 2 (1,068 - 1,049)	190.31	108.36	21.78	--	--	320.45
Zone 3 (1,049 - 1,048)	7.84	5.23	1.17	--	--	14.24
Total Area (acres)	**217.56**	**124.17**	**24.79**	**--**	**--**	**366.52**
Mongaup Falls Reservoir						
Zone 2 (935 - 929)	16.80	13.75	0.49	1.23	0.51	32.78
Zone 3 (929 - 910)	59.67	24.19	0.33	--	0.02	84.21
Total Area (acres)	**76.47**	**37.94**	**0.82**	**1.23**	**0.53**	**116.99**
Rio Reservoir						
Zone 2 (815 - 808)	23.41	10.85	6.46	--	0.05	40.77
Zone 3 (808 - 805)	11.74	7.38	3.68	--	0.05	22.85
Total Area (acres)	**35.15**	**18.23**	**10.14**	**--**	**0.10**	**63.62**

TABLE 5-2
SUBSTRATE CATEGORIES FOR THE RESERVOIRS' FLUCTUATION ZONES

Zone (reservoir elevation)	Substrate Category Area (acres)								
	Fine	Gravel	Gravel, Rubble, Cobble	Rocky Fine	Rocky Boulder	Bedrock	Sandy/Silt-Loam-Soil Complex	Riprap/ Artificial Shore	Total Area (acres)
Toronto Reservoir									
Zone 1 (1,220 - 1,218)	4.00	0.83	5.03	10.37	0.36	0.64	--	0.21	21.44
Zone 2 (1,218 - 1,200)	75.81	3.89	36.79	105.28	2.51	3.41	0.06	2.39	230.14
Zone 3 (1,200 - 1,170)	406.00	--	1.02	35.22	4.87	--	--	--	447.11
Total Area (acres)	**485.81**	**4.72**	**42.84**	**150.87**	**7.74**	**4.05**	**0.06**	**2.60**	**698.69**
Cliff Lake Reservoir									
Zone 1 (1,071.1 - 1,068)	12.11	--	2.72	0.40	0.70	--	2.94	0.08	18.95
Zone 2 (1,068 - 1,049)	78.34	--	18.18	4.60	2.02	--	0.58	0.28	104.00
Zone 3 (1,049 - 1,048)	2.98	--	0.33	--	--	--	--	--	3.31
Total Area (acres)	**93.43**	**--**	**21.23**	**5.00**	**2.72**	**--**	**3.52**	**0.36**	**126.26**
Swinging Bridge Reservoir									
Zone 1 (1,070 - 1,068)	8.04	0.21	3.14	11.88	1.82	0.22	6.34	0.18	31.83
Zone 2 (1,068 - 1,049)	147.86	1.69	32.15	117.87	14.30	2.04	2.78	1.77	320.46
Zone 3 (1,049 - 1,048)	6.60	0.01	1.75	5.02	0.69	0.06	--	0.08	14.21
Total Area (acres)	**162.50**	**1.91**	**37.04**	**134.77**	**16.81**	**2.32**	**9.12**	**2.03**	**366.50**
Mongaup Falls Reservoir									
Zone 2 (935 - 929)	13.18	6.73	7.24	2.72	--	--	2.18	0.10	32.15
Zone 3 (929 - 910)	54.60	2.07	19.61	7.92	--	--	0.02	--	84.22
Total Area (acres)	**67.78**	**8.80**	**26.85**	**10.64**	**--**	**--**	**2.20**	**0.10**	**116.37**
Rio Reservoir									
Zone 2 (815 - 808)	15.11	--	13.66	10.46	0.54	--	0.58	0.42	40.77
Zone 3 (808 - 805)	9.29	--	6.04	6.89	0.38	--	--	0.25	22.85
Total Area (acres)	**24.40**	**--**	**19.70**	**17.35**	**0.92**	**--**	**0.58**	**0.67**	**63.62**

5.3 Cover Type

Within the reservoirs' fluctuation zones, cover types were mapped/verified simultaneously with the slopes and substrates. A summary of the total acreage of cover types mapped/verified within the fluctuation zones for the Projects' reservoirs is provided in Table 5-3. Mapped cover types for the Projects' reservoirs are provided in Attachment 1, and representative photographs of the varying cover types are provided in Attachment 2.

In Toronto Reservoir, the predominate cover type is submerged aquatic vegetation (SAV), particularly occurring in Zone 2, with a few areas of large wood debris and Centrarchid nesting occurring in Zones 1 and 2. In Cliff Lake Reservoir, relatively small areas of large woody debris occur in Zones 1, 2, and 3 and Centrarchid nesting in Zone 2. In Swinging Bridge Reservoir, relatively small areas of SAV and Centrarchid nesting occur in Zone 2 along with small areas of large woody debris in Zones 1, 2, and 3. In Mongaup Falls Reservoir, relatively small areas of large woody debris occur in Zones 2 and 3, SAV in Zone 2, and Centrarchid nesting in Zone 3. In Rio Reservoir, relatively small areas of large woody debris occur in Zones 2 and 3 and Centrarchid nesting in Zone 2. Additionally, aquatic invasive plants observed during the study were limited to a small narrow band of Phragmites was observed along the southwestern shoreline on the Rio Reservoir (Attachment 1).

TABLE 5-3
COVER TYPE CATEGORIES FOR THE RESERVOIRS' FLUCTUATION ZONES

Zone (reservoir elevation)	Cover Type Category				Total Area (acres)
	Large Woody Debris	Invasive Aquatic Plant Species	Submerged Aquatic Vegetation	Centrarchid Nesting Areas[1]	
Toronto Reservoir					
Zone 1 (1,220 - 1,218)	0.70	--	0.82	0.08	1.60
Zone 2 (1,218 - 1,200)	1.41	--	117.49	3.04	121.94
Zone 3 (1,200 - 1,170)	--	--	0.45	--	0.45
Total Area (acres)[1]	**2.11**	**--**	**118.76**	**3.12**	**124.00**
Cliff Lake Reservoir					
Zone 1 (1,071.1 - 1,068)	0.22	--	--	--	0.22
Zone 2 (1,068 - 1,049)	0.80	--	--	0.10	0.90
Zone 3 (1,049 - 1,048)	0.01	--	--	--	0.01
Total Area (acres)[1]	**1.03**	**--**	**--**	**0.10**	**1.13**
Swinging Bridge Reservoir					
Zone 1 (1,070 - 1,068)	0.24	--	--	--	0.24
Zone 2 (1,068 - 1,049)	1.44	--	2.35	1.11	4.90
Zone 3 (1,049 - 1,048)	--	--	--	--	--
Total Area (acres)[1]	**1.68**	**--**	**2.35**	**1.11**	**5.14**
Mongaup Falls Reservoir					
Zone 2 (935 - 929)	0.93	--	0.04	--	0.97
Zone 3 (929 - 910)	2.35	--	--	0.75	3.13
Total Area (acres)[1]	**3.28**	**--**	**0.04**	**0.75**	**4.10**
Rio Reservoir					
Zone 2 (815 - 808)	0.59	0.15	--	2.06	2.80
Zone 3 (808 - 805)	0.27	0.01	--	--	0.28
Total Area (acres)[1]	**0.86**	**0.16**	**--**	**2.06**	**3.08**

[1] Centrarchid nesting areas were digitized based on approximated boundaries.

Centrarchid Nests

Centrarchid nests were counted/mapped when observed and the encompassing concentrated areas were digitized on the maps provided in Attachment 1. For this study, depressions were counted as remnant or previously used Centrarchid nests; however, due to the condition of the depressions during the study, it is impossible to distinguish between nests used during the most recent spawning season and those used in previous spawning seasons. It is also impossible to distinguish which species (e.g., sunfish or basses) occupied the nests or if they were utilized by other species (i.e., turtles for overwintering or predation burrows). Most Centrarchids are either colony nesters or prefer similar habitats leading to their nests occupying groups, clusters, or concentrated areas (see representative photos in Attachment 2) within their preferred habitats.

Table 5-3 shows that a majority of the observed Centrarchid nests occur in Zone 2 (Toronto, Cliff Lake, Swinging Bridge, and Rio reservoirs), with nests also occurring in Zone 1 in Toronto Reservoir and limited to Zone 3 in Mongaup Falls Reservoir.

Submerged Aquatic Vegetation

The presence of SAV was generally sparse in the study area, with the exception of Zone 2 in Toronto Reservoir (Table 5-3 and Attachment 1). Generally, the majority of mapped SAV beds were co-located with unconsolidated substrates in the upper portions of the reservoirs. Relatively dense beds were observed in Toronto Reservoir and were most prevalent in the littoral zone of the northern and eastern shorelines, particularly in the vicinity of Black Lake Creek and Kilcoin Pond tributaries. Another relatively significant area of SAV was mapped in the Toronto Reservoir along the northern shoreline paralleling Homestead Trail. SAV beds were generally dominated by various *Potamogeton* species, wild celery (*Vallisneria americana*), coontail (*Ceratophyllum demersum*), waterweed species (*Elodea* spp.), and *Callitriche* species (Attachment 2).

5.4 Erosion

A number of different erosion types in the study area were observed during the surveys along some portions of the reservoirs' shorelines, which are described below with representative photos provided in Figures 5-1 through 5-5.

1. Undercut bank - Undercut banks occur in locations where the soil or rock is consolidated enough to form steep, sometimes nearly vertical banks. Erosion occurring at the base of a bank removes material, which results in an undercut bank. The undercutting proceeds until the weight of the overlying material exceeds the material strength, the bank topples or slides, and the process repeats. Roots and vegetation can provide additional strength to material at the top of the bank.

2. Shallow translational slides - Shallow translational slides occur on steep banks. The surficial soil layer (generally 3 to 5 feet thick) slides down the slope. Shallow translational slides can be initiated by removal of toe support or by saturated soils within or at the base of the slope.

3. Slumping - Slumping is a deep-seated, rotational mass movement of material that often occurs in more homogeneous, fine-grained sediments. Slumping can be initiated by removal of toe support or saturated soils within or at the base of the slope.

4. Rills/gullies - Rills and gullies form when surface runoff is concentrated and has enough energy to erode and transport soil particles.

5. Trampling - Trampling occurs in locations where people or animals congregate, trample vegetation, and scuff underlying soils.

FIGURE 5-1
UNDERCUT BANK ON SWINGING BRIDGE RESERVOIR

FIGURE 5-2
SHALLOW TRANSLATIONAL SLIDE ON CLIFF LAKE RESERVOIR

FIGURE 5-3
SLUMPING ON SWINGING BRIDGE RESERVOIR

FIGURE 5-4
GULLY ON SWINGING BRIDGE RESERVOIR AT PUBLIC BOAT LAUNCH

FIGURE 5-5
TRAMPLING ON RIO RESERVOIR

Table 5-4 illustrates the total estimated percentage of observed shoreline erosion for the Projects' reservoirs. Areas of erosion observed along the shorelines of the reservoirs are shown on the maps provided in Attachment 1, and representative photographs of observed erosion areas are provided in Attachment 2.

TABLE 5-4
PERCENTAGE OF SHORELINE EROSION OBSERVED AT THE PROJECTS' RESERVOIRS

Reservoir	Total Length of Shoreline (miles)	Total Estimated Erosion (% of Total Shoreline)
Toronto	11.37	3.00
Cliff Lake	5.93	11.79
Swinging Bridge	19.87	3.74
Mongaup Falls	5.08	17.00
Rio	9.15	4.20

5.5 Additional Observations

No live mussels and very few mussel shells were observed during the study. A few mussel shells were observed along the shoreline of Swinging Bridge Reservoir in Zone 2 on exposed sand and are believed to be Eastern ellliptio (*Elliptio complanata*) (photos are provided in Attachment 2). One of the occurrences was located in the northern portion of the reservoir and the second observation was located just south of the Starlight Marina.

During the field verification surveys, two small, localized areas of fish stranding were observed in Zone 2 at Swinging Bridge Reservoir and Mongaup Falls Reservoir. At the Swinging Bridge Reservoir, the first stranding area (approximately 890 square feet) contained a single live *Lepomis* spp. (sunfish), approximately 5 inches in length. This fish was observed stranded (loss of connectivity to the main water body) in a small water-filled depression along the eastern edge in the northern portion of the reservoir. At the time of the observation, water depths in this area measured approximately 2 to 18 inches in depth. The second stranding area at the Swinging Bridge Reservoir also consisted of a small depression (approximately 275 square feet) located approximately 100 feet northwest of the first location. This pool contained approximately 1 to 6 inches of water with numerous live tadpoles (larval toad or frog species). At the time of the observation, Swinging Bridge Reservoir elevation was approximately 1,061 feet. At the Mongaup Falls Reservoir, two locations of fish stranding were observed, both of which were on river left (facing downstream), slightly upstream from Route 43. Within the first stranding area (approximately 375 square feet), 8 (+/-) live unidentified minnows were observed stranded (loss of connectivity to the main water body) in a small water-filled depression. The second area (approximately 70 square feet), occurred approximately 300 feet northwest of the first area with water depths ranging from approximately 0 to 6 inches. Several live newts (in the red eft [juvenile] stage), as well as 8 (+/-) live unidentified individual minnows were observed stranded in this pool. At the time of the observation, Mongaup Falls Reservoir elevation was approximately 929 feet. No other fish stranding was observed at the Projects' reservoirs during this study or other studies performed in support of the Mongaup River Projects FERC relicensing field work.

6.0 Potential Effects on Aquatic Habitat at the Projects

Aquatic habitat and water levels in the fluctuation zones at the Projects' reservoirs may be affected by various factors including, but not limited to, natural processes and/or Project operations. As a result, littoral aquatic habitat and aquatic species that utilize the habitat may be affected by water level fluctuations.

6.1 Natural Processes

Water level fluctuations and aquatic habitat in the Projects' reservoirs can be influenced by natural variations in precipitation/runoff and associated inflows as well as wind/waves.

Precipitation and Flows

Rainfall within the Mongaup River Drainage Basin can greatly affect water levels. Due to the size of the drainage area (approximately 210 square miles), rainfall can have varying effects on reservoir elevations based on how widespread the rain event is, as well as the magnitude of the rainfall. Given this influence on water elevations, in support of management of the system and Project operations, Eagle Creek tracks and monitors inflows to Swinging Bridge Reservoir on a routine basis.

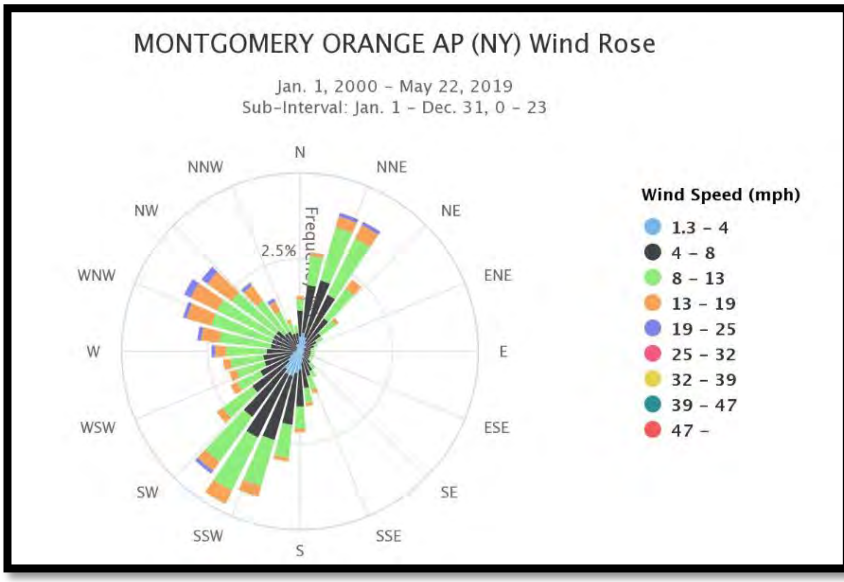
Wind and Waves

Wind or boats generally cause waves. Wind waves are generated by the friction of air passing over the water, and the wave height is a function of wind velocity, fetch distance (distance over which the wind can interact with an open body of water), wind direction, water depth, the amount of time that the wind has been blowing, and boundary effects. Generally, for a given sustained wind velocity, the longer the fetch, the higher the wave that will develop. The impact that wind velocity has in affecting wave height is typically a function of the average sustained wind speed and the length of time during which the wind blows. Wind waves generally are not significant in areas of an impoundment that are narrow (e.g., the majority of Swinging Bridge Reservoir and Mongaup Falls Reservoir) and/or in areas protected from wind by hills, trees, or other obstructions (e.g., Cliff Lake Reservoir).

A shoreline that is located in protected areas and has not been exposed to, or come to equilibrium with, the force of significant wind waves may be particularly susceptible to erosion caused by boat waves. Accordingly, narrow riverine reaches (e.g., the central portion of the Swinging Bridge Reservoir) and some backwater areas at the confluence of streams within a reservoir are examples of areas that may be sensitive to recreational boat waves. Boat wave height is dependent on the draft and length of the boat, boat velocity, and distance from shore. Conversely, areas exposed to significant wind waves are generally relatively unaffected by boat waves. As a shoreline is exposed to waves and erosion progresses, the shoreline has a natural tendency to assume a more stable geometry over time.

Local wind data collected at the Montgomery Orange Airport from January 1, 2000, through May 22, 2019, was reviewed to characterize typical wind direction and speed at the Projects (Midwestern Regional Climate Center 2019). This data shows that the wind direction is highly variable and dependent upon time of year. However, based on the period of record used, the primary wind directions are from the west-northwest, southwest, and north-northeast with wind speeds averaging approximately 4 through 13 miles-per-hour (mph) (Figure 6-1). This would infer that the greatest impacts or erosion from winds would be on the northerly, southerly, and easterly sides of the reservoirs. Given the generally broad, open expanse of Toronto Reservoir (length: 2.1 miles, width: 0.2 to 0.7 miles), it is occasionally subject to strong winds during storm events that may result in wind-generated wave action along shorelines of the reservoir and tributaries. If the intensity of these events is sustained over sufficiently long periods, the potential for shoreline erosion increases.

FIGURE 6-1
MONTGOMERY ORANGE AIRPORT (NEW YORK) WIND ROSE



Source: Midwestern Regional Climate Center 2019.

While the objectives of this Aquatic Habitat Assessment Study do not include quantification of potential impacts of wave-induced changes in reservoir levels on littoral/nearshore habitat, the potential exists for effects to occur on the littoral habitat from human-induced activities such as boating on the Swinging Bridge and Toronto reservoirs, particularly during the summer when recreational activities are most prevalent.

6.2 Project Operations

The Projects operate in a peaking mode while maintaining minimum flow requirements (Table 6-1) and seasonal target reservoir elevations (Table 3-1 and further described below). Eagle Creek monitors current and forecasted load demands, reservoir elevations, available storage, and weather/inflow data to determine effective operation of the generating stations. The Projects are required to operate in a coordinated manner such that the downstream units at the Mongaup Falls and Rio Projects are operated first in order to draw down their respective reservoirs to accommodate the water released from the operation of the unit(s) at the larger upstream Swinging Bridge Project. The minimum flow requirements for each Project are summarized in the water quality certificates issued for each Project by the New York State Department of Environmental Conservation (NYSDEC) in September 1989 and below in Table 6-1.

TABLE 6-1
CURRENT MINIMUM FLOW REQUIREMENTS

Location	Flow Requirement
Swinging Bridge Project	---
Toronto Dam	10 cubic feet per second (cfs)
Cliff Lake Dam	10 cfs
Swinging Bridge Dam	100 cfs or inflow (but not less than 60 cfs)
Mongaup Falls Project	---
Bypassed Reach	70 cfs or inflow (but not less than 60 cfs)
Powerhouse	20 cfs
Rio Project	--
Bypassed Reach	100 cfs or inflow (but not less than 60 cfs)

Although not requirements of the current licenses, Eagle Creek utilizes the normal upper and lower target reservoir elevations to balance hydrologic conditions and the demands of the power grid with environmental and recreational considerations. Water levels in the Projects' reservoirs at any location at any time is, therefore, a complex function of both natural and human factors.

Toronto Reservoir is targeted for at least elevation 1,187.7 feet by June 1 to ensure there is sufficient water to provide the minimum downstream flow of 10 cfs through a period of low inflows without drawing the reservoir elevation below elevation 1,170 feet. The reservoir is maintained at an elevation of at least 1,170 feet throughout the year to permit use of the upper outlet works for protection of water quality.

Swinging Bridge Reservoir is maintained at or above elevation 1,060 feet between June 1 and September 30 for recreation. Eagle Creek operations aim to maintain the reservoir above elevation 1,063.0 feet on June 1, decreasing to elevation 1,061.0 feet on September 30, along with elevations in the months leading up to June 1 to ensure an elevation of 1,063.0 on June 1. Swinging Bridge Reservoir is maintained at an elevation above 1,049.0 feet during all times of the year to ensure dependable performance of project equipment. If the Toronto Reservoir is near its minimum elevations, Swinging Bridge may need to be maintained higher than elevation 1,049 feet to ensure adequate water for downstream minimum flow releases.

Cliff Lake Reservoir is hydraulically connected to Swinging Bridge Reservoir via an underground tunnel and, therefore, does not have specific target operating reservoir elevations. Target reservoir elevations for Cliff Lake Reservoir are approximately equal to Swinging Bridge Reservoir elevations or up to 10 feet higher than Swinging Bridge Reservoir elevation depending on releases from Toronto Reservoir.

Mongaup Falls Reservoir is maintained above elevation 933.5 feet between May 15 and June 30 to ensure the reservoir remains within one foot of a target elevation of 934.5 feet (to be reached on May 15) to protect bass spawning habitat. Mongaup Falls Reservoir is generally maintained above elevation 927.0 feet during other times of the year to maintain dependable performance of project equipment.

Rio Reservoir is maintained above elevation 813.5 feet from May 15 to June 30 to ensure the reservoir remains within one foot of a target elevation of 814.5 feet (to be reached on May 15) to protect bass spawning habitat. Rio Reservoir is generally maintained above elevation 807.0 feet during other times of the year to maintain dependable performance of project equipment.

7.0 Summary and Discussion

Sonar habitat data was collected by boat between June 19 and July 3, 2018, in the Projects' reservoirs and verification surveys occurred the weeks of May 13, 2019, and September 9, 2019. In total, approximately 1,371 acres of substrate and 137 acres of cover types within the Projects' reservoirs and associated tributaries and drainages were surveyed as part of this study. Attachment 1 presents the mapped habitat within the study area, and representative photographs of the varying habitat and cover types are provided in Attachment 2.

Toronto Reservoir has a maximum fluctuation zone of 50 feet (between elevations 1,220 and 1,170 feet), represented by Zones 1, 2, and 3 in this report, and a normal/typical fluctuation zone of 18 feet (between elevations 1,218 and 1,200 feet), represented by Zone 2 in this report. Toronto Reservoir is dominated by gradual slopes with fine and rocky fine substrates. The dominant cover type at Toronto Reservoir is SAV, primarily found in Zone 2, with smaller areas of large woody debris and Centrarchid nesting observed in Zones 1 and 2. Erosion was observed along approximately 3 percent of the total shoreline of Toronto Reservoir.

Cliff Lake Reservoir has a maximum fluctuation zone of 23.1 feet (between elevations 1,071.1 and 1,048 feet) represented by Zones 1, 2, and 3 in this report, and a normal/typical fluctuation zone of 19 feet (between elevations 1,068 and 1,049 feet), represented by Zone 2 in this report. Cliff Lake Reservoir is dominated by gradual slopes, and fine and gravel/rubble/cobble substrates. Small areas of large woody debris were observed in Zones 1, 2, and 3 as well as a small area of Centrarchid nesting in Zone 2. Erosion was observed along approximately 12 percent of the total shoreline of Cliff Lake Reservoir.

Swinging Bridge Reservoir has a maximum fluctuation zone of 22 feet (between elevations 1,070 and 1,048 feet), represented by Zones 1, 2, and 3 in this report, and a normal/typical fluctuation zone of 19 feet (between elevations 1,068 and 1,049 feet), represented by Zone 2 in this report. Swinging Bridge Reservoir is dominated by gradual slopes and (lesser amounts of) moderate slopes and primarily consists of fine and rocky fine substrates. Small areas of large woody debris were observed in Zones 1 and 2 along with small areas of SAV and Centrarchid nesting in Zone 2. Erosion was observed along approximately 4 percent of the total shoreline of Swinging Bridge Reservoir. A few mussel shells were observed in Zone 2. Additionally, a live minnow-sized Lepomis spp. (sunfish) and tadpoles were observed stranded in two small water-filled depressions along the eastern edge in the northern portion of the reservoir.

Mongaup Falls Reservoir has a maximum fluctuation zone of 25 feet (between elevations 935 and 910 feet), represented by Zones 2 and 3 in this report, and a normal/typical fluctuation zone of 6 feet (between elevations 935 and 929 feet), represented by Zone 2 in this report. Mongaup Falls Reservoir is dominated by gradual and (lesser amounts of) moderate slopes and primarily consists of fine and gravel/rubble/cobble substrates. Small areas of large woody debris were observed in Zones 2 and 3 along with small areas of SAV in Zone 2 and Centrarchid nesting in Zone 3. Erosion was observed along approximately 17 percent of the total shoreline of Mongaup Falls Reservoir. Additionally, several live (unidentified) minnows and newts were observed stranded in two water-filled depressions north of the Forestburgh Road (Rt 43) crossing.

Rio Reservoir has a maximum fluctuation zone of 10 feet (between elevations 815 and 805 feet), represented by Zones 2 and 3 in this report, and a normal/typical fluctuation zone of 7 feet (between elevations 815 and 808 feet), represented by Zone 2 in this study report. Rio Reservoir is dominated by gradual and (lesser amounts of) moderate and steep slopes with primarily fine, gravel/rubble/cobble, and rocky fine substrates. Small areas of large woody debris and aquatic invasive species were observed in Zones 2 and 3 along with approximately 2 acres of Centrarchid nesting observed in Zone 2. Erosion was observed along approximately 4 percent of the total shoreline of Rio Reservoir.

Water-level fluctuations in the Projects' reservoirs are largely driven by Eagle Creek's commitments to the electric system, natural atmospheric and hydrologic conditions, and existing license requirements associated with the reservoirs' water level fluctuations, as well as minimum base flows downstream of some of the projects. Project operations are often in response to the first three of these factors, while license requirements are planned as part of the operational regime of the Projects.

The effect of water level fluctuations on aquatic habitat is dependent on the zone in which the habitat occurs. Shallow littoral zone habitats are most affected by fluctuations. Project operations result in a shifting of the littoral zone as water levels fluctuate. Some of the Projects' reservoirs shorelines are steep (approximately 47 acres) and are dominated by larger substrates in these areas. As a result, these littoral areas do not provide quality nursery or spawning habitat for most resident fish species. Some areas within the Projects' reservoirs exhibiting these characteristics include the central portions of the Mongaup Falls and Rio reservoirs. The protected backwater areas and the areas of the Projects' reservoirs with more gentle slopes are generally the most affected habitats from water level fluctuations as the area and period of inundation and/or exposure is most extensive in these areas. As indicated by the Fisheries Survey Study, juvenile and other small fish species that use littoral zone habitat were relatively abundant in the Projects' reservoirs. Further, as previously described, there was very little evidence of fish stranding in areas between the Projects' normal operating ranges during the fieldwork, suggesting that the fish community has adapted to the fluctuating water levels present at the Projects.

8.0 Variances from Approved Study Plan

Eagle Creek has generally accepted and built upon the methodologies requested by FERC, the U.S. Fish and Wildlife Service), NYSDEC, and the Homeowners of Toronto in order to accurately represent the aquatic habitat within the fluctuation zones. However, as indicated in the ISR, the timing of the verification phase of the study was slightly modified to the spring/summer/early fall of 2019 due to ice and safety concerns. Additionally, at some of the Projects' reservoirs, the verification phase of the study was conducted in early spring, just at the onset of the growing season for emergent aquatic vegetation and SAV.

Eagle Creek also did not obtain relative embeddedness ratings while performing the study. Embeddedness is a substrate attribute reflecting the degree to which larger particles (boulder, cobble, and large gravel) are surrounded or covered by fine sediment such as sand, silt, or clay. Embeddedness ratings are typically not applied to lakes and reservoirs since interstitial space and water flow are based on flowing water bed dynamics (Bain and Stevenson 1999). As the study was implemented, Eagle Creek utilized multiple survey methods over multiple seasons to obtain an accurate representation of aquatic habitat within the reservoirs fluctuation zones.

9.0 Correspondence and Consultation

There has been no consultation or correspondence conducted for this study to date.

10.0 Literature Cited

Alpine Ocean Seismic Survey, Inc. (Alpine). 2018. Marine Operations Report. Alpine Ocean Seismic Survey, Inc., Norwood, New Jersey. 21 pp.

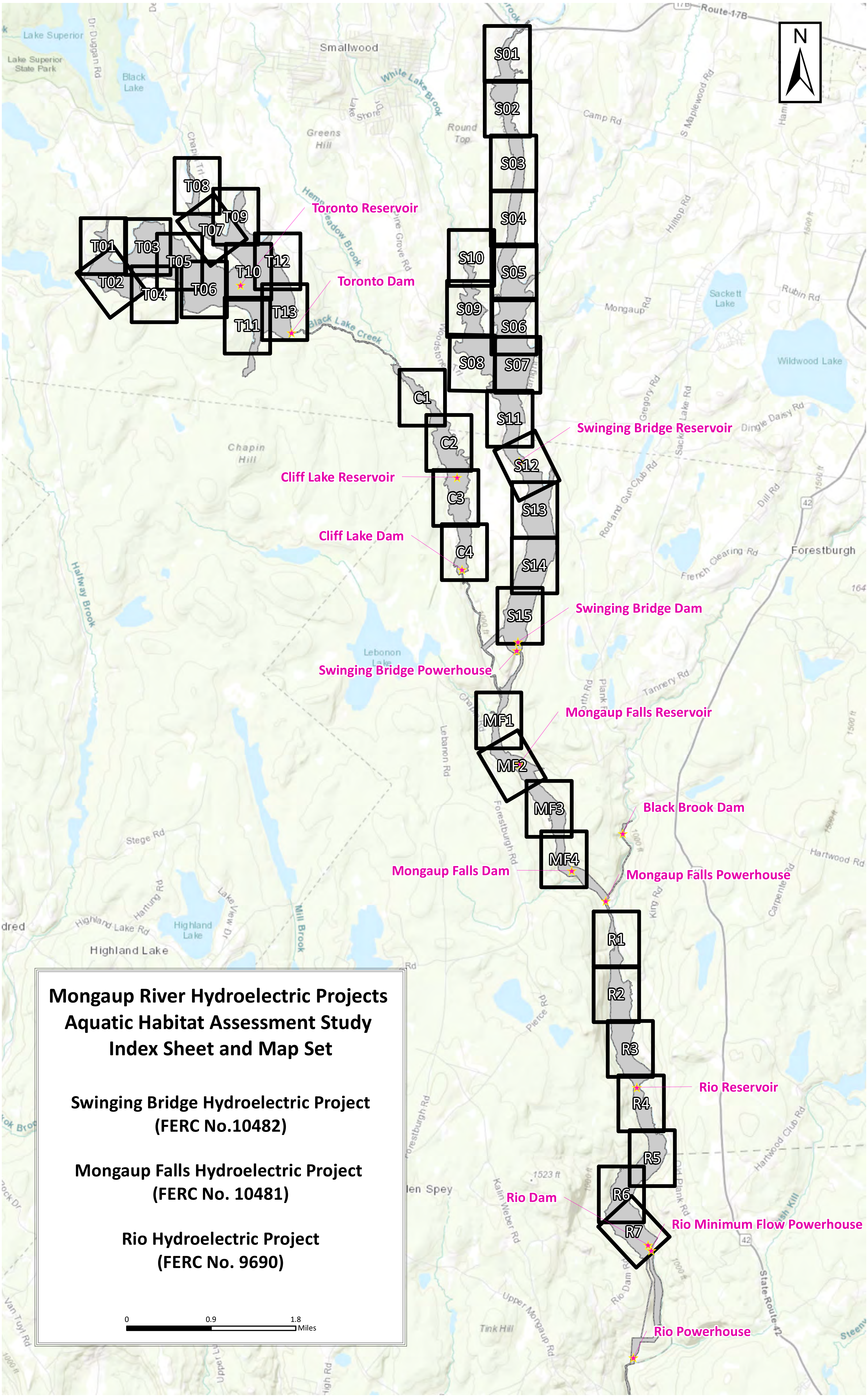
Bain, M. B., and N. J. Stevenson, editors. 1999. Aquatic Habitat Assessment: Common Methods. American Fisheries Society, Bethesda, Maryland.

Eagle Creek Renewable Energy, LLC. 2018. Revised Study Plan, Swinging Bridge Hydroelectric Project (No. 10482), Mongaup Falls Hydroelectric Project (No. 10481), and Rio Hydroelectric Project (No. 9690), Eagle Creek Renewable Energy, LLC, Neshkoro, WI.

Midwestern Regional Climate Center. 2019. Data and Services. Online [URL]: https://mrcc.illinois.edu/data_serv/dataTypes.jsp.

Attachment 1

Aquatic Habitat Assessment Study Maps



Toronto Reservoir
Toronto Dam
Cliff Lake Reservoir
Cliff Lake Dam
Swinging Bridge Reservoir
Swinging Bridge Dam
Swinging Bridge Powerhouse
Mongaup Falls Reservoir
Black Brook Dam
Mongaup Falls Dam
Mongaup Falls Powerhouse
Rio Reservoir
Rio Dam
Rio Minimum Flow Powerhouse
Rio Powerhouse
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Mongaup River Hydroelectric Projects
Aquatic Habitat Assessment Study
Index Sheet and Map Set
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(FERC No.10482)
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(FERC No. 10481)
Rio Hydroelectric Project
(FERC No. 9690)
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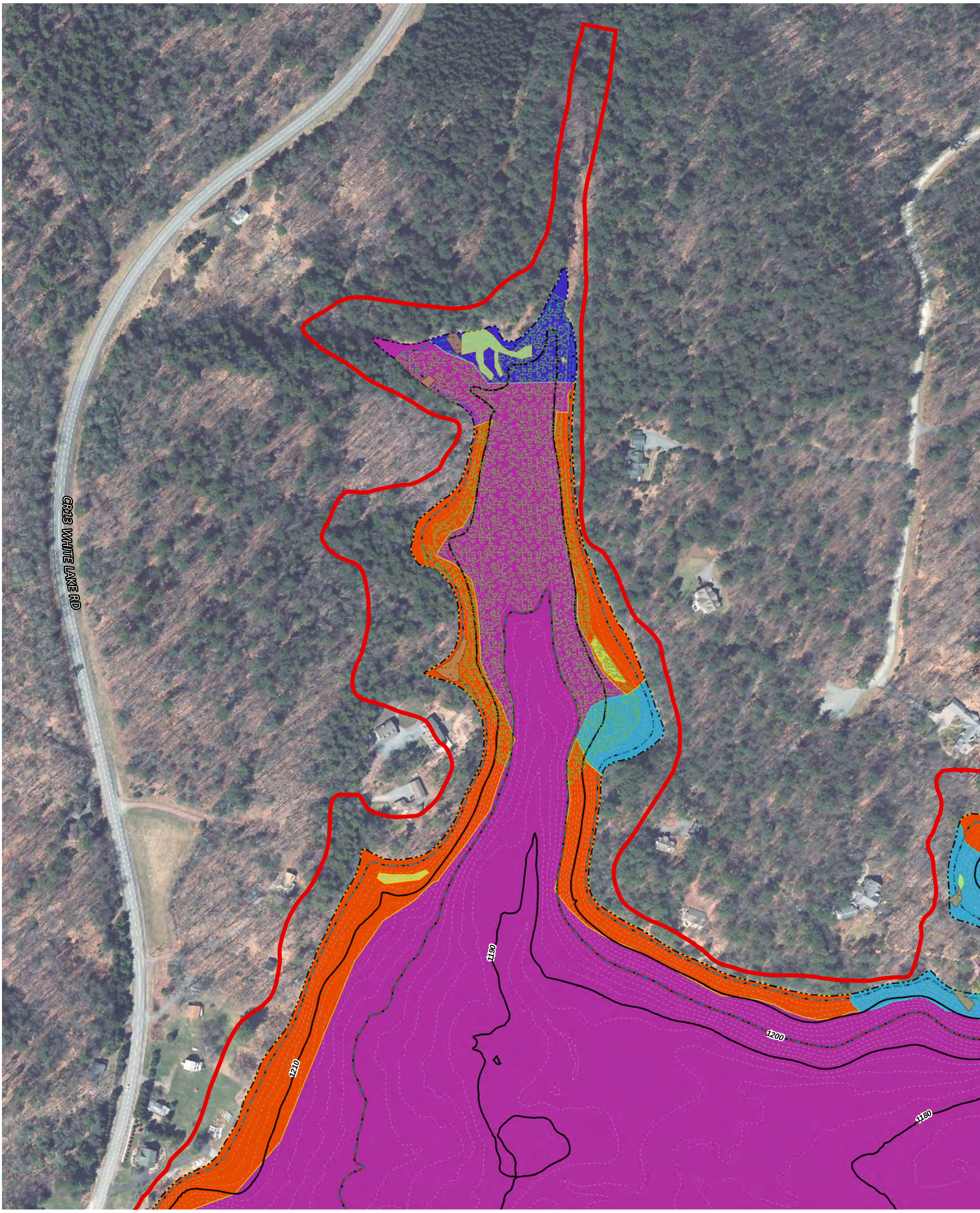

Toronto Study Zone(s)

- Zone 1 - 1218' to 1220' (NGVD29)
- Zone 2 - 1200' to 1218' (NGVD29)
- Zone 3 - 1170' to 1200' (NGVD29)
- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

- Project Boundary
- 10-ft Contours
- 2-ft Contours

N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - TORONTO RESERVOIR

(FERC NO. 10482)

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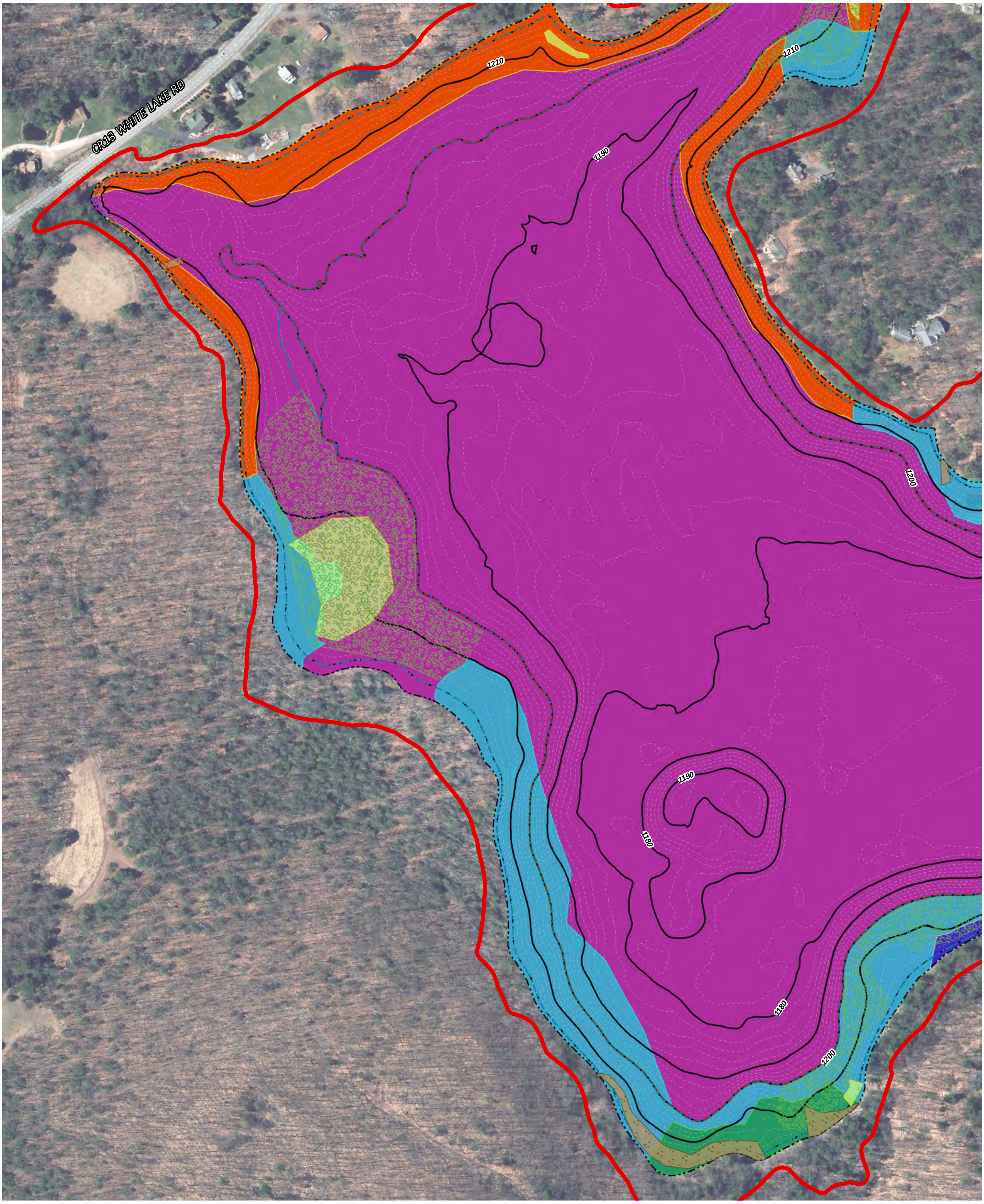

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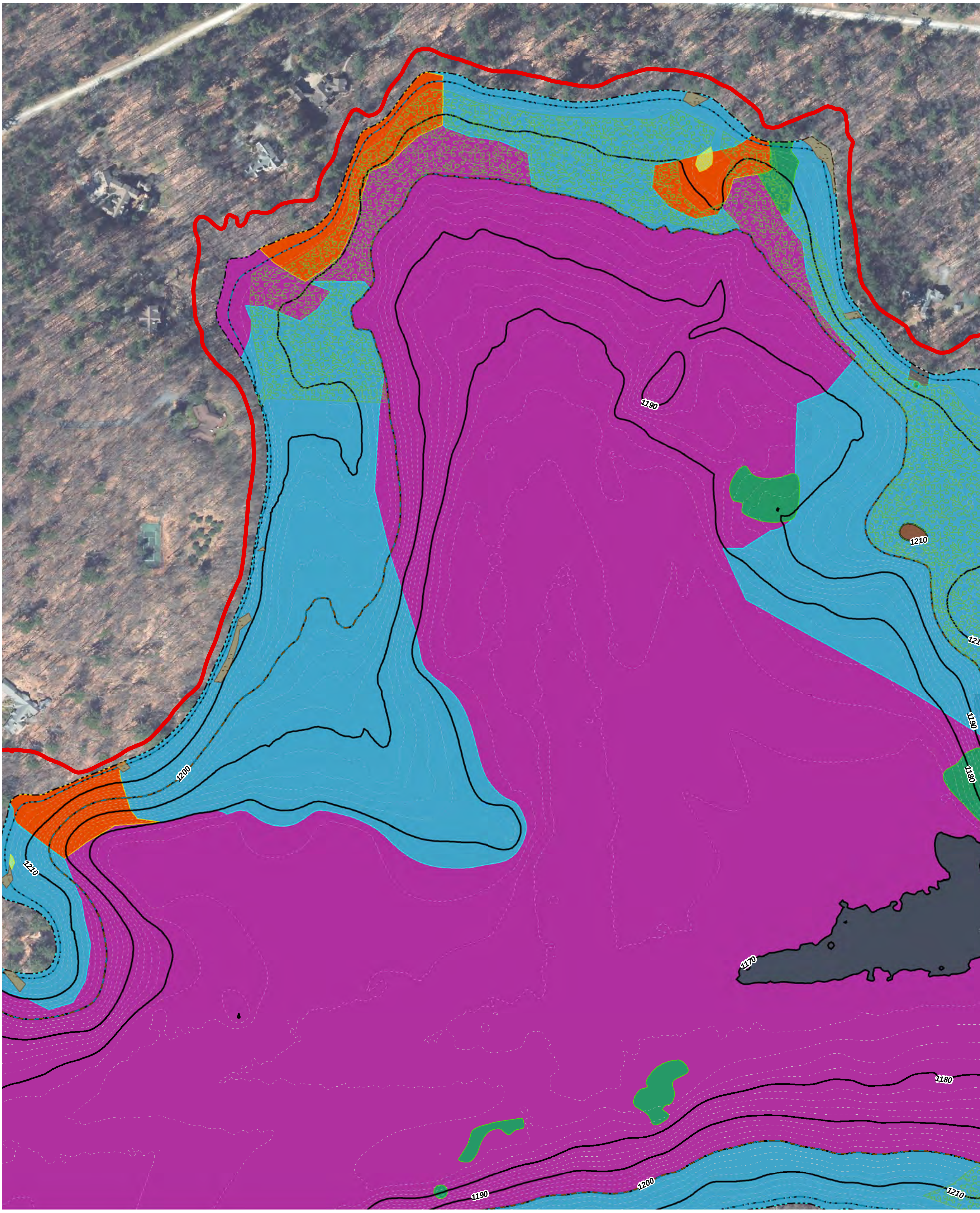

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- XXXXXXX Observed Shoreline Erosion

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- LWD - Large Woody Debris

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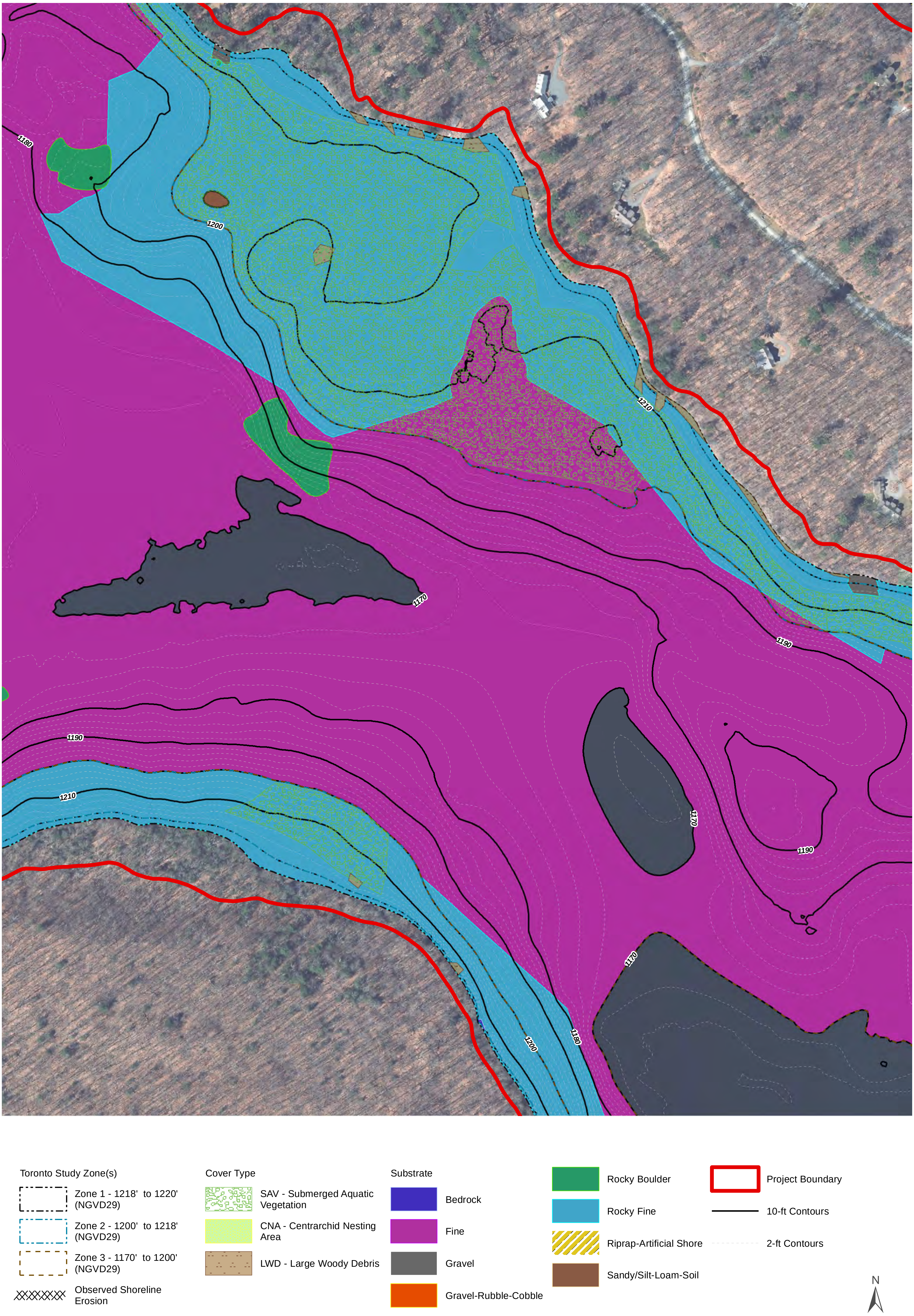

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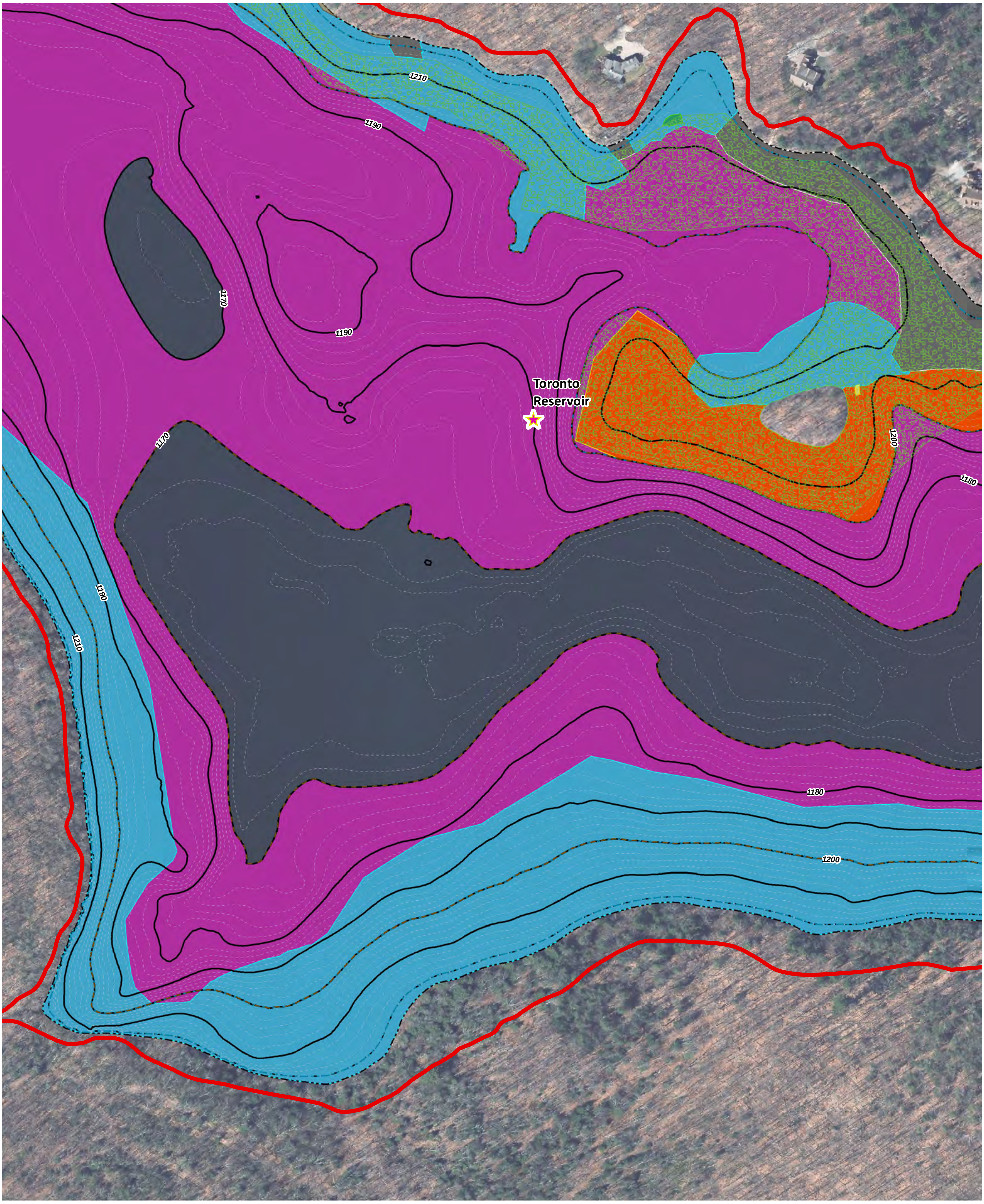

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Observed Shoreline Erosion

Cover Type

SAV - Submerged Aquatic Vegetation

CNA - Centrarchid Nesting Area

LWD - Large Woody Debris

Substrate

Bedrock

Fine

Gravel

Gravel-Rubble-Cobble

Rocky Boulder

Rocky Fine

Riprap-Artificial Shore

Sandy/Silt-Loam-Soil

Project Boundary

10-ft Contours

2-ft Contours

N

0 250 500 Feet

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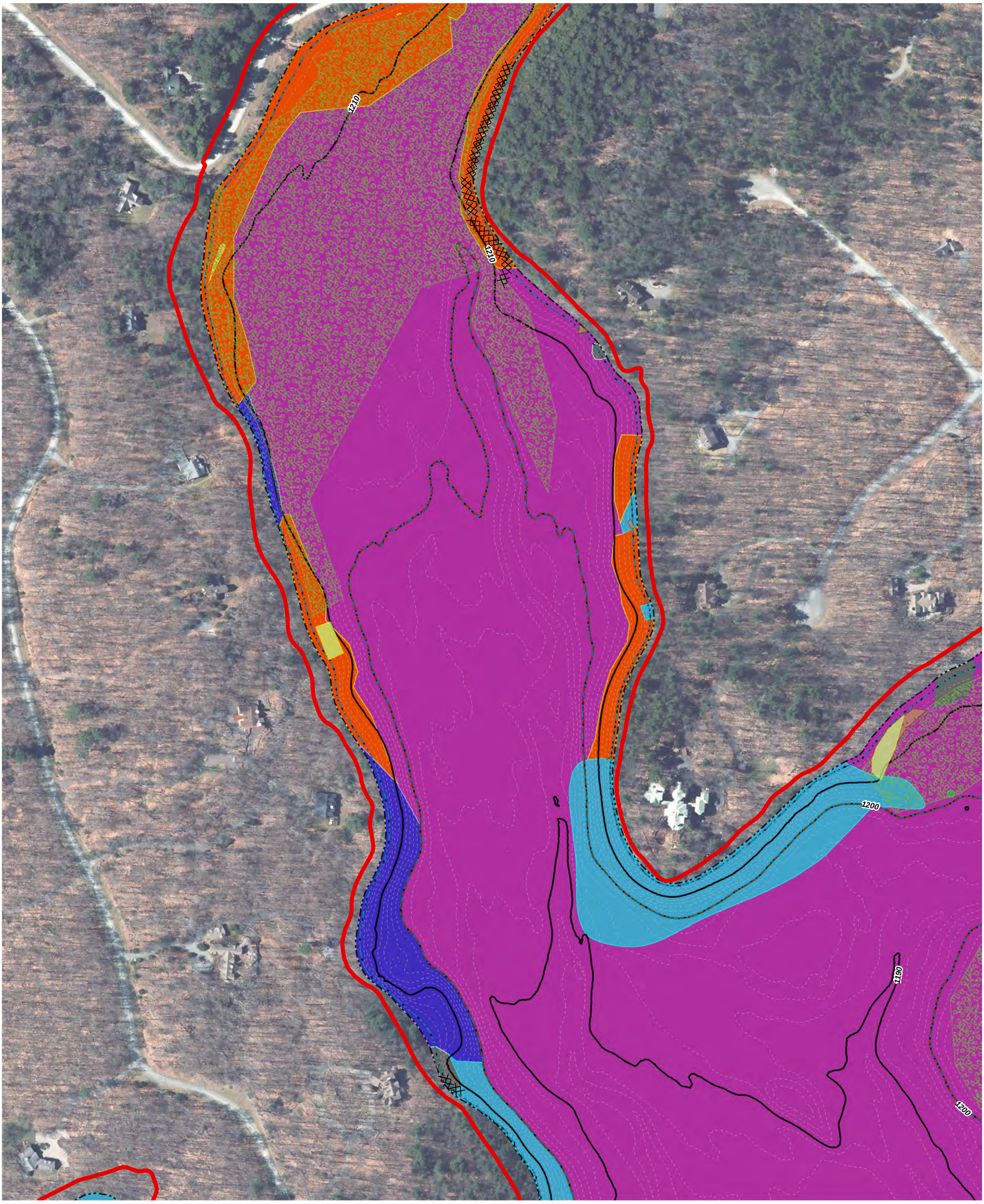

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(FERC NO. 10482)

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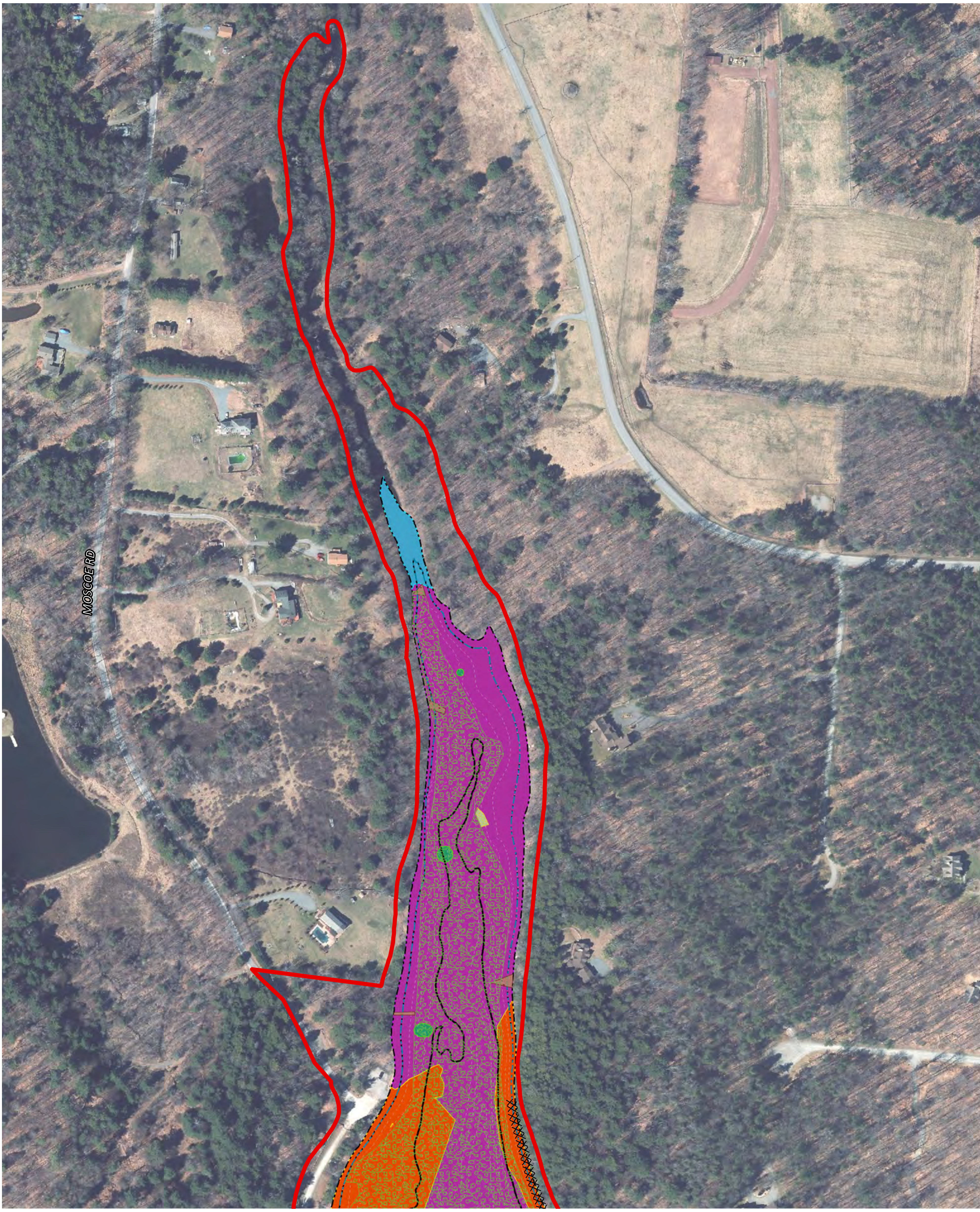

Toronto Study Zone(s)

- Zone 1 - 1218' to 1220' (NGVD29)
- Zone 2 - 1200' to 1218' (NGVD29)
- Zone 3 - 1170' to 1200' (NGVD29)
- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

- Project Boundary
- 10-ft Contours
- 2-ft Contours

N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - TORONTO RESERVOIR

(FERC NO. 10482)

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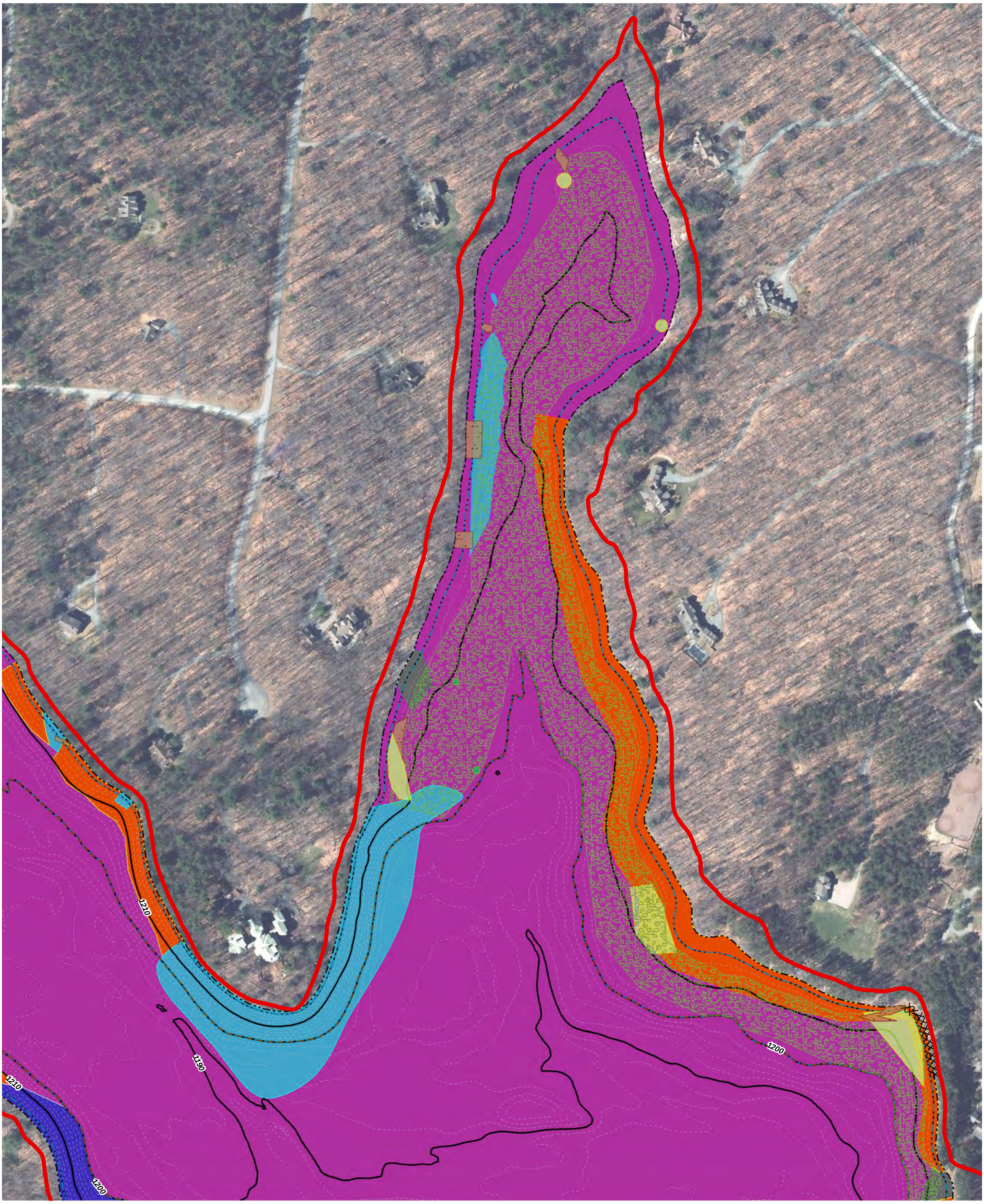

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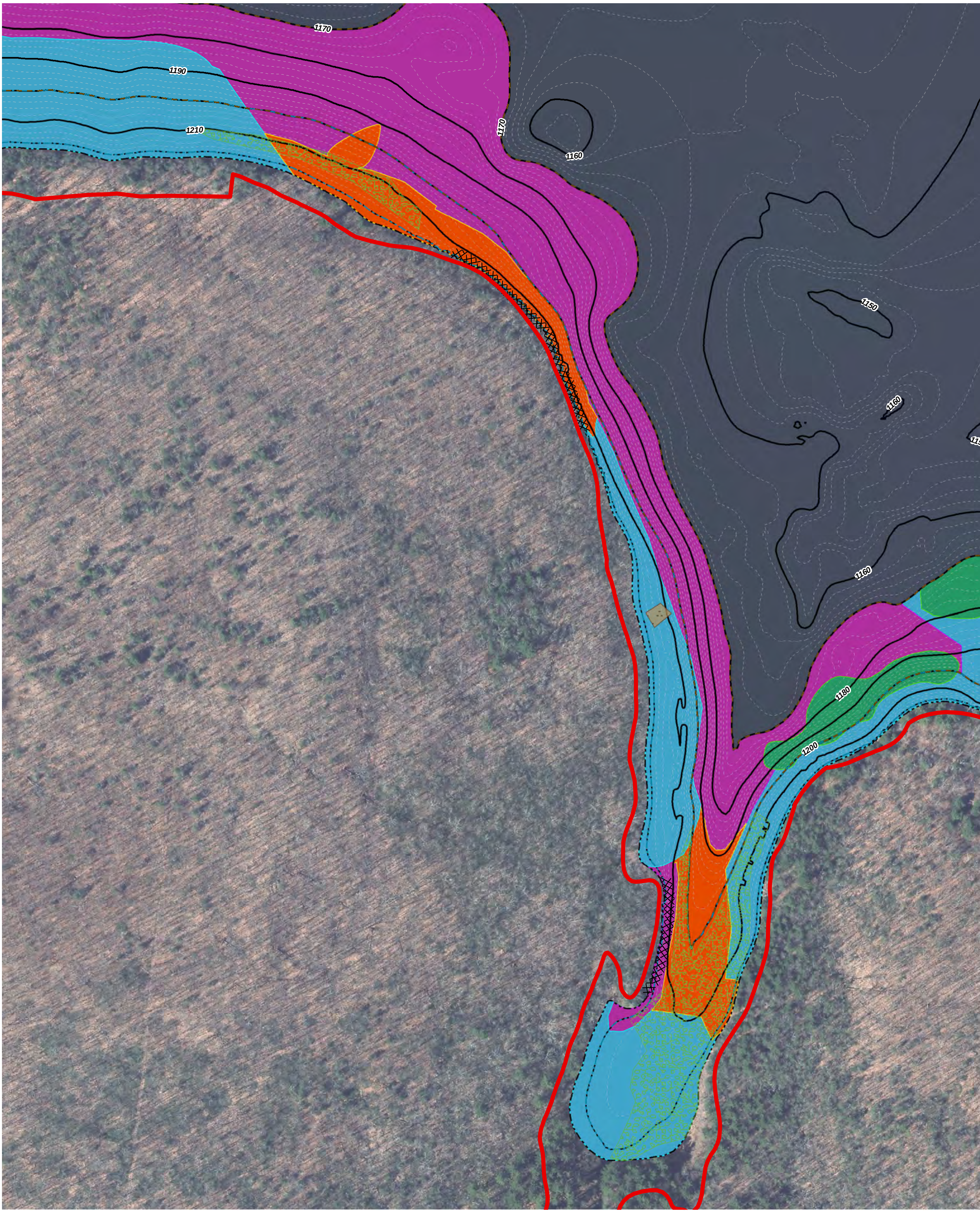
(FERC NO. 10482)



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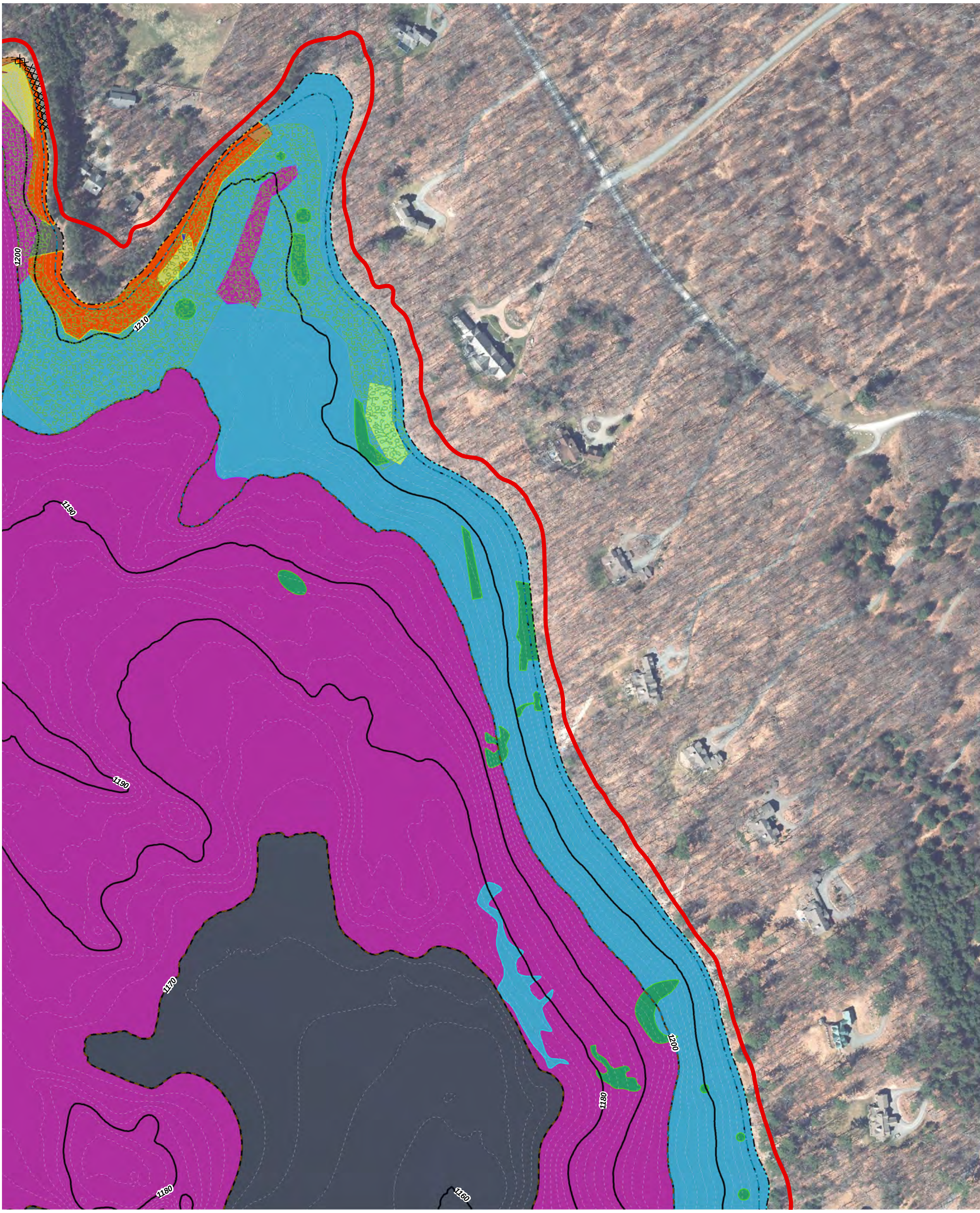

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Substrate

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Gravel

Gravel-Rubble-Cobble

Rocky Boulder

Rocky Fine

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2-ft Contours

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SWINGING BRIDGE HYDROELECTRIC PROJECT - TORONTO RESERVOIR

(FERC NO. 10482)

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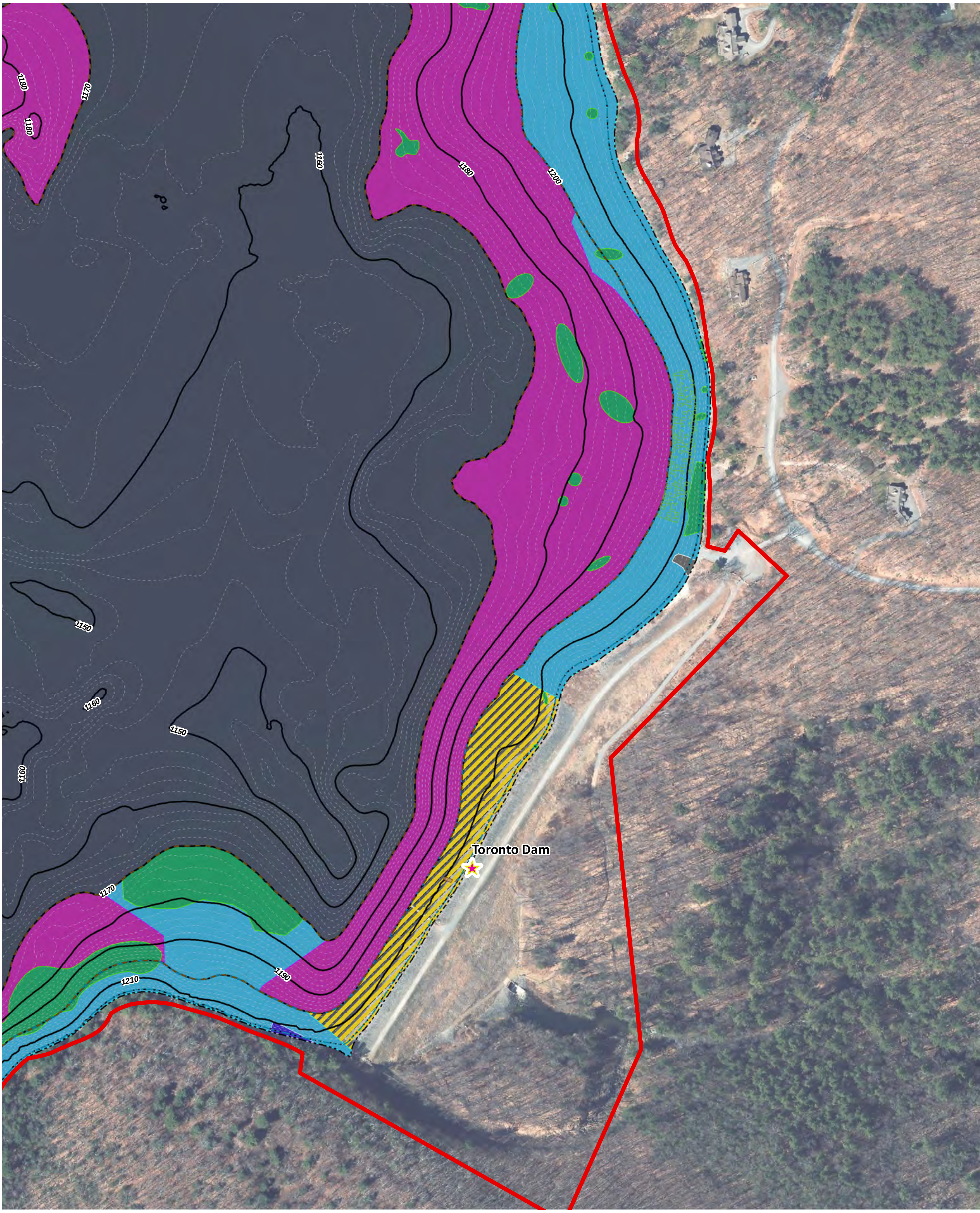

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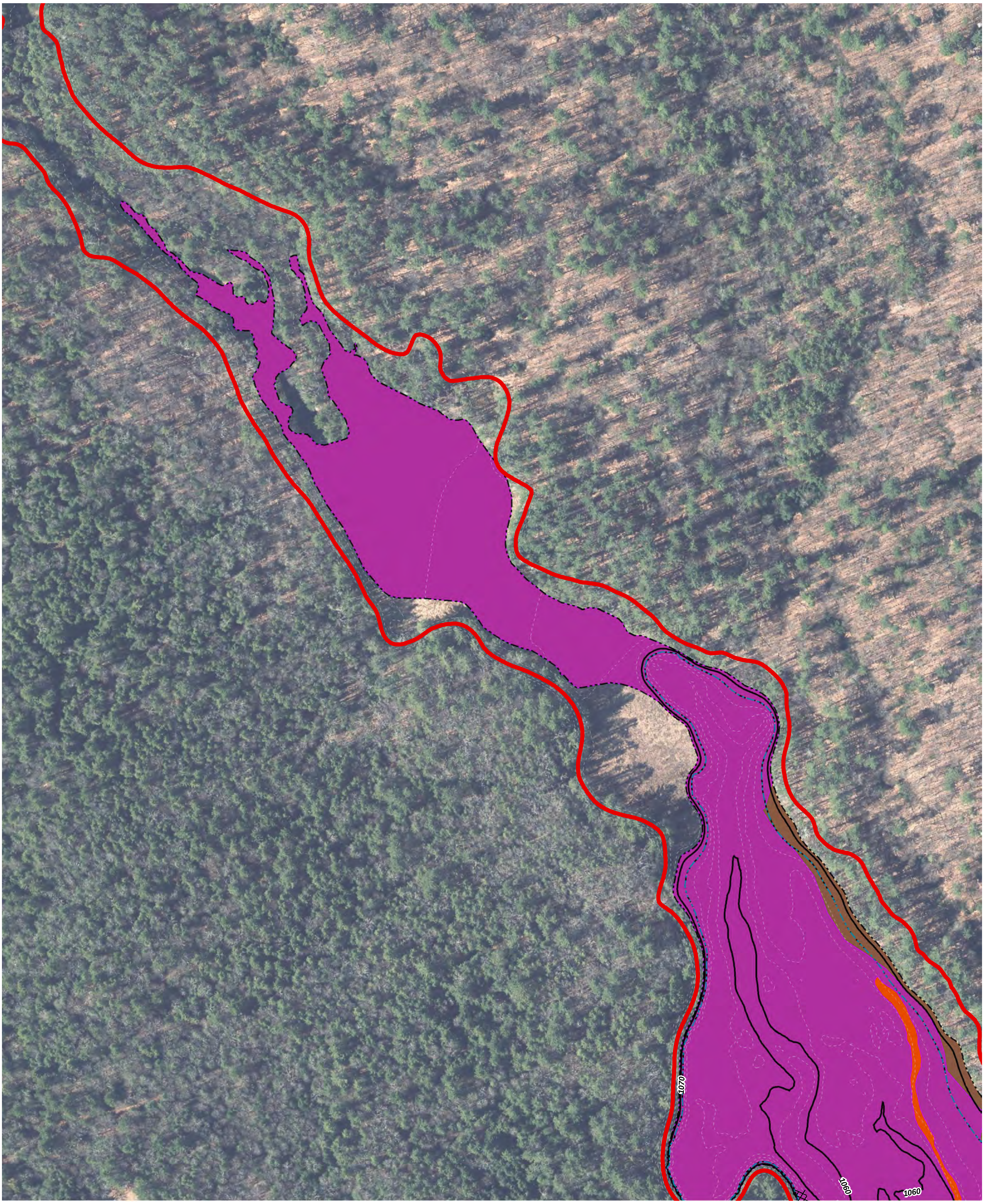

Cliff Lake Study Zone(s)

Zone 1 - 1068' to 1071.1' (NGVD29)

Zone 2 - 1049' to 1068' (NGVD29)

Zone 3 - 1048' to 1049' (NGVD29)

Observed Shoreline Erosion

Cover Type

SAV - Submerged Aquatic Vegetation

CNA - Centrarchid Nesting Area

LWD - Large Woody Debris

Substrate

Bedrock

Fine

Gravel

Gravel-Rubble-Cobble

Rocky Boulder

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Riprap-Artificial Shore

Sandy/Silt-Loam-Soil

Project Boundary

10-ft Contours

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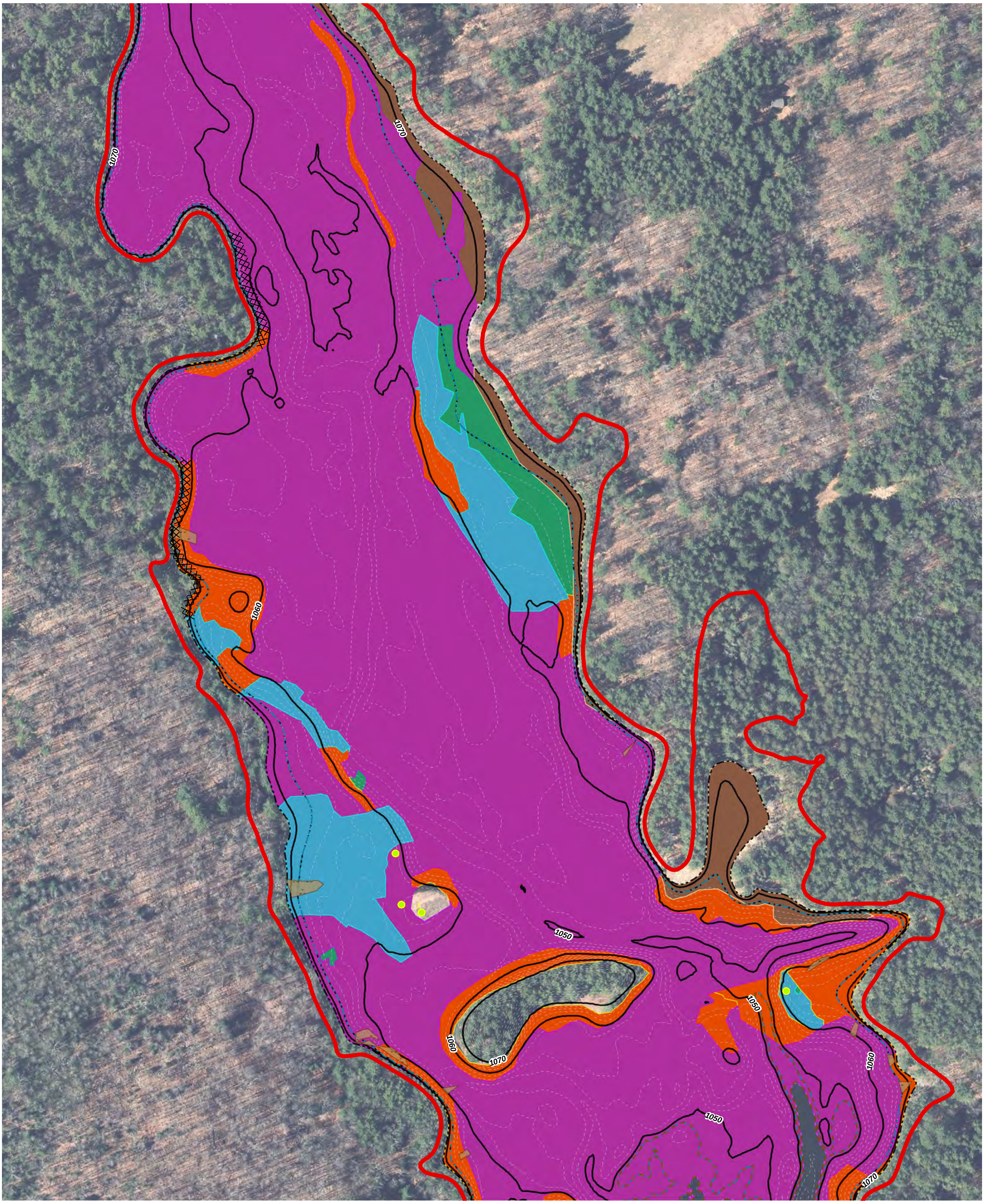
N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - CLIFF LAKE RESERVOIR

(FERC NO. 10482)



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AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - CLIFF LAKE RESERVOIR

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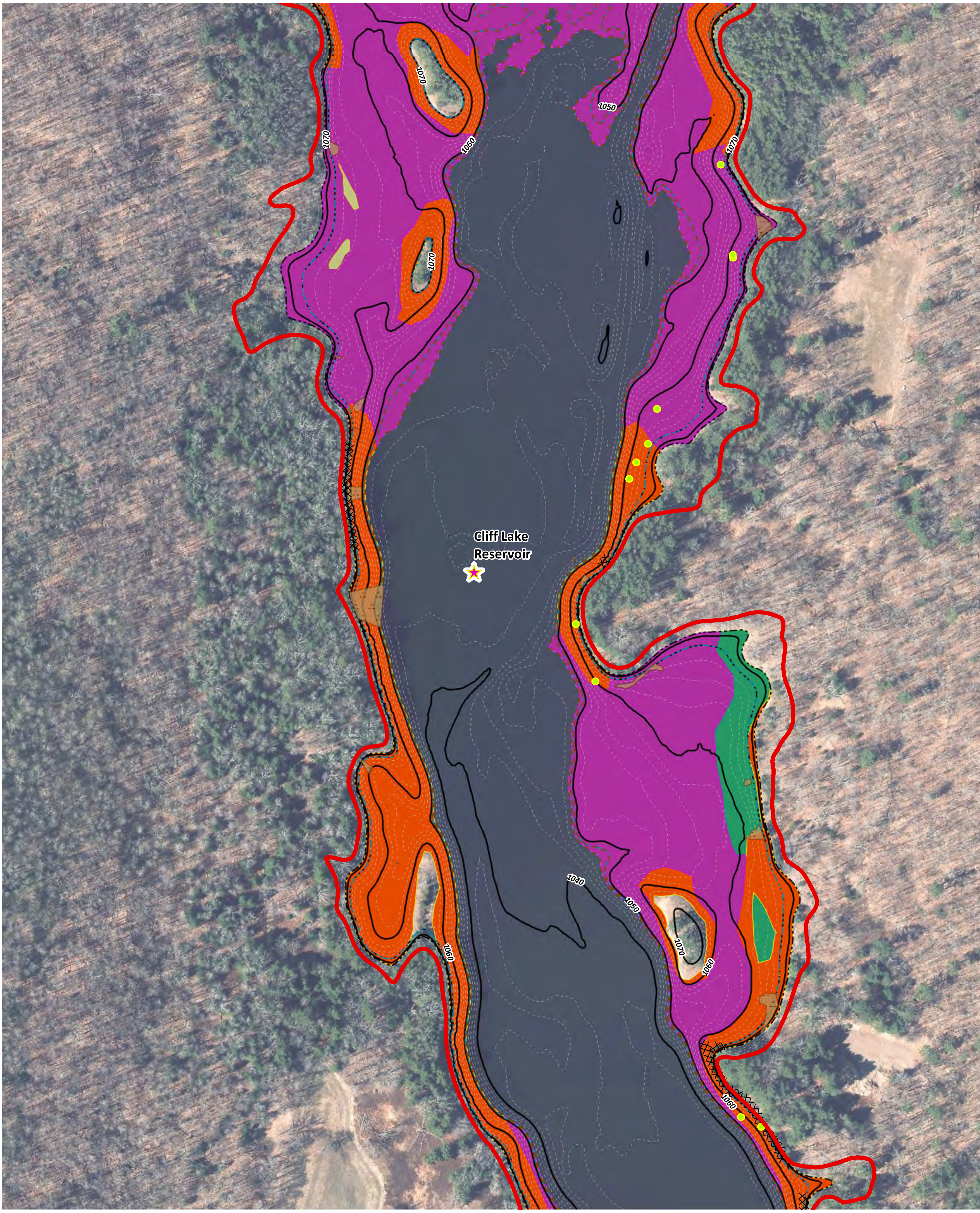

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AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - CLIFF LAKE RESERVOIR

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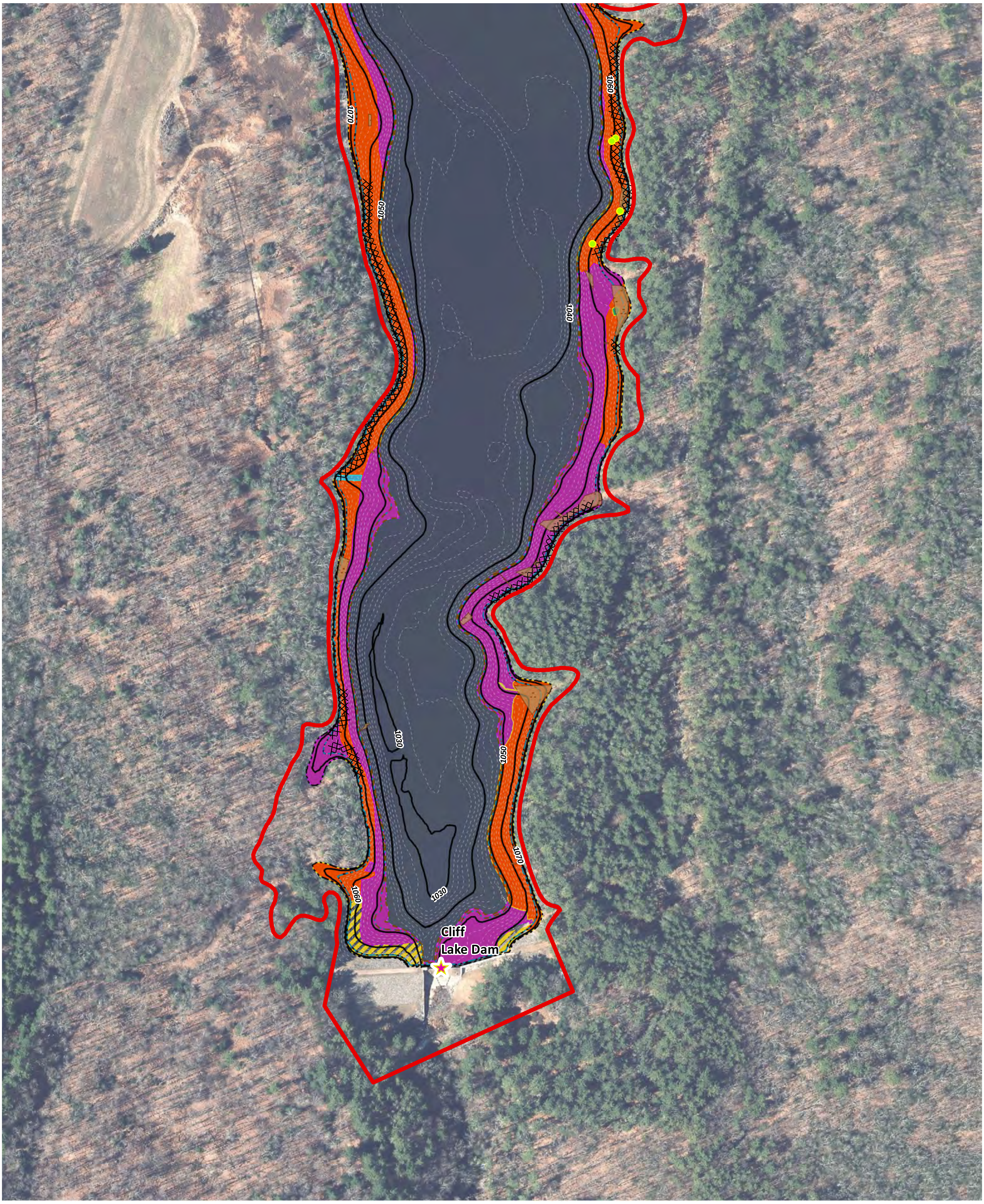

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SWINGING BRIDGE HYDROELECTRIC PROJECT - CLIFF LAKE RESERVOIR (FERC NO. 10482)

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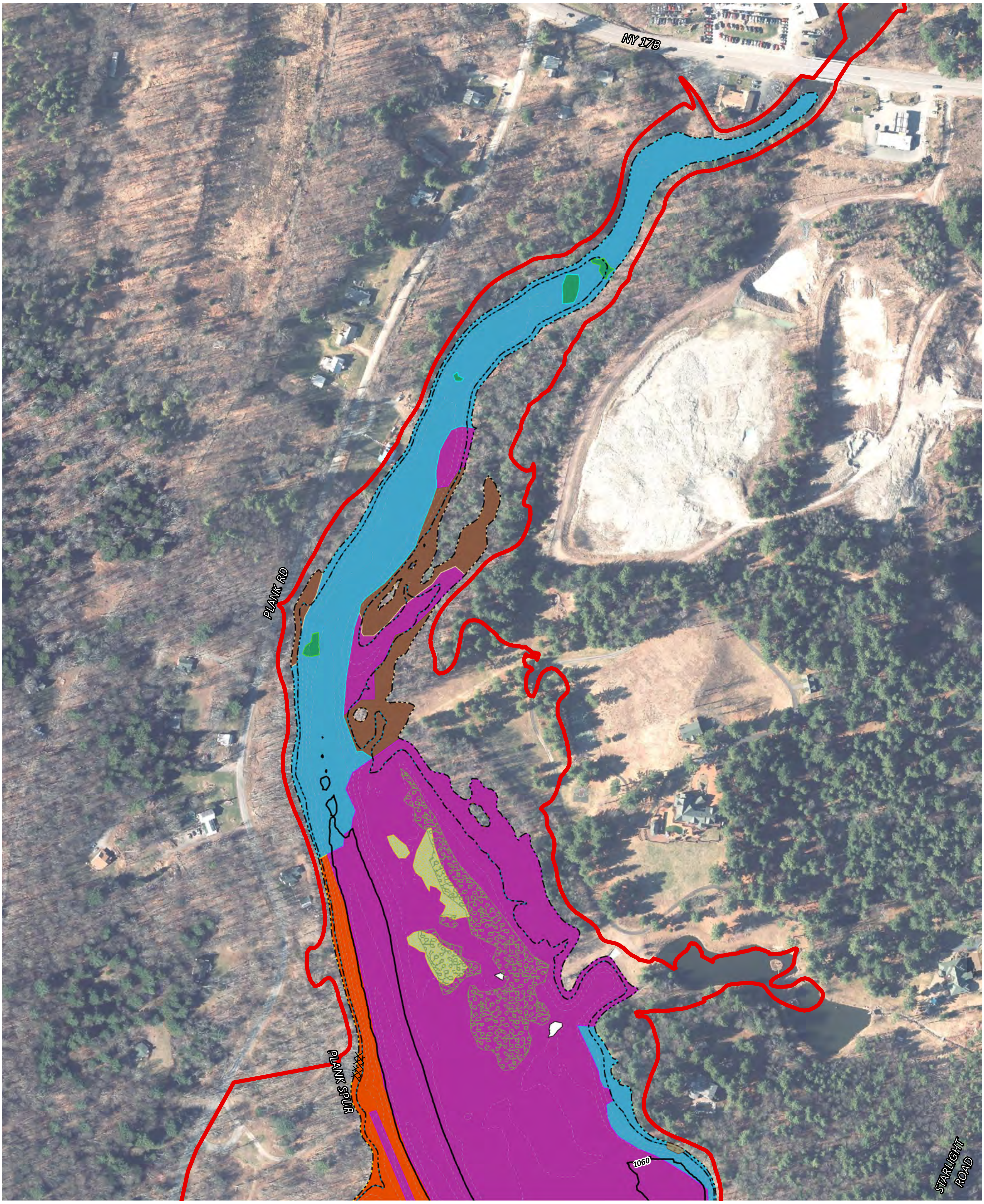

Swinging Bridge Study Zone(s)

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- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris
- OS - Observed Stranding

Substrate

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SWINGING BRIDGE HYDROELECTRIC PROJECT - SWINGING BRIDGE RESERVOIR

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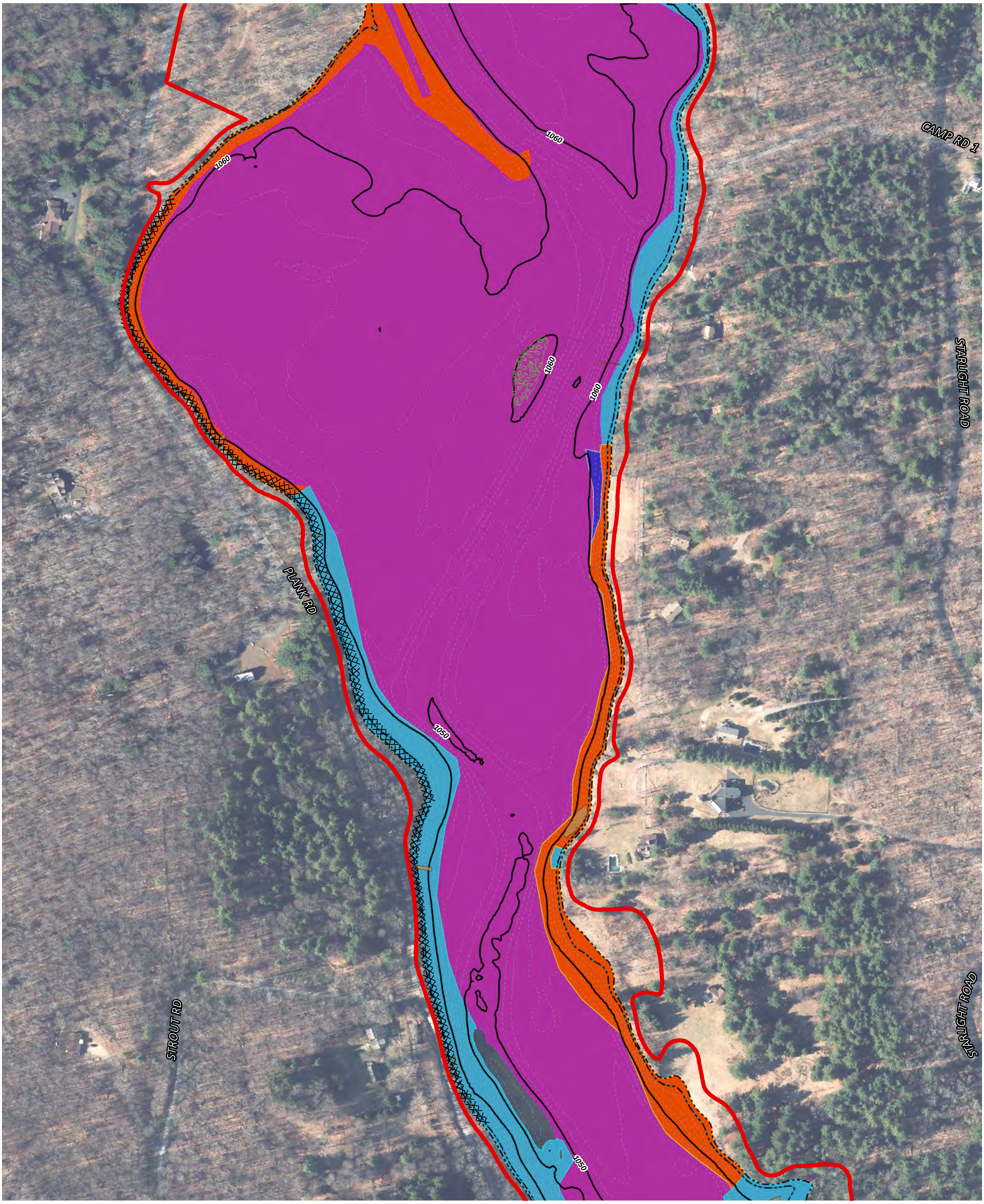

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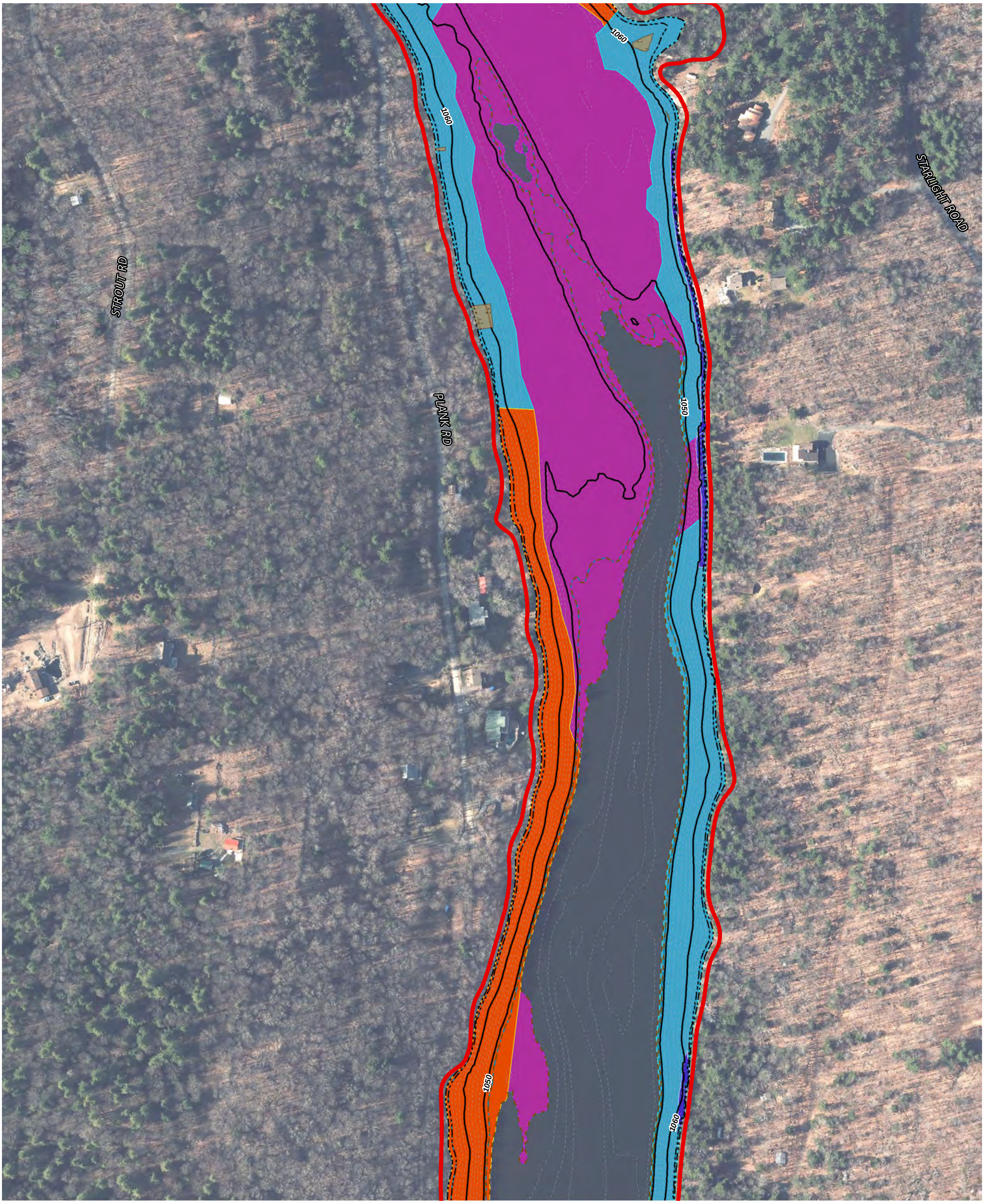

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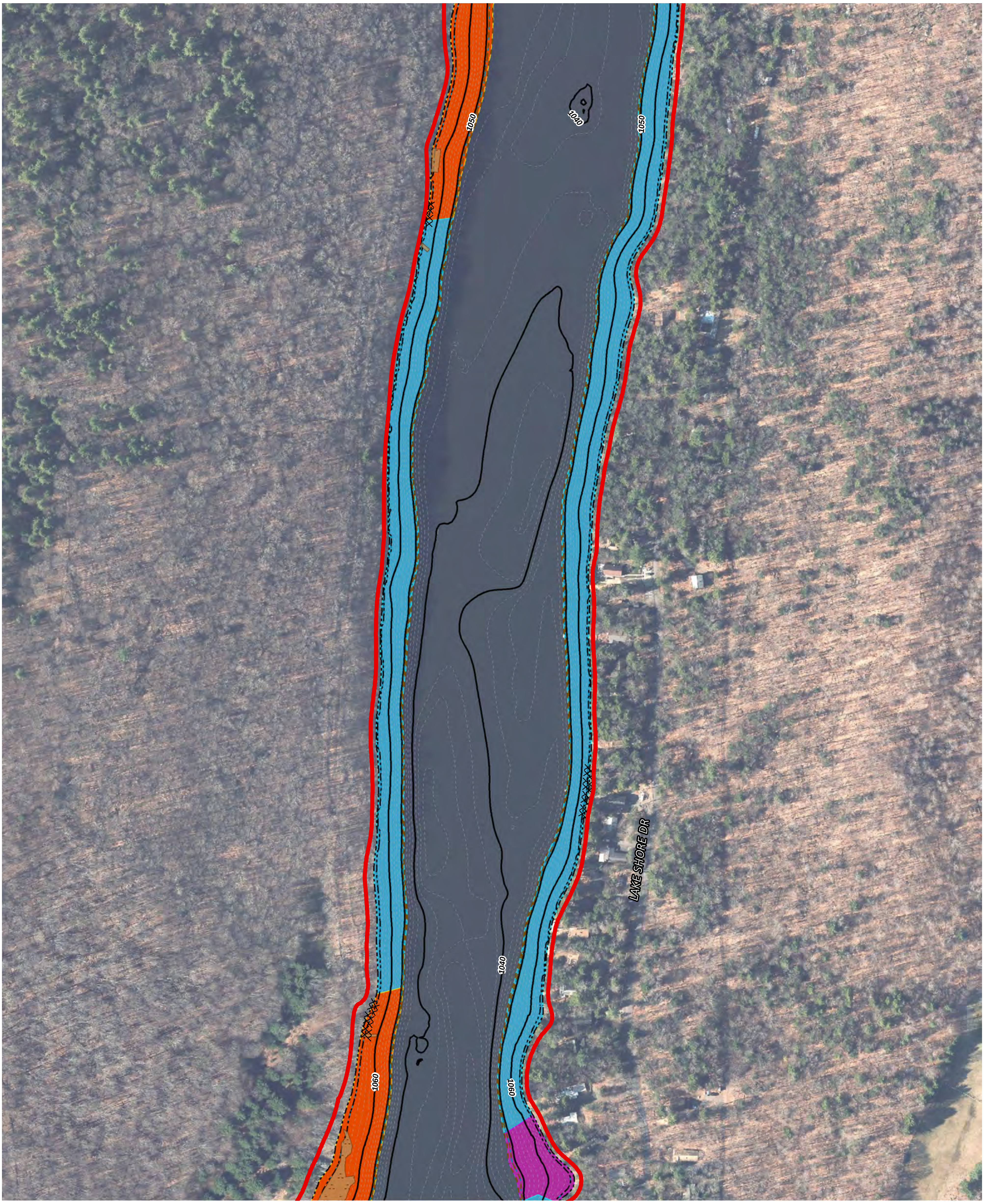

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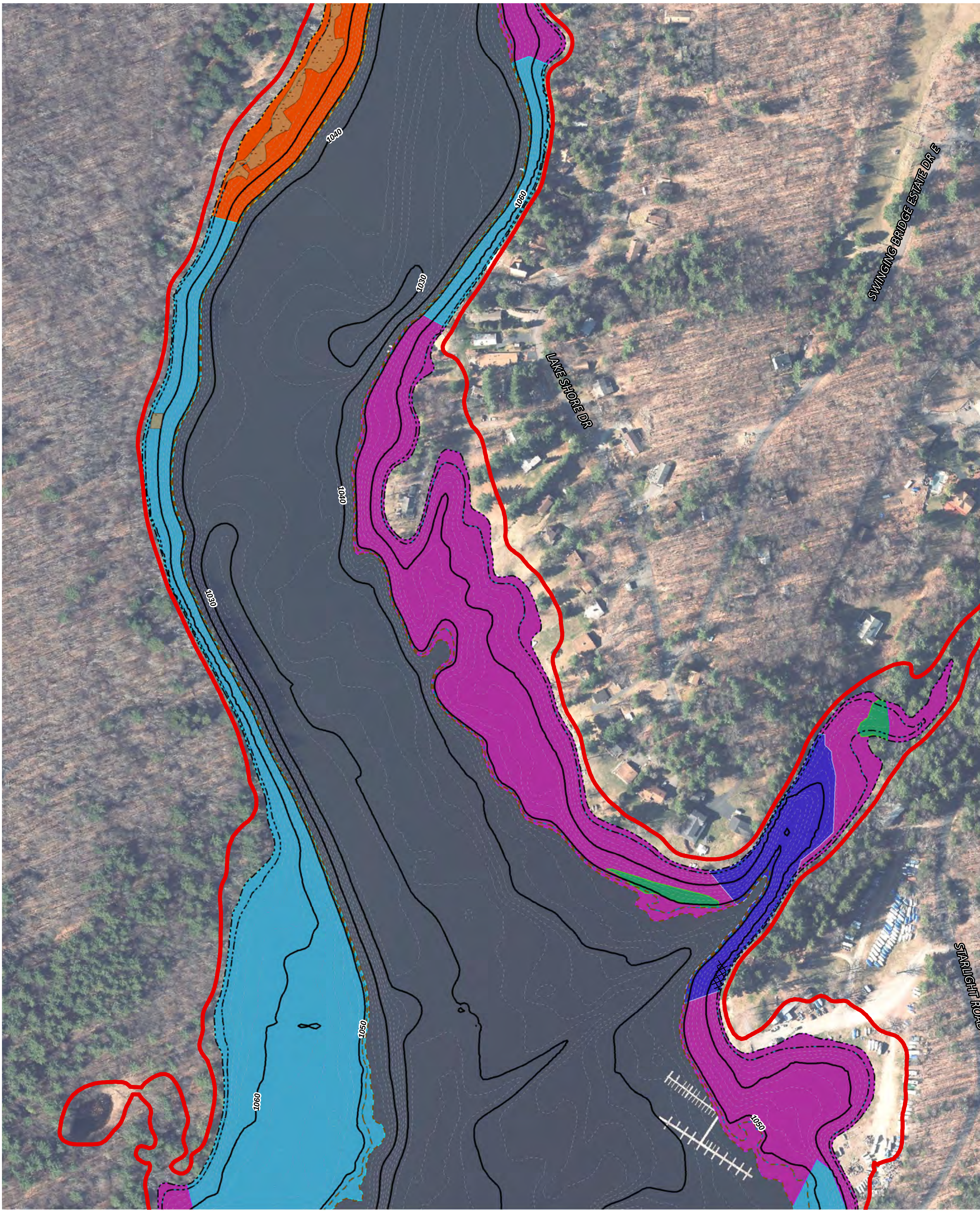

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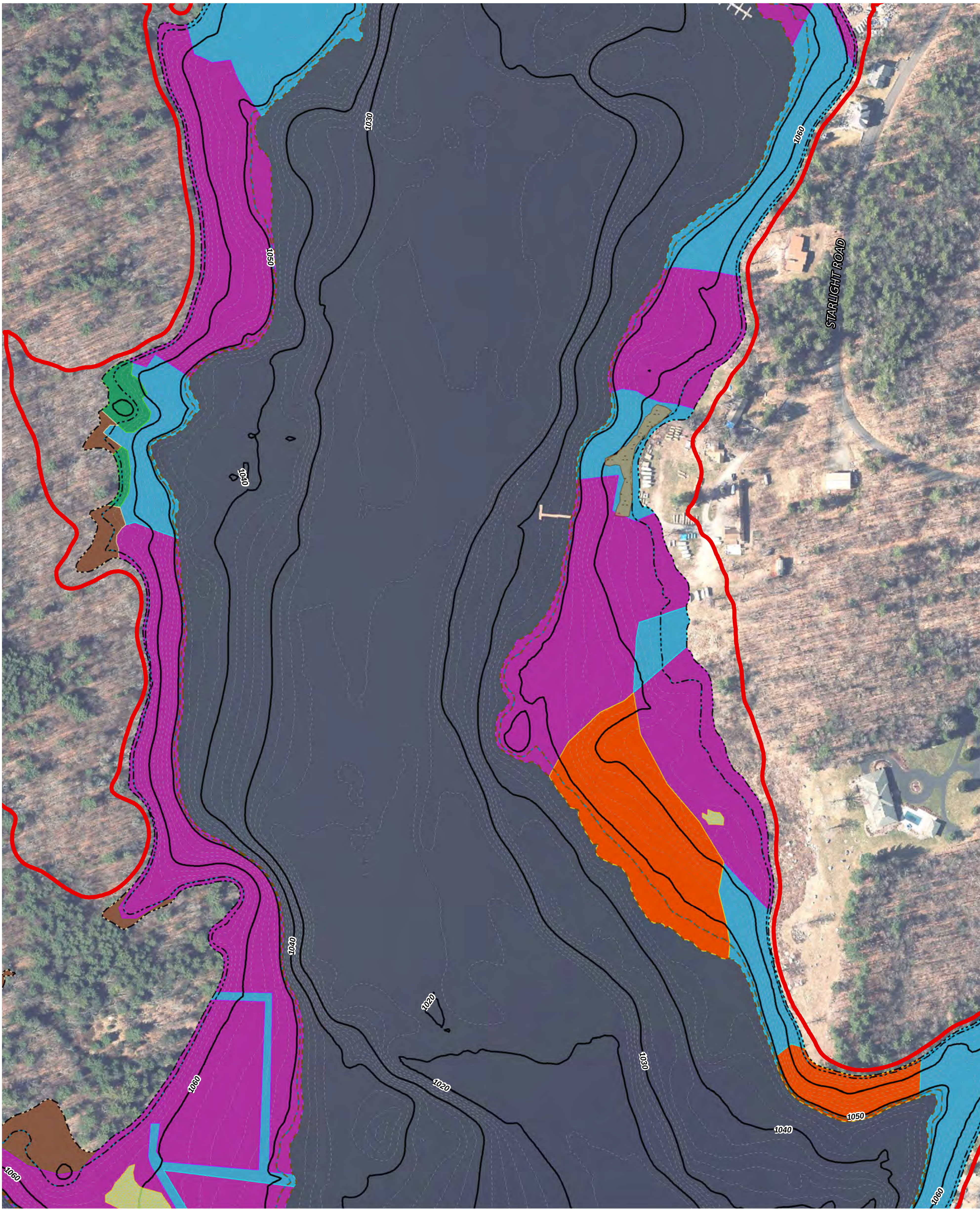

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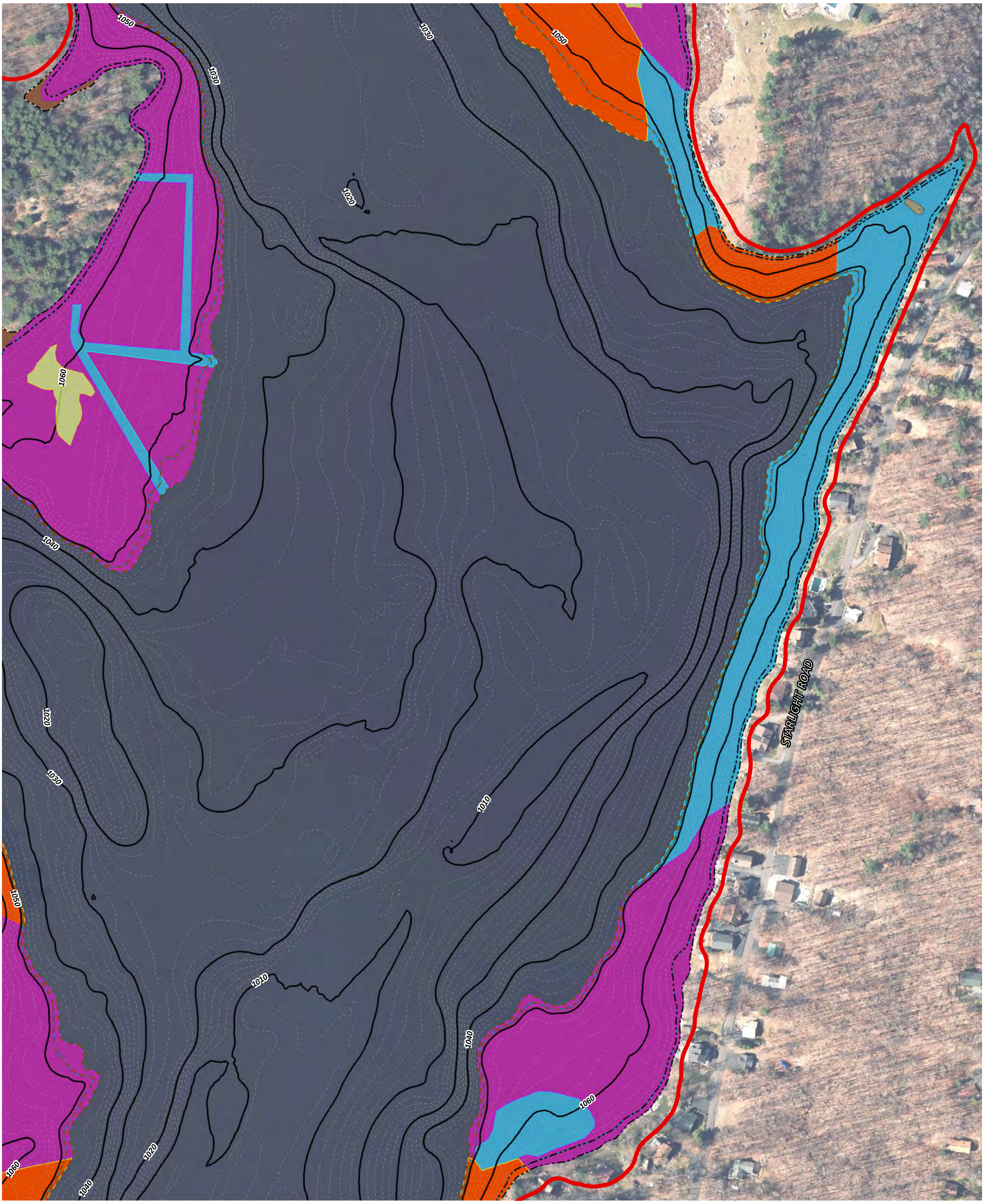

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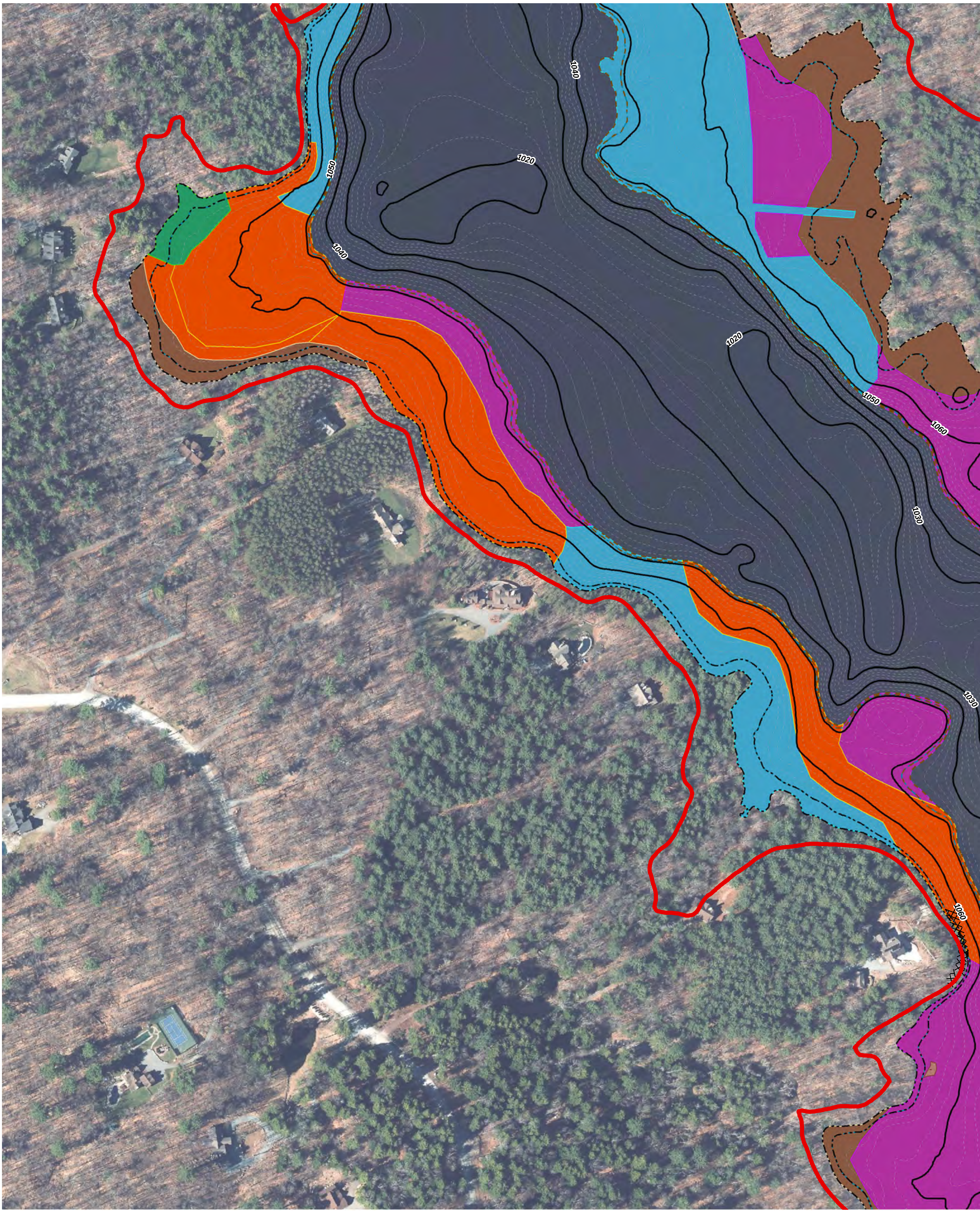

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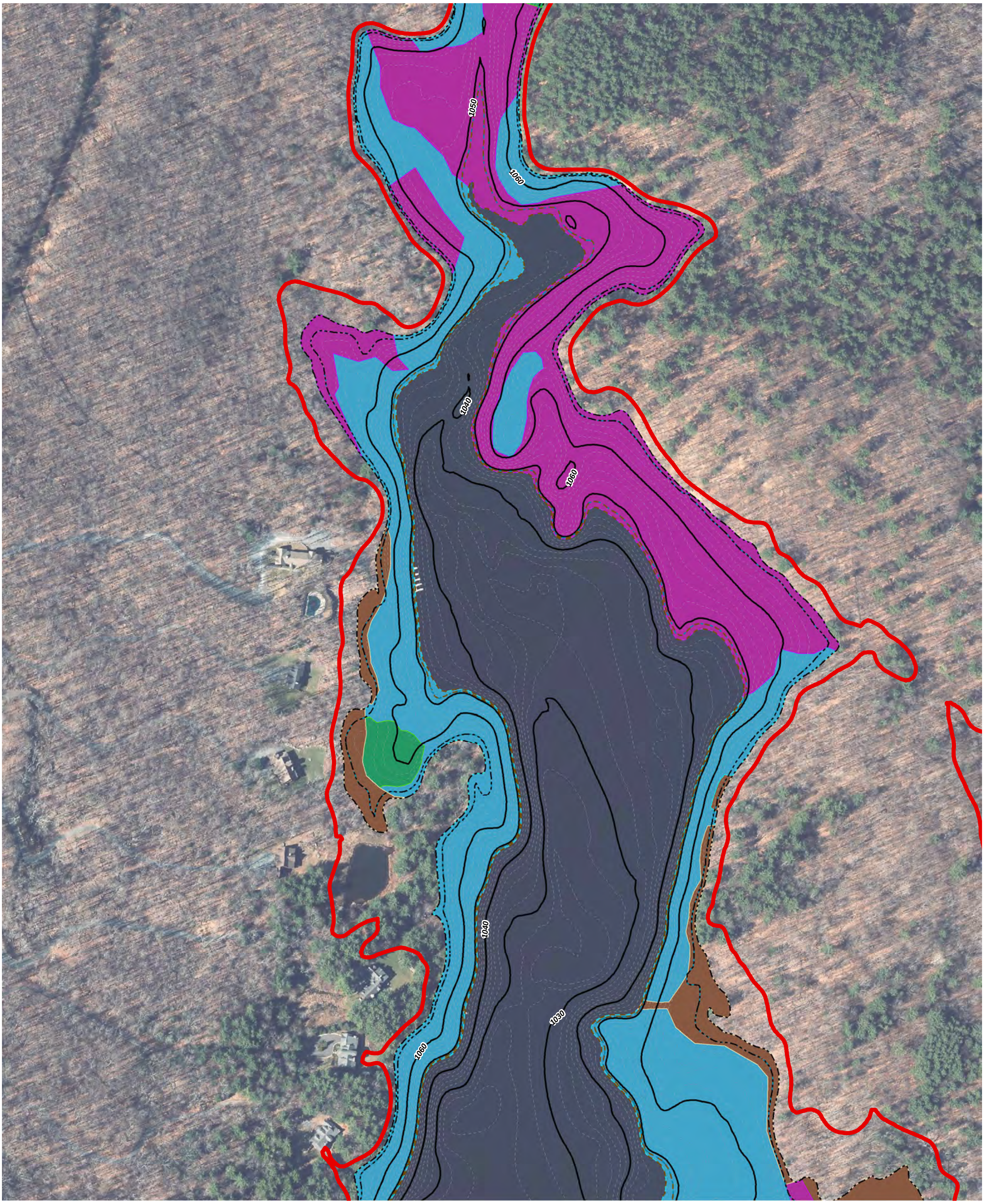

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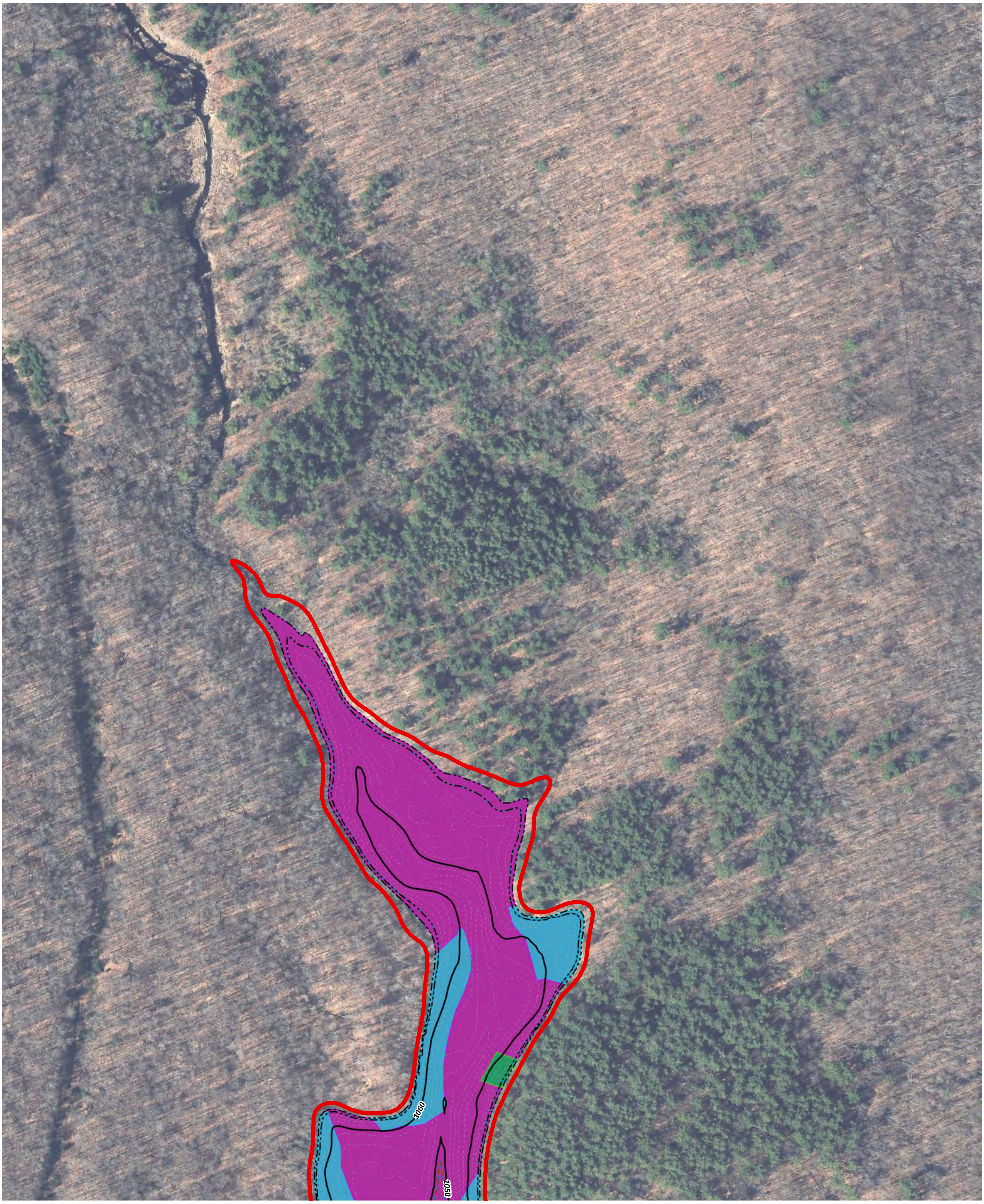

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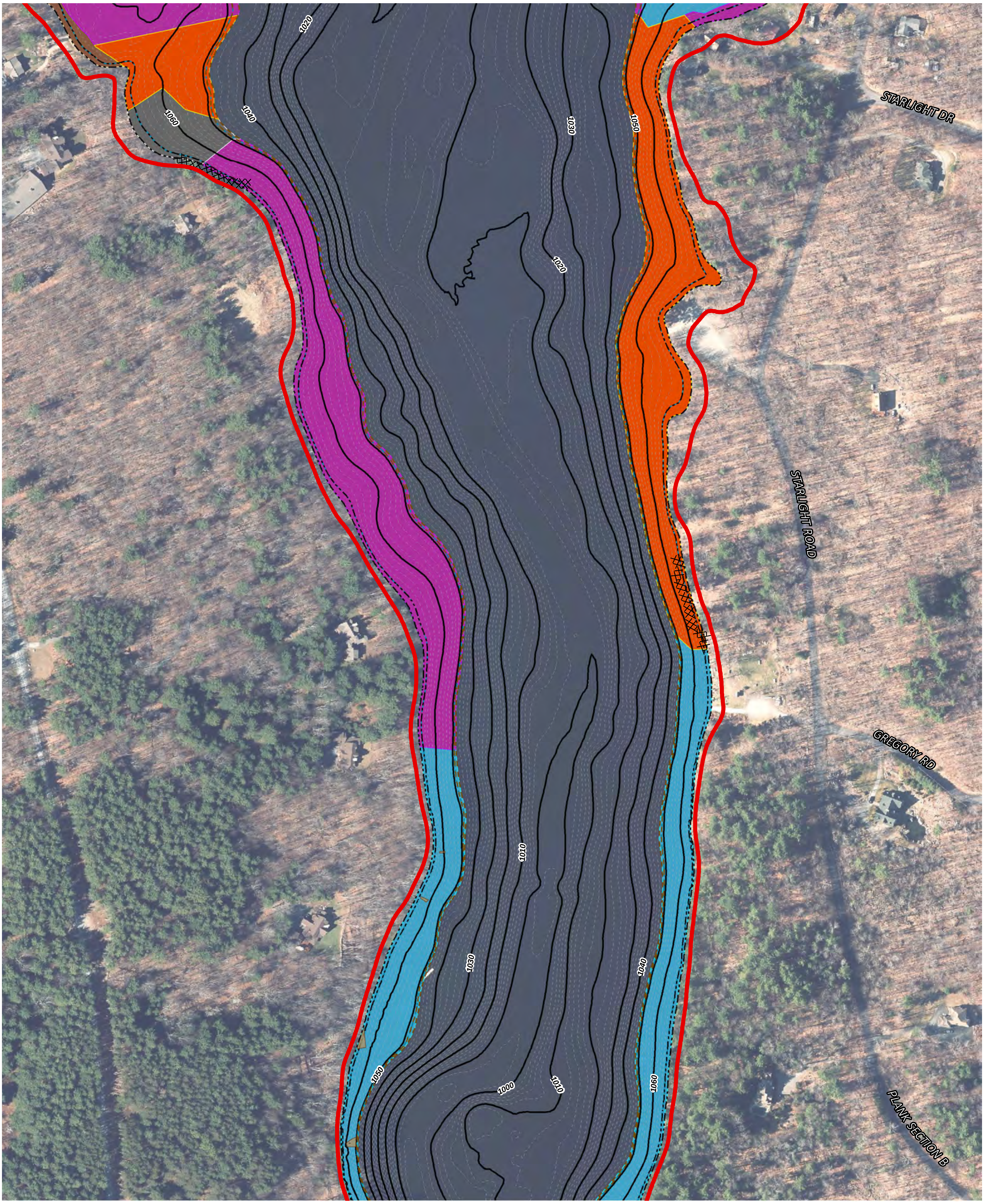
AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - SWINGING BRIDGE RESERVOIR (FERC NO. 10482)



Swinging Bridge Study Zone(s)

- Zone 1 - 1068' to 1070' (NGVD29)
- Zone 2 - 1049' to 1068' (NGVD29)
- Zone 3 - 1048' to 1049' (NGVD29)
- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

- Project Boundary
- 10-ft Contours
- 2-ft Contours

N

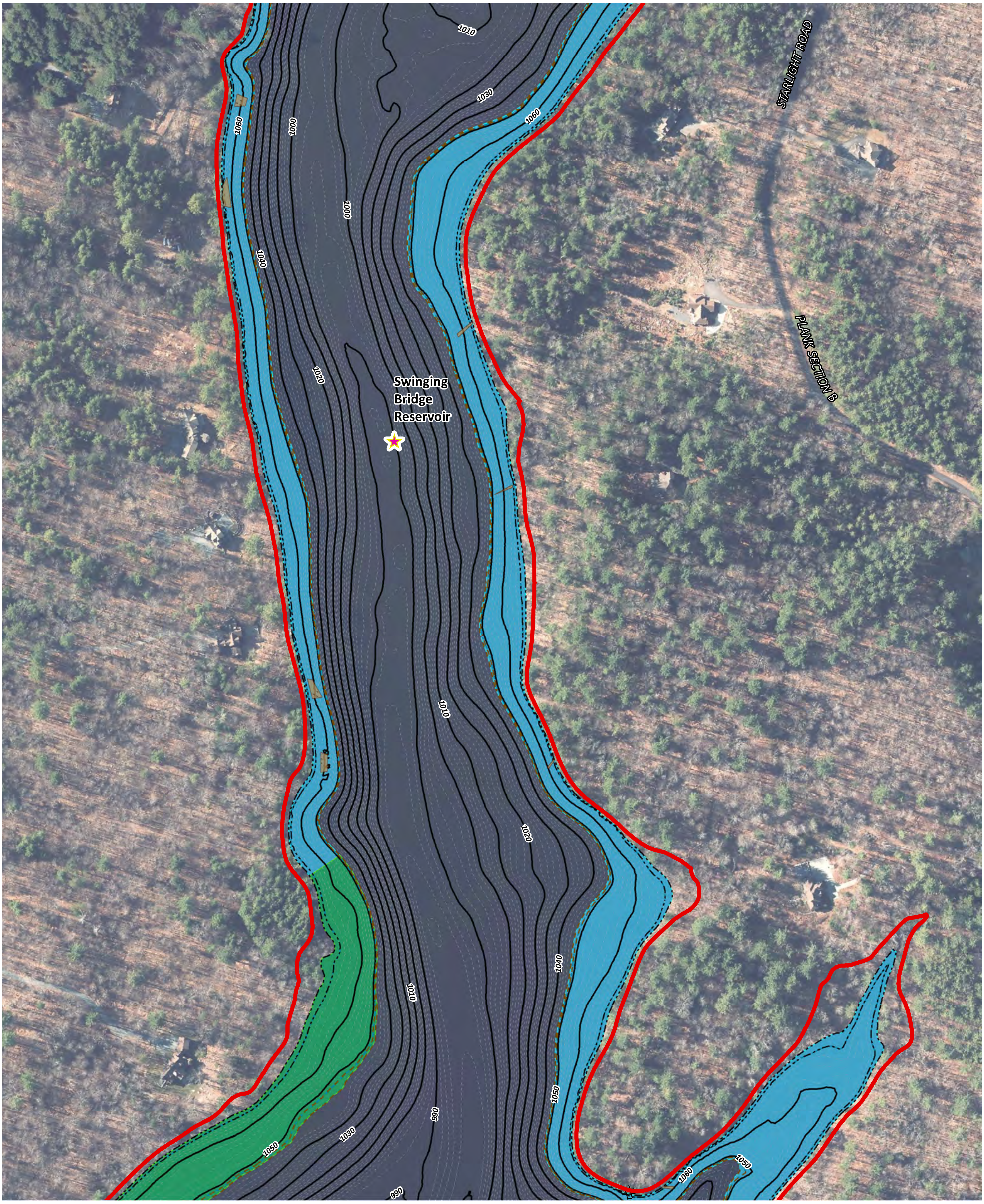
0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - SWINGING BRIDGE RESERVOIR

(FERC NO. 10482)

PATH: \\SYR-SRV01\GIS\PROJECTS\EAGLECREEK\MONGAUP_RELICE\MAP_DOCS\STUDIES\MESOHABITAT\FINAL\MAP_MESO_SWB_20191111.MXD - USER: KAUSTIN - DATE: 11/11/2019



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N

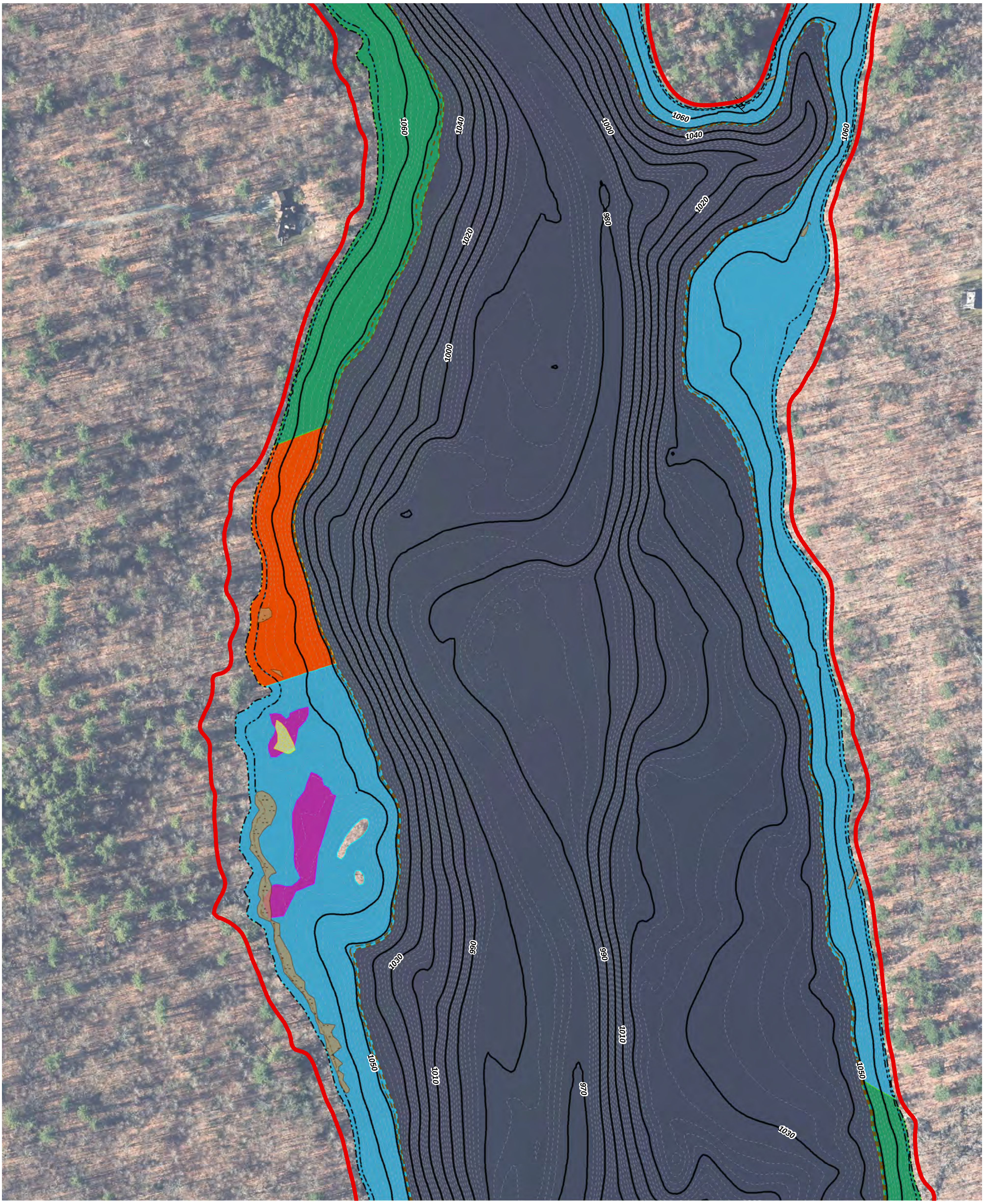
0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - SWINGING BRIDGE RESERVOIR

(FERC NO. 10482)

PATH: \\SYR-SRV01\GIS\PROJECTS\EAGLECREEK\MONGAUP_RELICE\MAP_DOCS\STUDIES\MESOHABITAT\FINAL\MAP_MESO_SWB_20191111.MXD - USER: KAUSTIN - DATE: 11/11/2019



Swinging Bridge Study Zone(s)

Zone 1 - 1068' to 1070' (NGVD29)

Zone 2 - 1049' to 1068' (NGVD29)

Zone 3 - 1048' to 1049' (NGVD29)

Observed Shoreline Erosion

Cover Type

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CNA - Centrarchid Nesting Area

LWD - Large Woody Debris

Substrate

Bedrock

Fine

Gravel

Gravel-Rubble-Cobble

Rocky Boulder

Rocky Fine

Riprap-Artificial Shore

Sandy/Silt-Loam-Soil

Project Boundary

10-ft Contours

2-ft Contours

N

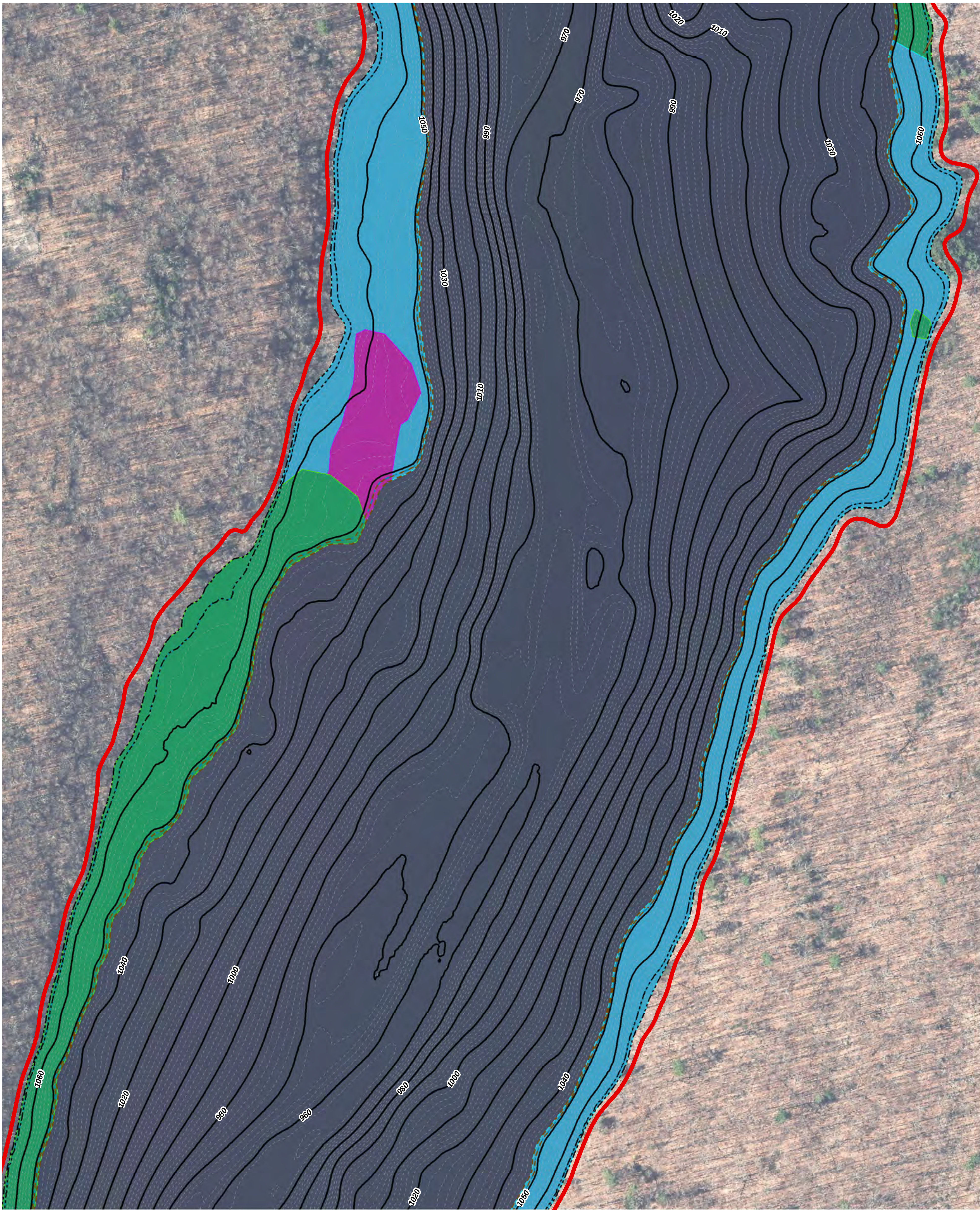
0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - SWINGING BRIDGE RESERVOIR

(FERC NO. 10482)

PATH: \\SYR-SRV01\GIS\PROJECTS\EAGLECREEK\MONGAUP_RELICE\MAP_DOCS\STUDIES\MESOHABITAT\FINAL\MAP_MESO_SWB_20191111.MXD - USER: KAUSTIN - DATE: 11/11/2019



Swinging Bridge Study Zone(s)

- Zone 1 - 1068' to 1070' (NGVD29)
- Zone 2 - 1049' to 1068' (NGVD29)
- Zone 3 - 1048' to 1049' (NGVD29)
- Observed Shoreline Erosion

Cover Type

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- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

- Project Boundary
- 10-ft Contours
- 2-ft Contours

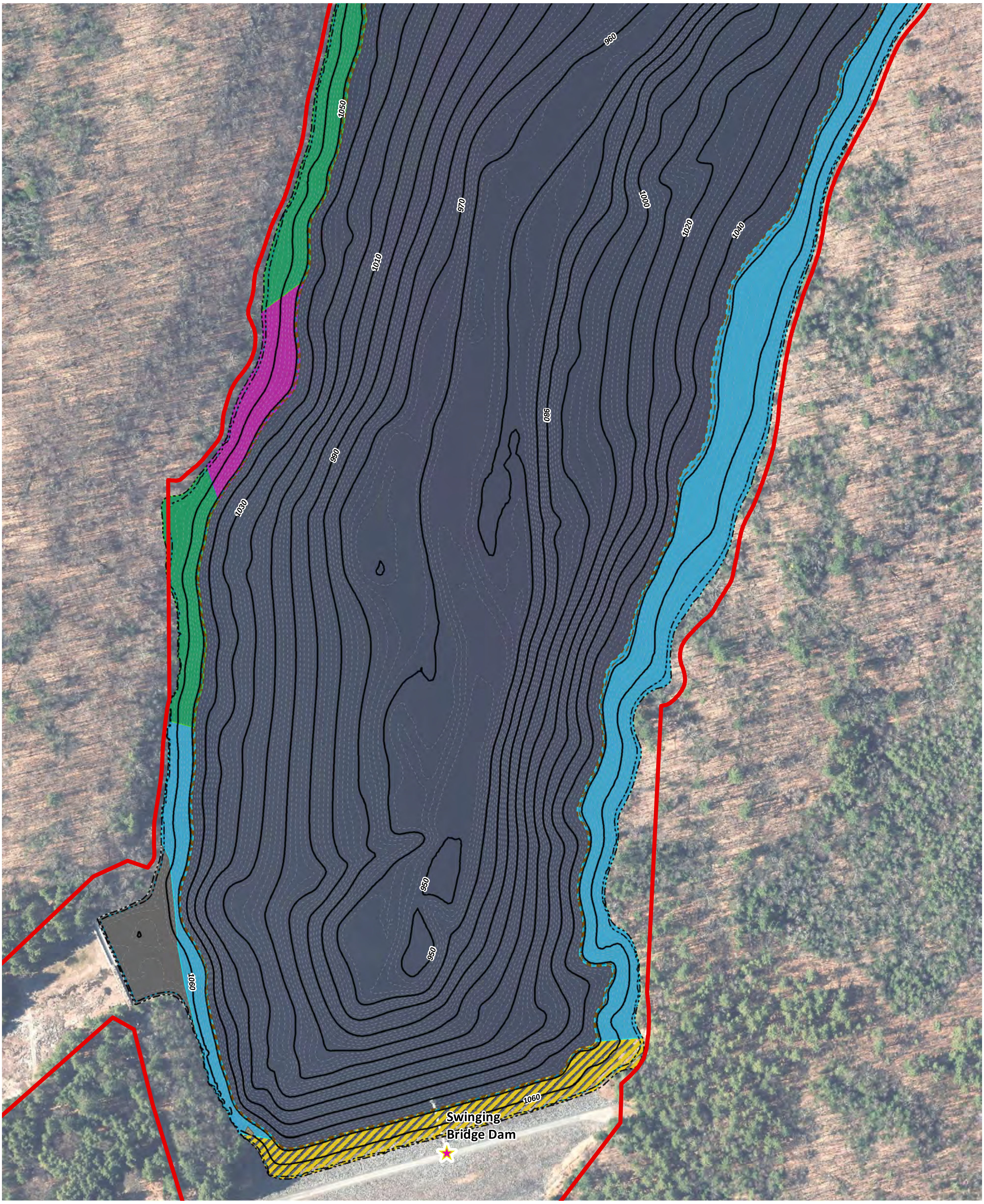
N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - SWINGING BRIDGE RESERVOIR

(FERC NO. 10482)



Swinging Bridge Study Zone(s)

- Zone 1 - 1068' to 1070' (NGVD29)
- Zone 2 - 1049' to 1068' (NGVD29)
- Zone 3 - 1048' to 1049' (NGVD29)
- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

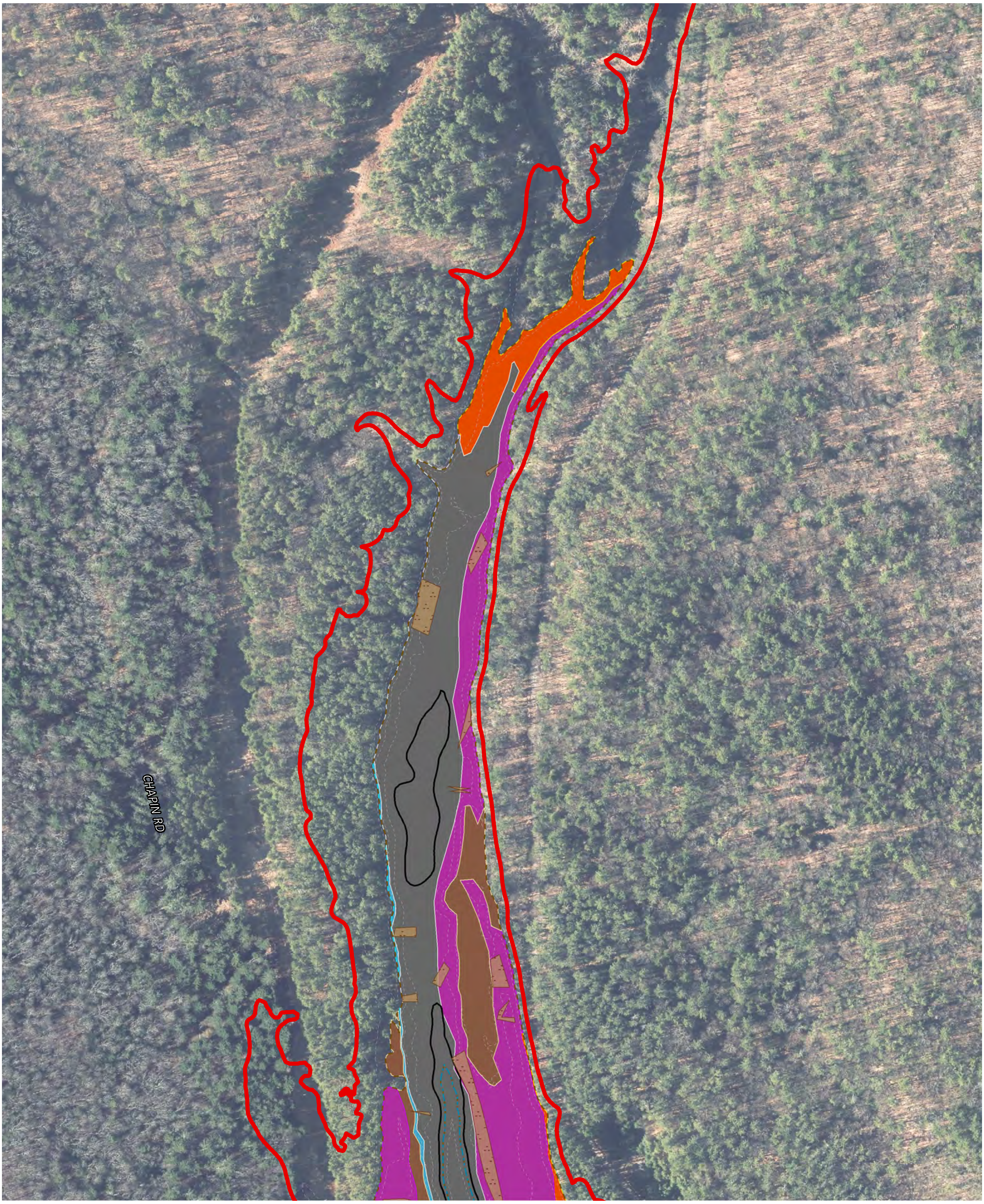
- Project Boundary
- 10-ft Contours
- 2-ft Contours

N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

SWINGING BRIDGE HYDROELECTRIC PROJECT - SWINGING BRIDGE RESERVOIR (FERC NO. 10482)



Mongaup Falls Study Zone(s)

- Zone 1 - N/A
- Zone 2 - 929' to 935' (NGVD29)
- Zone 3 - 910' to 929' (NGVD29)
- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

- Project Boundary
- 10-ft Contours
- 2-ft Contours

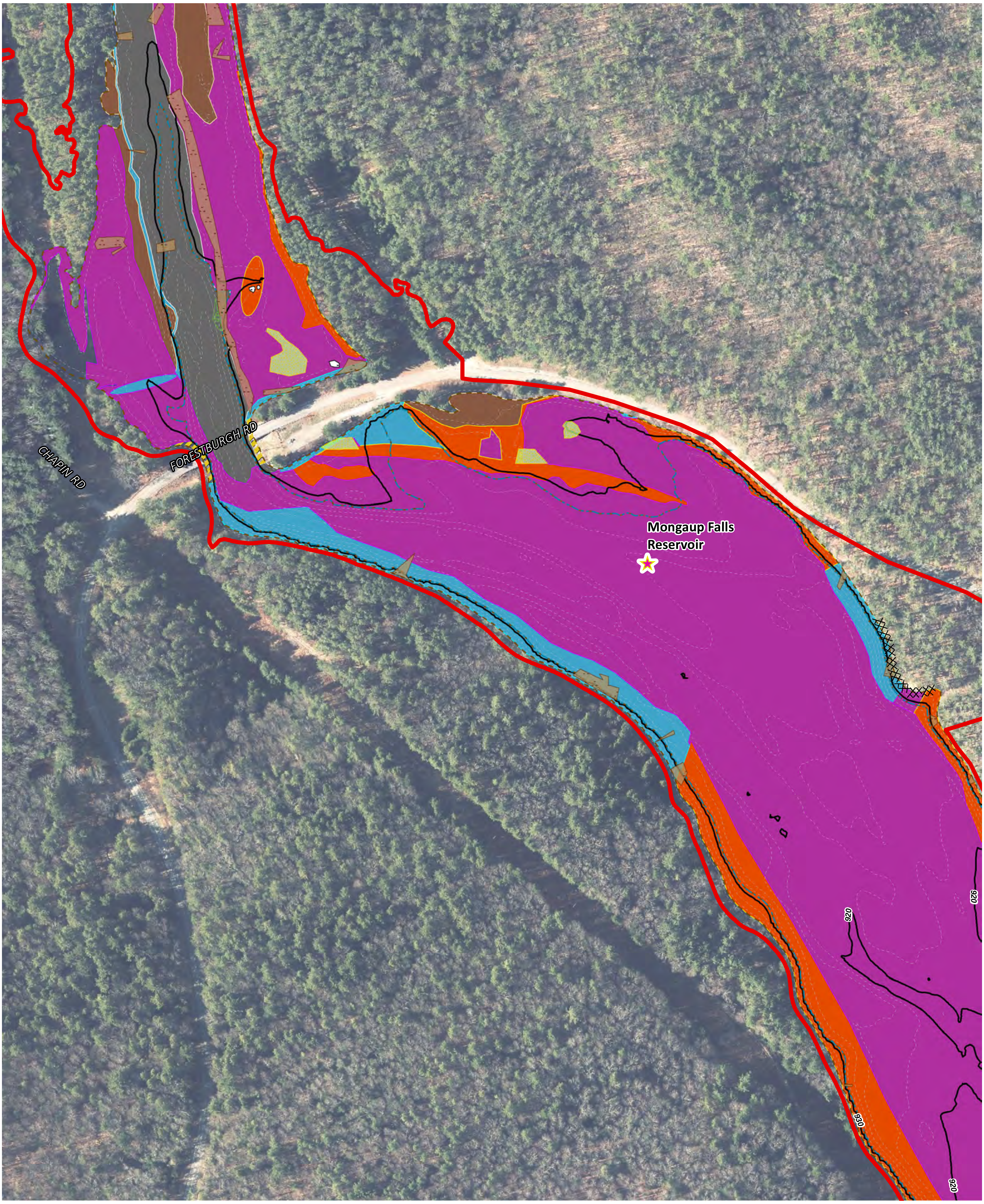
N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

MONGAUP FALLS HYDROELECTRIC PROJECT - MONGAUP FALLS RESERVOIR

(FERC NO. 10481)



Mongaup Falls Study Zone(s)

- Zone 1 - N/A
- Zone 2 - 929' to 935' (NGVD29)
- Zone 3 - 910' to 929' (NGVD29)
- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris
- OS - Observed Stranding

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

- Project Boundary
- 10-ft Contours
- 2-ft Contours

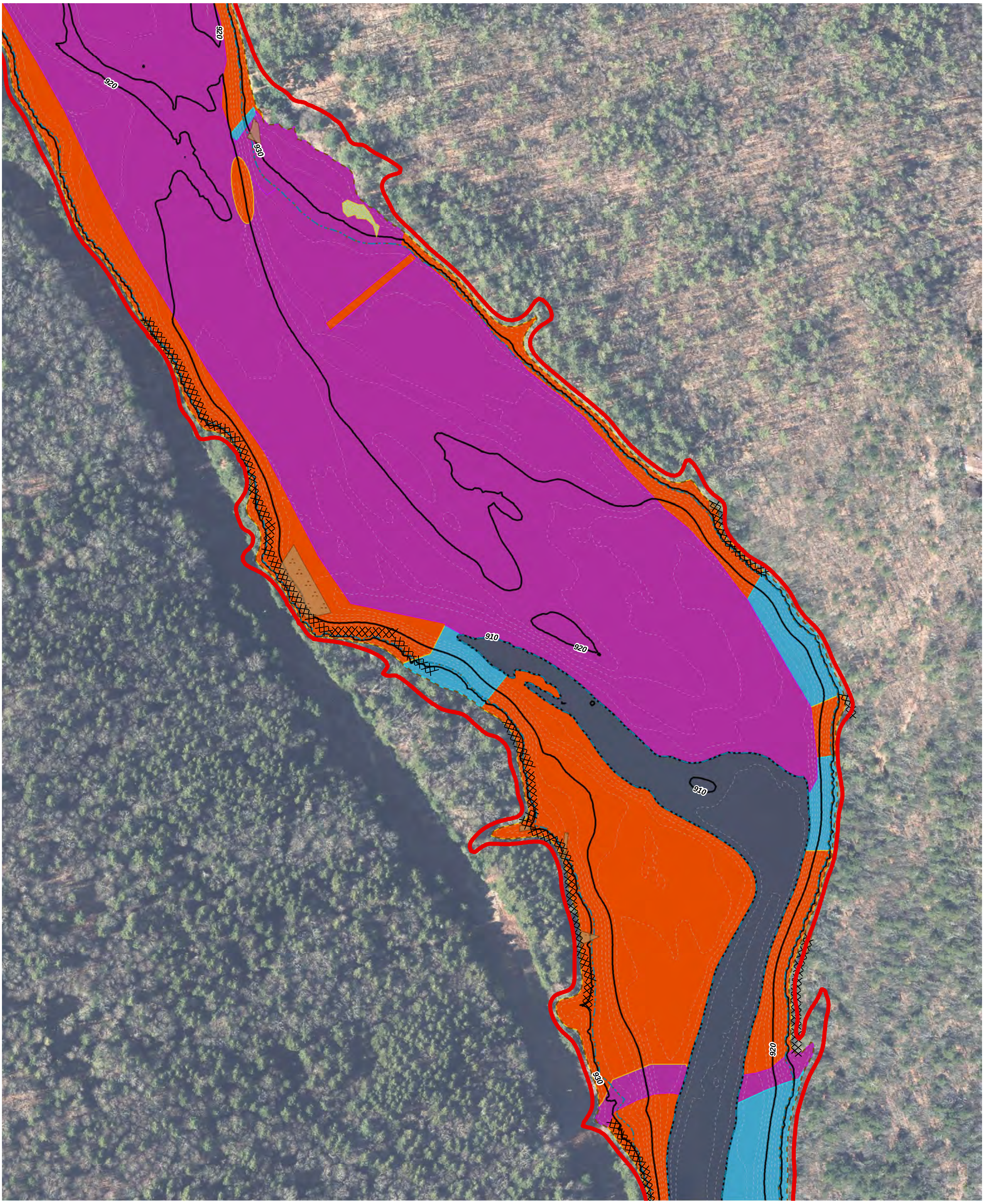
N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

MONGAUP FALLS HYDROELECTRIC PROJECT - MONGAUP FALLS RESERVOIR

(FERC NO. 10481)



Mongaup Falls Study Zone(s)

Zone 1 - N/A

Zone 2 - 929' to 935' (NGVD29)

Zone 3 - 910' to 929' (NGVD29)

Observed Shoreline Erosion

Cover Type

SAV - Submerged Aquatic Vegetation

CNA - Centrarchid Nesting Area

LWD - Large Woody Debris

Substrate

Bedrock

Fine

Gravel

Gravel-Rubble-Cobble

Rocky Boulder

Rocky Fine

Riprap-Artificial Shore

Sandy/Silt-Loam-Soil

Project Boundary

10-ft Contours

2-ft Contours

N

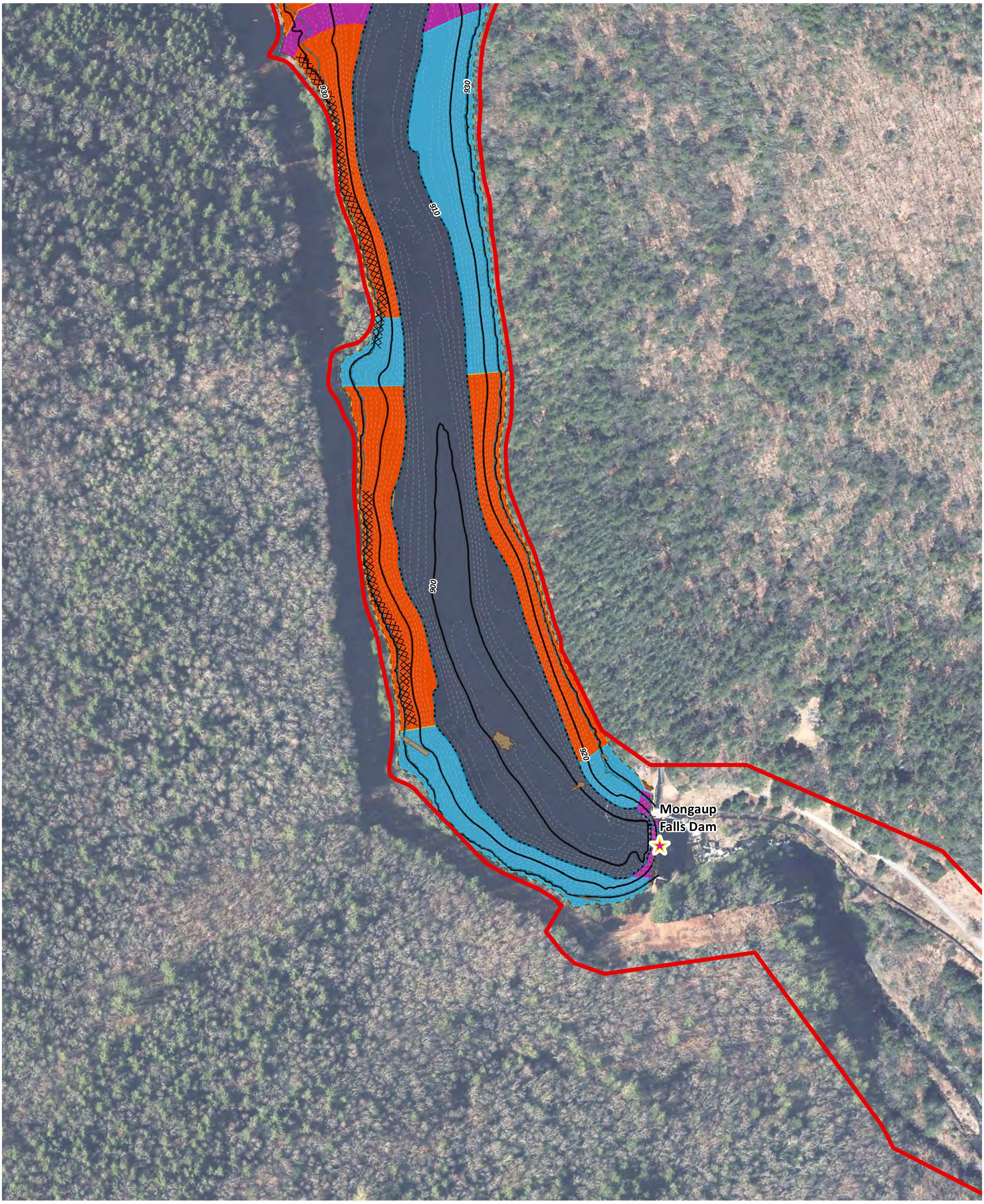
0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

MONGAUP FALLS HYDROELECTRIC PROJECT - MONGAUP FALLS RESERVOIR

(FERC NO. 10481)

PATH: \\SYR-SRV01\GIS\PROJECTS\EAGLECREEK\MONGAUP_RELICE\MAP_DOCS\STUDIES\MESOHABITAT\FINAL\MAP_MESO_MF_20191111.MXD - USER: KAUSTIN - DATE: 11/11/2019



Mongaup Falls Study Zone(s)

- Zone 1 - N/A
- Zone 2 - 929' to 935' (NGVD29)
- Zone 3 - 910' to 929' (NGVD29)
- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

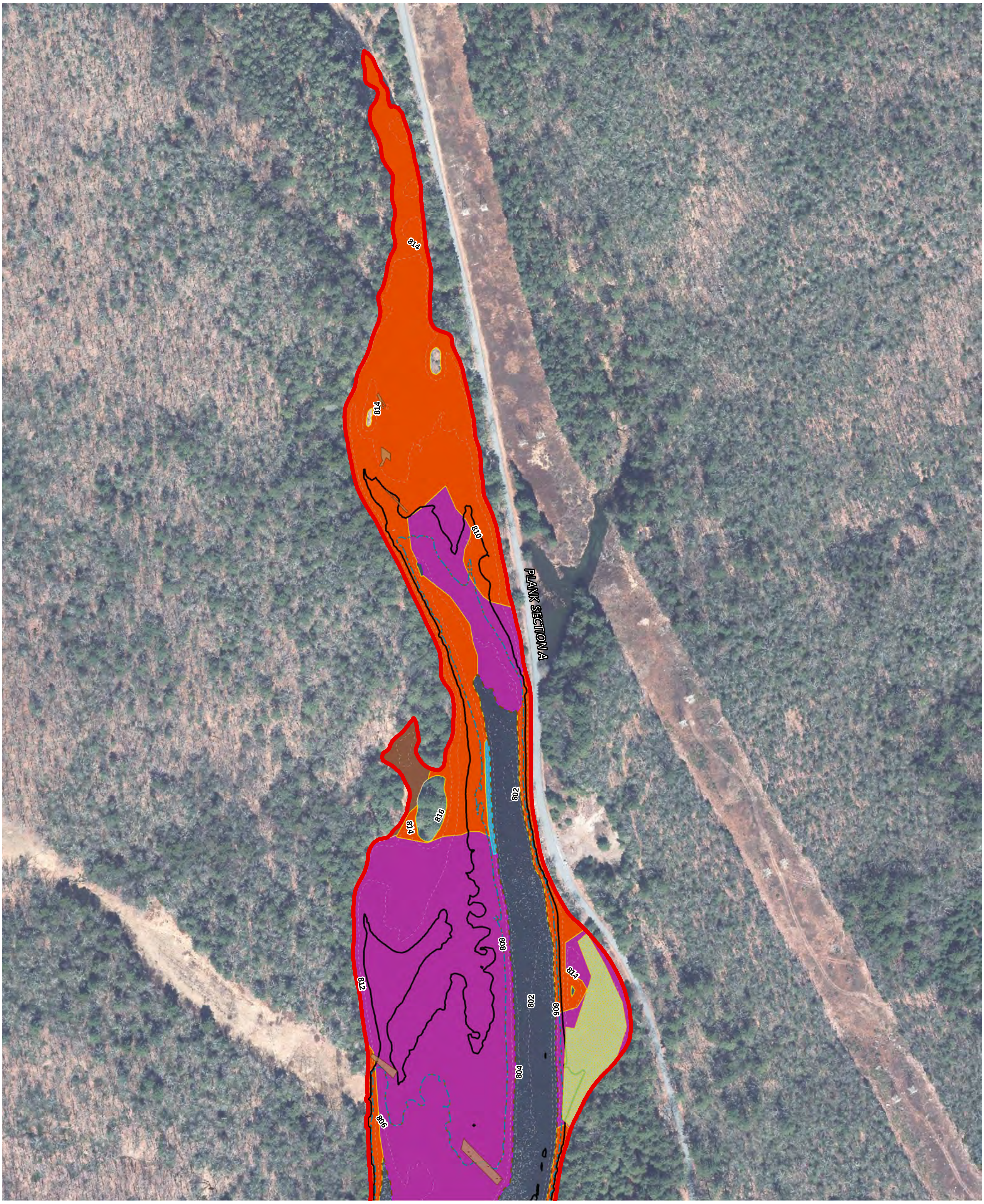
- Project Boundary
- 10-ft Contours
- 2-ft Contours

N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

MONGAUP FALLS HYDROELECTRIC PROJECT - MONGAUP FALLS RESERVOIR (FERC NO. 10481)



Rio Study Zone(s)
- Zone 1 - N/A
- Zone 2 - 808' to 815' (NGVD29)
- Zone 3 - 805' to 808' (NGVD29)
- Observed Shoreline Erosion

Cover Type
- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris

Substrate
- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

- Project Boundary
- 10-ft Contours
- 2-ft Contours

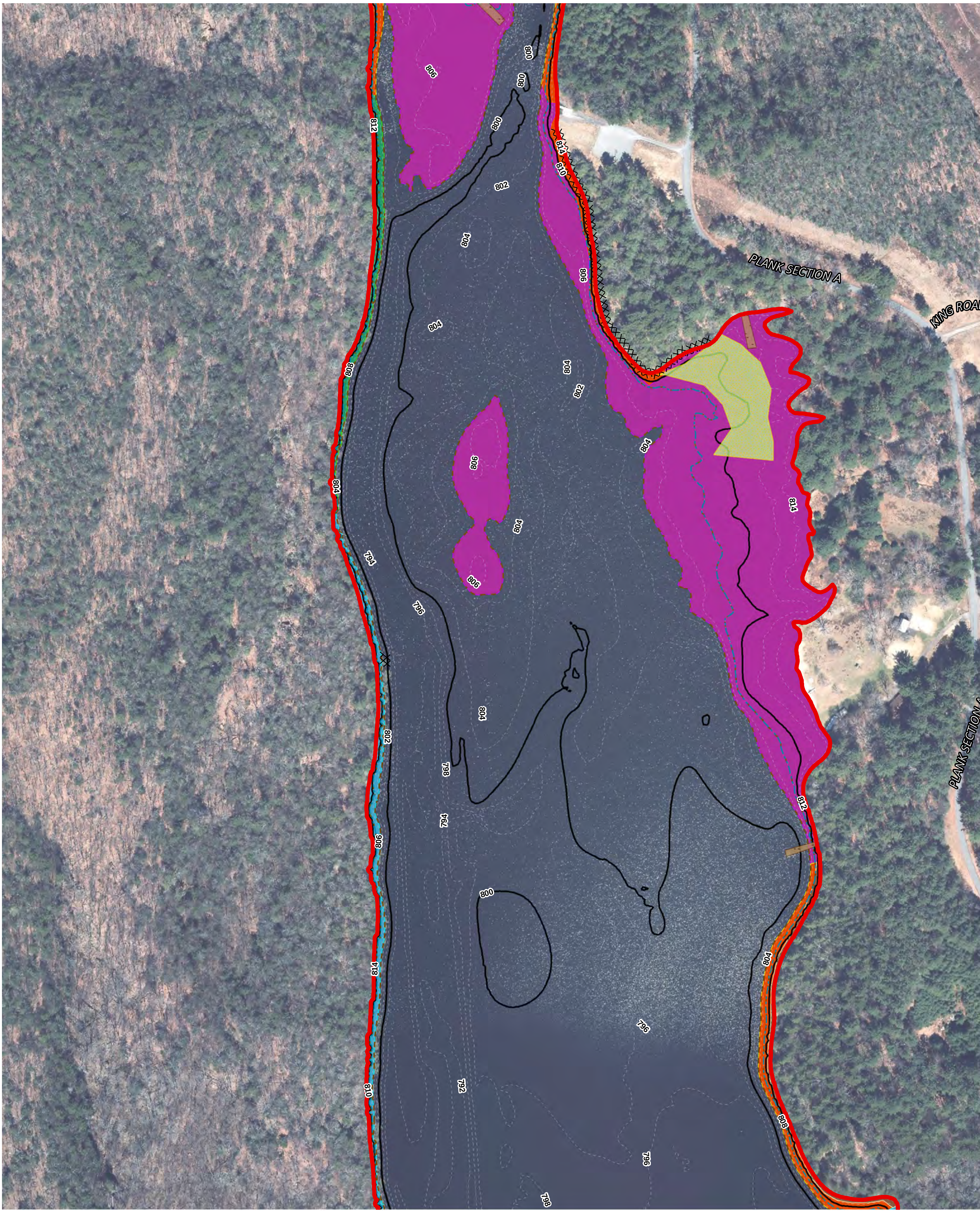
N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

RIO HYDROELECTRIC PROJECT - RIO RESERVOIR

(FERC NO. 9690)



Rio Study Zone(s)

Zone 1 - N/A

Zone 2 - 808' to 815' (NGVD29)

Zone 3 - 805' to 808' (NGVD29)

Observed Shoreline Erosion

Cover Type

SAV - Submerged Aquatic Vegetation

CNA - Centrarchid Nesting Area

LWD - Large Woody Debris

Substrate

Bedrock

Fine

Gravel

Gravel-Rubble-Cobble

Rocky Boulder

Rocky Fine

Riprap-Artificial Shore

Sandy/Silt-Loam-Soil

Project Boundary

10-ft Contours

2-ft Contours

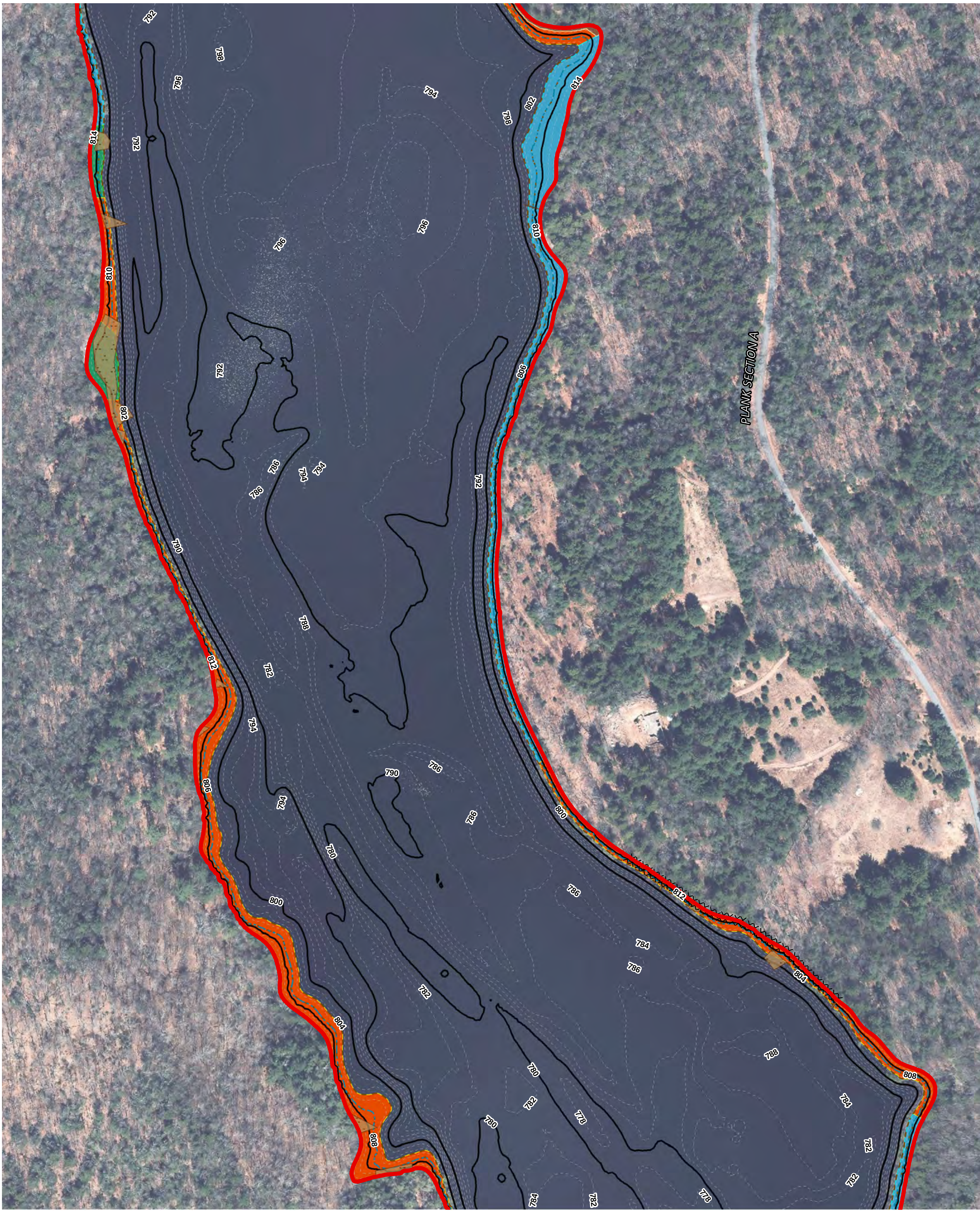
N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

RIO HYDROELECTRIC PROJECT - RIO RESERVOIR

(FERC NO. 9690)



Rio Study Zone(s)

- Zone 1 - N/A
- Zone 2 - 808' to 815' (NGVD29)
- Zone 3 - 805' to 808' (NGVD29)
- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

- Project Boundary
- 10-ft Contours
- 2-ft Contours

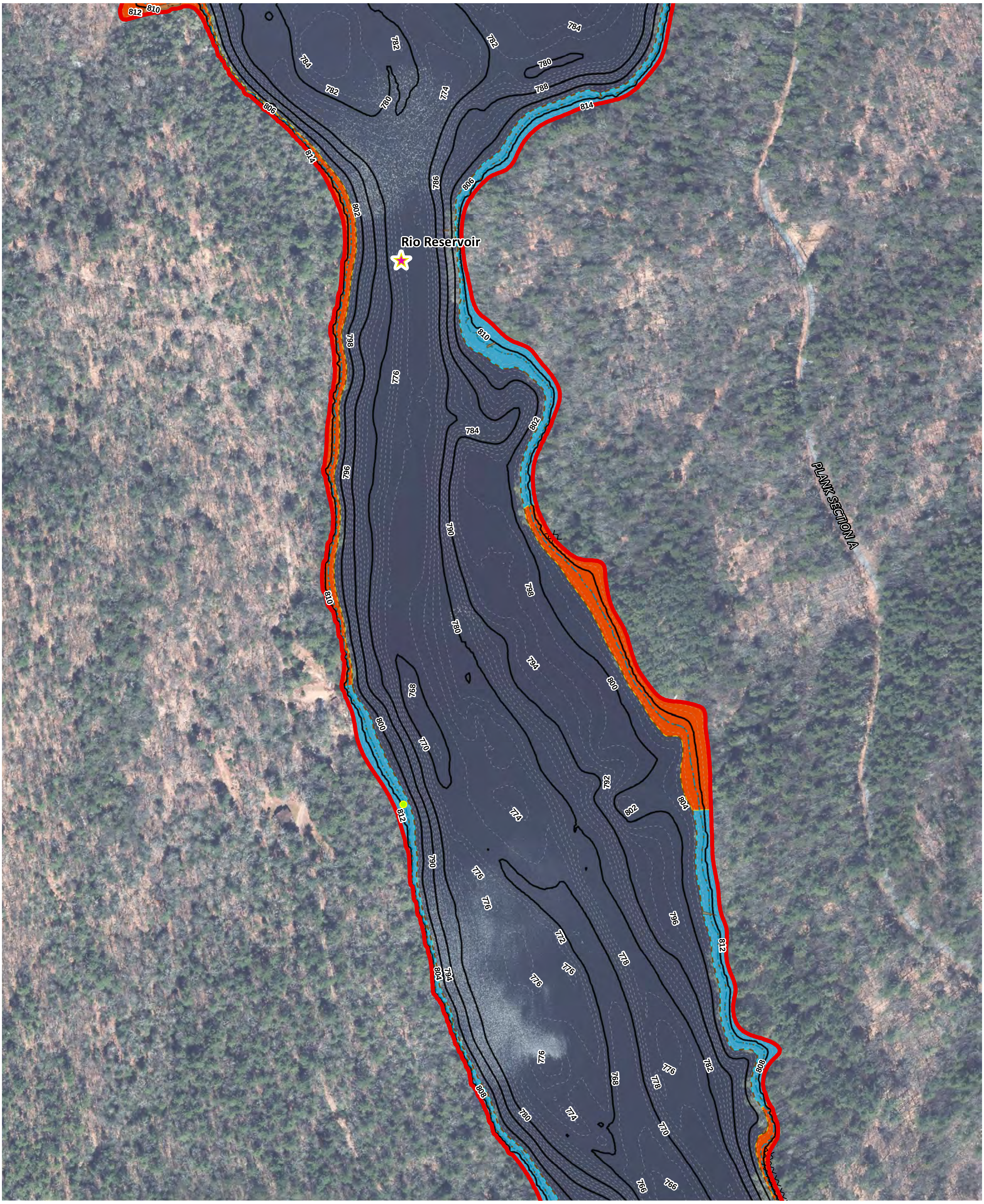
N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

RIO HYDROELECTRIC PROJECT - RIO RESERVOIR

(FERC NO. 9690)



Rio Study Zone(s)

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- Zone 3 - 805' to 808' (NGVD29)
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Cover Type

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- LWD - Large Woody Debris

Substrate

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- Gravel-Rubble-Cobble
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- Project Boundary
- 10-ft Contours
- 2-ft Contours

N

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

RIO HYDROELECTRIC PROJECT - RIO RESERVOIR

(FERC NO. 9690)

Rio Study Zone(s)

- Zone 1 - N/A
- Zone 2 - 808' to 815' (NGVD29)
- Zone 3 - 805' to 808' (NGVD29)
- Observed Shoreline Erosion

Cover Type

- SAV - Submerged Aquatic Vegetation
- CNA - Centrarchid Nesting Area
- LWD - Large Woody Debris
- IS - Invasive Plant Species

Substrate

- Bedrock
- Fine
- Gravel
- Gravel-Rubble-Cobble
- Rocky Boulder
- Rocky Fine
- Riprap-Artificial Shore
- Sandy/Silt-Loam-Soil

- Project Boundary
- 10-ft Contours
- 2-ft Contours

N

0 250 500 Feet

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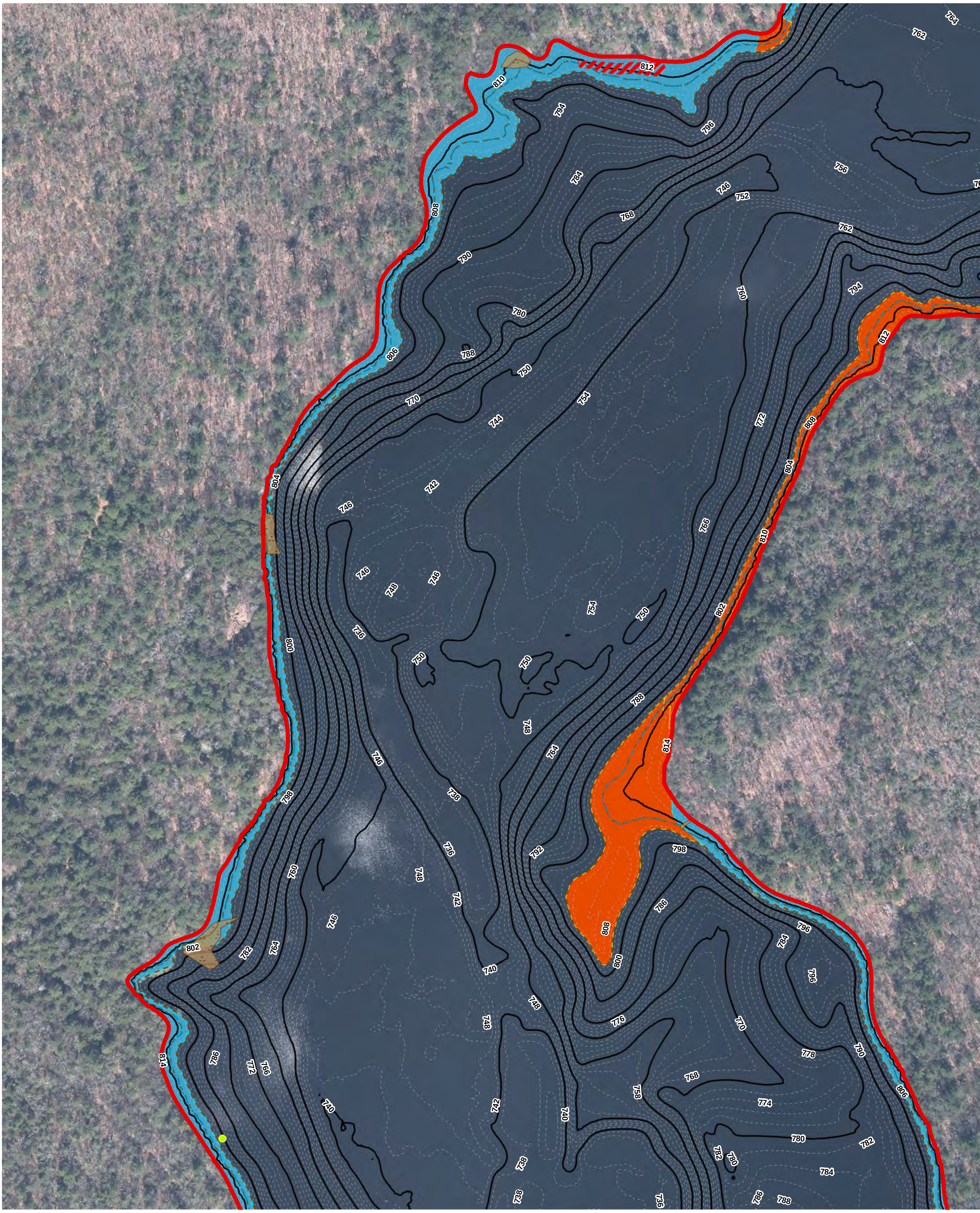
RIO HYDROELECTRIC PROJECT - RIO RESERVOIR

(FERC NO. 9690)



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- LWD - Large Woody Debris
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Substrate

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- 2-ft Contours

N

0 250 500 Feet

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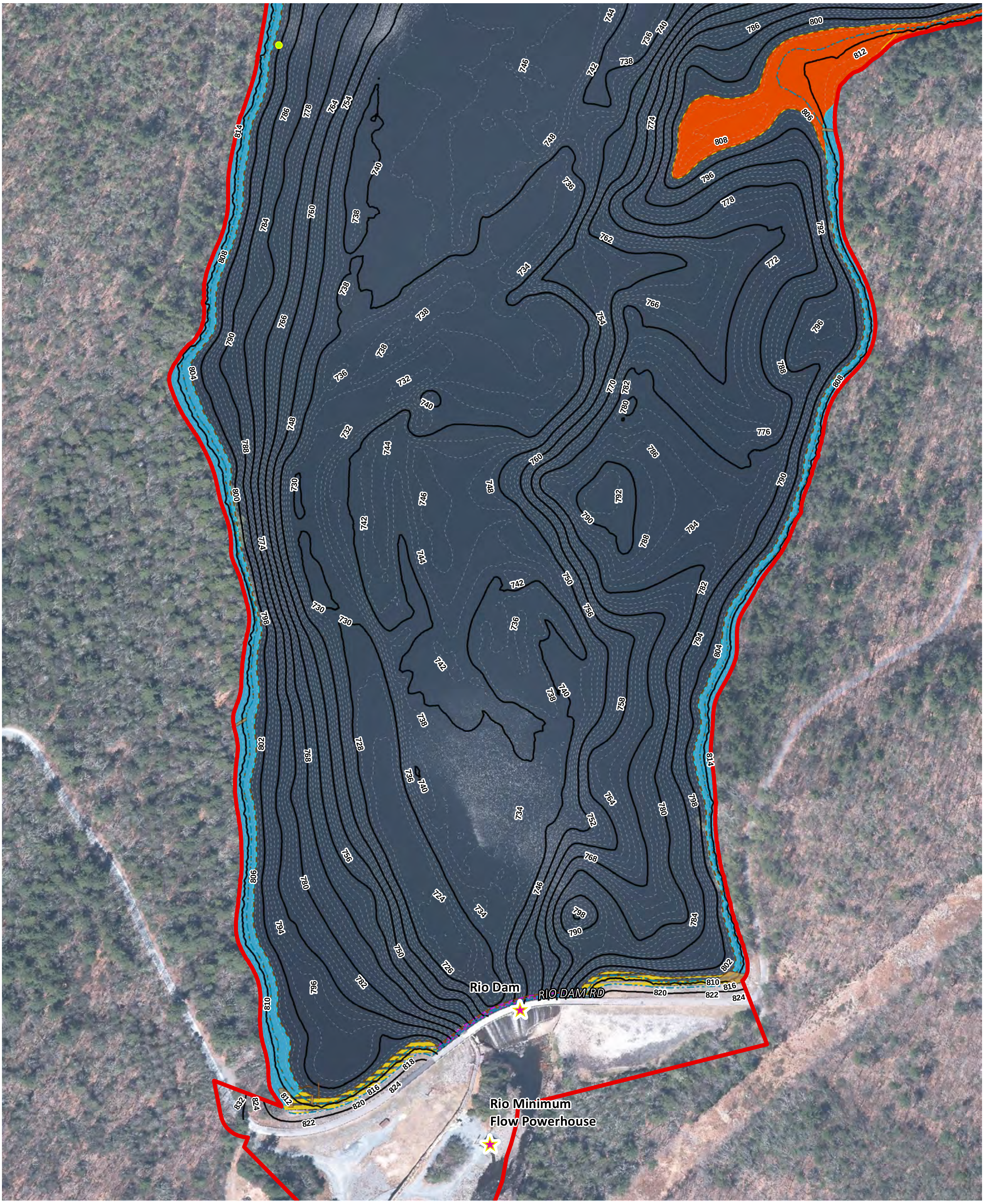
RIO HYDROELECTRIC PROJECT - RIO RESERVOIR

(FERC NO. 9690)



Rio Study Zone(s)

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Cover Type

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Substrate

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- Rocky Fine
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- Project Boundary
- 10-ft Contours
- 2-ft Contours

0 250 500 Feet

AQUATIC HABITAT ASSESSMENT STUDY

RIO HYDROELECTRIC PROJECT - RIO RESERVOIR

(FERC NO. 9690)

Attachment 2

Representative Photographs

Toronto Reservoir

Photo No.	Date:
1	9/10/19

Direction Photo Taken:
Northerly

Description:
Rocky fine substrate near boat ramp by Toronto dam. Riprap/artificial substrate along access road to Toronto Dam near top right of photo.

Photo No.	Date:
2	9/10/19

Direction Photo Taken:
Southwest

Description:
Rocky fine substrate near southern edge of Toronto Dam.

Photo No. 3	**Date:** 9/10/19	
Direction Photo Taken: Southerly		
Description: Rocky fine substrate with gradual slope associated with area of palustrine emergent wetland vegetation located in backwater area of reservoir.		

Photo No. 4	**Date:** 9/10/19	
Direction Photo Taken: Northerly		
Description: Bedrock with steep slope located along southwestern edge of reservoir.		

Photo No. 5	**Date:** 9/10/19
Direction Photo Taken: Northerly	
Description: Gravel, rubble, cobble substrate located along southern portion of reservoir.	

Photo No. 6	**Date:** 9/10/19
Direction Photo Taken: Westerly	
Description: Rocky fine substrate located in southern portion of the reservoir.	

Photo No.	**Date:**
7	9/10/19
Direction Photo Taken: N/A	
Description: Large woody debris located in southwestern section of the reservoir.	

Photo No.	**Date:**
8	9/10/19
Direction Photo Taken: N/A	
Description: Large woody debris located in southwestern section of the reservoir.	

Photo No. 9	**Date:** 9/10/19
Direction Photo Taken: Southerly	
Description: Rocky boulder substrate located on the southwestern portion of the reservoir with areas of large woody debris.	

Photo No. 10	**Date:** 9/10/19
Direction Photo Taken: Westerly	
Description: Fine substrate in the southwestern section of the reservoir.	

Photo No. 11

Date: 9/10/19

Direction Photo Taken: Westerly

Description: Bedrock with nearly vertical slope located in the southwestern portion of the reservoir adjacent to White Lake Road.

Photo No. 12

Date: 9/10/19

Direction Photo Taken: Southerly

Description: Gravel, rubble, cobble substrate located in small bay of reservoir across from Breezy Point Road in northwestern portion of the reservoir.

Photo No. 13	**Date:** 9/10/19	
Direction Photo Taken: Northerly		
Description: Gravel, rubble, cobble substrate located along northern shoreline of the reservoir to the south of Sunset Point Road.		

Photo No. 14	**Date:** 9/10/19	
Direction Photo Taken: N/A		
Description: Centrarchid nest found along the reservoir shoreline.		

Photo No. 15	**Date:** 9/10/19	
Direction Photo Taken: N/A		
Description: *Potamogetan* species located in backwater area of reservoir southwest of the Toronto Dam.		

Photo No. 16	**Date:** 9/10/19	
Direction Photo Taken: N/A		
Description: Wild celery (*Vallisneria americana*) growing along reservoir shoreline.		

Photo No. 17	**Date:** 9/10/19
Direction Photo Taken: N/A	
Description: *Potamogetan* species and suspected *Callitriche* species growing along shoreline of the reservoir.	

Cliff Lake Reservoir

Photo No.	Date:	
1	5/15/19	
Direction Photo Taken: Southerly		
Description: Gravel, rubble, cobble substrate on east side of reservoir near Cliff Lake Dam.		

Photo No.	Date:	
2	5/15/19	
Direction Photo Taken: Southerly		
Description: Fine substrate with gravel, rubble, cobble substrate as sub-dominant.		

Photo No. 3	**Date:** 5/15/19	
Direction Photo Taken: Southerly		
Description: Gravel, rubble, cobble substrate located along the eastern side of the reservoir with areas of rocky fine substrate. Note bedrock at bottom right corner of photograph.		

Photo No. 4	**Date:** 5/15/19	
Direction Photo Taken: Southerly		
Description: Gravel, rubble, cobble substrate with scattered areas of rocky fine substrate as sub-dominant.		

Photo No. 5	**Date:** 5/15/19
Direction Photo Taken: Northeast	
Description: Large woody debris.	

Photo No. 6	**Date:** 5/15/19
Direction Photo Taken: N/A	
Description: Single Centrarchid nest in center of photograph.	

Photo No. 7	**Date:** 5/15/19	
Direction Photo Taken: Southerly		
Description: Gravel, rubble, cobble with scattered rocky fine substrate.		

Photo No. 8	**Date:** 5/15/19	
Direction Photo Taken: N/A		
Description: Three old Centrarchid nests.		

<table>
<tr><td>Photo No.
9</td><td>Date:
5/15/19</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Direction Photo Taken:
Southerly</td></tr>
<tr><td colspan="2">Description:
Gravel, rubble, cobble substrate with a lot of fine substrate and scattered areas of both rocky fine and rocky boulder substrates.</td></tr>
</table>

<table>
<tr><td>Photo No.
10</td><td>Date:
5/15/19</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Direction Photo Taken:
Easterly</td></tr>
<tr><td colspan="2">Description:
Fine substrate with scattered areas of rocky fine substrate along the reservoir margin.</td></tr>
</table>

Photo No. 11	**Date:** 5/15/19
Direction Photo Taken: Northwest	
Description: Large woody debris and some emergent wetland vegetation.	

Photo No. 12	**Date:** 5/15/19
Direction Photo Taken: Easterly	
Description: Gravel, rubble, cobble substrate with areas of scattered rocky fine substrate near water conveyance tunnel connecting to Swinging Bridge Reservoir.	

<table>
<tr><td>Photo No.
13</td><td>Date:
5/16/19</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Direction Photo Taken:
N/A</td></tr>
<tr><td colspan="2">Description:
Gravel, rubble, cobble substrate with areas of scattered rocky fine substrate along island.</td></tr>
</table>

<table>
<tr><td>Photo No.
14</td><td>Date:
5/15/19</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Direction Photo Taken:
N/A</td></tr>
<tr><td colspan="2">Description:
Rocky fine substrate with a lot of fine substrate as sub-dominant.</td></tr>
</table>

Photo No. 15	**Date:** 5/15/19
Direction Photo Taken: Southeast	
Description: Primarily fine substrate with scattered areas of rocky fine and gravel, rubble, cobble substrates near northern end of reservoir.	

Photo No. 16	**Date:** 5/16/19
Direction Photo Taken: Westerly	
Description: Large woody debris.	

Photo No.	**Date:**
17	5/16/19
Direction Photo Taken: Southerly	
Description: Rocky fine substrate with areas of rocky boulder and fine substrates with scattered emergent wetland vegetation.	

Photo No.	**Date:**
18	5/16/19
Direction Photo Taken: Southerly	
Description: Centrarchid nesting area with seven remnant nests observed.	

Photo No. 19	**Date:** 5/16/19
Direction Photo Taken: Northwesterly	
Description: Gravel, rubble, cobble substrate on western shoreline.	

Photo No. 20	**Date:** 5/16/19
Direction Photo Taken: Northwest	
Description: Large woody debris.	

Photo No. 21	Date: 5/16/19
Direction Photo Taken: Westerly	
Description: Fine substrate with area of large woody debris.	

Swinging Bridge Reservoir

Photo No. 1	**Date:** 5/14/19	
Direction Photo Taken: Easterly		
Description: Fine substrate located along the eastern side of the reservoir south of the Swinging Bridge Campground.		

Photo No. 2	**Date:** 5/15/19	
Direction Photo Taken: Southwest		
Description: Gravel, rubble, cobble substrate located near the northern end of the reservoir. Photo taken along the western side of the reservoir.		

Photo No. 3	**Date:** 5/15/19	
Direction Photo Taken: N/A		
Description: Gravel, rubble, cobble substrate located along the western side of the reservoir along a relatively wide gravel, rubble, cobble exposed beach area.		

Photo No. 4	**Date:** 5/15/19	
Direction Photo Taken: Southwest		
Description: Gravel, rubble, cobble substrate located along the western side of the reservoir along a relatively wide gravel, rubble, cobble exposed beach area.		

Photo No. 5	**Date:** 5/14/19	
Direction Photo Taken: N/A		
Description: Gravel, rubble, cobble substrate located along eastern side of the reservoir south of the Starlight Marina.		

Photo No. 6	**Date:** 5/15/19	
Direction Photo Taken: Southerly		
Description: Rocky fine substrate located on east side of reservoir north of Swinging Bridge Campground.		

Photo No. 7	**Date:** 5/15/19	
Direction Photo Taken: N/A		
Description: Rocky fine substrate with scattered rocky boulder substrate located on east side of reservoir south of Swinging Bridge Lake Marina along Starlight Road.		

Photo No. 8	**Date:** 5/14/19	
Direction Photo Taken: Northerly		
Description: Rocky fine substrate with scattered rocky boulder substrate located on east side of reservoir south of Swinging Bridge Lake Marina along Starlight Road.		

Photo No. 9	**Date:** 5/15/19	
Direction Photo Taken: Northerly		
Description: Bedrock substrate with scattered rocky fine substrate located north of the Swinging Bridge Lake Marina near the confluence of Kinne Brook.		

Photo No. 10	**Date:** 5/13/19	
Direction Photo Taken: Northerly		
Description: Rocky fine substrate.		

Photo No. 11	**Date:** 5/13/19	
Direction Photo Taken: Southerly		
Description: Fine substrate.		

Photo No. 12	**Date:** 5/14/19	
Direction Photo Taken: N/A		
Description: Gravel, rubble, cobble substrate.		

Photo No. 13	**Date:** 5/14/19	
Direction Photo Taken: N/A		
Description: Rocky fine substrate.		

Photo No. 14	**Date:** 5/14/19	
Direction Photo Taken: N/A		
Description: Rocky boulder dominant substrate with areas of bedrock.		

Photo No. 15	**Date:** 5/14/19	
Direction Photo Taken: Northerly		
Description: Rocky fine substrate with areas of rocky boulder substrate as sub-dominant.		

Photo No. 16	**Date:** 5/14/19	
Direction Photo Taken: N/A		
Description: Rocky fine substrate.		

Photo No. 17	**Date:** 5/14/19
Direction Photo Taken: Southerly	
Description: Fine substrate with areas of rocky boulder substrate.	

Photo No. 18	**Date:** 5/14/19
Direction Photo Taken: Northwest	
Description: Gravel substrate with areas of bedrock substrate.	

Photo No. 19	**Date:** 5/14/19
Direction Photo Taken: Westerly	
Description: Rocky fine substrate with areas of exposed bedrock near Swinging Bridge Dam.	

Photo No. 20	**Date:** 5/14/19
Direction Photo Taken: Westerly	
Description: Riprap substrate along Swinging Bridge Dam.	

Photo No. 21	**Date:** 5/14/19
Direction Photo Taken: Easterly	
Description: Potential Centrarchid nesting area. Site appeared to contain old Centrarchid nests.	

Photo No. 22	**Date:** 5/14/19
Direction Photo Taken: Westerly	
Description: Typical area of large woody debris.	

Photo No.	**Date:**
23	5/14/19
Direction Photo Taken: Southerly	
Description: Large woody debris.	

Photo No.	**Date:**
24	5/13/19
Direction Photo Taken: Southerly	
Description: Centrarchid nesting area.	

Photo No. 25	**Date:** 5/14/19	
Direction Photo Taken: N/A		
Description: Single mussel shell observed; appears to be *Elliptio* sp.		

Photo No. 26	**Date:** 5/13/19	
Direction Photo Taken: N/A		
Description: Single opened mussel shell observed at north end of reservoir.		

Mongaup Falls Reservoir

Photo No. 1	**Date:** 9/11/19
Direction Photo Taken: Northerly	
Description: Large woody debris on the Mongaup River in the northern section of the reservoir (facing upstream).	

Photo No. 2	**Date:** 9/11/19
Direction Photo Taken: Southeast	
Description: Fine substrate along the Mongaup River located north of the Route 43 bridge crossing.	

Photo No. 3	**Date:** 9/11/19	
Direction Photo Taken: Northerly		
Description: Fine substrate located north of the Route 43 bridge crossing.		

Photo No. 4	**Date:** 9/11/19	
Direction Photo Taken: Southeast		
Description: Riprap/artificial substrate located along the Route 43 bridge crossing of the reservoir.		

Photo No. 5	**Date:** 9/11/19
Direction Photo Taken: Southerly	
Description: Rocky fine substrate with areas of rocky boulder substrate located south of the Route 43 bridge crossing on the western side of the reservoir.	

Photo No. 6	**Date:** 9/11/19
Direction Photo Taken: Southerly	
Description: Gravel, rubble, cobble substrate located on exposed flat south of the Route 43 bridge crossing.	

Photo No. 7	**Date:** 9/11/19
Direction Photo Taken: N/A	
Description: Centrarchid nesting area on flat south of the Route 43 bridge crossing.	

Photo No. 8	**Date:** 9/11/19
Direction Photo Taken: Westerly	
Description: Fine substrate located in northeast portion of reservoir south of Route 43.	

Photo No. 9	**Date:** 9/11/19	
Direction Photo Taken: Southerly		
Description: Gravel, rubble, cobble substrate located on the northeast side of the reservoir north of the boat launch.		

Photo No. 10	**Date:** 9/11/19	
Direction Photo Taken: Easterly		
Description: Erosion potentially caused by trampling of the area by fisherman accessing the reservoir.		

Photo No. 11	**Date:** 9/11/19	
Direction Photo Taken: Northerly		
Description: Fine substrate with scattered gravel, rubble, cobble substrate on eastern side of the reservoir.		

Photo No. 12	**Date:** 9/11/19	
Direction Photo Taken: Northerly		
Description: Rocky fine substrate with gravel, rubble, cobble substrate as sub-dominant located on eastern side of the reservoir.		

Photo No.	Date:	
13	9/11/19	
Direction Photo Taken: Southerly		
Description: Gravel, rubble, cobble substrate with section of large woody debris on western side of the reservoir.		

Photo No.	Date:	
14	9/11/19	
Direction Photo Taken: Southwest		
Description: Gravel, rubble, cobble substrate from submerged rock wall located on the eastern side of the reservoir.		

Photo No. 15	**Date:** 9/11/19
Direction Photo Taken: Southwest	
Description: Partially submerged large woody debris on western side of the reservoir.	

Photo No. 16	**Date:** 9/11/19
Direction Photo Taken: Southerly	
Description: Rocky fine substrate with scattered rocky boulder substrate on eastern side of the reservoir.	

Photo No. 17	**Date:** 9/11/19	
Direction Photo Taken: Southerly		
Description: Rocky fine substrate on western side of the reservoir north of Mongaup Falls Dam.		

Photo No. 18	**Date:** 9/11/19	
Direction Photo Taken: Northerly		
Description: Rocky fine substrate on the eastern side of the reservoir near Mongaup Falls Dam.		

Rio Reservoir

Photo No.	Date:
1	5/17/19
Direction Photo Taken: N/A	
Description: Rocky fine substrate with rocky boulder substrate as sub-dominant.	

Photo No.	Date:
2	5/17/19
Direction Photo Taken: N/A	
Description: Large woody debris.	

Photo No.	**Date:**
3	5/17/19
Direction Photo Taken: N/A	
Description: Gravel, rubble, cobble substrate.	

Photo No.	**Date:**
4	5/17/19
Direction Photo Taken: N/A	
Description: Gravel, rubble, cobble substrate.	

Photo No. 5	**Date:** 5/17/19	
Direction Photo Taken: N/A		
Description: Large woody debris.		

Photo No. 6	**Date:** 5/17/19	
Direction Photo Taken: N/A		
Description: Gravel, rubble, cobble substrate.		

Photo No. 7	Date: 5/17/19
Direction Photo Taken: N/A	
Description: Large woody debris.	

Photo No. 8	Date: 5/17/19
Direction Photo Taken: N/A	
Description: Rocky fine substrate with some rocky boulder substrate scattered throughout.	

Photo No. 9	**Date:** 5/17/19	
Direction Photo Taken: N/A		
Description: Rocky fine substrate with some rocky boulder substrate scattered throughout.		

Photo No. 10	**Date:** 5/17/19	
Direction Photo Taken: N/A		
Description: Gravel, rubble, cobble substrate mixed with some rocky fine substrate.		

Photo No. 11	**Date:** 5/17/19	
Direction Photo Taken: Northerly		
Description: Large woody debris in area with fine substrates.		

Photo No. 12	**Date:** 5/17/19	
Direction Photo Taken: N/A		
Description: Rocky boulder substrate with areas of rocky fine substrate as sub-dominant.		

<table>
<tr><td>Photo No.
13</td><td>Date:
5/17/19</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Direction Photo Taken:
N/A</td></tr>
<tr><td colspan="2">Description:
Rocky fine substrate with areas of rocky boulder substrate as sub-dominant with some gravel, rubble, cobble inclusions.</td></tr>
</table>

<table>
<tr><td>Photo No.
14</td><td>Date:
5/17/19</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Direction Photo Taken:
N/A</td></tr>
<tr><td colspan="2">Description:
Rocky boulder substrate with areas of rocky fine substrate as sub-dominant.</td></tr>
</table>

Photo No.	Date:
15	5/17/19
Direction Photo Taken: N/A	
Description: Gravel, rubble, cobble substrate.	

Photo No.	Date:
16	5/17/19
Direction Photo Taken: N/A	
Description: Gravel, rubble, cobble. Some cobble size material is “platy”.	

Photo No. 17	**Date:** 5/17/19	
Direction Photo Taken: Southerly		
Description: Relatively large area of accumulated large woody debris.		

Photo No. 18	**Date:** 5/17/19	
Direction Photo Taken: N/A		
Description: Gravel, rubble, cobble substrate.		

Photo No. 19	Date: 5/17/19	
Direction Photo Taken: N/A		
Description: Centrarchid nest observed in center of photograph.		

Photo No. 20	Date: 5/17/19	
Direction Photo Taken: N/A		
Description: Gravel, rubble, cobble substrate.		

<table>
<tr><td>Photo No.
21</td><td>Date:
5/17/19</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Direction Photo Taken:
N/A</td></tr>
<tr><td colspan="2">Description:
Rocky fine substrate with some rocky boulder substrate.</td></tr>
</table>

<table>
<tr><td>Photo No.
22</td><td>Date:
5/17/19</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Direction Photo Taken:
N/A</td></tr>
<tr><td colspan="2">Description:
Rocky fine substrate with some rocky boulder substrate.</td></tr>
</table>

Photo No. 23	**Date:** 5/17/19
Direction Photo Taken: N/A	
Description: Small band of Phragmites (*Phragmites australis*) growing along western shoreline in southern section of reservoir.	

Photo No. 24	**Date:** 5/17/19
Direction Photo Taken: N/A	
Description: Small band of Phragmites growing along western shoreline in southern section of reservoir.	

Appendix E

Updated Fish Entrainment and Turbine Survival Study

Fish Entrainment and Turbine Survival Study

Mongaup River Hydroelectric Projects:

Swinging Bridge Hydroelectric Project (No. 10482)

Mongaup Falls Hydroelectric Project (No. 10481)

Rio Hydroelectric Project (No. 9690)

February 2020

Contents

Tables

Figures

List of Acronyms

A	Area
°C	degree Celsius
°F	degrees Fahrenheit
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
DO	dissolved oxygen
DOE	United States Department of Energy
DRBC	Delaware River Basin Commission
EPRI	Electric Power Research Institute
FERC or Commission	Federal Energy Regulatory Commission
FPA	Federal Power Act
fps	feet per second
ft	feet
ILP	Integrated Licensing Process
in	inches
mg/L	milligram per liter
mm	millimeter
MW	Megawatt
NYSDEC	New York State Department of Conservation
PAD	Pre-Application Document
Projects	Mongaup River Hydroelectric Projects
PSP	Proposed Study Plan
Q	flow
rpm	Rotations per Minute
RSP	Revised Study Plan
SD1	Scoping Document 1
SPD	Study Plan Determination
U.S.C.	United States Code
USGS	United States Geological Survey
V	velocity
YOY	Young of year

1.0 Introduction and Background

1.1 Introduction

Eagle Creek Hydro Power, LLC; Eagle Creek Water Resources, LLC; and Eagle Creek Land Resources, LLC (collectively and hereinafter "Eagle Creek") are the Licensees of the Swinging Bridge Hydroelectric Project (FERC No. 10482), the Mongaup Falls Hydroelectric Project (FERC No. 10481), and the Rio Hydroelectric Project (FERC No. 9690) (collectively "Mongaup River Projects" or "Projects"). Collectively, the Projects are located on Black Lake Creek, Black Brook, and the Mongaup River in Sullivan and Orange Counties, New York.

On April 14, 1992, the Federal Energy Regulatory Commission ("FERC" or "Commission") issued three original and separate licenses for the operation of the Projects in accordance with the Commission's delegated authority under the Federal Power Act. Each Project's original license was issued for a term of 30 years and expires on March 31, 2022. Consequently, Eagle Creek is pursuing new licenses for the Projects and has opted to use the Commission's Integrated Licensing Process (ILP), as detailed at 18 Code of Federal Regulations (CFR) Part 5 of the Commission's regulations.

In accordance with 18 CFR §5.15, Eagle Creek conducted studies pursuant to Eagle Creek's January 10, 2018 Revised Study Plan (RSP) as modified in the Commission's February 9, 2018 Study Plan Determination (SPD). In addition, following the 2019 Initial Study Report (ISR) and subsequent ISR Meeting, Eagle Creek updated the 2018 study report to incorporate additional data (related to the newly installed Unit 3 at the Swinging Bridge Project) required by the Commission's June 10, 2019 SPD. This report describes the methods and results of the Fish Entrainment and Turbine Survival Study conducted in support of obtaining new licenses for the Projects.

1.2 Background

In the February 9, 2018 SPD, the Commission provided its review of the 1992-1993 fish entrainment study (Lawler, Matusky and Skelly 1994) performed at the Projects and found that the entrainment data collected between November 1992 and March 1993 is reliable and sound and would inform an analysis of late-fall, winter, and early spring entrainment at the Projects sufficient to inform potential license applications. However, the Commission required Eagle Creek to conduct two seasonal experimental gill net sample events during spring, summer, and fall (a total of six sampling events) to characterize the occurrence, relative abundance, and size distribution of fish in proximity to the Projects' intakes during the months that were not equitably sampled during the 1992-1993 study. The gill net sampling provides complementary data to the prior study, as well as baseline information to guide the qualitative desktop analysis of entrainment, impingement and turbine passage survival for species encountered in the vicinity of each of the Projects' powerhouse intakes.

Hydroelectric facilities have the potential for some level of entrainment of biota into intakes. The potential for fish to become entrained or impinged at a hydroelectric facility is dependent on a variety of factors such as fish life history, size, and swimming ability, as well as operating regimes, inflow, magnitude and duration of intake velocities, trashrack bar spacing, and intake/turbine configurations (Cada et al. 1997). Proximity to feeding and rearing habitats also affect the potential for a fish to become entrained. These factors and several others are used to make general assessments of entrainment and impingement potential at hydroelectric projects using a desktop study approach.

Numerous fish turbine passage survival evaluations have been conducted over the past few decades, which provide a considerable data set to use to qualitatively assess turbine passage survival at the Projects. Winchell *et al*. (2000) summarized turbine passage survival data reported in the Electric Power Research Institute (EPRI) (1997) database by turbine type and characteristics and fish size. Based on the consistency of results from numerous studies, it is apparent that fish size rather than species is the primary variable in determining the probability of survival through turbines (Franke et al. 1997; Winchell et al. 2000). Smaller fish are more likely to survive turbine passage. In addition, species-specific estimates of fish mortality through Francis type turbines (EPRI 1992) indicate that survival rates across species are generally uniform.

2.0 Goals and Objectives

The primary purpose of this study is to supplement the information collected during and used in support of the 1992-1993 entrainment study at the Projects to update the mortality/turbine survival analysis for each Project and characterize the occurrence, relative abundance, and size distribution of fish in proximity to the Projects' intakes.

3.0 Study Area

The study area includes the Swinging Bridge, Mongaup Falls, and Rio reservoirs, powerhouses, and associated intakes.

3.1 Intakes and Water Conveyance

3.1.1 Swinging Bridge

The Swinging Bridge Development includes three powerhouses, one of which (Unit No. 1 Powerhouse) has been permanently decommissioned since 2005. Unit Nos. 2 and 3 are supplied from the Swinging Bridge Reservoir through the same intake and a concrete-lined tunnel running approximately 784 feet around the west end of the dam, connected to an all-steel penstock approximately 188 feet long. The centerline of the tunnel intake is located at elevation 1,020 feet. The lined tunnel has a diameter of approximately 9 feet, 9 inches; the steel penstock has a diameter of 10 feet. A penstock measuring approximately 20 feet long and 4 feet in diameter was installed off the existing penstock of Unit No. 2 to convey flows to the (newly constructed) Unit No. 3 powerhouse. The intake is covered by an inclined, 22-foot-wide, 32.3-foot-high trashrack from elevation 1,015 to 1,045 feet[1]. The trashracks have bar clear spacing of 2.6 inches.

[1] Elevations expressed in NGVD29, unless indicated otherwise.

A Broome headgate, located 145 feet downstream of the intake, controls flows to the scroll case of the Swinging Bridge No. 2 and No. 3 units. The gate is 8.5 feet wide and 11.5 feet high and is located in a shaft driven from elevation 1,085 to 1,024.9 feet.

A steel surge tank is located approximately 571 feet downstream of the intake. The surge tank is 30 feet in diameter with wood exterior, which is located on the longitudinal centerline of the penstock. The top of the foundation of the penstock is at elevation 1,026 feet and is hydraulically effective to elevation 1,098 feet.

3.1.2 Mongaup Falls

The Mongaup Falls Project has one powerhouse, which is supplied from the Mongaup Falls Reservoir by an 8-foot-diameter, wood-stave penstock with a steel penstock section. The inclined 14-feet-wide, 32-feet-high trashrack covers the intake entrance to the penstock from elevation 900 to 932 feet. The trashracks have bar clear spacing of 1.7 inches. The penstock is 2,650 feet long and is supported above ground by wood or steel cradles, respectively, on rock or concrete foundations throughout its entire length.

Water flow into the penstock is controlled by a Broome Gate located on the centerline of and in front of the penstock inlet. The bottom of the intake is at elevation 900 feet and the top is at 912 feet. The gate is 10 feet wide by 12 feet high and is raised and lowered by an electric hoist. A steel surge tank is located approximately 125 feet upstream of the powerhouse. This tank, 106 feet high, and 26 feet in diameter, is hydraulically efficient to elevation 961.5 feet. A 9-foot-diameter, concrete-encased steel pipe manifold, reducing down into 4 concrete-encased steel pipe legs, each 5 feet in diameter, directs water into each of the four hydraulic turbines at the powerhouse.

3.1.3 Rio

The Rio Project includes two powerhouses, which utilize the same intake: Rio Minimum Flow Powerhouse (located immediately downstream of the dam) and Rio Main Powerhouse. The Rio Main Powerhouse is supplied by the Rio Reservoir by means of a 7,000-foot steel penstock, 11 feet in diameter. The Rio Minimum Flow Powerhouse is supplied with water by a 4-foot-diameter, high-density polyethylene penstock, which tees off the existing steel penstock for the main powerhouse about 300 feet downstream of the dam and travels about 100 feet downhill to the minimum flow powerhouse on the riverbank.

The intake structure to the penstock consists of the trashracks, intake gate, and entrance to the penstock. The trashrack structure is approximately 15 feet wide and extends approximately from the top of the dam (elevation 810 feet) to elevation 764 feet. The trashracks have a bar clear spacing of 2.9 inches. A steel intake gate measures 14 feet high by 11 feet wide. The intake opening measures 12 foot, 6 inches high by 9 foot, 6 inches wide. The gate and its operator are located in the gate house. Water exits the intake area through a 90-foot-long steel elbow penstock, with centerline at an elevation of 750 feet. This steel section connects into the steel penstock. The 7000-foot-long penstock is connected to a surge tank. The surge tank has a diameter of 40 feet, is 65 feet high, and is constructed of riveted steel plate. The surge tank is hydraulically efficient to an elevation of 835 feet.

3.2 Turbines

The Swinging Bridge Development has one vertical-axis Francis turbine (Unit No.2) and one horizontal-axis Francis turbine (Unit No.3). The Mongaup Falls Powerhouse has four vertical-axis Francis turbines. The Rio Main Powerhouse has two vertical-axis turbines, and the Rio Minimum Flow Powerhouse has one horizontal-axis Francis turbine. Turbine information for the Projects is provided in Table 3-1.

TABLE 3-1
TURBINE DATA FOR MONGAUP RIVER PROJECTS

	Swinging Bridge Powerhouse (Unit No. 2)	Swinging Bridge Minimum Flow Powerhouse (Unit No. 3)	Mongaup Falls Powerhouse (Units No. 1-4)	Rio Minimum Flow Powerhouse (Unit No. 3)	Rio Main Powerhouse (Units No. 1-2)
Number of Units	1	1	4	1	2
Type	Francis	Francis	Francis	Francis	Francis
Head	110 feet	127 feet	110 feet	98 feet	170 feet
Maximum Hydraulic Capacity	1,015 cfs	125 cfs	155 cfs (each unit)	120 cfs	435 cfs (each unit)
Operating Speed	240 rpm	720 rpm	360 rpm	720 rpm	360 rpm
Number of Blades	18	14	16	14	14
Runner Diameter	61 inches	29 inches	42 inches	29 inches	53 inches
Efficiency	86.8%	91.6%	82.6%	85.9%	84.3%

4.0 Methodology

4.1 Fisheries Community in Projects' Reservoirs

Historic and 2018 fish survey results were reviewed to define the fisheries community in the Projects' reservoirs in support of identifying the target species to evaluate for entrainment potential and turbine survival. In addition to the 2018 baseline fisheries survey in the Projects' reservoirs, six separate experimental gill net surveys were performed during the spring, summer, and fall of 2018 to identify and characterize fish species that occur in the vicinity of the Swinging Bridge, Mongaup Falls, and Rio intakes. Gill nets were set at the Swinging Bridge, Mongaup Falls, and Rio reservoirs near and at the depth of the intakes on May 24, June 13, July 24, September 19, October 2, and October 17, 2018 (Table 4-1).

TABLE 4-1
GILL NET DEPTHS BELOW WATER SURFACE DURING INTAKE GILL NET SURVEYS

Date	Swinging Bridge (feet)	Mongaup Falls (feet)	Rio (feet)
5/24/2018	40 - 62	8 - 30	30 - 70
6/13/2018	32 - 64	8 - 39	30 - 70
7/24/2018	46 – 74	5 - 35	≤ 44
9/19/2018	16 - 44	5 - 35	34 - 75
10/2/2018	24 - 66	5 - 35	63 - 82
10/17/2018	38 - 72	6 - 48	16 - 75

The monofilament experimental gill nets consisted of several panels of different mesh sizes to allow catch of a range of fish sizes. Each net consisted of five, 6-feet-deep by 25-feet-long panels (125 feet total). Each net contained a 1.0-, 1.5-, 2.0-, 2.5-, and 3.0-inch stretched mesh panel. A pair of nets were set at each of the three sites in the evening and retrieved the following morning (an overnight set lasted between 11 and 16 hours). The nets were set upstream of the intakes and perpendicular to the shorelines bordering the dams. The nets were set along the bottom at the depth of the intake. The depth of the net also varied along its length as it followed the topography of the reservoir bottom. One net was set just upstream of the other to allow the larger- and smaller-mesh net panels to overlap at the point closest to the intake. During retrieval of the nets, captured specimens were identified, measured, weighed, and subsequently released. The number of units generating at each facility during the period of time that the nets were set was also recorded.

4.2 Life History and Habitat Requirements

A description of the life history, habitat requirements, and behavior of fish species was compiled to determine the likelihood of presence near the Swinging Bridge, Mongaup Falls, and Rio intakes and to evaluate entrainment potential. The "Traits Based Assessment" of Čada and Schweizer (2012) was used to qualitatively assess the potential entrainment risk for fish species, which considers each species' primary location within the reservoir, preferred habitat, local movements and reproductive strategy. Biotic habitat conditions such as the presence of forage fish can influence the behavior of piscivorous fish species in the vicinity of intake structures. Species-specific behavioral requirements determine if and when a given life stage interacts with intake operation. The potential for each species to be susceptible to entrainment can be determined based on their life history characteristics in relation to the location of the intake structures at each reservoir.

Categories of entrainment potential, based on the likelihood that a fish species/life stage will be located near the intake structures, are described as:

- **None** – species/life stage (*e.g.*, adult, spawning, or juvenile) are not known to prefer the habitat near the intake structures
- **Minimal** – species may only occasionally be found occupying the habitat near the intake structures
- **Moderate** – species routinely or seasonally found occupying the habitat near the intake structures
- **High** – species likely to be found occupying the habitat near the intake structures

Fish species with similar traits, such as life history, habitat requirements, behavior, and swimming performance, are grouped to concisely describe their entrainment potential, with a focus on game, forage, and rough or benthic dwelling fish. Species groupings include:

- Trout
- Walleye
- Black bass
- Pickerel
- Panfish

- Forage fish, such as alewife, minnows, shiners and darters
- Benthic fish, such as carp, suckers and catfish

4.3 Fish Swimming Capabilities

The ability for an individual fish to avoid being impinged or entrained at a powerhouse intake depends on its swimming performance (Castro-Santos and Haro 2005). The swimming performance is directly related to the size of an individual fish; however, the swimming capability also varies among species based on morphological differences. Although there is no standard method that defines how swimming performance is measured, three commonly used definitions or types of swim speed are described in the scientific body of literature for fish (Katopodis and Gervais 2016) as described below.

1) Cruising or sustained swim speeds can be maintained indefinitely (Bain and Stevenson 1999).
2) Prolonged swim speeds can be maintained between 5 and 8 minutes (Bain and Stevenson 1999).
3) Burst (also called startle, darting or sprint) swim speeds can be maintained for less than 20 seconds (Beamish 1978).

Burst swim speeds are used to assess if a fish can adequately escape involuntary entrainment. If a fish has a greater burst swim speed than the turbine intake velocity, it is capable of moving away from the intake flow field to avoid entrainment. To assess swimming capabilities among species found in the Projects' reservoirs, burst swim speeds were compiled from the available scientific literature. When species-specific data were unavailable, data from one or more closely related surrogate species of similar body size and morphology were used.

4.4 Intake Velocity Calculation

The water approach velocity at the surface of each of the intake trashracks (i.e., cross sectional velocity) for the Projects was calculated. First, the wetted surface areas of the intake trashracks was calculated as the product of the width and the height of the trashracks. Second, the maximum flow through the intake trashracks was defined as the total maximum hydraulic capacity at the Projects' intakes. Finally, the trashrack cross sectional velocity was calculated by dividing the total hydraulic capacity by the trashrack wetted area:

Wetted Area of Intake Trashrack (A) = Width of Trashrack (W) x Height of Trashrack (H)

Trashrack Cross Sectional Velocity (V) = Total Hydraulic Capacity (Q) / Wetted Area of Trashrack (A)

4.5 Impingement and Turbine Entrainment Potential

To ascertain whether or not a certain size fish of a particular species is likely to be impinged or entrained, the burst swim speeds were compared to the calculated cross-sectional velocities one foot in front of the intake at maximum hydraulic capacity. The species and sizes whose burst swim speeds are less than the cross sectional velocities at each project intake are likely to be impinged by the trashracks or entrained in the turbine(s) depending on the size of an individual.

Proportional estimates of body width to total length (scaling factor) were compiled by Smith (1985) for the identified target species. If scaling factors were not available for a particular species, a surrogate from the same genus was used. This scaling factor was then used to determine the minimum length of each species excluded from the intake by the trashracks at each Project. The trashrack clear spacing widths were divided by the scaling factors to calculate this minimum length for each species. These minimum lengths were compared to the length of the longest individual (maximum length) of species collected during the 2018 fisheries surveys in the Projects' reservoirs. If the calculated minimum length at which an individual is excluded from the Project's trashrack was less than the maximum length collected in 2018 for that species, it was designated as a size at which an individual avoids entrainment. If the calculated minimum length of exclusion was larger than the maximum length collected for a particular species, it was designated as a size that would not be excluded from entraining. American Eel (*Anguilla rostrata)* minimum exclusion lengths at each project were included for informational purposes.

4.6 EPRI Entrainment Database Review

The EPRI (1997) entrainment database provides results from entrainment field studies conducted at 43 hydroelectric facilities east of the Mississippi River using full-flow tailrace netting. The database contains site characteristics of each of these facilities. It also provides the total number of individuals collected of each species each month for each of the sites. Furthermore, the monthly species counts are separated into variable size classes ranging from 2 to 30 inches.

A comparison of the EPRI entrainment database was made to provide a literature based assessment of potential entrainment at the Projects. To do so, the EPRI database was filtered for characteristics that match or are similar to those found at the Mongaup Falls, Swinging Bridge and Rio projects including the following:

1) Trashrack clear spacing between 1.7 and 2.9 inches;
2) Powerhouse hydraulic capacities ranging from 620 cfs to 1,140 cfs (see Table 5-4 below);
3) Plants operated in peaking or unknown mode;
4) Same or surrogate fish species collected in the Projects' reservoirs (although not collected upstream of Rio Dam in 2018, American Eel is included); and
5) Summarized collection totals during the months of May – October.

The monthly collection totals were summarized into a single total in each size class for the species collected in the Projects' fisheries survey (or a closely related surrogate). The smaller size classes (<2 inches, 2 to 4 inches, 4 to 6 inches, and 6 to 8 inches) were combined into two size classes (<4 inches and 4 to 8 inches).

4.7 EPRI Turbine Survival Database Review

Similar to the comparison of the EPRI entrainment database review, the EPRI turbine survival database was reviewed to provide an equitable literature-based comparison of the turbine survival estimates developed for the Projects. To do so, the EPRI database was filtered for characteristics that match or are similar to those found at the Mongaup Falls, Swinging Bridge and Rio powerhouses including the following:

1) Vertical and horizontal Francis turbines;
2) Rated heads between 98 and 170 feet;

3) Turbine operating speeds between 240 and 720 rpm;
4) Turbine runner diameters between 29 and 61 inches;
5) Same or surrogate fish species as collected in the Projects' intake gill nets (although not collected upstream of Rio Dam in 2018, American Eel is included)

The immediate and 48-hour survival estimates were selected as they provided the greatest range of time difference post-turbine passage for each species.

4.8 Turbine Survival Evaluation

To estimate survival of fish that may be entrained and passed through the turbines at the Projects' powerhouses, mortality studies conducted at similar hydroelectric facilities with similar turbine types and hydraulic capacities to those at the Projects were examined. Additionally, theoretical predictions of turbine passage survival performed by the Department of Energy (DOE) (Franke et al. 1997) were used to estimate a survival rate using a blade-strike model. The model uses various turbine, fish and operations characteristics to calculate a strike and survival probability. The probability of blade strike in the model is based on several factors, including the number of runner blades, fish length, runner blade speed, turbine type, runner diameter, turbine efficiency, and total discharge. The parameters are inputs into the model which predict survival for a fish of any species at 1-inch length increments. The model calculations and input parameters vary slightly according to the type of turbine being evaluated. In the case of the Projects, they all employ Francis turbines, thus, the probability of strike equation is:

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\sin\alpha_t \cdot \frac{B}{D_1}}{2Q_{wd}} + \frac{\cos\alpha_t}{\pi} \right]$$

Descriptions of the variables in the equation are:

P	=	Probability of strike
N	=	Number of turbine blades
L	=	Fish length
D	=	Runner diameter
D_1	=	Diameter of runner at inlet
λ	=	Strike mortality correlation factor
B	=	Runner height at inlet
Q_{wd}	=	Discharge coefficient
α_t	=	Angle to tangential of absolute flow upstream of runner

The equation for predicted survival, S, is:

$$S = 1 - P$$

The discharge coefficient, $Q_{wd,}$ is derived by the following equation:

$$Q_{wd} = Q \div (\omega D^3)$$

Descriptions of the additional variables in the discharge coefficient equation are:

Q	=	Maximum turbine flow rate
ω	=	Rotational speed

The angle to tangential of absolute flow upstream of runner is derived by the following equation:

$$\tan(90-\alpha_i)=\frac{2\pi E_{wd}\cdot\eta}{Q_{wd}}\cdot\frac{B}{D_1}+\frac{\pi\cdot 0.707^2}{2Q_{wd}}\frac{B}{D_1}\left(\frac{D_2}{D_1}\right)^2-4\cdot 0.707\cdot\tan\beta\frac{B}{D_1}\frac{D_1}{D_2}$$

An additional variable in the angle to tangential of absolute flow equation is:

E_{wd}	=	Energy coefficient

The energy coefficient is derived by the following equation:

$$E_{wd} = \frac{g{\cdot}H}{(\omega\cdot D)^2}$$

In the energy coefficient equation, g is acceleration of gravity and H is the net head of the turbine.

Also, included in the angle to tangential of absolute flow equation is the following variable:

B	=	Relative flow angle at runner discharge

The relative flow angle at runner discharge is calculated by the following equation:

$$\tan\beta=\frac{0.707\cdot\frac{\pi}{8}}{\xi\cdot Q_{wd}opt\left(\frac{D_1}{D_2}\right)^3}$$

The additional variables in the relative flow angle equation are:

ξ	=	Ratio between Q with no exit swirl and Qopt
Qopt	=	Turbine discharge at best efficiency
D_2	=	Diameter of runner at discharge

Survival predictions were calculated for each turbine at each facility. The survival predictions were calculated at 1-inch intervals up to the length of the longest individual of any species collected in the intake gillnets. The strike mortality correlation factor also varies according to where on the body the fish is struck by the blade. For example, a blade strike at the head is more likely to cause mortality than a strike at the tail. Finally, this correlation factor varies according to how the fluid dynamics at the leading edge of the blade influence an individual's movement around this blade feature,(i.e., the leading edge blade thickness influences probability of survival). Franke et al. (1997) suggested strike mortality correlation factors, λ, between 0.1 and 0.2 to address these varying conditions that influence the likelihood of a blade strike. For this reason, correlation factors of 0.10, 0.15, and 0.20 were used in the probability of strike calculations.

5.0 Results

5.1 Fish Community in the Projects' Reservoirs

The results of the general fisheries survey performed in 2018 confirmed the fish communities of the Project reservoirs consist of common warmwater fishes. The apex predators consist of popular gamefish species such as Chain Pickerel (*Esox niger),* Walleye (*Sander vitreus)*, black basses (*Micropterus)* and trout. Brown Trout (*Salmo trutta)* and Walleye populations persist as a result of stocking. The majority of the fish community consists of panfish species such as Bluegill (*Lepomis macrochirus)*, Pumpkinseed (*Lepomis gibbosus)*, Redbreast Sunfish (*Lepomis auritus)*, Rock Bass (*Ambloplites rupestris)*, and Yellow Perch (*Perca flavescens)*. Numerous benthic dwelling species such as Brown Bullhead (*Ameiurus nebulosus)*, Yellow Bullhead (*Ameiurus natalis)*, White Sucker (*Catastomus commersoni)* and Common Carp (*Cyprinus carpio)* are present. Forage fish are also present. Alewife (*Alosa pseudoharengus)* is present also due to historic stocking efforts. Other forage species present include White Perch (*Morone Americana)*, Bluntnose Minnow (*Pimephales notatus*), Common Shiner (*Luxilus cornutus)*, and Golden Shiner (*Notemigonus crysoleucas)*. The forage species is the group that differs greatest between the historic and 2018 collections (as reported in the Pre-Application Document filed with FERC in 2017 [Eagle Creek 2017] as well as the Fisheries Study Report included as Appendix C of this Initial Study Report).

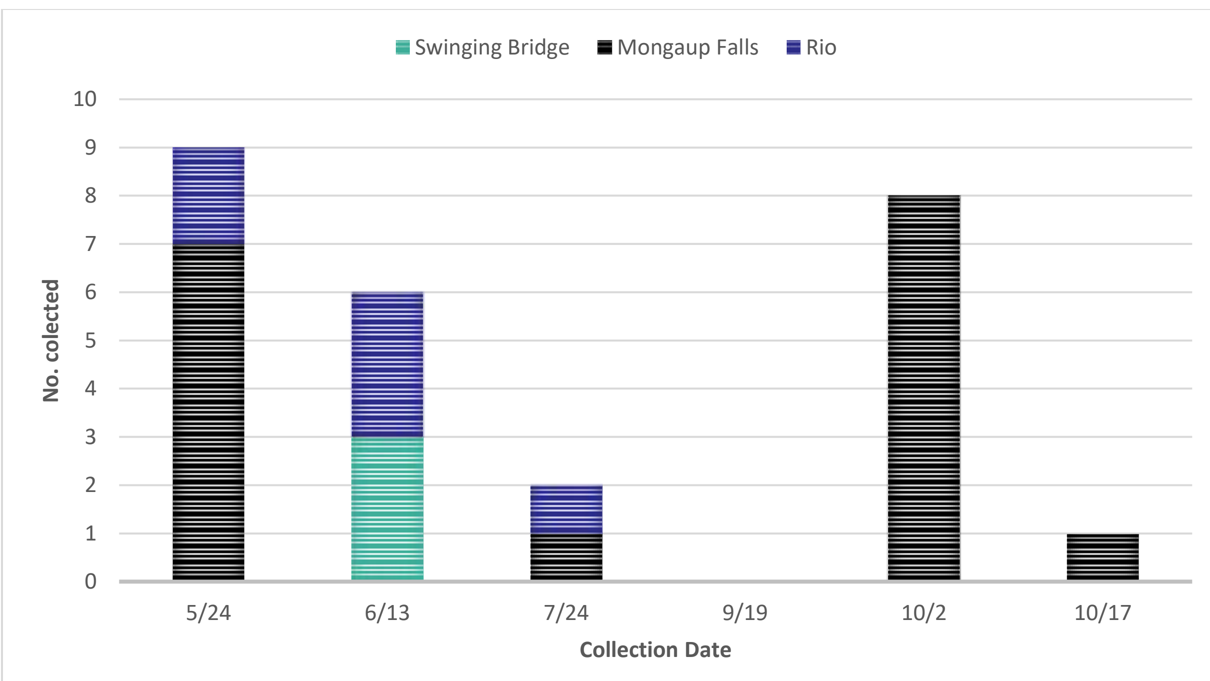
During the six experimental intake gill net surveys at the three reservoirs in 2018, the total number of individuals collected among all nets and dates was 26. The greatest number of individuals of a single species was nine for both Walleye and White Sucker. Other species collected were Brown Bullhead, Brown Trout, Chain Pickerel, White Perch and Yellow Bullhead (Table 5-1). The greatest number of individuals collected during a survey event were eight on October 2 and seven on May 24, both at the Mongaup Falls Reservoir. The surveys at the Swinging Bridge Reservoir had the lowest number of individuals collected during all survey events, limited to three on June 13. No individuals were collected at any location on September 19. The Mongaup Falls Reservoir was the only location where individuals were collected in October (Figure 5-1).

TABLE 5-1
FISH SPECIES COLLECTED IN THE VICINITY OF THE PROJECTS' INTAKES

Reservoir	Date	Generation[1] (Y/N)	Brown Bullhead	Brown Trout	Chain Pickerel	Walleye	White Perch	White Sucker	Yellow Bullhead	Total
Swinging Bridge	5/24	Y	0	0	0	0	0	0	0	**0**
	6/13	N	0	0	0	**1**	0	**2**	0	**3**
	7/24	N	0	0	0	0	0	0	0	**0**
	9/19	N	0	0	0	0	0	0	0	**0**
	10/2	Y	0	0	0	0	0	0	0	**0**
	10/17	Y	0	0	0	0	0	0	0	**0**
Mongaup Falls	5/24	Y	0	**3**	**1**	0	0	**2**	**1**	**7**
	6/13	N	0	0	0	0	0	0	0	**0**
	7/24	Y	0	0	0	0	0	**1**	0	**1**
	9/19	Y	0	0	0	0	0	0	0	**0**
	10/2	Y	**1**	0	0	**2**	**1**	**4**	0	**8**
	10/17	Y	0	0	0	**1**	0	0	0	**1**
Rio	5/24	Y	0	0	0	**2**	0	0	0	**2**
	6/13	Y	**1**	0	0	**2**	0	0	0	**3**
	7/24	Y	0	0	0	**1**	0	0	0	**1**
	9/19	Y	0	0	0	0	0	0	0	**0**
	10/2	Y	0	0	0	0	0	0	0	**0**
	10/17	Y	0	0	0	0	0	0	0	**0**
	Total	--	**2**	**3**	**1**	**9**	**1**	**9**	**1**	**26**

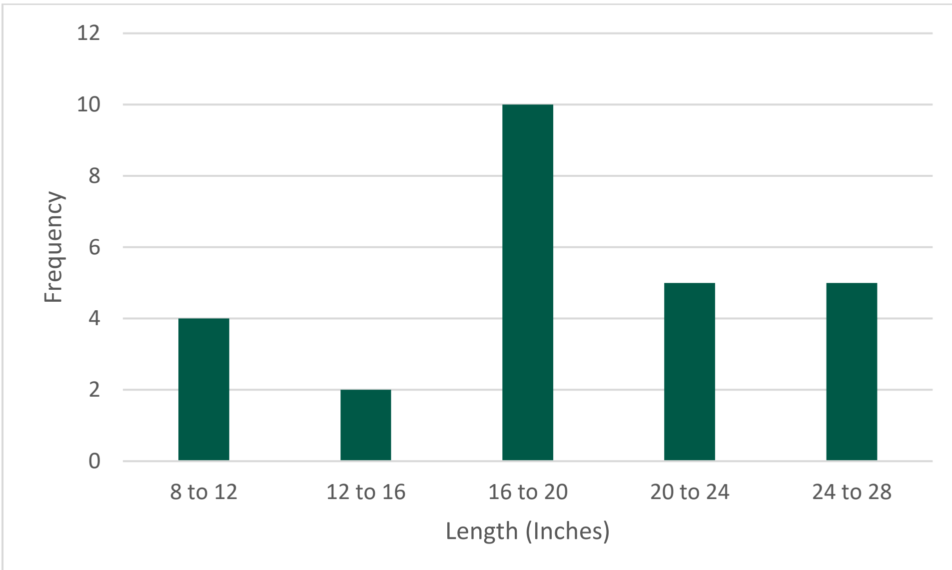
[1]Y indicates generation occurred for all or a portion of the net set time.

FIGURE 5-1
NUMBER OF INDIVIDUALS COLLECTED IN THE VICINITY OF THE PROJECTS' INTAKES



The length frequencies of the majority of the individuals collected were in the 16 – 24 inch length category (Figure 5-2). The two Bullhead species were the shortest of all species with lengths in the 8 – 12 inch category. Two White Sucker individuals were in the 12 – 16 inch length category. The three Brown Trout individuals were in the 24 – 28 inch length category. Walleye lengths were between 16 – 28 inches.

FIGURE 5-2
LENGTH FREQUENCIES OF INDIVIDUALS COLLECTED IN THE VICINITY OF THE PROJECTS' INTAKES



In support of the Water Quality Study (provided as Appendix F in the Initial Study Report), continuous dissolved oxygen (DO) and water temperature data as well as profile water quality data were collected in the vicinity of the intakes in the Projects' reservoirs from late April through early November 2018.

- **Swinging Bridge Reservoir**: Thermal stratification began to develop in early June, was strongly developed by mid-June, and continued through October. Depth of the thermocline moved over time establishing above the Unit No. 2 and 3 intake in June, then at the Unit No. 2 and 3 intake in July and gradually moving downward in August until eventually dissolved by late October. DO concentrations at the intake depth varied with the depth of stratification, with anoxic DO conditions occurring at the intake depth from late July to mid-September. By mid-October, the layers of stratification began to move downward in the water column as lake turnover occurred.
- **Mongaup Falls Reservoir**: A weak and temporary thermocline began to develop in early June, became more established by mid-June, and primarily dissolved by early August. The weak thermocline remained above the intake depth through July. A strong DO stratification was established from late August to late September when DO concentrations at the surface rapidly decreased, then were relatively uniform with depth (including the intake depth) until decreasing near the bottom. By late September, it appears fall turnover had occurred. DO concentrations at the intake depth generally remained above 6 mg/L between April and November.
- **Rio Reservoir**: Thermal stratification was evident throughout the entire monitoring period with variable strengths. DO concentrations at the intake depth were generally greater than 4 mg/L during the summer

and greater than 6 mg/L for much of the season. By early to mid-October, it appears that the layers of stratification began to dissolve and move downward in the water column (with anoxic conditions near the bottom) as lake turnover occurred.

5.2 Life History and Habitat Requirements

5.2.1 Trout

Brook and Brown Trout were either historically or are currently found in one or more of the Projects' reservoirs. Adult and juvenile trout require clear, cold, well-oxygenated waters of streams, rivers, ponds, lakes and reservoirs (Table 5-2). In addition, trout are generally intolerant of DO concentrations ≤ 5 mg/L (Raleigh 1982) and temperatures greater than 26 ^{0}C (Werner 2004). Adults of both species spawn in October and November in streams with clean gravel bottoms (Stanton 2000; Werner 2004). Successful trout spawning would occur in the riverine sections upstream of each reservoir or in adjoining tributaries with suitable water temperatures and substrate conditions, which are not found in the reservoirs.

Because spawning habitat is not in the vicinity of the intakes, entrainment of spawning adults is not a concern. However, because of their preference for cool and well oxygenated water, adult trout have a moderate potential of entrainment in the reservoirs during time periods of thermal stratification as long as DO has not been depleted in the hypolimnion. Based on the water quality data collected in 2018 at the Projects' reservoirs (Figures 5-3 through 5-11), depleted DO concentrations (less than 4 mg/L) occur during periods of thermal stratification at the depths where the intakes are located. Therefore, trout may be less likely to be in the vicinity of the intake structures during these periods of depleted DO concentrations.

5.2.2 Walleye

Walleye are present in the Mongaup River basin as a result of a large-scale stocking effort that has lasted nearly a century (Carlson et al. 2016). Walleye usually occur in larger rivers and lakes and prefer a bottom of loose aggregates. They are generally found in deeper waters during the day and tend to move into shallower areas during heavy cloud cover and at night for feeding (Table 5-2). Walleye are opportunistic predators, beginning on crustaceans and aquatic invertebrates as juveniles, and then moving to fish and other larger vertebrates and invertebrates as they mature (Smith 1985). Male walleye mature at 2 to 3 years, whereas females mature at 4 to 5 years. They spawn in the spring following ice out when water temperatures reach 1.6°C to 6.6°C. Walleye prefer to spawn over substrates ranging in size from sand to boulders, but preferably select cobble to rock size substrate in water generally 2 to 4 feet deep (Smith 1985; Jenkins and Burkhead 1993).

Walleye spawning would occur in the riverine sections upstream of each reservoir or in adjoining tributaries with suitable water temperatures and substrate conditions that are not found in the reservoirs. Because spawning habitat is not in the vicinity of the intakes, entrainment of spawning adults is not a concern. However, because of their preference for low-light conditions (Werner 2004) that generally occur at moderate depths, non-spawning adult and juvenile Walleye have a moderate potential of entrainment in reservoirs as these conditions can occur in the vicinity of intakes.

5.2.3 Black Bass

Largemouth and Smallmouth Bass have slightly different habitat preferences, but are grouped together for this analysis. Largemouth Bass generally prefer warm, quiet areas of lakes and reservoirs, with extensive shallow areas (≤20 feet) with abundant object cover and/or areas that support abundant submerged aquatic vegetation (Stuber et al. 1982c). Largemouth Bass are relatively sedentary and do not make large excursions throughout a water body. Smallmouth Bass tend to prefer large, clear lakes and rivers or streams with an abundance of pools, rocky cover and relatively cool summer temperatures (Table 5-2). Smallmouth Bass may move from littoral areas in late fall to winter aggregations associated with cover in deep water (Langhurst and Schoenike 1990). Both species are littoral zone spawners that generally spawn in the spring or early summer when water temperatures are between 16 ^{0}C and 18 ^{0}C (Smith 1985). Males guard the eggs and fry for up to a month after hatching, or until the fry mature to young of year and disperse on their own. Young bass remain in shallow, protected habitats following cessation of parental care, typically in shallow areas with brush or rock (Edwards et al. 1983).

Given their habitat preferences and life history, adult black bass have minimal potential for being in the proximity of the intakes of the Projects' reservoirs. Spawning black bass have no entrainment potential because spawning occurs in shallow areas. Given that all life stages of black bass generally occupy water more shallow than the intake depths of each reservoir, entrainment potential is minimal. Only during periods of extremely low water levels would the potential for black bass entrainment occur.

5.2.4 Pickerel

Chain Pickerel spawn in marshes or shallow bays over soft muck sediment in early spring just after the ice thaws. Juveniles and adults occupy weed beds in shallow areas of lakes and reservoirs (Werner 2004) (Table 5-2). This type of habitat is nonexistent near the Projects' intakes; therefore, potential for entrainment is none.

5.2.5 Panfish

The panfish group includes Yellow Perch and species from the Centrarchidae (Bluegill, Black Crappie, Green Sunfish, Pumpkinseed, and Redbreast Sunfish), and Moronidae (White Perch) families. The Centrarchids include three genera: *Lepomis* (Sunfish), *Pomoxis* (Crappie) and *Ambloplites* (Rock Bass). These species are grouped together as they share similar life histories and habitat requirements.

Sunfish are relatively sedentary and can be found in quiet, slow flowing waters of streams and rivers, but are more commonly found in the littoral zone of lakes, ponds and reservoirs. Both adults and juveniles require cover in the form of submerged structure such as coarse woody debris intermixed with submerged aquatic vegetation (Stuber et al. 1982a; Stuber et al, 1982b; Aho et al, 1986; Werner 2004). Sunfish species spawn in shallow littoral areas in the spring and summer. Their nests are constructed in sand and gravel near woody debris and aquatic vegetation in water depths less than 5 feet (Table 5-2). The entrainment potential of spawning adults and juvenile Sunfish in the Projects' reservoirs is none because they are found in littoral habitats within abundant cover. Sunfish of any species and/or life stages do not occupy depths at the Projects' intakes, thus the potential for their entrainment is none.

Black Crappie are primarily found in lakes and occupy littoral zones with abundant cover over rocky substrate. They frequently school under woody debris extending from the shoreline (Table 5-2). Similar to the Sunfish, Black Crappie also build nests in shallow water and spawn in late spring and early summer (Werner 2004). Black Crappie are not susceptible to entrainment as this species is not found at water depths at the Projects' intakes.

Rock Bass occur in a variety of habitats, but are most abundant in lakes and moderate to larger-sized streams with rocky bottoms and abundant cover (Smith 1985; Werner 2004). In lakes, both adult and juvenile Rock Bass are primarily found within the littoral zone, preferring clear, rocky, and vegetated margins (Page and Burr 1991). Rock Bass tend to be more active at night, moving into shallow open areas to feed. Spawning takes place in late spring over shallow areas with gravel, mud, and vegetation when water temperatures reach 16 ^{0}C (Smith 1985) (Table 5-2). The entrainment potential for spawning adults and juvenile Rock Bass is none because of their preference for shallow water habitats.

White Perch can be found in clear medium to large, low gradient rivers, as well as lakes, ponds and reservoirs (NatureServe 2012). White Perch travel in schools following their prey base, regularly moving inshore at night and offshore in the day (Werner 2004). The spawning season of White Perch occurs in late spring in water depths less than 5 feet over fine sand and gravel (Stanley and Danie 1983). Juveniles tend to use inshore areas or creeks as nurseries, but like adults, they regularly move offshore during the day (Stanley and Danie, 1983). The entrainment potential for spawning adult White Perch is none because they spawn at depths less than 5 feet. The entrainment potential for adult and juvenile White Perch is moderate because they make daily inshore to offshore movements that could occur in the vicinity of the intakes if water levels are extremely low in the reservoirs (Table 5-2).

Yellow Perch often travel in schools (Smith 1985). They primarily occur in littoral areas and are most abundant near vegetation in lakes, but they also frequently occur in streams. Yellow Perch feed actively during the day and rest motionless at night. Adult Yellow Perch usually occupy deeper littoral waters than juveniles, but overall, both have similar habitat requirements (Krieger et al 1983). Spawning takes place in the spring when adults move from open water into tributaries, lake shallows, or low velocity areas of rivers from April to June (Table 5-2). The entrainment potential for Yellow Perch of all life stages is none because they do not occur at the depths of the Projects' intakes.

5.2.6 Forage Fish

Common forage fish species found in the Projects' reservoirs include shiners (*Cyprinidae*), killifish (*Fundulidae*), darters (*Percidae*), and Alewife (*Clupeidae*). Members of the minnow family (*Cyprinidae*) include Bluntnose Minnow, Fallfish, Common Shiner, and Golden Shiner.

Alewife are the primary forage fish in the Projects' reservoirs, which school in open water and make seasonal and diurnal movements within the water column. These characteristics result in a high entrainment potential (Table 5-2). The propensity of Alewife to entrain is well known and documented in the Projects' reservoirs and elsewhere (as reported in the Alewife Study Report included as Appendix D of this Initial Study Report).

Other forage fish species include Tessellated Darter, Logperch, and Banded Killifish. Fallfish are normally found in the streams where they enter each reservoir. Tessellated Darter and Banded Killifish occupy the shallow littoral zone and reservoir margins. The entrainment potential for Fallfish, Tesselated Darter and Banded

Killifish is none because they are not found in the vicinity of the Projects' intakes. Although Common Shiner, Golden Shiner and Bluntnose Minnows are schooling fishes they are generally found in littoral zones among vegetated cover. Their entrainment potential is also minimal given their preference for shallow water depths (Table 5-2).

5.2.7 Benthic Fish

Benthic fishes are those that spend their lives at the bottom of waterbodies. Benthic fishes found in the Projects' reservoirs during the 2018 fisheries surveys include one Cyprinidae species (Common Carp), one Catastomidae species (White Sucker), and three Ictaluridae species (Brown Bullhead, Yellow Bullhead and White Catfish). The Common Carp and White Sucker are herbivores that feed directly from the substrate. The omnivorous catfishes also associate with the substrate for cover. Because they actively seek substrate, the benthic fishes will move up or down in the water column as water levels rise and fall in reservoirs to maintain preferred water depths for feeding and cover. In general, this vertical movement towards the bottom results in higher entrainment potential for the species in this group although it does vary among life stages, preference for warm temperatures, and according to seasonal changes in behavior.

White Suckers generally migrate into tributaries from early spring to early summer to spawn. Juveniles tend to inhabit streams or lake margins with sand and gravel substrate, while adults occupy the cold, deep areas of oligotrophic lakes and reservoirs (Table 5-2). Non-spawning adult White Suckers have a moderate entrainment potential due to their habitat preferences because they may be in the vicinity of the Projects' intakes during the summer, fall, and winter. Spawning White Suckers are not within the vicinity of the Projects' intakes because they migrate to tributaries to spawn. Juvenile White Suckers have a minimal likelihood of occurring near the Projects' intakes because in lacustrine environments, they are generally found in shallow, shoreline areas with sand and gravel substrate; however, they can tolerate low DO concentrations and high turbidity (Krieger 1980; Twomey et al 1984). Consequently, juvenile White Suckers have a minimal potential of entrainment in the Mongaup reservoirs.

Common Carp spawn in the spring and may have a prolonged spawning period in warm waters. The ideal spawning habitat consists of shallow areas with submerged aquatic or terrestrial vegetation (Edwards and Twomey 1982). Both adults and juveniles prefer warm, shallow water with abundant cover and silt/mud substrate. Adults will move to slightly deeper water as temperatures decrease in the winter. As adult Common Carp tend to exhibit little directed movement, they stay in warm shallow water most of the year and move to slightly deeper water in the winter they are considered to have moderate entrainment potential (Table 5-2). However, because spawning occurs in shallow aquatic vegetation beds and juveniles tend to remain in shallow water areas with cover, the entrainment potential for both spawning adults and juvenile Common Carp is none.

Both Brown and Yellow Bullhead are benthic oriented fish, and generally inhabit warm, eutrophic waters, usually in vegetated shallows over sand, mud, or silt. Although adult and juvenile bullhead generally prefer warm water, they are considered to have moderate entrainment potential due to their benthic nature as they may venture into the proximity of the intake structures when the reservoirs are thermally mixed. White Catfish share a similar life history to the two Bullhead species. They spawn when water temperature is 21 ^{0}C, a temperature that is likely to be reached at shallower depths. All life stages of White Catfish actively seek warmer temperatures in a lake or reservoir (Table 5-2). Thermal stratification in the summer and fall will limit the potential for White Catfish and Bullheads presence near the Projects' intakes. During other seasons of the year when thermal stratification is absent, the potential for their presence near the Projects' intakes increases.

TABLE 5-2
HABITAT AND BEHAVIOR OF FISH SPECIES FOUND IN THE PROJECTS' RESERVOIRS AND LIKELIHOOD OF PROXIMITY TO PROJECTS' INTAKES

Common Name	Life Stage	Habitat Requirement	Behavioral Movements	Likelihood of Proximity To Intakes
Brook Trout	Adult Spawning	Gravel with upwelling water	Moves to tributary streams or shallow gravel bars	None
	Adult	Cool, well oxygenated water	Moves to cool water in summer	Minimal
	Juvenile	Calm, cool water	None	None
Brown Trout	Adult Spawning	Rivers or streams	Moves to tributary streams	None
	Adult	Cool, well oxygenated water	Moves to cool water in summer	Moderate
	Juvenile	Calm, cool water	None	None
Chain Pickerel	Adult Spawning	Marshes, shallow bays	Move to shallow areas after ice thaws	None
	Adult	Lakes or ponds	Prefers thick submerged vegetation in littoral zone	
	Juvenile		Prefers thick submerged vegetation in littoral zone	
Walleye	Adult Spawning	Shallow shoreline areas, shoals, riffles	Moves to near-shore areas or tributaries to spawn	None
	Adult	Lakes with moderate turbidity and substantial areas of rocky substrate	Moves to near-shore areas at night to feed	Moderate
	Juvenile			
Largemouth Bass	Adult Spawning	Shallow water over gravel substrate	Moves to shallow water to spawn	None
	Adult	Littoral zone in summer, deep water in winter	Local migration to deeper water in winter	Minimal
	Juvenile	Shallow water with vegetation and cover	None	None
Smallmouth Bass	Adult Spawning	Gravel or broken rock	May travel to streams to spawn	None
	Adult	Clear water with rocky shoals; epilimnion in summer	Occasionally moves to deep water during the day, forms aggregation in deep water in winter	Minimal
	Juvenile	Shallow, calm water with cover	None	None
Bluegill	Adult Spawning	Shallow water over fine gravel	None	None
	Adult	Shallow water with vegetation and structure, or high in water column over deep water	Local migration to deeper water in winter and summer for thermal refuge	Minimal
	Juvenile	Shallow water with vegetation and structure	None	None

Common Name	Life Stage	Habitat Requirement	Behavioral Movements	Likelihood of Proximity To Intakes
Green Sunfish	Adult Spawning	Shallow water with gravel and vegetation	None	None
	Adult	Prefers aquatic vegetation as cover, tolerant of turbidity	Local migration to deeper water in winter and summer for thermal refuge	Minimal
	Juvenile	Shallow water with vegetation and structure	None	None
Pumpkinseed	Adult Spawning	Shallow water near aquatic vegetation	None	None
	Adult	Prefers vegetation or brush cover	Local migration to deeper water in winter and summer for thermal refuge	Minimal
	Juvenile	Shallow water with vegetation	None	None
Redbreast Sunfish	Adult Spawning	Shallow water over sand and gravel	None	None
	Adult	Littoral zone in summer near cover and vegetation, deeper water in winter.	Local migration to deeper water in winter and summer for thermal refuge	Moderate
	Juvenile	Shallow water near cover and vegetation	None	None
Rock Bass	Adult Spawning	Shallow water with gravel and vegetation	None	None
	Adult	Rocky and vegetated littoral zone in summer, deeper water in winter	Local migration to deeper water in winter	Moderate
	Juvenile	Shallow water with rock and vegetation	None	None
Yellow Perch	Adult Spawning	Lake shorelines with vegetation, streams	Moves to near-shore shallows with sand, gravel, rubble, or vegetation	None
	Adult	Rocky and vegetated littoral zone in summer, deeper water in winter	Occasionally moves to deep water to feed	Minimal
	Juvenile	Shallow water with rock and vegetation	Tends to remain in shallower water	None
White Perch	Adult Spawning	Lakes, and medium to large rivers with low turbidity and muck, clay and silt substrate	Moves into streams, wind-swept points or shoals	None
	Adult		Migrates to shallows at night and offshore in day	Moderate
	Juvenile		Tends to remain in shallower water	None
Fallfish	Adult Spawning	Streams or margins of lakes	Moves to tributaries or near-shore areas to spawn	None
	Adult	Shallow water with gravel and rubble substrate	Stays in shallow water	
	Juvenile			
Golden Shiner	Adult Spawning	Shallow, clear, and quiet water with abundant aquatic vegetation; forages at the surface or in midwater	Moves to tributaries or shallow near-shore areas to spawn	None
	Adult		May move between littoral and limnetic zones	Minimal
	Juvenile			

Common Name	Life Stage	Habitat Requirement	Behavioral Movements	Likelihood of Proximity To Intakes
Tessellated Darter	Adult Spawning	Streams with sandy bottoms, or lake shorelines with silt and gravel bottoms	Moves to shallow streams to spawn	None
	Adult		None	
	Juvenile			
Banded Killifish	Adult Spawning	Shallow, quiet water with abundant vegetation	Generally remains in shallow, near-shore areas with cover	None
	Adult			
	Juvenile			
Alewife	Adult Spawning	Shallow water	Moves to tributaries or near-shore areas in spring to spawn	None
	Adult	Open water	Local migration to deeper water in winter, diel vertical foraging migrations (See Alewife Study: Section 6.6)	High
	Juvenile	Shallow water		
White Sucker	Adult Spawning	Fast flowing streams with gravel bottoms	Moves into tributaries or shallow shoals	None
	Adult	Small creeks to large lakes, benthic, high turbidity and anoxia tolerance	None	Moderate
	Juvenile		Emigrates from natal streams to lake margins	Minimal
Common Carp	Adult Spawning	Shallow water with abundant cover	Moves to aquatic vegetation beds	None
	Adult		Little directed movement, move from shallow to deeper water in winter	Moderate
	Juvenile		Little directed movement	None
Brown Bullhead	Adult Spawning	Close to shore, in coves or creek mouths	Moves to near-shore vegetation	None
	Adult	Wide ranging benthic omnivore	Remains near the benthic zone	Moderate
	Juvenile	Benthic omnivore	May move to shallow water when rearing	
Yellow Bullhead	Adult Spawning	Shallow areas of lakes with abundant vegetation and clear water	Moves to near-shore areas with cover	None
	Adult	Clear ponds and streams with some vegetation, benthic omnivore	Remains near the benthic zone	Moderate

5.3 Fish Swimming Capabilities

The burst swim speeds vary greatly among species and between sizes of the same species. Generally, larger individuals of the same species have greater burst swim speeds. For those species found in the Projects' reservoirs, Brown Trout have the highest burst swim speeds and juvenile *Esox* (Pike) have the lowest burst swim speeds (Table 5-3).

TABLE 5-3
BURST SWIM SPEEDS COMPILED FROM SCIENTIFIC LITERATURE FOR FISH SPECIES COLLECTED IN THE PROJECTS' RESERVOIRS

Common Name	Mean Size (in)	Mean Size Burst Swim Speed (ft/s)	Minimum Size (in)	Minimum Size Burst Swim Speed (ft/s)	Maximum Size (in)	Maximum Size Burst Swim Speed (ft/s)	*Comments*, Citation
Alewife	--	--	4.0	3.8	6.0	3.8	*Landlocked*, Bell 1991.
Black Bullhead	2.4	3.5[1]	--	--	--	--	*Surrogate for Brown and Yellow Bullhead*, Prenosil et al 2015.
Bluegill	--	--	2.0	1.4[1]	5.9	1.8[1]	*Surrogate for Redbreast Sunfish*, Beamish 1978; Gardner et al. 2006.
Brown Trout	--	--	6.0	7.0	14.0	12.7	Bell 1991; Peake 2008.
Channel Catfish	5.8	3.0[1]	--	--	--	--	*Surrogate for White Catfish*, Hocutt 1973.
Common Carp	2.8	3.5[1]	--	--	--	--	Katopodis and Gervais 2016.
	--	--	4.1	2.8	--	--	Bell 1991.
	--	--	--	--	>4.1	3.9	MTO 2006.
European Eel	17.4 (yellow)	2.1[1]	14.8 (male silver)	3.2[1]	24.4 (female silver)	3.6[1]	*Surrogate for American Eel*, Quintenella et al. 2010.
Green Sunfish	2.5	3.6[1]	--	--	--	--	*Surrogate for Rock Bass*, Prenosil et al. 2015.
Largemouth Bass	--	--	3.5	3.2	--	--	Bell 1991.
	--	--	--	--	10.6	3.3[1]	Kolok 1991, 1992a, 1992b
Northern Pike	4.3	1.1[1]	4.7	0.9[1]	37.8	13.0[1]	*Surrogate for Chain Pickerel*, Katopodis and Gervais 2016; Jones et al. 1974; Bell 1991.
Pumpkinseed	5.0	1.8[1]	--	--	--	--	*Surrogate for Redbreast Sunfish*, Brett and Sutherland 1965.
Smallmouth Bass	11.8	4.4[1]	3.6	2.6[1]	--	--	Katopodis and Gervais 2016; Bell 1991.
	--	--	--	--	15.0	5.6	Peake and Farrell 2004.
Walleye	--	--	3.0	2.4	--	--	Bell 1991.
	--	--	--	--	15.0	4.1[1]	Katopodis and Gervais 2016.
White Perch	--	--	3.0	2.4	10.0	5.7[1]	Bell 1991; Katopodis and Gervais 1991.
White Crappie			6.7	1.8[1]	--	--	*Surrogate for Black Crappie*, Katopodis and Gervais 2016.
White Crappie	7.4	1.7[1]			--	--	Parsons and Sylvester 1992.
White Sucker	--	--	7.0	2.4	9.0	3.8	Bell 1991.
Yellow Perch	--	--	3.5	2.0	9.6	5.6	Katopodis and Gervais 1991.

[1]Calculated as 50% greater than prolonged swim speed.

5.4 Intake Velocity Calculation

The intake or cross sectional velocity is defined by the relationship between the hydraulic capacity of the intake and associated water conveyance infrastructure and the surface area dimensions of the trashrack covering the intake. The cross sectional velocity ranged between 1.38 and 160 fps at the Projects' intakes (Table 5-4).

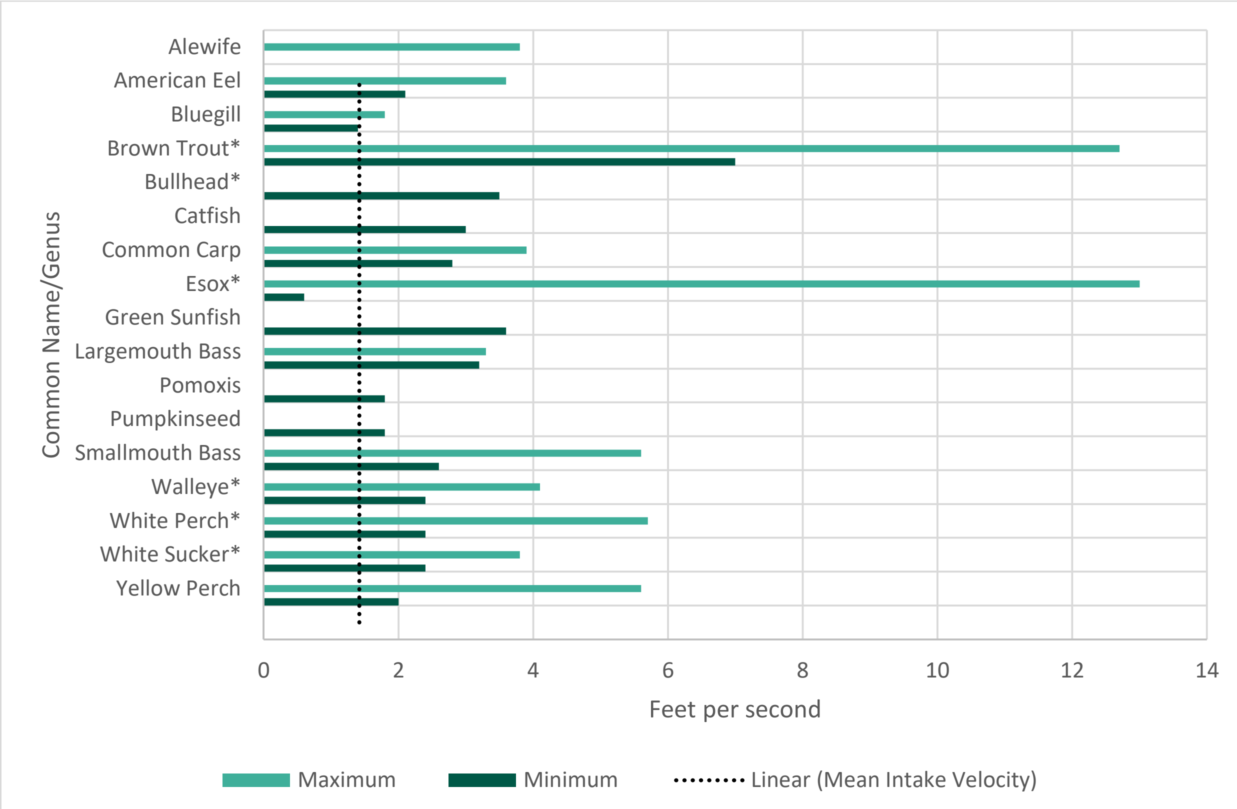
TABLE 5-4
CROSS SECTIONAL VELOCITIES AND CLEAR SPACING OF INTAKE TRASHRACKS OF THE MONGAUP PROJECTS

Project	Maximum Hydraulic Capacity (cfs)	Trashrack Surface Area (square feet)	Cross Sectional Velocity at Maximum Hydraulic Capacity (feet/second)	Trashrack Clear Spacing (in)
Swinging Bridge (Units 2 and 3)	1,140	711	1.60	2.6
Mongaup Falls (Units 1-4)	620	448	1.38	1.7
Rio (Units 1-3)	990	690	1.44	2.9

5.5 Impingement and Turbine Entrainment Potential

The species and sizes of fish whose burst swim speeds are less than the cross sectional velocities at each Project intake are likely to be entrained or impinged depending on the size of an individual. For example, juvenile Chain Pickerel (*Esox*) are likely to be entrained as their burst swim speed is less than the mean cross sectional velocity of the Projects' intakes. However, as an example of how size of the same species influences susceptibility to entrainment, the burst swim speed of an adult Chain Pickerel would allow it to escape the cross sectional velocities at the Projects' intakes (Figure 5-3).

FIGURE 5-3
BURST SWIM SPEEDS OF FISH SPECIES COLLECTED IN THE PROJECTS' RESERVOIRS



*Species collected in intake gill nets.

Proportional estimates of body width to total length (scaling factor) were used to determine the minimum length of each species collected in the 2018 reservoir fisheries surveys that would be excluded from the intake by the trashracks at each Project. If the maximum length collected for a species is smaller than the minimum length excluded then all individuals would be capable of passing through the trashracks. For example the maximum length of yellow perch collected at the Project in 2018 was 11.7 inches, which is smaller than the minimum lengths of exclusion at the Swinging Bridge (22.8 inches), Mongaup Falls (14.9 inches), and Rio (25.6 inches) intakes. Therefore all size classes of yellow perch have the potential to pass through the trashracks and become entrained at the Projects. If the maximum length for a species is larger than the minimum length excluded, those individuals larger the minimum size of exclusion would not be able to pass through the trashracks while young life stages, juveniles, and smaller adults that are smaller would have the potential to pass through the trashracks and become entrained. For example, the maximum length of walleye collected at the Projects in 2018 was 29.7 inches, which is larger than the minimum lengths of exclusion at Swinging Bridge (20.8 inches), Mongaup Falls (13.5 inches), and Rio (23.3 inches) intakes. Therefore those walleye larger than the minimum length excluded at each Project would not be able to pass through the trashracks while the portion of the population that is smaller has the potential to be entrained. Based on this analysis a total of 12 species would not be excluded from the intakes at all three Projects (Table 5-5).

TABLE 5-5
MINIMUM LENGTHS OF FISH SPECIES EXCLUDED BY TRASHRACKS AT THE MONGAUP PROJECTS

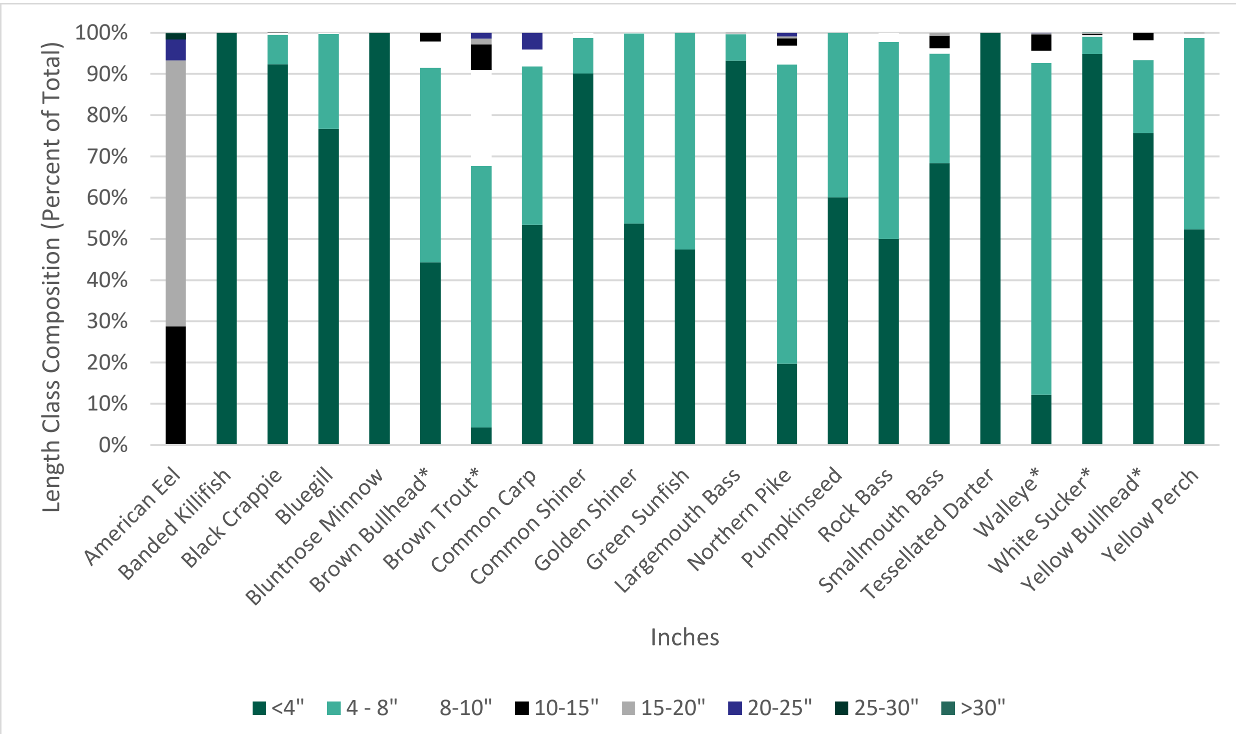
Common Name	Scaling Factor for Body Width	Maximum Length Collected[2] (in)	Minimum Length Excluded (in)[4]		
			Swinging Bridge	Mongaup Falls	Rio
Alewife	0.105	*na*	24.7	16.1	27.7
American Eel	0.037	21.7	70.2	45.8	78.7
American Shad	0.105	19.1	24.7	16.1	27.7
Black Crappie	0.085	14.6	30.6	19.9	34.3
Bluegill	0.132	10.0[3]	19.7	12.8	22.1
Bluntnose Minnow	0.101	4.0[3]	25.7	16.8	28.8
Brown Bullhead[1]	0.166	14.3	15.7	10.2	17.6
Brown Trout[1]	0.118	24.7	22.0	14.3	24.7
Chain Pickerel[1]	0.078	29.1	33.3	21.7	37.4
Common Carp	0.162	12.8	16.0	10.5	18.0
Common shiner	0.187	10.0[3]	13.9	9.1	15.6
Golden Shiner	0.187	10.0[3]	13.9	9.1	15.6
Green Sunfish	0.130	8.0[3]	20.0	13.0	22.4
Largemouth Bass	0.134	21.5	19.4	12.6	21.7
Pumpkinseed	0.130	8.0[3]	20.0	13.0	22.4
Redbreast Sunfish	0.132	6.4	19.7	12.8	22.1
Rock Bass	0.156	9.3	16.7	10.9	18.7
Smallmouth Bass	0.128	19.1	20.3	13.2	22.8
Tessellated Darter	0.109	4.0[3]	23.8	15.5	26.7
Walleye[1]	0.125	29.7	20.8	13.5	23.3
White Catfish	0.156	17.3	16.7	10.9	18.7
White Perch[1]	0.102	11.5	25.5	16.6	28.6
White Sucker[1]	0.146	25.4	17.8	11.6	20.0
Yellow Bullhead[1]	0.166	11.2	15.7	10.2	17.6
Yellow Perch	0.114	11.7	22.8	14.9	25.6

[1]Species collected in intake gill nets.
[2]Collected during the 2018 fisheries surveys performed in the Projects' reservoirs unless otherwise noted.
[3]Maximum length taken from EPRI 1997 entrainment database.
[4]Red text indicates that species would not be excluded by the trashracks since the maximum length collected at the Projects in 2018 is smaller than the minimum length of exclusion.

5.6 EPRI Entrainment Database Review

Seven facilities in the EPRI database met the selection criteria for similarity to the Mongaup River Projects. Twenty species collected during entrainment studies at the seven facilities in the EPRI database matched the ones collected in the Mongaup River Projects' reservoirs. Among these twenty species selected from the database, the most abundant species was Black Crappie in the smallest size class (<4 inches). Most Brown Trout, the least abundant species collected in the 2018 intake gill nets, were in the 6 to 10 inch size classes. Most of the Brown and Yellow Bullhead individuals were less than 8 inches. The majority of the Walleye were in the 4 to 8 inches size class. Most of the Northern Pike, (used as a surrogate for Chain Pickerel), were less than 8 inches. Although not collected in the 2018 intake gill net surveys, the majority of the American Eel were in the 15 to 20 inch size classes (Figure 5-4).

FIGURE 5-4
LENGTH CLASS COMPOSITION OF FISH SPECIES SELECTED FROM THE EPRI ENTRAINMENT DATABASE



*Species collected in intake gill nets.
Northern Pike is a surrogate for Chain Pickerel.

5.7 Turbine Survival Evaluation

The Franke blade strike survival estimates were greatest for the smaller lengths and incrementally decreased as lengths increased at each Project (Tables 5-6 through 5-10). The highest survival estimates for the longest individuals are at the Rio Main Powerhouse (Table 5-10) and lowest at the Rio Minimum Flow Powerhouse (Table 5-9).

TABLE 5-6
SWINGING BRIDGE UNIT NO. 2 TURBINE SURVIVAL ESTIMATES

Fish Length (in)	Correlation Factor		
	0.10	0.15	0.20
1	97.3%	95.9%	94.6%
2	94.6%	91.9%	89.2%
3	91.9%	87.8%	83.8%
4	89.2%	83.8%	78.3%
5	86.5%	79.7%	72.9%
6	83.8%	75.6%	67.5%
7	81.0%	71.6%	62.1%
8	78.3%	67.5%	56.7%
9	75.6%	63.4%	51.3%
10	72.9%	59.4%	45.8%
11	70.2%	55.3%	40.4%
12	67.5%	51.3%	35.0%
13	64.8%	47.2%	29.6%
14	62.1%	43.1%	24.2%
15	59.4%	39.1%	18.8%
16	56.7%	35.0%	13.3%
17	54.0%	30.9%	7.9%
18	51.3%	26.9%	2.5%
19	48.5%	22.8%	0.0%
20	45.8%	18.8%	0.0%
21	43.1%	14.7%	0.0%
22	40.4%	10.6%	0.0%
23	37.7%	6.6%	0.0%
24	35.0%	2.5%	0.0%
25	32.3%	0.0%	0.0%
26	29.6%	0.0%	0.0%

TABLE 5-7
SWINGING BRIDGE UNIT NO. 3 TURBINE SURVIVAL ESTIMATES

Fish Length (in)	Correlation Factor		
	0.10	0.15	0.20
1	95.52%	93.27%	91.03%
2	91.03%	86.55%	82.06%
3	86.55%	79.82%	73.09%
4	82.06%	73.09%	64.12%
5	77.58%	66.36%	55.15%
6	73.09%	59.64%	46.18%
7	68.61%	52.91%	37.21%
8	64.12%	46.18%	28.24%
9	59.64%	39.45%	19.27%
10	55.15%	32.73%	10.30%
11	50.67%	26.00%	1.33%
12	46.18%	19.27%	0.00%
13	41.70%	12.54%	0.00%
14	37.21%	5.82%	0.00%
15	32.73%	0.00%	0.00%
16	28.24%	0.00%	0.00%
17	23.76%	0.00%	0.00%
18	19.27%	0.00%	0.00%
19	14.79%	0.00%	0.00%
20	10.30%	0.00%	0.00%
21	5.82%	0.00%	0.00%
22	1.33%	0.00%	0.00%
23	0.00%	0.00%	0.00%
24	0.00%	0.00%	0.00%
25	0.00%	0.00%	0.00%
26	0.00%	0.00%	0.00%

TABLE 5-8
MONGAUP FALLS UNIT NOS. 1-4 TURBINES SURVIVAL ESTIMATES

Fish Length (in)	Correlation Factor		
	0.10	0.15	0.20
1	97.5%	96.2%	95.0%
2	95.0%	92.4%	89.9%
3	92.4%	88.6%	84.9%
4	89.9%	84.9%	79.8%
5	87.4%	81.1%	74.8%
6	84.9%	77.3%	69.7%
7	82.3%	73.5%	64.7%
8	79.8%	69.7%	59.6%
9	77.3%	65.9%	54.6%
10	74.8%	62.1%	49.5%
11	72.2%	58.3%	44.5%
12	69.7%	54.6%	39.4%
13	67.2%	50.8%	34.4%
14	64.7%	47.0%	29.3%
15	62.1%	43.2%	24.3%
16	59.6%	39.4%	19.2%
17	57.1%	35.6%	14.2%
18	54.6%	31.8%	9.1%
19	52.0%	28.1%	4.1%
20	49.5%	24.3%	0.0%
21	47.0%	20.5%	0.0%
22	44.5%	16.7%	0.0%
23	41.9%	12.9%	0.0%
24	39.4%	9.1%	0.0%
25	36.9%	5.3%	0.0%
26	34.4%	1.5%	0.0%

TABLE 5-9
RIO UNIT NO.3 TURBINE SURVIVAL ESTIMATES

Fish Length (in)	Correlation Factor		
	0.10	0.15	0.20
1	92.7%	89.1%	85.4%
2	85.4%	78.1%	70.9%
3	78.1%	67.2%	56.3%
4	70.9%	56.3%	41.7%
5	63.6%	45.4%	27.1%
6	56.3%	34.4%	12.6%
7	49.0%	23.5%	0.0%
8	41.7%	12.6%	0.0%
9	34.4%	1.6%	0.0%
10	27.1%	0.0%	0.0%
11	19.9%	0.0%	0.0%
12	12.6%	0.0%	0.0%
13	5.3%	0.0%	0.0%
14	0.0%	0.0%	0.0%
15	0.0%	0.0%	0.0%
16	0.0%	0.0%	0.0%
17	0.0%	0.0%	0.0%
18	0.0%	0.0%	0.0%
19	0.0%	0.0%	0.0%
20	0.0%	0.0%	0.0%
21	0.0%	0.0%	0.0%
22	0.0%	0.0%	0.0%
23	0.0%	0.0%	0.0%
24	0.0%	0.0%	0.0%
25	0.0%	0.0%	0.0%
26	0.0%	0.0%	0.0%

TABLE 5-10
RIO UNIT NOS. 1-2 TURBINES SURVIVAL ESTIMATES

Fish Length (in)	Correlation Factor		
	0.10	0.15	0.20
1	98.4%	97.6%	96.8%
2	96.8%	95.1%	93.5%
3	95.1%	92.7%	90.3%
4	93.5%	90.3%	87.0%
5	91.9%	87.8%	83.8%
6	90.3%	85.4%	80.5%
7	88.6%	82.9%	77.3%
8	87.0%	80.5%	74.0%
9	85.4%	78.1%	70.8%
10	83.8%	75.6%	67.5%
11	82.1%	73.2%	64.3%
12	80.5%	70.8%	61.0%
13	78.9%	68.3%	57.8%
14	77.3%	65.9%	54.5%
15	75.6%	63.5%	51.3%
16	74.0%	61.0%	48.0%
17	72.4%	58.6%	44.8%
18	70.8%	56.2%	41.5%
19	69.1%	53.7%	38.3%
20	67.5%	51.3%	35.0%
21	65.9%	48.8%	31.8%
22	64.3%	46.4%	28.5%
23	62.7%	44.0%	25.3%
24	61.0%	41.5%	22.1%
25	59.4%	39.1%	18.8%
26	57.8%	36.7%	15.6%

5.8 EPRI Turbine Survival Database Review

Three facilities in the EPRI database met the selection criteria for similarity to the Projects or had applicable data for American Eel. Eight species that matched those collected in the 2018 Projects' reservoir fisheries surveys have reported survival estimates in the EPRI database (Table 5-11). The reported immediate and 48-hour survivals estimates for Bluegill are the lowest among all species. Largemouth Bass had the highest immediate and 48-hour survival estimates among species collected in the Projects' reservoirs. Both survival estimates ranged between 43.6 and 64.3 percent among the three species that were also collected in the intake gill net surveys, Brown Trout, Walleye, and White Sucker.

TABLE 5-11
TURBINE SURVIVAL ESTIMATES OF FISH SPECIES SELECTED FROM EPRI DATABASE

Species	Immediate Survival	48 Hour Survival
American Eel	100.0%	93.6%
Bluegill	41.4%	31.8%
Brown Trout[1]	45.2%	NA
Golden Shiner	61.7%	56.1%
Largemouth Bass	66.6%	86.5%
Walleye[1]	38.2%	38.9%
White Sucker[1]	61.5%	64.3%
Yellow Perch	79.1%	78.4%

[1]Species collected in intake gill nets.

6.0 Summary

Evaluating the potential for entrainment for the fish community within the Projects' reservoirs requires combining and synthesizing the species-specific behavioral traits, life stages, and swimming capabilities and comparing them to each of the Projects' unique intake, water conveyance and turbine infrastructure characteristics.

In general, smaller sized forage fish and panfish are likely to become entrained because they fit through the trashrack spacing at each of the Projects. However, forage fish and panfish were not collected in the 2018 intake gill nets and are unlikely to be present in the vicinity of the intakes during the months of May through October. Larger predatory and benthic dwelling fish species were collected in the 2018 intake gill nets during this time period. Although present in the vicinity of the intakes during the spring, summer and fall months, the large body sizes of the predatory fishes caught in the gill nets exclude them from being entrained. Smaller-sized benthic species would likely be entrained similar to the estimates reported by EPRI (1997). If entrained, the smaller-sized individuals are more likely to survive passing downstream through the turbines as the Franke blade strike survival rate estimates are highest for the smallest size classes.

The primary findings of the fish entrainment, impingement and turbine survival evaluation include:

- A total of 26 individuals of seven different fish species were collected during the May 24, June 13, July 24, September 19, October 2, and October 17, 2018 intake gill net surveys at the Projects.
- The lengths of the individuals collected in the 2018 intake gill nets from all species were between 10 and 25 inches.
- The majority of the individuals caught during the 2018 intake gill nets were collected at the Mongaup Falls Reservoir.
- Operations at the Projects did not appear to influence the number of individuals collected during the 2018 intake gill net surveys.
- Persistent low DO concentrations existed at the depth of the intake at the Swinging Bridge Reservoirs from July through mid-September during water quality monitoring performed in 2018.
- Burst swim speeds differ between life stages of each fish species found in the Projects' reservoirs. Because of this, the entrainment potential for each fish species depends on the life stage found in the vicinity of the Projects' intakes.

- The intake trashracks at the Mongaup Falls Project exclude fishes of smaller sizes than the Swinging Bridge and Rio Projects.
- The EPRI entrainment database search for sites similar to the Projects yielded five of the seven fish species collected during the Projects' 2018 intake gill net surveys; White Sucker and Bullhead less than 6 inches in length were the most abundant of all five species.
- The highest turbine survival estimates for the longest individuals are at the Rio Main Powerhouse and lowest at the Rio Minimum Flow Powerhouse.

7.0 Variances from Approved Study Plan

This study was conducted in conformance with the requirements of the Commission's SPD.

8.0 Literature Cited

Aho, J.M., C.S. Anderson, J.W. Terrell. 1986. Habitat suitability index models and instream flow suitability curves: redbreast sunfish. Biological Report 82(10.119). U.S. Department of the Interior, Fish and Wildlife Service, Fort Collins, Colorado. 23 p.

Bain, M. and N. Stevenson. 1999. Aquatic Habitat Assessment: Common Methods. American Fisheries Society, Bethesda, Maryland.

Beamish, F.W.H. 1970. Oxygen consumption of largemouth bass, Micropterus salmoides, in relation to swimming speed and temperature. Canadian J. Zoology 48:1221-1228.

Beamish, F.W.H. 1978. Swimming capacity. In: Hoar, W.S. and D.J. Randall, eds. Fish Physiology, Volume 7, Locomotion. Academic Press, NY. 576 pp.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon. 380 p.

Brett, J. R., and D. B. Sutherland. 1965. Respiratory metabolism of pumpkinseed, *Lepomis gibbosus*, in relation to swimming speed. Journal of the Fisheries Research Board of Canada 22: 405–409.

Cada, G. F., C. C. Coutant, and R. R. Whitney. 1997. Development of Biological Criteria for the Design of Advanced Hydropower Turbines. DOE/ID-10578. Prepared for the U.S. Department of Energy, Idaho Falls, Idaho.

Čada, G.F. and P.E. Schweizer. 2012. The application of trait-based assessment approaches to estimate the effects of hydroelectric turbine passage on fish populations. Report ORNL/TM-2012/110. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Idaho Falls, Idaho. 36 pp.

Carlson, D. M., R. A. Daniels, J. J. Wright. 2016. Atlas of Inland Fishes of New York. New York State Museum Record 7. New York State Education Department and Department of Environmental Conservation.

Castro-Santos, T. and A. Haro. 2005. Biomechanics and fisheries conservation. Chapter 12 in Fish Physiology: Fish Biomechanics. Vol. 23. Elsevier, Inc.

Eagle Creek Renewable Energy. 2017. Mongaup River Hydroelectric Projects Pre-Application Document. March 2017.

Edwards, E.A. and K.A. Twomey. 1982. Habitat suitability index models: common carp. Biological Report FWS/OBS-82/10.12. U.S. Department of the Interior, Fish and Wildlife Service, Fort Collins, Colorado. 38 p.

Edwards, E.A., G. Gebhart, and O.E. Maughan. 1983. Habitat suitability information: smallmouth bass. Biological Report FWS/OBS-82/10.36. U.S. Department of the Interior, Fish and Wildlife Service, Fort Collins, Colorado. 47 p.

Electric Power Research Institute (EPRI). 1992. Fish entrainment and turbine mortality review and guidelines. Technical Report TR-101231, Project 2694-01. Electrical Power Research Institute, Palo Alto, California. 282 p.

Electric Power Research Institute (EPRI). 1997. Turbine entrainment and survival database - field tests. EPRI Report No. TR-108630.

Franke, G.F., D.R. Webb, R.K. Fisher, Jr., D. Mathur, P.N. Hopping, P.A. March, M.R. Headrick, I.T. Laczo, Y. Ventikos, and F. Sotiropoulos. 1997. Development of environmentally advanced hydropower turbine system design concepts. Prepared for U.S. Department of Energy, Idaho Operations Office.

Gardner, A.N., G.D. Jennings, W.F. Hunt, and J.F. Gilliam. 2006. Non-anadromous fish passage through road culverts. Paper No. 067034, Annual Meeting, American Society of Agricultural and Biological Engineers, St. Joseph, MI.

Hocutt, C. H. 1973. Swimming performance of three warmwater fishes exposed to a rapid temperature change. Chesapeake Science 14:11–16.

Jenkins, R.E. and N.M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Jones, D.R., Kiceniuk, J.W., and O.S. Bamford. 1974. Evaluation of the swimming performance of several fish species from MacKenzie River. J. Fish. Res. Bd. Canada. 31:1641-1647.

Katopodis, C. and R. Gervais, 1991. Icthyomechanics: working document. Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba. June 1991. 46 p.

Katopodis, C. and R. Gervais. 2016. Fish swimming performance database and analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/002.

Kolok, A. S. 1991. Photoperiod alters the critical swimming speed of juvenile largemouth bass, *Micropterus salmoides*, acclimated to cold water. Copeia 1991:1085–1090.

Kolok, A. S. 1992a. Morphological and physiological correlates with swimming performance in juvenile largemouth bass. American Journal of Physiology 263: R1042– R1048.

Kolok, A. S. 1992b. The swimming performances of individual largemouth bass, *Micropterus salmoides*, are repeatable. Journal of Experimental Biology 170: 265–270.

Krieger, D.A. 1980. Life histories of catostomids in Twin Lakes, Colorado, in relation to a pump-storage power plant. M.S. Thesis. Colorado State University, Ft. Collins, Colorado. 116 pp.

Krieger, D.A., J.W. Terrell, and P.C. Nelson. 1983. Habitat suitability information: yellow perch. Biological Report: FWS/OBS-83/10.55. U.S. Department of the Interior, Fish and Wildlife Service, Fort Collins, Colorado. 49 pp.

Langhurst, R.W., and D.L. Schoenike. 1990. Seasonal migration of smallmouth bass in the Embarrass and Wolf rivers, Wisconsin. North American Journal of Fisheries Management. 10(2): 224-227.

Lawler, Matusky and Skelly Engineers. 1994. 1992-1993 Entrainment Studies: Mongaup Hydroelectric Projects.

Ministry of Transportation of Ontario (MTO). 2006. Environmental guide for fish and fish habitat, Appendix 6.B: Fish swimming speeds. Provincial and Environmental Planning Office, Ministry of Transportation, Ontario.

Nature Serve. 2012. NatureServe Explorer: An online encyclopedia of life. NatureServe, Arlington, Virginia. [Online] URL: http://www.natureserve.org/explorer. Accessed: November 29, 2012.

Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes: North America North of Mexico. The Peterson Field Guide Series. Houghton Mifflin Company, New York, New York. 432 pp.

Parsons, G. R., and J. L. Sylvester, Jr. 1992. Swimming efficiency of the white crappie, *Pomoxis annularis*. Copeia 1992:1033–1038.

Peake, S.J. 2008. Swimming performance and behaviour of fish species endemic to Newfoundland and Labrador: a literature review for the purpose of establishing design and water velocity criteria for fishways and culverts. Canadian Manuscript Report of Fisheries and Aquatic Sciences: 2843. Fisheries and Oceans Canada, St. Johns, Newfoundland and Labrador. 52 p.

Peake, S.J. and A.P. Farrell. 2004. Locomotor behaviour and post-exercise physiology in relation to swimming, gait transition, and metabolism in free swimming Smallmouth Bass, *Micropterus dolomieu*. Journal of Experimental Biology. 207: 1563-1575.

Prenosil, E., K. Koupal, J. Grauf, C. Schoenebeck, W. W. Hoback. 2015. Journal of Freshwater Ecology. 0 (0) 1-8.

Quintenella, B. R., C. Mateus, J. L. Costa, I. Domigos, P. R. Almeida. 2010. Critical swimming speed of yellow- and silver-phase European eel (Anguilla Anguilla). Journal of Applied Ichthyology 26 (3): 432-435.

Raleigh, R.F. 1982. Habitat suitability index models: Brook Trout. Biological Report: FWS/OBS-82/10.24. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 42 pp.

Smith, C.L. 1985. The inland fishes of New York State. New York State Department of Environmental Conservation, Albany, New York.

Stanley, J.G., and D. S. Danie. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic): white perch. Biological Report: FWS/OBS-82/11.7. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 12 pp.

Stanton, S. D. 2000. Trout Movement on Delaware River System Tailwaters in New York State. Occasional Paper 34. State University at Oneonta. Biological Field Station, Cooperstown, New York.

Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982a. Habitat suitability index models: bluegill. Biological Report: FWS/OBS-82/10.8. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 26 pp.

Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982b. Habitat suitability index models: green sunfish. Biological Report: FWS/OBS-82/10.15. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 28 pp.

Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982c. Habitat suitability index models: largemouth bass. Biological Report: FWS/OBS-82/10.16. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 32 pp.

Twomey, K.A., K.L. Williamson and P.C. Nelson. 1984. Habitat suitability index models and instream flow suitability curves: white sucker. Biological Report: FWS/OBS-82-10.64. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 56 pp.

Werner, R.G. 2004. Freshwater fishes of the northeastern United States: a field guide. First edition. Syracuse University Press, Syracuse, New York.

Winchell, F., S. Amaral, and D. Dixon. 2000. Hydroelectric turbine entrainment and survival database: an alternative to field studies. Hydrovision 2000: New Realities, New Responses. HCI Publications, Kansas City, MO.

Appendix F

Fish Passage and Protection Study

Fish Passage and Protection Study

Mongaup River Hydroelectric Projects:
Swinging Bridge Hydroelectric Project (No. 10482)
Mongaup Falls Hydroelectric Project (No. 10481)
Rio Hydroelectric Project (No. 9690)

February 2020

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List of Acronyms

°C	degree Celsius
°F	degrees Fahrenheit
CAB	Conte Airlift Bypass
CFR	Code of Federal Regulations
cfs	cubic feet per second
DO	dissolved oxygen
FERC or Commission	Federal Energy Regulatory Commission
GIS	Geographic Information System
GPS	Global Positioning System
ILP	Integrated Licensing Process
ISR	Initial Study Report
mg/L	milligram per liter
NGVD29	National Geodetic Vertical Datum of 1929
Projects	Mongaup River Hydroelectric Projects
RSP	Revised Study Plan
D1	Scoping Document 1
SPD	Study Plan Determination
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
WFTS	Whooshh Fish Transport System

1.0 Introduction and Background

Eagle Creek Hydro Power, LLC; Eagle Creek Water Resources, LLC; and Eagle Creek Land Resources, LLC (collectively and hereinafter "Eagle Creek") are the Licensees of the Swinging Bridge Hydroelectric Project (FERC No. 10482), the Mongaup Falls Hydroelectric Project (FERC No. 10481), and the Rio Hydroelectric Project (FERC No. 9690) (collectively "Mongaup River Projects" or "Projects"). Collectively, the Projects are located on Black Lake Creek, Black Brook, and the Mongaup River in Sullivan and Orange Counties, New York.

On April 14, 1992, the Federal Energy Regulatory Commission (“FERC” or “Commission”) issued three original and separate licenses for the operation of the Projects in accordance with the Commission’s delegated authority under the Federal Power Act. Each Project’s original license was issued for a term of 30 years and expires on March 31, 2022. Consequently, Eagle Creek is pursuing new licenses for the Projects and has opted to use the Commission’s Integrated Licensing Process (ILP), as detailed at 18 Code of Federal Regulations (CFR) Part 5 of the Commission’s regulations.

In accordance with 18 CFR §5.15, Eagle Creek conducted studies pursuant to Eagle Creek’s January 10, 2018 Revised Study Plan (RSP) as modified in the Commission’s February 9, 2018 Study Plan Determination (SPD). A Fisheries Survey Study and a Fish Entrainment and Turbine Survival Study were performed in 2018 with results presented in the Initial Study Report (ISR) filed with the Commission on February 8, 2019 and the ISR Meeting conducted on February 13-14, 2019.

Subsequent to the ISR Meeting, the U.S. Fish and Wildlife Service (USFWS) filed comments and new study requests with the Commission indicating that information generated by the Fish Entrainment and Turbine Survival Study and the Fisheries Survey Study, which documented the presence of American eel and American shad downstream of the Rio Project, warrants a Fish Passage and Protection Study. Eagle Creek filed responses to the USFWS’ comments and new study requests indicating potential limitations and negative effects of passing American shad and American eel upstream of the Projects. However, on June 10, 2019, the Commission issued a Second SPD requiring Eagle Creek to complete a Fish Protection and Passage Study to evaluate the potential effects and costs of passing migratory fish upstream and downstream of the Projects.

2.0 Goals and Objectives

The primary goal of this study is to provide information to evaluate the feasibility and potential effects and costs of passing migratory fish upstream and downstream of the Projects.

The primary objectives of this study include the following:

- Discuss existing passage routes and mortality at each development;
- Identify potential measures to achieve safe upstream and downstream passage and fish protection;
- Provide cost estimates to install, operate, and maintain the fish passage measures; and
- Discuss the potential effects of introducing migratory fish upstream of the Mongaup River Hydroelectric Projects on the resident fish community.

3.0 Study Area

The study area includes the five developments associated with the three Mongaup River Hydroelectric Projects.

4.0 Project Description

The Mongaup River Hydroelectric Projects consist of three separate FERC-jurisdictional projects: Swinging Bridge, Mongaup Falls, and Rio. The Swinging Bridge Project includes the Toronto Development, the Cliff Lake Development, and the Swinging Bridge Development. Water stored in Toronto Reservoir is released to Cliff Lake Reservoir, which is connected to Swinging Bridge Reservoir via a tunnel, enabling the flow to be utilized at the Swinging Bridge Development and at the two downstream projects for renewable energy generation. The Toronto Dam creates a reservoir on Black Lake Creek, a tributary of the Mongaup River. The Cliff Lake Dam is also on Black Lake Creek, approximately 2 miles downstream of Toronto Dam. The Swinging Bridge Dam is the most upstream dam of the Projects on the Mongaup River. The Mongaup Falls Dam is located on the Mongaup River approximately 2.9 miles downstream of the Swinging Bridge Dam. The Rio Dam is located on the Mongaup River, approximately 4.5 miles downstream of the Mongaup Falls Dam and 4.6 miles upstream of the confluence of the Mongaup River with the Delaware River.

The physical composition, dimensions, and generation configuration of the facilities that comprise the Mongaup River Hydroelectric Projects are described in the following subsections.

4.1 Dam and Spillway

<u>Swinging Bridge Project</u>

Toronto Development

The Toronto Dam is an earth-fill structure, constructed in 1926, which is 1,620 feet long with a maximum height of 103 feet, a crest width of 25 feet, and an impervious core. The crest of the dam is at elevation 1,225 feet (National Geodetic Vertical Datum of 1929 [NGVD 29])[1]. The dam creates the Toronto Reservoir above the junction of the Black Lake Creek and Hemp Meadow Brook, a tributary to Black Lake Creek.

This dam has a 50-foot-wide, concrete-and-rock, side-channel spillway at its west end, blasted through solid rock for a distance of 700 feet. The sill of the spillway is at an elevation of 1,215 feet. The dam's side-channel spillway has a total capacity of 8,900 cfs and is equipped with 5-foot-high, pin-type flashboards that are designed to fail when overtopped by approximately 2 feet of water.

Cliff Lake Development

Cliff Lake Dam was constructed in 1939 and includes east and west earthen embankments, a 100-foot-long concrete overflow spillway, and a 150-foot-long concrete gravity non-overflow wall, which is located adjacent to the spillway. The east earth embankment is 95 feet long and joins the left abutment with the non-overflow

[1] All elevations referenced in this application are expressed in NGVD29, unless indicated otherwise.

wall. The west embankment is 50 feet long and is located right of the spillway. The dam, concrete abutments, and earth embankments total approximately 610 feet in length. The crests of the earth dam sections are at an elevation of 1,080 feet and are 20 feet wide. The top of the concrete non-overflow wall is at elevation 1,080 feet and is approximately 5 feet wide. The dam's spillway has a height of 25 feet high with a crest elevation of 1,070 feet. In addition, the spillway is equipped with 13-inch-high flashboards that are designed to fail when overtopped by approximately 2 feet of water.

Swinging Bridge Development

The Swinging Bridge Dam is an earth-fill structure, which is approximately 965 feet long and 135 feet high. The crest of the earth dam is at elevation 1,080 feet and is 25 feet wide. The dam was constructed in 1930 with a clay and fine sand core. A separate concrete side-channel spillway is located approximately 750 feet upstream of the dam. The spillway channel was cut through the rock at the right rim of the reservoir. The spillway is approximately 250 feet wide, with the structure's sill at elevation 1,065 feet. The northern half of the spillway crest is equipped with a 5-foot-high Obermeyer gate section that spans 122.5 feet between two abutments. On the remaining half of the spillway, there are five motor-driven, vertical-lift timber gates. Each gate is approximately 22.5 feet wide.

Mongaup Falls Project

The Mongaup Falls Dam was constructed in 1923 at the crest of Mongaup Falls. The dam's major features consist of a 155-foot-long, ungated, concrete gravity spillway; an 83-foot-long earth dam section with a concrete core wall along the right abutment; and an approximately 125-foot-long, concrete retaining wall along the left abutment. A 20-foot-long intake house is located adjacent to the spillway. The dam's spillway is 40 feet high, with a crest elevation of 930 feet. The spillway is equipped with 4-foot-10-inch-high flashboards. The spillway's flashboards are designed to fail when overtopped by approximately 2 feet of water. A lower earthen closure dike is located approximately 150 feet from the spillway and supports a lower section of the reservoir rim. The maximum height of the earthen closure section is about 10 feet. The crest elevation corresponds approximately to the top of the non-overflow walls of the dam, which has an elevation of 945 feet. The length of the earthen dike is about 250 feet.

Black Brook Development

The Black Brook Development is located on Black Brook (approximately 5,200 feet upstream from the confluence with the Mongaup River) in Forestburgh, New York, and is currently part of the Mongaup Falls Project. The Black Brook Development has been permanently out of service since 1984 when portions of the penstock, stop logs and flashboards were removed. The Black Brook Dam consists of an approximately 70-foot-long dam with a 34-foot-long concrete spillway section and a 10-foot-long stoplog section. The stoplog section consists of a 2-foot-wide concrete pier that divides the 8-foot-long stoplog section from the spillway. The concrete spillway is approximately 10 feet high from the base to the crest and, based on drawings of the dam, is shown as being keyed into bedrock at its upstream face with a 3-foot by 3-foot keyway.

Rio Project

The Rio Dam is an earth-fill structure with an ungated concrete overflow spillway that was constructed in 1927. The overall length of the dam is approximately 1,500 feet. The dam includes a 264-foot-long, gravity-type concrete spillway with a maximum height of 101 feet. The spillway was built with a horizontal radius of 400 feet to best fit the topography. The spillway section is flanked by east and west abutments.

The west abutment consists of a 22-foot-long, concrete gravity intake structure; a 99-foot-long, concrete gravity non-overflow section; and a 540-foot-long, earth-fill embankment. The east abutment consists of a 102-foot-long concrete gravity non-overflow section and an approximately 460-foot-long earth-fill embankment. The crest of the earth-fill embankment is at an elevation of 825 feet and is approximately 20 feet wide.

A public road runs along the top of the dam and abutments. The surface elevation of the highway and of the reinforced-concrete bridge over the spillway is at an elevation of 825 feet, which is 15 feet above the structure's permanent spillway crest.

The crest of the spillway is at an elevation of 810 feet. The spillway is divided into eight clear openings, each 30 feet long, by the bridge piers. The bridge and roadway over the embankments leading to the spillway have a clear width of 16 feet. The top of the dam is equipped with 5-foot-high flashboards that are designed to fail when overtopped by approximately 2 feet of water.

4.2 Sluiceway Gates and Low-Level Outlets

Swinging Bridge Project

Toronto Development

Toronto Dam has a gated tower located 150 feet from the intake. The gate and gate operators are located in the tower, which is located 140 feet upstream of the centerline of the dam, and approximately 410 feet northeast of the side-channel spillway. The water release is controlled by two gates with invert elevations at 1,179.5 feet and 1,143.5 feet. The upper gate is 4 feet wide by 5 feet high and the lower gate is 3 feet wide by 5 feet high. Both gates are manually controlled and electrically operated via a portable power generator located in the tower.

Cliff Lake Development

A 4-foot by 4-foot sluice gate is located within the right portion of the dam's spillway. The sluice gate has an invert elevation of 1,037 feet and has a discharge capability of 460 cfs when the pond is at elevation 1,074 feet. The gate is manually operated to maintain downstream minimum flows. The outlet gate and its outlet channel are located in rock, below the base of the spillway. The upstream half of the outlet channel is lined with concrete.

Swinging Bridge Development

A 3-foot-diameter steel pipe with at 24-inch-diameter butterfly valve and a 16-inch jet valve are connected to the penstock just west of the Swinging Bridge Dam. Water is bypassed from Unit 2 to provide minimum flows downstream of the earth-fill dam.

Mongaup Falls Project

The instream flow-bypass-works at Mongaup Falls were installed in 1996. The bypass works provide a minimum flow downstream of the toe of the dam and includes a 3-foot-diameter steel outlet pipe with two butterfly valves in series. The downstream valve is equipped with an electric motor operator. The upstream valve has a manual operator and serves as a guard valve.

Rio Project

The instream bypass outlet, constructed in 1996, was designed to provide a minimum flow at the base of the Rio Dam and includes a 3-foot-diameter steel outlet pipe with butterfly valve, which connects to the steel penstock immediately downstream of the intake. Following construction of the minimum flow powerhouse in 2013, the bypass outlet is normally closed when the Rio Minimum Flow Powerhouse is online, but it is configured to open automatically if the Rio Minimum Flow Powerhouse is offline.

4.3 Intakes and Water Conveyance

Swinging Bridge Project

Toronto Development

Discharges from Toronto Reservoir to Black Lake Creek and Cliff Lake Reservoir are made through an 8-foot by 8-foot, reinforced-concrete, horseshoe-shaped conduit, 565 feet long from intake to outlet. The invert of the conduit is located at elevation 1,143 feet at the intake and at elevation 1,140 feet at the outlet. There is a diffuser chamber located at the discharge end of the conduit, which is designed to prevent erosion of the downstream channel by dissipating the energy of the water discharged.

Cliff Lake Development

Water flows between Cliff Lake Reservoir and Swinging Bridge Reservoir through an unlined, horseshoe-shaped tunnel. The tunnel extends approximately 2,115 feet and is 5 feet, 4 inches wide and 6 feet, 8 inches high. The invert of the tunnel at the Cliff Lake end is at an elevation of 1,040.6 feet. Flows through the tunnel are controlled by a 5-foot-wide by 5-foot-high lift gate, located on the Swinging Bridge end of the tunnel. The invert of the tunnel at the Swinging Bridge end is at elevation 1,038.8 feet. The discharge gate is located at an invert elevation of 1,040 feet, approximately 55 feet from the Swinging Bridge end of the tunnel. The gate is operated by a manual screw stem operator located on a deck at the top of the gate shaft. The discharge gate is generally left in the open position and water levels in each reservoir are approximately equal.

Swinging Bridge Development

Swinging Bridge Unit No. 1 has been permanently out of service since 2005 and is decommissioned in place. The penstock was permanently filled with cementitious flowable fill in 2007 for the entire length of the penstock.

Swinging Bridge Unit No. 2 is supplied from the Swinging Bridge Reservoir through a concrete-lined tunnel running approximately 784 feet around the west end of the dam, connected to an all-steel penstock approximately 188 feet long. The inclined, 22-feet-wide, 32.3-feet-high trashrack covers the intake entrance from elevation 1,015 to 1,045 feet. The trashracks have 2.6-inch clear bar spacing. The lined tunnel has a diameter of approximately 9 feet, 9 inches; the steel penstock diameter is 10 feet. The centerline of the tunnel intake is located at elevation 1,020 feet. A penstock measuring approximately 20 feet long and 4 feet in diameter is installed off the existing penstock of Unit No. 2 to convey flows to the Unit No. 3 powerhouse, constructed in 2019.

A Broome gate, located 145 feet downstream of the intake, controls flow to the scroll case of the Swinging Bridge Unit No. 2 and is the headgate for this unit. The Broome gate is 8.5 feet wide and 11.5 feet high. The Broome gate is located in a shaft driven from elevation 1,085 feet to elevation 1,024.9 feet.

A steel surge tank is located approximately 571 feet downstream of the intake. The surge tank is 30 feet in diameter with wood exterior and is located on the longitudinal centerline of the penstock. The top of the foundation of the surge tank is at elevation 1,026 feet and is hydraulically effective to an elevation of 1,098.08 feet.

Mongaup Falls Project

The Mongaup Reservoir is connected to the Mongaup powerhouse by an 8-foot-diameter, wood-stave penstock with a steel penstock section. The inclined, 14-feet-wide, 32-feet-high trashrack covers the intake entrance to the penstock from elevation 900 to 932 feet. The trashracks have 1.7-inch clear bar spacing. The penstock is 2,650 feet long and is supported above ground by wood or steel cradles on rock or concrete foundations, respectively, throughout its entire length.

Water into the penstock is controlled by a Broome gate located on the centerline of and in front of the penstock inlet at an elevation of 905 feet. The gate is 10 feet wide by 12 feet high and is raised and lowered by an electric hoist.

A steel surge tank is located approximately 125 feet upstream of the powerhouse. This tank, 106 feet high by 26 feet in diameter, is hydraulically effective to elevation 961.5 feet. A 9-foot-diameter, concrete-encased steel pipe manifold, reducing down into 4 concrete-encased steel pipe legs, each 5 feet in diameter, directs water into each of the four turbines at the powerhouse.

Rio Project

Water from the Rio Reservoir is supplied to the main Rio Powerhouse by means of a 7,000-foot-long steel penstock, 11 feet in diameter. The intake structure to the penstock consists of the trashracks, intake gate, and entrance to the penstock. The trashrack structure is approximately 15 feet wide and extends approximately from the top of the dam to an elevation of 764 feet. The trashracks have 2.9-inch clear bar spacing. A steel intake gate measures 14 feet high by 11 feet wide. The intake opening measures 12 foot, 6 inches high by 9 foot, 6 inches wide. The gate and gate operator are located in the gate house. The intake gate is controlled by a single screw-stem hoist operated by a motor through a set of worm and spur gears. The capacity of the hoist is 75 tons, which is sufficient to operate the gate under unbalanced conditions. A 30-inch, motor-operated, filler gate is also provided. Both motors can be operated from the gate house which is provided on the intake. Water exits the intake area through a 90-foot-long, steel elbow penstock, with centerline at an elevation of 750 feet. This steel section connects into the steel penstock.

The 7,000-foot-long penstock is connected to a surge tank. The surge tank has a diameter of 40 feet, is 65 feet high, and is constructed of riveted-steel plate. The surge tank is hydraulically efficient to elevation 835 feet.

Flow from the surge tank to the powerhouse is carried by means of a buried, 10-foot-diameter, steel penstock, with two 7-foot-diameter legs. The penstock wye is located approximately 100 feet from the centerline of the units. A 6-foot, 6 inch-diameter butterfly valve is located at the inlet to the scroll case of each unit.

The Minimum Flow Powerhouse is supplied with water by a 4-foot-diameter, high-density polyethylene penstock, which is tapped off of the Main Powerhouse penstock about 300 feet downstream of the dam and travels about 100 feet down a hill to the Minimum Flow Powerhouse on the riverbank. The polyethylene penstock is buried beneath a minimum of two feet of earth for most of its length.

4.4 Powerhouses

Swinging Bridge Project

There are three powerhouses at the Swinging Bridge Development (Unit No. 1, Unit No. 2, and Unit No. 3). The Unit No. 1 powerhouse has been permanently out of service since 2005. The Unit No. 2 powerhouse is currently operational. The Unit No. 3 powerhouse construction was completed late 2019.

The Unit No. 2 powerhouse is constructed of brick and steel and is 48 feet wide, 33 feet long, and rises approximately 35 feet, 8 inches above the concrete substructure. The main floor of the powerhouse is located at elevation 959.5 feet.

The Unit No. 3 powerhouse is located immediately adjacent to (north of) the existing Unit No. 2 powerhouse and consists of a concrete and steel structure measuring approximately 30 feet long by 30 feet wide, with an average height of 20 feet from operating floor to roof.

Mongaup Falls Project

The Mongaup Powerhouse is constructed on a reinforced-concrete substructure. The substructure is designed to support the penstock and the connections to the turbine scroll cases. The powerhouse superstructure is constructed of brick in the shape of the letter "L."

The generating room is approximately 90 feet, 8 inches long by 25 feet, 2 inches wide. The distance from the generator floor to the bottom of the steel roof trusses is 22 feet, 3 inches. The overall building height is 33 feet, 3 inches. The roof is constructed of shingles on wood planking. The generating floor of the powerhouse is located at an elevation of 838 feet. The powerhouse consists of four discharge bays, each measuring approximately 14 feet wide by 16 feet high. Each discharge bay contains a suspended steel conical draft tube.

Rio Project

The main powerhouse is constructed of brick and steel on a reinforced-concrete substructure which is designed to support the penstocks and their connections to the turbine scroll cases. The powerhouse superstructure is constructed of brick and is 82 feet long, 30 feet wide, and approximately 33 feet high. The main operating floor is located at elevation 649.5 feet. The roof is constructed of reinforced concrete covered with tar and gravel. The concrete powerhouse contains two horseshoe-shaped discharge bays, each measuring 18 feet wide by 17 feet high. The discharge bays contain suspended steel conical draft turbines.

The minimum flow powerhouse was constructed in 2013 and is a 30-foot-long, 27-foot-wide, by approximately 24-foot-high reinforced-concrete structure.

4.5 Tailraces

Swinging Bridge Project

The Unit No. 2 tailrace is 25 feet wide and extends approximately 75 feet from the draft tube discharge to the Mongaup River. Normal tailwater is at elevation 945.5 feet. The draft tube discharges through a short, 20-foot tailrace to the Mongaup River.

The Unit No. 3 tailrace is currently under construction and will be approximately 6 feet wide by 20 feet long, located adjacent to the tailrace of the existing Unit No. 2 powerhouse.

Mongaup Falls Project

The four generating units at the powerhouse discharge directly into the Mongaup River, with normal tailwater at elevation 818 feet.

Rio Project

Discharge from the main powerhouse flows into a 45-foot-wide by 225-foot-long tailrace. An approximately 65-foot-long, concrete weir at the bank of the Mongaup River maintains normal tailrace water at elevation 630 feet in order to keep the draft tubes submerged.

Water from the minimum flow powerhouse leaves the powerhouse through a 10-foot-wide by 38-foot-long tailrace comprised of concrete training walls and riprap and returns to the Mongaup River about 300 feet downstream from the dam.

4.6 Turbine Specifications

Turbine data for the powerhouses at the Mongaup River Projects is provided below in Table 4-1.

TABLE 4-1
TURBINE DATA FOR MONGAUP RIVER HYDROELECTRIC PROJECTS

	Swinging Bridge Powerhouse (Unit 2)	Swinging Bridge Powerhouse (Unit 3)	Mongaup Falls Powerhouse (Units 1-4)	Rio Minimum Flow Powerhouse (Unit 3)	Rio Main Powerhouse (Units 1-2)
Number of Units	1	1	4	1	2
Type	Vertical Francis	Horizontal Francis	Vertical Francis	Horizontal Francis	Vertical Francis
Head	110 feet	127 feet	110 feet	98 feet	170 feet
Maximum Hydraulic Capacity	1,015 cfs	125 cfs	155 cfs (each unit)	120 cfs	435 cfs (each unit)
Operating Speed	240 rpm	720 rpm	360 rpm	720 rpm	360 rpm
Number of Blades	18	14	16	14	14
Runner Diameter	61 inches	29 inches	42 inches	29 inches	53 inches
Efficiency	86.8%	91.6%	82.6%	85.9%	84.3%

5.0 Methodology

5.1 Existing Fish Passage Routes and Mortality

Existing fish passage routes were evaluated using Project attributes, the findings of the turbine entrainment and impingement evaluation, and a review of fish passage literature applicable to American shad and American eel. Although eels were not observed upstream of Rio Dam, each development was assessed as if eels were present.

5.2 Potential Fish Passage Routes

Upstream and downstream passage routes were evaluated for American shad at the Rio Dam using Project attributes and a review of fish passage literature and design standards. Upstream and downstream passage routes were similarly evaluated at each development for American eel.

5.3 Estimated Costs for Potential Fish Passage Routes

Eagle Creek performed an evaluation of costs associated with potential fish passage and protection measures for both American shad and American eel. Eagle Creek reviewed several documents (see literature cited section) and online resources to perform a Level V cost estimate (Concept Screening Estimate). Where applicable, examples of costs of implemented projects were used with the understanding that the estimates are in the dollar values from the year published and project elements and factors may be significantly different than those found at the Mongaup River Projects.

5.4 Effects of Introducing Migratory Species at the Projects

A review of Project features, habitats, and relevant literature was performed to evaluate the potential effects of (re)introducing American shad and American eel into the Project areas. Specifically, the availability and suitability of habitats in the Project area, the effects of passage, and ecological impact of reintroducing American shad above the Rio Dam and below the Mongaup Falls Dam and American eel into all Project areas were evaluated. For American shad a carrying capacity analysis was performed to assess the amount of suitable shad spawning habitat, as well as the number of shad that could be supported in the Project area.

6.0 Results

6.1 Existing Fish Passage Routes and Mortality

6.1.1 Upstream Fish Passage

6.1.1.1 Rio Project

Currently, American shad and American eel are able to migrate from the Delaware River upstream into the lower portion of the Mongaup River, which extends approximately 4.6 miles from the Delaware River to the Rio Dam.

There are currently no upstream passage routes or structures for American shad or American eel at the Rio Project. Regarding potential upstream eel passage at the dam, although the Rio Dam spillway surface is typically wetted via leakage through the flashboards, is rough, and has a non-vertical slope, the dam is 101 feet high, which may inhibit upstream passage of most juvenile eels attempting to migrate upstream on the Mongaup River. During 2018 field studies, juvenile eels were observed ascending the dam under leakage conditions to approximately thirty feet above the base of Rio Dam (Eagle Creek 2019a).

6.1.1.2 Mongaup Falls Project

There are currently no upstream passage routes/structures for American shad at the Mongaup Falls Project. The Mongaup Falls Dam is approximately 40 feet high and is constructed atop a natural waterfall, which is the known natural barrier for upstream migration of American shad in the Mongaup River (Quinlan 1873) (Dittman et al. 2009).

There are currently no upstream passage structures for American eel at the Mongaup Falls Project. Similar to the Rio Dam, upstream eel passage is possible, but it would likely be limited to few juvenile eels. Eels capable of climbing may potentially be able to pass the Mongaup Falls Dam during periods of low or moderate spill but overall passage rates would be expected to be relatively low.

<u>Black Brook Development</u>

The Black Brook Dam is approximately 10 feet high and is constructed atop a natural waterfall in Black Brook located approximately 5,200 feet upstream from the Mongaup River (Figure 4-1). The Black Brook confluence is located on the Mongaup River upstream of the Rio Reservoir and downstream of the Mongaup Falls Powerhouse. There are currently no upstream passage routes/structures for American shad at the Black Brook

Development. Based on the size and characteristics of Black Brook, it is unlikely that spawning American shad would seek to migrate upstream into Black Brook; however, it they did, it is likely that the natural falls at the site of the Black Brook Dam would represent the natural upstream barrier for American shad.

There are currently no upstream passage structures for American eel at the Black Brook Development. Black Brook Dam is approximately 10 feet high and is constructed atop a natural waterfall (Figure 4-1). Unlike Rio and Mongaup Falls dams, upstream eel passage is more likely at Black Brook Dam due to the run of river flow; the slope, roughness, and configuration of the spillway; and the relatively low height of the dam. Eels capable of climbing would potentially be able to pass the Black Brook Dam during periods of low or moderate spill with overall passage rates expected to be moderate.

FIGURE 4-1
BLACK BROOK DAM (PHOTOGRAPH TAKEN JUNE 28, 2018)

6.1.1.3 Swinging Bridge Project

Swinging Bridge Development

There are currently no upstream passage structures or routes for American eel at the Swinging Bridge Development. Swinging Bridge Dam is a large, 135-foot-tall earthen dam that does not contain an integrated conventional spillway. As described in Section 4.1 above, a separate concrete side-channel spillway is located approximately 750 feet northwest of the dam and is equipped with a 5-foot-high Obermeyer gate section and five motor-driven, vertical-lift timber gates. The spillway is typically only utilized for high water events to release water from the Swinging Bridge Reservoir to avoid an overtopping of the earthen dam. Water that passes over this spillway flows across 1,300 feet of bedrock and large boulders and discharges into Black Lake

Creek approximately 0.8 mile upstream from the confluence with the Mongaup River. Eels capable of climbing may potentially be able to navigate this natural spillway during periods of low or moderate spill, but would likely be unable to pass over the Obermeyer gates and may be able to navigate over the timber gates; therefore, overall passage rates via this route would be expected to be relatively low.

Cliff Lake Development

There are currently no upstream passage structures for American eel at the Cliff Lake Development. Cliff Lake Dam is approximately 25 feet high and located on Black Lake Creek approximately 1.75 miles upstream of the confluence with the Mongaup River. Cliff Lake Dam does not consistently spill, which limits the potential upstream passage of eels via the spillway. Eels capable of climbing may be able to pass the Cliff Lake Dam during periods of low or moderate spill but overall passage rates would be expected to be relatively low. Those eels able to pass Cliff Lake Dam would be able to access Cliff Lake Reservoir and Swinging Bridge Reservoir via the connecting tunnel (described above in Section 4.3) as well as Black Lake Creek to the base of Toronto Dam.

Toronto Development

There are currently no upstream passage structures for American eel at the Toronto Development. Toronto Dam is located on Blake Lake Creek approximately 5.75 miles from the confluence with the Mongaup River. The dam is a 103-foot-high earthen dam with a natural spillway carved out of the existing bedrock at the southern corner of the dam. Toronto Dam does not regularly spill, which limits the potential upstream passage of eels. Eels capable of climbing may potentially be able to ascend the natural spillway during periods of low or moderate spill but overall passage rates would be expected to be low.

6.1.2 Downstream Fish Passage

6.1.2.1 Rio Project

There are currently no dedicated downstream passage structures installed at the Rio Dam. Existing routes of downstream passage include over the spillway or through the penstock.

Passage over the spillway would require an approximate 101-foot-long drop to the spillway pool at the base of the dam. This would occur only during spill events, which do not occur regularly at the Project and would likely result in mortality and/or injury due to the height of the drop and shallow pool at the base of Rio Dam.

Passage through the Project's penstock provides three alternate routes, each of which would require passage through the intake trashracks protecting the entrance to the penstock. The Rio Project intake is equipped with 2.9-inch clear-spaced trashracks (Eagle Creek 2019b). Proportional estimates of body width to total length (scaling factor) were used to determine the minimum length of American shad and American eel that would be excluded from the intake by the trashracks at the Rio Project (Eagle Creek 2019b). The minimum length of shad excluded, 27.7 inches, is larger than any shad collected during the 2018 field studies and is approaching the maximum documented length for the species. (Eagle Creek 2019a, 2019b). The minimum length of eel excluded, 78.7 inches, is larger than the maximum sizes attained by American eels (Eagle Creek 2019a). Therefore, both shad and eel are not expected to be excluded from the intake by the existing trashracks.

The first penstock alternative route is through a portion of the penstock and then through the minimum flow pipe with an egress location approximately 50 feet downstream of the spillway. This minimum flow pipe is currently fitted with a butterfly valve that is operated automatically in the case of a Unit No. 3 trip or can be opened manually. Egress from this minimum bypass flow pipe is an approximate 25-foot plunge into the spillway pool. The pressure and flow path through this valve is not conducive for fish passage survival and does not meet the existing fish passage criteria of the USFWS' guidelines (USFWS 2019).

The second penstock alternative route is through a portion of the penstock and then through the minimum flow unit. Fish utilizing this route would pass approximately 350 feet through the penstock and then egress through the minimum flow unit and into the bypassed reach approximately 325 feet downstream of the dam. Based on the results of the Fish Entrainment and Turbine Survival Study performed by Eagle Creek in 2018, fish greater than six inches would experience 0% survival (λ=0.20)[2] when attempting to pass the Rio Dam via this route. Expected survival rates for fish from 1-6 inches would be 85.4-12.6% (λ=0.20), respectively (Eagle Creek 2019b). In relation to the USFWS' guidelines (USFWS 2019), this is not considered an acceptable fish passage route.

The third penstock alternative route would consist of entering the penstock at the Project's intake and traveling approximately 1.4 miles and then egress through Unit No. 1 or 2 of the Main Powerhouse and into the tailrace. Based on the results of the Entrainment and Turbine Survival Study performed by Eagle Creek in 2018 , expected survival rates for fish ranging from 1-26 inches[3] in length were calculated and ranged from 96.8-15.6% (λ=0.20), respectively (Eagle Creek 2019b). In relation to the USFWS' guidelines (USFWS 2019), this is not considered an acceptable fish passage route.

The survival rates discussed above are for fish that would potentially enter the intakes and pass through the turbines. For significant portions of the year, fish may be unlikely to enter the intake due the thermal stratification of the reservoir and low dissolved oxygen (DO) concentrations at the depth of the intake. The 1992 Order Issuing License determined that from mid-April to mid-November, Project reservoirs are stratified and DO concentrations in the vicinity of the intakes would be depressed, such that fish would avoid the intake area and would be unlikely to become entrained during this period and that the entrainment of fish in the winter months would provide an important forage base for bald eagles. The time period from mid-April to mid-November encompasses the downstream migration period for post-spawn adult shad, juvenile shad, and silver eels.

In support of the 2018 Water Quality Study, continuous DO and water temperature data, as well as profile water quality data, were collected in the vicinity of the intakes in the Projects' reservoirs from late April through early November 2018. Thermal stratification in Rio Reservoir was evident throughout the entire monitoring period with variable strengths. By early to mid-October, it appears that the layers of stratification began to

[2] λ = Strike Mortality Correlation Factor from Franke et al. 1997. This value typically ranges from 0.1 to 0.2, and this range was evaluated in the 2019 Fish Entrainment Study (Eagle Creek 2019b).The results using λ=0.2 are discussed here since they are the most conservative.

[3] In the 2019 Fish Entrainment and Turbine Survival Study, the survival rates were calculated up to the maximum size of fish collected in the Intake Gillnet Study (26 inches). Shad and particularly silver eels can reach lengths greater than 26 inches and may have lower survival rates than the range reported.

dissolve and move downward in the water column (with anoxic conditions near the bottom) as lake turnover occurred. The reported minimum DO concentration for eels is greater than 4 milligrams per liter (mg/L) and for shad is greater than 4 to 5 mg/L, depending on the life stage (Greene et al. 2009). For portions of August to September, DO concentrations were at or below these thresholds at the intake centerline elevation in the Rio Reservoir.

6.1.2.2 Mongaup Falls Project

There are currently no dedicated downstream passage structures installed at the Mongaup Falls Project. Existing routes of downstream passage include over the spillway, through the minimum flow pipe, or through the powerhouse.

Passage over the spillway would require an approximate 40-foot-long plunge into the spillway plunge pool at the toe of the dam. Once there, fish would navigate downstream through an approximate 20-foot-wide cascading waterfall into a plunge pool and then continue to navigate downstream through the bypassed reach towards the Rio Reservoir.

Passage through the instream flow pipe would require passing through a 3-foot-diameter steel outlet pipe for approximately 75 feet. The outlet is equipped with two butterfly valves in series. Flow from the minimum flow pipe is currently 70 cfs and is expelled at a high velocity into the spillway plunge pool. Once there, fish would navigate downstream through an approximately 20-foot-wide cascading waterfall into a plunge pool and then continue to navigate downstream through the bypassed reach towards the Rio Reservoir. The force and direction of water through this valve is not currently conducive to fish passage survival and does not meet the existing fish passage criteria of the USFWS' guidelines (USFWS 2019).

Passage through the Project's penstock would require navigating down the penstock approximately 2,800 feet and through the surge tower, then through the generating units and egress into the tailrace of the powerhouse. This route would require passage through the intake trashracks protecting the entrance to the penstock. The Mongaup Falls Project intake is equipped with 1.7-inch clear-spaced trashracks (Eagle Creek 2019b). Proportional estimates of body width to total length (scaling factor) were used to determine the minimum length of American eel that would be excluded from the intake by the trashracks at the Mongaup Falls Project. American eel 45.8 inches and larger would be excluded from the Mongaup Falls Project intakes (Eagle Creek 2019b). All other individuals attempting to utilize this route of passage would be able to physically enter the penstock intake. All American eel collected during 2018 field studies would be able to pass through the intake trashracks at the Mongaup Falls Project (Eagle Creek 2019b). Based on the results of the Entrainment and Turbine Survival Study performed by Eagle Creek in 2018, survival rates for the general fish population including American eel with lengths from 1-19 inches would be 95.0-4.1% (λ=0.20), respectively (Eagle Creek 2019b). For fish larger than 19 inches, survival rates are estimated to be 0%. In relation to the USFWS' guidelines (USFWS 2019), this is not considered an acceptable fish passage route.

The survival rates discussed above are for fish that would potentially enter the intakes and pass through the turbines. For significant portions of the year, fish may be unlikely to enter the intake due the thermal stratification of the reservoir and low DO concentration at the depth of the intake. The 1992 Order Issuing License determined that from mid-April to mid-November, Project reservoirs are stratified and DO concentrations in the vicinity of the intakes would be depressed, such that fish would avoid the area and would be unlikely to become entrained and that the entrainment of fish in the winter months would provide an important forage base for bald eagles. The time period from mid-April to mid-November encompasses the downstream migration of post spawn adult shad, juvenile shad, and silver eels.

In support of the 2018 Water Quality Study, continuous DO and water temperature data, as well as profile water quality data, were collected in the vicinity of the intakes in the Projects' reservoirs from late April through early November 2018. A weak and temporary thermocline began to develop in early June, became more established by mid-June, and primarily dissolved by early August. The weak thermocline remained above the intake depth through July. A strong DO stratification was established from late August to late September when DO concentrations at the surface rapidly decreased, then were relatively uniform with depth (including the intake depth) until decreasing near the bottom. By late September, it appears fall turnover had occurred. DO concentrations at the intake depth generally remained above 6 mg/L between April and November. The reported minimum DO concentration for eels is >4 mg/L (Greene et al. 2009). For portions of July to September DO concentrations were at or below this minimum threshold in the area of the intake in Mongaup Falls Reservoir.

6.1.2.3 Swinging Bridge Project

Swinging Bridge Development

There are currently no dedicated downstream passage structures installed at the Swinging Bridge Development. Existing routes of downstream passage include over the side-channel spillway or through the Unit No. 2 or Unit No. 3 powerhouses.

Passage over the side-channel spillway would require fish to navigate upstream from the intake area approximately 750 feet to the spillway gates. Upon opening of the spillway gates, fish that utilize this route would then descend approximately 150 feet over a bedrock-spillway channel to the confluence of Black Lake Creek and navigate further downstream to the Mongaup River and Mongaup Falls Reservoir. While passage via the spillway is a potential downstream passage route, the extent to which the route would be available and silver eels may be able to efficiently locate and pass it during a temporary spill event is unknown and likely dependent on the volume and duration of spill as well as the availability of other routes. Migrating silver eels typically follow the dominant flow fields in an environment and if passage is unavailable, will exhibit searching behaviors until a passage route is located. The spillway gates are infrequently overtopped and reservoir levels are regularly below the elevation at which water would discharge even if the spillway gates were to be opened. The spillway gates are not opened routinely during normal Project operations; therefore, this downstream passage route is unlikely to be regularly available under normal operating conditions.

Passage through the Swinging Bridge Development's penstock provides two alternate routes. Each of which would require passage through the intake trashracks protecting the entrance to the penstock. The Swinging Bridge Development intake is equipped with 2.6-inch clear-spaced trashracks (Eagle Creek 2019b). Proportional estimates of body width to total length (scaling factor) were used to determine the minimum length of American eel that would be excluded from the intake by the trashracks at the Swinging Bridge Development. The minimum length of eel excluded, 70.2 inches, is larger than the maximum sizes attained by American eel. Therefore, eels are not expected to be excluded from the intake by the existing trashracks. Passage through the Unit No. 2 powerhouse would require fish navigating down the penstock and through the Unit No. 2

powerhouse. Swinging Bridge Unit No. 2 is supplied from the Swinging Bridge Reservoir through a concrete-lined tunnel running approximately 784 feet around the west end of the dam, connected to an all-steel penstock approximately 188 feet long. Based on the results of the Entrainment and Turbine Survival Study performed by Eagle Creek in 2019, survival rates for the general fish population including American eel with lengths from 1-18 inches ranged from 94.6-2.5% (λ=0.20), respectively (Eagle Creek 2019b). Fish larger than 18 inches were estimated to have a 0% survival rate. In relation to the USFWS' guidelines (USFWS 2019), this is not considered an acceptable fish passage route.

Passage through the newly installed Unit No. 3 would require passing through the penstock, then pass through the horizontal Francis turbine and into the tailrace. Based on the results of the Entrainment and Turbine Survival Study performed by Eagle Creek in 2018 (and updated in 2020 to incorporate the newly installed Unit No. 3), survival rates for the general fish population including American eel with lengths from 1-6 inches ranged from 85.4-12.6% (λ=0.20), respectively (Eagle Creek 2019b). Fish larger than 6 inches were estimated to have a 0% survival rate. In relation to the USFWS' guidelines (USFWS 2019), this is not considered an acceptable fish passage route. Additionally, Swinging Bridge Reservoir and Cliff Lake Reservoir are connected through an underground tunnel; therefore, fish have the potential to move between these two reservoirs.

The survival rates discussed above are for fish that would potentially enter the intakes and pass through the turbines. For significant portions of the year, fish may be unlikely to enter the intake due the thermal stratification of the reservoir and low DO concentrations at the depth of the intake. The 1992 Order Issuing License determined that from mid-April to mid-November, Project reservoirs are stratified and DO levels in the vicinity of the intakes would be depressed, such that fish would avoid the area and would be unlikely to become entrained. The time period from mid-April to mid-November encompasses the downstream migration of post spawn adult shad, juvenile shad, and silver eels.

In support of the 2018 Water Quality Study, continuous DO and water temperature data, as well as profile water quality data, were collected in the vicinity of the intakes in the Projects' reservoirs from late April through early November 2018. Thermal stratification began to develop in early June, was strongly developed by mid-June, and continued through October. Depth of the thermocline moved over time, establishing above the intake in June, then at the intake in July, and gradually moving downward in August until it eventually dissolved by late October. DO concentrations at the intake depth varied with the depth of stratification, with anoxic DO conditions occurring at the intake depth from late July to mid-September. By mid-October, the layers of stratification began to move downward in the water column as lake turnover occurred. The reported minimum DO concentration for eels is >4 mg/L (Greene et al. 2009). For portions of June through October DO concentrations were at or below this minimum threshold in the area of the intake in Swinging Bridge Reservoir.

<u>Cliff Lake Development</u>

There are currently no dedicated downstream passage structures installed at the Cliff Lake Development. Existing routes of downstream passage include over the spillway or through the minimum flow outlet structure.

Passage over the spillway would require an approximately 25-foot-long plunge onto a bedrock spillway channel and then into the minimum flow outlet channel. The outlet channel is located in bedrock, below the base of the spillway. The upstream half of the outlet channel is lined with concrete. Fish attempting to pass downstream would then need to traverse approximately 575 feet of bedrock cascades before Black Lake Creek gradient levels off. The force and direction of water over the existing spillway does not meet the existing fish passage criteria of the USFWS' guidelines (USFWS 2019).

Passage through the minimum flow outlet structure would require fish to pass through a 4-foot by 4-foot sluice gate located within the right portion of the dam's spillway. The gate has a capacity of 460 cfs and is manually operated to maintain downstream minimum flows of 10 cfs in Black Lake Creek downstream of Cliff Lake Dam. The outlet gate and its outlet channel are located in rock, below the base of the spillway. The existing outlet structure potentially meets the existing fish passage criteria of the USFWS' guidelines (USFWS 2019) but additional information on flow depth, pressure, and velocity associated with the outlet gate would be necessary to confirm.

Toronto Development

There are currently no dedicated downstream passage structures installed at the Toronto Development. Existing routes of downstream passage include over the bedrock side-channel spillway or through the minimum flow outlet structure.

Passage over the bedrock side-channel spillway would require navigating a 50-foot-wide concrete and bedrock side-channel spillway for a distance of 700 feet. The spillway is designed to discharge a flow of approximately 5,000 cfs but has a total capacity of 8,900 cfs and is equipped with 5-foot-high, pin-type flashboards. Fish would then navigate down an approximate 75-foot-high bedrock and large boulder cascade to reach Black Lake Creek and Cliff Lake Reservoir. The force and direction of water over the bedrock side-channel spillway does not likely meet the existing fish passage criteria of the USFWS' guidelines (USFWS 2019).

Passage through the minimum flow outlet structure from Toronto Reservoir to Black Lake Creek and eventually Cliff Lake Reservoir are made through an 8-foot by 8-foot, reinforced-concrete, horseshoe-shaped conduit, 565 feet long from intake to outlet. Flow is controlled by two gates with invert elevations at 1,179.5 feet and 1,143.5 feet. The upper gate is 4 feet wide by 5 feet high and the lower gate is 3 feet wide by 5 feet high. Fish would need to pass through a diffuser chamber located at the discharge end of the conduit, which is designed to prevent erosion of the downstream channel by dissipating the energy of the water discharged. This diffuser discharges into a large pool at the end of the outlet structure. This passage route potentially meets the existing fish passage criteria of the USFWS' guidelines (USFWS 2019).

6.2 Potential Fish Passage Routes and Measures

Potential fish passage measures that could be implemented at Projects are described below. The measures that would be feasible at each Project development are summarized in Section 6.2.5.

6.2.1 Upstream Passage Measures for Shad at Rio Dam

6.2.1.1 Full Elevation Fish Lift

Fish lifts or elevators are a technical and non-volitional means of fish passage where, in general, fish are crowded into a hopper and lifted vertically within a supporting tower and released to an exit flume that provides access to the headpond and/or a sorting facility. It is necessary to attract fish to the entrance of the structure and they eventually pass to a holding pool where they are crowded into the hopper for lifting. Since fish lifts move fish vertically, they generally have a much smaller footprint than other styles of volitional fishways where shad would swim up the full elevation through a sloped fishway. Fish lifts require an adequate attraction flow, are more suited towards fish that are not effective at fish ladder use, and can be labor intensive unless automated. Fish lifts can be similar to fish ladders in capital costs, but involve high operational and maintenance expenses and can be susceptible to mechanical failure (OTA 1995). This type of upstream passage measure has generally been reserved for projects with significant runs of fish (e.g. Susquehanna and Connecticut Rivers). The Conowingo Project on the Susquehanna River is similar to the Rio Project in height of the dam and species of fish being targeted, however the Susquehanna River and its shad run are several orders of magnitude larger than the Mongaup River. Spawning migrations for American shad typically occur when water temperatures range from 12-21 degrees Celsius (^{o}C) (Langdon et al. 2006, Whalberg and Nichols 1967, Leggett and Whitney 1972, Smith 1985). Based on the results of the Fisheries Survey Study (Eagle Creek 2019a) and the Water Quality Study (Eagle Creek 2019c) performed by Eagle Creek in 2018, the spawning run on the Mongaup River potentially occurred from approximately mid-May through late July. Additionally, a full elevation fish lift without a sorting facility would allow for the potential passage of invasive species above Rio Dam that currently do not exist.

6.2.1.2 Partial Elevation Fish Lift in Conjunction with Additional Measure

A smaller, partial elevation fish lift sited at the minimum flow powerhouse that lifts fish only as high as the existing roadway where they can be released to another fish passage measure is another fish passage alternative. Given the tall height (100 feet) of Rio Dam, the more than 300 foot distance between the dam and primary source of attraction flow at the minimum flow powerhouse tailrace, as well as the existing access and infrastructure in the vicinity of minimum flow powerhouse, this alternative considers other available technologies that could be used in tandem with a partial elevation lift to move fish upstream.

Fish would be released from the lift hopper into a flume that discharges to a temporary holding pool or tank. From the holding area, the shad could be transferred to another passage measure such as a fish transport truck or a fish pump that uses a vacuum and soft flexible tubing to rapidly pass shad above the dam. A partial elevation fish lift would cost less than a full elevation lift but would still entail significant capital costs and be on the order of millions of dollars. The additional measures to pass shad the remaining distance above the dam, a trap and truck program, or Whooshh Fish Transport System are discussed in greater detail below.

<u>Trap and Truck Program</u>

Trap and truck programs utilizes a fish collection system in conjunction with another fish passage measure such as a fish lift or ladder to attract and trap upstream migrants. Fish are then transferred into holding tanks or directly into specialized tank trucks for transport to upstream locations. The trap and truck method is often used on rivers with high-head barriers where traditionally-designed upstream fish passage is not feasible or in rivers where there are multiple barriers with little valuable habitat between barriers. This method allows resource managers to distribute the resource to more ideal and suitable locations while reducing delay or the need to pass fish over multiple barriers (Thomas and Mann 2018). This method is more labor intensive and requires staff and equipment to be available throughout the migrating season. Trap and truck programs expose fish to additional handling and increase the potential for injury. In river systems with very large runs of fish, trap and truck programs may not have the capacity to pass all incoming fish. The shad run on the Mongaup

River is expected to be limited in size and is likely within the capacity of a typical trucking program. Additionally, a partial elevation fish lift and trap and truck program may allow for the potential passage of invasive species, particularly smaller life stages that would not be visible at a sorting facility, above Rio Dam that currently does not exist.

FIGURE 6-1
EXAMPLE FISH TRANSPORT TRUCK RELEASING SHAD (PHOTO SOURCED FROM CT DEEP 2015)

Whooshh Fish Transport System

The Whooshh Fish Transport System (WFTS) is an innovative fish passage system designed to decrease passage time with the benefit of requiring minimal fish energy expenditure during transport. The WFTS utilizes a novel differential pressure system that facilitates movement of individual fish through a soft, flexible, lightly-misted tube structure in a matter of seconds. The WFTS has successfully demonstrated safe, timely, efficient, and effective transport for a number of species including salmonids (Chinook, Atlantic, Pink, Sockeye, and Coho salmon), Steelhead, Rainbow trout, and Sturgeon (Amaral et al. 2016, Buckley 2016, Fryer 2017, Geist et al. 2016, Mesa et al. 2013, Summerfelt et al. 2015,). Live salmon have been safely transported distances ranging from 40 to 1,700 feet with a vertical elevation change of up to 180 feet (Whooshh Innovations 2017). Transport-associated concerns evaluated to date include: injury, descaling, increased stress, reduction in survival or egg viability, delayed migration or passage timing, aberrant homing, increased disease transmission, or unusual behavior (Geist et al. 2016, Fryer 2017). In controlled studies, WFTS transported species have exhibited no significant transport-associated concerns. A 2017 study demonstrated the rapid passage and high survival rates of American shad with 100 percent initial survival and 97.4 percent at 24 hours (HDR 2017).

The WFTS passage can be somewhat labor intensive as shad do not volitionally enter the transport tube and are currently manually loaded. For shad, the WFTS fish pump would likely need to be used in conjunction with another fish passage structure such as a fish lift that would attract and aggregate fish for passage. This WFTS generally requires less capital cost than traditional engineered passage structures due its small size and minimal amount of materials used that would pass fish the entire vertical distance above a dam.

FIGURE 6-2
EXAMPLE WHOOSHH FISH TRANSPORT SYSTEM

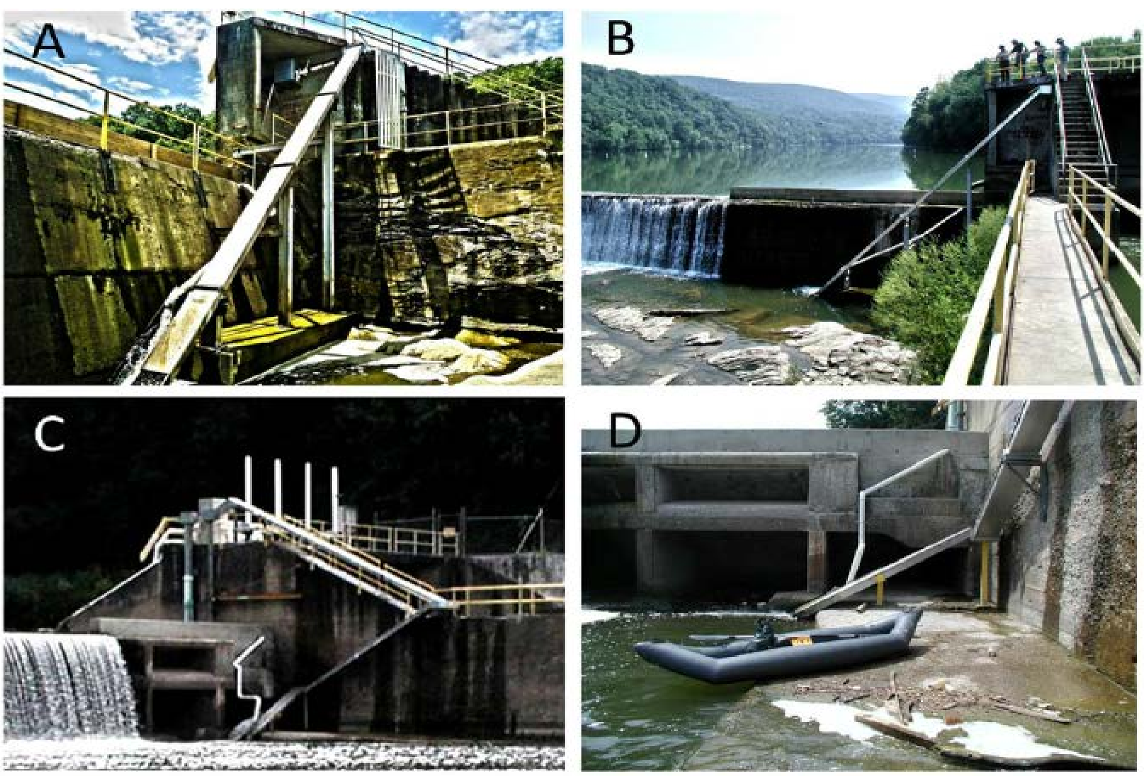
6.2.2 Upstream Passage Measures for Eel

6.2.2.1 Permanent Engineered Eel Pass Ladder

Eel ladders are designed specifically for eels with the use of different substrates to facilitate climbing dependent on the life stage most abundant in the river at the project location. Eel ramps are often constructed from aluminum or wood and are sloped from 10-45 degrees from the horizontal plane and are continuously wetted. Attraction flow is variable among sites but is necessary to attract the eels to the ramp. Some ramps extend up and over the dam with the outlet of the ramp in the impoundment, while others are shorter ramps leading to a trap and holding tank for later transport to upstream habitats. Given the significant height of Project dams such as Rio and Swinging Bridge dams and the long lengths of ladder necessary for an eel to ascend each dam, a full-height ladder that passes eels into the impoundment would not be practical in these locations. A partial elevation ladder that discharges to a trap where eels can be later transported above one or more Project barriers would be more feasible. Rio Dam is the lowermost dam on the Mongaup River system and where the greatest density of eels have been observed and would be expected on a yearly basis due to the arrival of new migrants. An eel ladder trap located below Rio Dam would allow for the collection and controlled distribution of eels above multiple Project barriers and likely represents the most efficient means of providing upstream passage of eels throughout the Project areas.

Eel ladders are generally low cost compared to other fish passage devices but permanent installations, particularly those that reach the full height of tall dams, may still involve significant capital costs.

FIGURE 6-3
EXAMPLE OF PERMANENT EEL PASS LADDERS ON THE SHENANDOAH RIVER
(PHOTO SOURCED FROM SA WALSH)



6.2.2.2 Portable Eel Pass Trap and Transport

Portable eel pass traps are similar to eel passes described above in that they use climbing substrates, ramps, and flowing water to attract and capture eels for transport above upstream barriers. Portable traps are a significantly lower cost passage option than a permanent engineered structure and are often made of readily available materials such as wood, PVC, pumps, hoses and plastic drums. Portable traps can be deployed temporarily or on a longer-term basis and are useful when identifying potential locations for permanent eel ladders. Compared to a permanent installation, portable traps offer flexibility in terms of location over time and fluctuating water levels. Rio Dam is the lowermost dam on the Mongaup River system and where the greatest density of eels have been observed and would be expected on a yearly basis due to the arrival of new migrants. A portable eel ladder trap located below Rio Dam would allow for the collection and controlled distribution of eels above multiple Project barriers and likely represents the most efficient means of providing upstream passage of eels throughout the Project areas. Portable eel pass traps would also be suitable for the provision of passage of eels at each dam within the Project system.

FIGURE 6-4
PORTABLE EEL PASS TRAPS GENERIC DESIGNS (PHOTO SOURCED FROM ASMFC 2013)

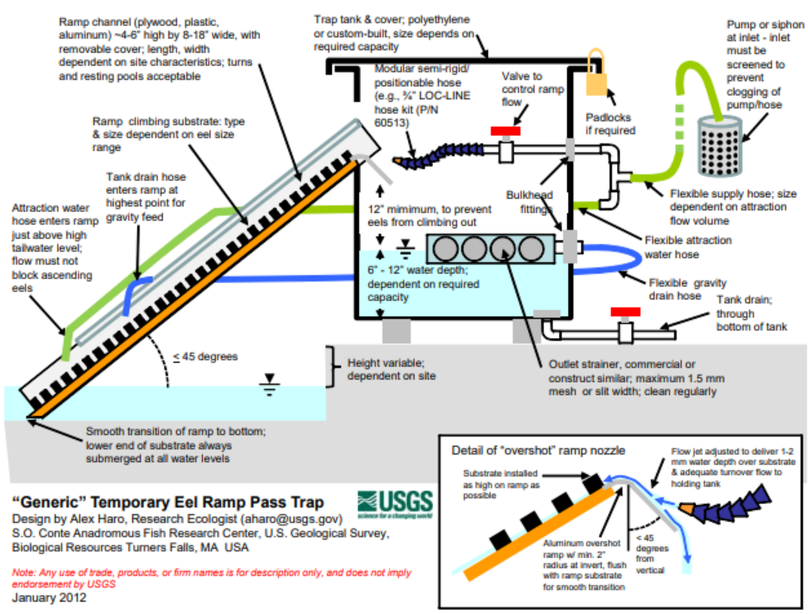


FIGURE 6-5
PORTABLE EEL PASS TRAPS GENERIC DESIGNS (PHOTO SOURCED FROM ASMFC 2013)

6.2.2.3 Delaware Style Trawl Net Pass

A Delaware style eel pass is a simple and inexpensive passage technology that uses nylon trawl netting draped over the dam or bedrock slopes to facilitate the climbing of eels. The trawl netting can be passed through flashboards to allow passage into the head pond and supply water. This type of pass is suitable for small to medium sized dams with spill, but in certain circumstances could be used at taller dams where wetted natural rock outcrops are present. This method could likely be used at Rio and Mongaup Falls. Swinging Bridge and Toronto are large earthern dams that do not spill and Cliff Lake Dam irregularly spills.

FIGURE 6-6
DELAWARE STYLE EEL PASS DEPLOYED AT MIANUS RIVER DAM IN GREENWICH CT
(PHOTO SOURCED FROM JACKMAN ET AL. 2009)

6.2.3 Downstream Passage Measures for Shad at Rio Dam

6.2.3.1 Surface Bypass with Downstream Conduit

Downstream migrating shad juveniles are primarily surface oriented (USFWS 2019) and relatively unlikely to enter the submerged intake, which is approximately 60 feet below the crest of the Rio spillway. Due to the approximately 100-foot-high Rio spillway and inconsistent spill, downstream passage over the spillway is unlikely to represent a suitable downstream fish passage route. A surface bypass with a conduit to convey shad to a plunge pool below the Rio Dam would be a potentially viable measure for downstream fish passage.

The 2019 USFWS fishway design criteria indicates that downstream passage facilities should provide a fishway flow between 2 and 5 percent of the maximum hydraulic capacity of the powerhouse/intake. Considering that the minimum flow unit powerhouse and the main powerhouse utilize the same intake structure, the total maximum hydraulic capacity is approximately 1,000 cfs, resulting in a potential flow of 20 to 50 cfs for a downstream fishway at the Rio Dam. The discharge from a surface bypass would likely lead to a moderate increase in water temperature in the stretch of the Mongaup River below Rio Dam, particularly in the bypassed reach, where it would represent a larger fraction of the total flow which is currently supplied by the deepwater intake, which would have cooler temperatures than the surface of Rio Reservoir.

6.2.3.2 Trashrack Spacing

The clear-spacing between trashrack bars at the Rio Project intake (2.9 inches) is currently large enough for adult American shad to pass through and enter the Project intake (Eagle Creek 2019b). Although shad are primarily surface oriented during downstream migrations, there is the potential for entrance into the submerged intake. A reduction in trashrack bar clear spacing would make it more likely for shad to utilize a surface bypass and avoid turbine entrainment. Juvenile shad are sufficiently small to fit through even reduced trashrack bar clear spacing; however, smaller fish are less likely to be killed by turbine blade strikes if entrained.

6.2.4 Downstream Passage and Protection Measures for Eels

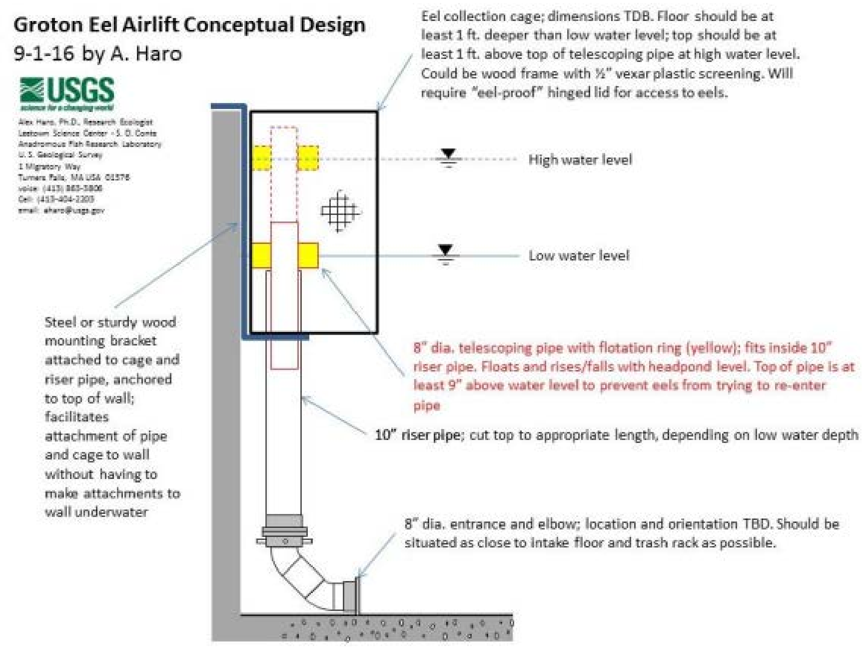
6.2.4.1 Trashrack Spacing

The trashrack spacing at the Swinging Bridge (2.6 inches), Mongaup Falls (1.7 inches), and Rio (2.9 inches) Project intakes are all currently large enough to allow migrating eels to enter the intakes and be exposed to turbine injury and mortality (Eagle Creek 2019b). The 2019 USFWS design criteria recommends ¾-inch trashrack bar spacing for the exclusion of silver eels. Narrower trashrack bar spacing would help exclude eels from entering the intake and increase the likelihood of utilizing an alternate downstream bypass route. Silver eels migrate downstream in the fall; therefore, the seasonal installation of trashrack overlays with narrower bar spacing could provide a protection measure during the period of time eels would be actively migrating. The replacement or seasonal installation of trashracks with narrower bar spacing at each turbine intake is likely to carry significant capital costs and may present technical challenges given the depth of each intake. The depth of water above the intake at each impoundment will vary with reservoir elevation; therefore, the following depths to each intake at the Swinging Bridge (50 feet), Mongaup Falls (20 feet), and Rio (40 feet) Projects represent the elevation difference from the full pond elevation to the centerline of each intake.

6.2.4.2 Conte Airlift Bypass

The Conte Airlift Bypass (CAB) is a relatively new downstream passage measure that was developed at the U.S. Geological Survey (USGS) Silvio Conte Diadromous Fish Research Laboratory and listed in the 2019 USFWS Design Criteria. It consists of a submerged PVC conduit where air is injected via a compressor toward the bottom of the pipe and creating an upward flow of water. Water is drawn into the pipe providing attraction flow for eels and flow for passage. In experimental deployments, eels were able to identify and successfully enter the conduit for passage (Haro et al. 2016) The CAB conduit discharges at the surface of the reservoir and into a holding pen, which allows eels to be retained and water to return to the headpond. The CAB has been successfully installed at a water supply reservoir in eastern Connecticut and during the 2019 season at least 1,227 silver eels were collected (CT DEEP 2019). The CAB can be constructed from relatively inexpensive materials and since it does not result in the release of water from the headpond, there are no losses in power generation due to water utilized for passage.

FIGURE 6-7
SCHEMATIC OF THE CAB AS WELL PHOTOGRAPH OF EEL STORAGE PEN FROM DEPLOYMENT IN EASTERN CONNECTICUT (PHOTOS AND DESCRIPTION SOURCED FROM CT DEEP 2016)



(above) *Conceptual design of the Groton Eel Airlift.*

6.2.4.3 Existing Low-Level Gates

The existing low-level release gates at Cliff Lake and Toronto Dams likely provide suitable downstream passage to migratory silver eels. There are no turbines or other mechanisms of injury through these gates.

6.2.5 Potential Passage Measures at Each Development

Potential upstream and downstream passage measures for American shad at the Rio Project is summarized in Table 6-1.

TABLE 6-1
POTENTIAL SHAD PASSAGE MEASURES AT THE RIO PROJECT

Project	Upstream	Downstream
RIO PROJECT	Partial elevation fish lift in conjunction with trap and truck program	Surface bypass into pipe

A list of recommended potential passage measures for eels at each dam is provided in Table 6-2 below. While potential upstream passage measures are provided for each dam, they may not be necessary if a trap and transport program is selected where eels collected below Rio Dam are released above multiple dams at the Projects or in another sub-watershed. While downstream passage measures are provided for each dam, the implementation of each measure may not be necessary for several years after juvenile eels have been passed above each barrier and reached maturity.

TABLE 6-2
POTENTIAL EEL PASSAGE MEASURES BY PROJECT AND DEVELOPMENT

Project	Upstream	Downstream
RIO PROJECT	Permanent eel pass trap to collect eels for distribution into upstream habitats. A portable eel trap should be used to help locate a suitable location for a permanent trap.	Conte Airlift Bypass (CAB) combined with reduced bar spacing (3/4-inch) trashracks
MONGAUP FALLS PROJECT	Portable eel pass trap and/or Delaware-style trawl net pass.	Spillway or CAB combined with reduced bar spacing (3/4-inch) trashracks
SWINGING BRIDGE PROJECT		
Swinging Bridge Development	Portable eel pass trap	CAB combined with reduced bar spacing (3/4-inch) trashracks
Cliff Lake Development	Portable eel pass trap	Existing bottom release gate
Toronto Reservoir Development	Portable eel pass trap	Existing bottom release gate

6.3 Estimated Costs for Potential Fish Passage Routes

Estimated costs associated with each potential passage or protection measure are detailed in Table 6-3 below.

TABLE 6-3
ESTIMATED COSTS ASSOCIATED WITH FISH PASSAGE AND PROTECTION MEASURES

Passage and Protection Measure	Estimated Cost	Considerations	Reference(s)
Full Elevation Fish Lift	\$25 to \$30 million	Maintenance costs for mechanical equipment and personnel to operate lift. Innovative use of aerial tram system may lower costs for full elevation lifts.	Based on recent fish lift, including sorting features and studies.
Partial Elevation Fish Lift	\$7 to \$12 million	Maintenance costs for mechanical equipment and personnel to operate lift.	Based on an 18-ft-high lift to a sorting facility
Trap and Truck	\$0.5 to \$1 million	Staff to operate and maintain transport vehicle.	Storage tanks, elevated sorting and holding facilities, and multiple transport vehicles.
Whooshh Fish Transport	\$1 to \$2 million	Maintenance and operation of specialized equipment. Staff necessary to manually load transport system.	--
Permanent Eel Ladder Trap	\$200,000 to \$350,000	Rugged design for permanent installation and water supply, including access to trap, includes design. Price will vary with access requirements. Staff needed for maintenance and eel handling.	--
Portable Eel Ladder Trap	\$200 - \$2,000	Battery powered pumps and solar panels can be necessary if gravity fed attraction flow or electricity to power pumps are not available or practical. Staff needed to maintain and check trap.	--
Downstream Surface Bypass	\$250,000 to \$2 million	High head downstream passage requires significant piping to meet USFWS criteria for safe passage. May involve construction of pools at point of discharge to achieve required depth.	--
CAB	\$20,000 to \$70,000	--	--
Trashrack Modifications	\$300 per square foot of rack area	--	Based on 30 feet of head without structural support; 2006 pricing escalated to 2020.

6.4 Effects of Introducing Migratory Species at the Projects

6.4.1 American Shad

6.4.1.1 Availability of Habitat

If shad were passed above the Rio Dam, they would gain access to the approximately 4.5 linear miles of reservoir and riverine habitat between the Rio Dam and the Mongaup Falls Dam, which is located at the site of the historic Mongaup Falls. Mongaup Falls represents the historic upstream limit of shad migration in the Mongaup River.

By length, the Rio Reservoir occupies 3.22 linear miles and at approximately 460 acres represents the vast majority of the area between the Rio and Mongaup Falls dams. Between the head of Rio Reservoir and the base of Mongaup Falls is approximately 1.25 miles and 6.97 acres of riverine habitat. This reach of the Mongaup River can be divided into two distinct sections located upstream and downstream of the bypassed reach fisherman access area. Upstream of the Mongaup Falls bypassed reach fisherman access area, the habitat is characterized as a moderate gradient split channel with a consistent composition of riffle, run, and pool habitats. This portion of the reach receives a continuous minimum flow of 70 cfs but occasionally sees higher flows during spring freshet and high precipitation events resulting in spill over Mongaup Falls Dam. Downstream of the Mongaup Falls bypassed reach fisherman access area, the channel turns to a more gradual gradient with a long riffle/glide complex leading to the confluence with Black Brook. Flows in this area are more variable due to releases from the Mongaup Falls Powerhouse, which range from 90 cfs (70 cfs minimum bypassed reach flow combined with 20 cfs provided as leakage from the powerhouse) to 620 cfs (155 cfs per unit). From Black Brook to the backwater of Rio Reservoir, the river is relatively steep and the habitat can be characterized primarily as riffle. Substrates vary from large boulders strewn throughout the upper portion of the channel to large gravel in the lower end of the reach, but cobble seems to dominate throughout.

Black Brook is a small tributary of the Mongaup River in this area and provides an additional 1.06 miles and 5.22 acres of riverine habitat; however, Black Brook is much smaller than rivers and tributaries typically associated with shad spawning.

Downstream of Rio Dam there is 4.5 miles of riverine habitat in the Mongaup River down to the confluence with the Delaware River. This stretch of river can be divided into two distinct segments: the bypassed reach and the lower Mongaup reach. The Rio bypassed reach extends approximately 1.5 miles from the Rio Dam to the Rio Main Powerhouse with a minimum flow of 100 cfs provided via the Rio Minimum Flow Powerhouse. The lower Mongaup reach extends approximately 3 miles from the Rio Main Powerhouse to the Delaware River with flows ranging from 100 cfs (from the bypassed reach) to 970 cfs (minimum flow plus two-unit generation at the Main Powerhouse).

The mainstem Delaware River is one of the largest stretches of undammed riverine habitat in the eastern United States and represents significant shad habitat. The Upper Delaware River provides key spawning and nursery habitat for the American shad along its entire length, with the most important spawning above the Delaware Water Gap and the most important nursery areas from Belvedere to Hancock and up into the East Branch and centered near Tusten and Lordville (Conference of Upper Delaware Townships 1986).

6.4.1.2 Suitability of Habitat

American shad are anadromous and make spawning migrations up medium to large coastal rivers in the spring and early summer months. American shad spawning habitat features are summarized in Greene et al. (2009) and generally consist of:

- Current velocity between 0.3 to 0.9 meters per second or 1 to 3 feet per second;
- DO concentrations greater than 4 mg/L;
- Water depths of 0.46 to 6.1 meters or 1.5 to 20 feet; and
- Water temperatures of 8 to 26°C or 46.4 to 78.8 degrees Fahrenheit (^{o}F).

Flowing water/current velocity is an important factor in determining the suitability of spawning habitat for American shad (Greene et al. 2009, Stier and Crance 1985, Bilkovic et al. 2002.) and that a minimum flow velocity may be necessary to prevent siltation on eggs (Williams and Bruger 1972; Bilkovic 2000). Due to the presence of the Rio Reservoir and the limited area of lotic habitat in the area between the Rio and Mongaup Falls dams, only a small portion of the available habitat represents suitable spawning and rearing habitat for American shad.

The acreage of riverine habitat below Rio Dam and below Mongaup Falls Dam were estimated by summing the areas of habitat features that were surveyed using handheld global positioning system (GPS) units during the 2018 field studies and, in areas that were not surveyed, the area of wetted channel was estimated by digitizing aerial imagery using geographic information system (GIS) mapping (Eagle Creek 2019d). The carrying capacities were applied to the acreages to provide a coarse estimate of spawning shad that could potentially be supported in each area of habitat.

The carrying capacity of riverine habitats for spawning shad has been estimated to range between 19.75 and 50 shad per acre. These estimates were developed using historical stock data from the Connecticut River and have been used as estimates for other river systems (St. Pierre 1979, Hightower and Wong 1997, Weaver et al. 2003, Harris and Hightower 2012). There is considerably more potential spawning habitat available in the Mongaup River downstream of the Rio Dam than the Mongaup River between Rio Dam and Mongaup Falls. As a conservative measure, Black Brook was assumed to represent potential shad spawning habitat for the purposes of this assessment; however, it is much smaller than rivers typically associated with shad runs and is not expected to provide meaningful amounts of shad spawning habitat. Based on the carrying capacity assessment, the Mongaup River downstream of Rio Dam can potentially support 970-2,455 spawning shad while the Mongaup River upstream of Rio Dam would only support an estimated 241-610 shad (Table 6-4). While shad were observed in the Mongaup River below Rio Dam, data is not available on the total run size or density of shad within the Mongaup River system relative to its carrying capacity.

TABLE 6-4
ESTIMATED NUMBER OF AMERICAN SHAD POTENTIALLY SUPPORTED BY RIVER SEGMENT

River Segment (downstream to upstream)	Length (miles)	Area (acres)	No. Shad Supported at 19.75 Shad/Acre Carrying Capacity	No. Shad Supported at 50 Shad/Acre Carrying Capacity
CURRENTLY AVAILABLE SHAD SPAWNING HABITAT DOWNSTREAM OF RIO DAM				
Mongaup River from Delaware River to Rio Dam	4.6	49.1	970	2,455
POTENTIAL SHAD SPAWNING HABITAT UPSTREAM OF RIO DAM				
Mongaup River from head of Rio Reservoir to Mongaup Falls	1.25	6.97	138	349
Black Brook from Mongaup River to Black Brook Dam	1.06	5.22	103	261
Total Upstream of Rio Dam	***2.31***	***12.19***	***241***	***610***

6.4.1.3 Passage Effects

The objective of an upstream shad passage program is generally to pass shad upstream of barriers to restore access to historical spawning habitat such that the restoration of access will result in the enhanced production of juvenile shad and ultimately a larger shad population. However, in some river systems where upstream passage has been provided upstream of hydropower dams, the enhanced production is frequently not realized for a number of reasons, chiefly the mortality and migratory delay associated with passing shad around barriers.

In the Northeast, American shad are typically iteroparous, meaning they make multiple spawning migrations before dying. Repeat spawning shad are typically larger and exponentially more fecund than smaller, first-time spawning shad and are an important component of healthy shad populations. Leggett et al. (2004) found that following the implementation of upstream passage enhancements at multiple dams on the Connecticut River, a significant reduction in the proportion of repeat spawning shad was observed, which resulted in corresponding reductions in overall population fecundity and annual recruitment to the population. Studies and modeling efforts in multiple river systems found that the provision of upstream shad passage and subsequent access to additional spawning habitat comes at the expense of repeat spawning (Leggett et al. 2004, Castro Santos and Letcher 2010, Harris and Hightower 2012, Stich et al. 2019). The decline in repeat spawning is believed to be due to a combination of direct mortality at hydropower facilities and the increased consumption of energy reserves due to migratory delay at barriers and the increased total migratory distance.

Shad that were trapped and transported above dams in the Roanoke River system were found to meander within reservoirs as opposed to making a directed upstream movement to areas of suitable spawning habitat above the reservoir (Harris and Hightower 2012). While the reservoirs in the Roanoke River system are considerably larger than Rio Reservoir, it is possible that shad passed into Rio Reservoir may experience upstream migratory delays as they navigate the reservoir and attempt to locate the suitable spawning habitat above the reservoir. Similarly, Harris and Hightower (2012) also found that very few of the shad passed upstream of the same barriers successfully migrated downstream.

Given the limited amount of suitable spawning habitat located upstream of Rio Dam, it is possible that limited potential additional production of shad would be offset by the mortality, delay, and reduction in repeat spawning associated with the downstream passage of post-spawn adults. The height of Rio Dam (100 feet) and the lack of regular spill will likely be a significant challenge to the passage and survival of post-spawn shad.

6.4.1.4 Ecological Effects

Adult American shad generally do not feed during their spawning migration and, therefore, would not be expected to exert predation pressure on the Mongaup River system. Adult American shad are generally sufficiently large that they would not be vulnerable to predation from the resident fish in Rio Reservoir or the Mongaup River. However, in the open area of Rio Reservoir, American shad are likely to be more vulnerable to predation by the resident bald eagles than they would be in the Mongaup River, which has a greater amount of canopy coverage.

Juvenile shad may provide an additional prey resource to the predatory species such as brown trout, walleye, and largemouth bass within Rio Reservoir prior to their downstream passage from Rio Reservoir. However, juvenile shad occupy a similar niche as the resident landlocked alewife population as they are both are known to feed on zoo-plankton, daphnia, copepods, insect larvae, and other small prey items (Greene et al. 2009). In the Columbia River system where there are large populations of non-native American shad, they were noted to consume a large portion of the total zoo plankton production and altered the plankton community structure (Haskell et al. 2013). While it is possible that competition between juvenile shad and alewife may lead to a minor reduction in production of alewife, based on the limited area of suitable spawning and rearing habitat above the Rio Dam, the production of juvenile shad is unlikely be sufficiently large enough to cause significant trophic changes in the reservoir.

6.4.2 American Eel

6.4.2.1 Availability and Suitability of Habitat

All segments of river and reservoirs associated with the Projects would be suitable for foraging, growth, and development of American eel prior to their downstream spawning migrations. American eels are adaptable and can utilize a wide range of riverine, lake, or reservoir habitat (McCleave 2001a, Greene et al. 2009).

6.4.2.2 Passage Effects

The passage of American eel upstream of hydropower dams can expose the eventual out-migrating silver eels to migratory delay at each dam and mortality when passing through turbines or over spillways. The passage of juvenile eels above barriers can relieve density dependent mechanisms that limit eel growth and reproductive potential below dams and lead to the production of larger and more fecund silver eels (Machut et al. 2007, Bowser et al. 2013). In systems with multiple dams, the cumulative mortality from the downstream passage of multiple dams can limit the reproductive potential of the watershed or river system (McCleave 2001b). For the benefit of additional eel production from upstream passage programs to be realized, a sufficient number of silver eels need to survive turbine passage and complete their downstream migration. Modeling efforts on the Susquehanna River have indicated that in order for benefits of upstream eel passage to be realized, cumulative downstream turbine survival past multiple dams must be at least 33 percent (Sweka et al. 2014). For the

Swinging Bridge, Mongaup Falls, and Rio Projects, the average survival at each development would have to be approximately 70 percent to achieve the 33 percent cumulative survival for eels that pass all three developments. However, the 33 percent survival estimate could be reached under lower, per-development survival rates given that not all eels will pass multiple developments and be exposed to the compounding risk of mortality.

6.4.2.3 Ecological Effects

In river systems where eels are present, they can represent a significant portion of the total fish biomass in the system (Machut et al. 2007) and are often the most abundant species. Eels were the most abundant species captured during electrofishing surveys in two reaches of the Mongaup River below the Rio Dam and comprised approximately 65 and 72 percent of the total catch in each reach (Eagle Creek 2019a). Juvenile eels can occur at high densities downstream of barriers and, due to competition, experience slower growth rates than eels upstream of barriers in habitats with lower eel densities (Machut et al. 2007, Bowser et al. 2013). The upstream dispersal and migration of juvenile eels is believed to be driven by the density dependent competition in the crowded habitats lower in the watershed as this competition limits feeding and growth (Feunten et al. 2003, Shepard 2015). High densities of eels can also alter sex ratios and result in a greater proportion of males, while habitats with lower densities of eels will produce more female eels (Tesch 2003). If eels were passed upstream of Rio Dam into available upstream habitat throughout the Projects, the density of eels below Rio Dam would be expected to decline and the growth rate of eels may potentially increase.

Eels are generalist predators and consume a variety of prey items depending on their availability and the size of the eel (Greene et al. 2009, Shepard 2015). Juvenile eels may consume macroinvertebrates, insects, demersal fish eggs, and other small-prey items while larger eels can consume live fish, crayfish, mussels, smaller eels, and macroinvertebrates (Greene et al. 2009). The introduction of juvenile eels into upstream habitats may result in increased competition for prey resources with resident species. Overtime, as the eels grow and reach sufficient size they will be able to consume other fish as prey, which will result in increased predation pressure. Given that eels can represent a significant portion of the biomass in habitats where they are present, it is possible that the reintroduction of eels into habitats upstream of Rio Dam may result in the potential decreased production of some resident species including game species. However, smaller eels may also provide an additional prey resource for resident species in habitats upstream of Rio Dam.

Of potential concern is increased predation pressure by eels on the wild population of Eastern brook trout (*Salvelinus fontinalis)* in Black Lake Creek. During the 2018 fisheries survey, the fish community in two segments of Black Lake Creek was found to be dominated by brook trout (70 and 95% of the catch in the two sampled reaches). Brook trout could potentially be consumed by larger adult eels and the presence of smaller eels could result in increased competition for prey resources. However, American eels and brook trout historically co-occupied stream habitats throughout large portions of their historic ranges.

7.0 Summary

There is a minor amount of suitable shad spawning habitat above Rio Dam and currently no means of upstream passage for shad. The habitat above Rio Dam is estimated to be capable of supporting approximately 200-600 shad. The implementation of upstream and downstream passage programs will represent significant capital costs for installation and long-term costs for operation and maintenance. Based on the reported challenges of providing downstream passage for post-spawn shad, it seems unlikely that downstream passage will result in the growth of the American shad population in the Mongaup River.

There is an abundance of suitable eel habitat throughout the Project areas. Currently upstream passage is restricted by Project dams and limited to the small fraction of eels that potentially climb Rio and Mongaup Falls dams. Given that there are multiple dams on the Mongaup River system, including two dams greater than 100 feet in height, the collection of eels below Rio dam and transportation into habitats above dams at the Projects is likely the most efficient means of providing upstream passage at the Projects. Migratory silver eels would be able to enter all turbine intakes due to the clear bar spacing of the existing trashracks and would likely experience significant turbine mortality. With the exception of Cliff Lake and Toronto dams, it would be necessary to install downstream passage measures at each development in order to safely pass silver eels.

8.0 Variances from Approved Study Plan

This study was conducted in conformance with the requirements of the Commission's SPD.

9.0 Literature Cited

Amaral, S, Grant, T, Dearden, S, Pyatskowit, J and Jacobson, P. 2016. Evaluation of Lake Sturgeon Passed through the Whooshh Fish Transport System. Presented at Fish Passage 2016 International Conference on River Connectivity.

Atlantic States Marine Fisheries Commission (ASMFC) 2013. Proceedings of a Workshop on American Eel Passage Technologies. July 2013.

Bilkovic, D. M. 2000. Assessment of spawning and nursery habitat suitability for American shad (Alosa sapidissima) in the Mattaponi and Pamunkey Rivers. Doctoral dissertation. The College of William and Mary, Williamsburg, Virginia.

Bilkovic, D. M., C. H. Hershner, and J. E. Olney. 2002. Macroscale assessment of American shad spawning and nursery habitat in the Mattaponi and Pamunkey Rivers, Virginia. North American Journal of Fisheries Management 22: 1176-1192.

Bowser, C., S. Mount, Z. Maloney, and L. Walker. 2013. The Hudson River Eel Project: Citizen Science Juvenile American Eel Surveys: 2008-2013. New York Department of Environmental Conservation, Hudson River Estuary Program.

Buckley. 2016. Studies: Buckley Study Report Whooshh Fish Transport System. Whooshh Innovations. Online [URL]: http://www.whooshh.com/studies.html

Castro Santos, T. and B.H. Letcher. 2010. Modeling Migratory Energetics of Connecticut River American Shad (Alosa sapidissima): Implications for the Conservation of an Iteroparous Anadromous Fish. Canadian Journal of Fisheries and Aquatic Science, 2010, 67(5): 806-830.

Conference of Upper Delaware Townships. 1986. Upper Delaware Scenic and Recreational River, Final Management Plan. Prepared by the Conference of Upper Delaware Townships. In Cooperation with the Commonwealth of Pennsylvania; State of New York; Delaware River Basin Commission; National Park Service; and the Upper Delaware Citizens Advisory Council. November, 1986.

Connecticut Department of Energy and Environmental Protection (CT DEEP) 2015. Connecticut Inland Fisheries Diadromous Fish Restoration and Enhancement Federal Aid in Sport Fish Restoration F-50-D-35 Annual Performance Report-F14AF00148.

Connecticut Department of Energy and Environmental Protection (CT DEEP) 2016. Inland Fisheries Division Program Notes and Updates (Fall).

Connecticut Department of Energy and Environmental Protection (CT DEEP) 2019. Fisheries Division Notes and Updates (Fall).

Dittman, D.E., L.S. Machut and J.H. Johnson. 2009. American eel history, status, and management options: Delaware River Drainage. Final Report for New York State Contract #C005548, Comprehensive study of the American eel. Tunison Laboratory of Aquatic Sciences, USGS, Great Lakes Science Center, Cortland, New York. 102pp.

Eagle Creek. 2019a. Mongaup River Hydroelectric Projects (FERC Project Nos. 10481, 10482, 9690), Initial Study Report. Appendix C Fisheries Survey Study Report. Filed with the Federal Energy Regulatory Commission on February 8, 2019.

Eagle Creek. 2019b. Mongaup River Hydroelectric Projects (FERC Project Nos. 10481, 10482, 9690), Initial Study Report. Appendix E Fish Entertainment Turbine Survival Study. Filed with the Federal Energy Regulatory Commission on February 8, 2019.

Eagle Creek 2019c. Mongaup River Hydroelectric Projects (FERC Project Nos. 10481, 10482, 9690), Initial Study Report. Appendix F Water Quality study Report. Filed with the Federal Energy Regulatory Commission on February 8, 2019.

Eagle Creek 2019d. Mongaup River Hydroelectric Projects (FERC Project Nos. 10481, 10482, 9690), Initial Study Report. Appendix O Bypass/Base Flow Transect Evaluation Study Report. Filed with the Federal Energy Regulatory Commission on February 8, 2019.

Feunteun, E. & Laffaille, Pascal & Robinet, Tony & Briand, Cedric & Baisez, Aurore & Olivier, Jean-Michel & Acou, Anthony. 2003. A Review of Upstream Migration and Movements in Inland Waters by Anguillid Eels: Toward a General Theory. 10.1007/978-4-431-65907-5_14.

OTA. 1995. Fish Passage Technologies: Protection at Hydropower Facilities, OTA-ENV-641 (Washington, DC: U.S. Government Printing Office, September 1995).

Franke, G.F., D.R. Webb, R.K. Fisher, Jr., D. Mathur, P.N. Hopping, P.A. March, M.R. Headrick, I.T. Laczo, Y. Ventikos, and F. Sotiropoulos. 1997. Development of environmentally advanced hydropower turbine system design concepts. Prepared for U.S. Department of Energy, Idaho Operations Office.

Fryer, J. 2017. Results of a PIT tag study at Priest Rapids Dam to assess the impact of the Whooshh Fish Transport System on upstream migrating Sockeye Salmon. Columbia River Inter-Tribal Fish Commission. Online [URL]: https://www.whooshh.com/files/Studies/Whooshh/Whooshh%20 sockeye%20repo rt% 202016%20Final%20(1).pdf.

Geist, DR, Colotelo, AH, Linley, TJ, Wagner, KA, and Miracle, AL. 2016. Physical, physiological, and reproductive effects on adult fall Chinook Salmon due to passage through a novel fish transport system. Journal of Fish and Wildlife Management

Gomez and Sullivan Engineers, P.C. 2012. Final Study Report Biological and Engineering Studies of American Eel. RSP 3.3. Conowingo Hydroelectric Project. (FERC No. 405). Prepared for Exelon.

Greene, K. E., J. L. Zimmerman, R. W. Laney, and J. C. Thomas-Blate. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C.

Haro, A., Watten, B., Noreika, J. 2016. Passage of downstream migrant American eels through an airlift-assisted deep bypass. Ecological Engineering 91 (2016) 545-552.

Harris, J.E. and J.E. Hightower 2012. Demographic Population Model for American Shad: Will Access to Additional Habitat Upstream of Dams Increase Population Sizes?, Marine and Coastal Fisheries, 4:1, 262-283.

Haskell, C.A., K. Tiffan, and D., Rondorf. 2013. The Effects of Juvenile American Shad Planktivory on Zooplankton Production in Columbia River Food Webs. Transactions of the American Fisheries Society. 142. 606.

HDR. 2017. American Shad Transport Feasibility Study Report, Cataract Dam, Saco River, Maine. Prepared for Whooshh Innovations. July 20, 2017.

Hightower, J. E. and Wong, R. 1997. Potential benefits to anadromous fishes of providing fish passage within the Roanoke River basin. Report to the U.S. Fish and Wildlife Service and Virginia Power, Raleigh, North Carolina

Jackman, G., M. Larson, and V. Ruzicka. 2009. American Eel Passage Enhancement Plan for the Bronx River, Recommendations and Protocols. .

Langdon, R.W., M.T. Ferguson, and K.M. Cox. 2006. Fishes of Vermont. Vermont Agency of Natural Resources. Vermont Department of Fish and Wildlife. Waterbury, Vermont.

Leggett, W.C., and R.R. Whitney. 1972. Water Temperature and the Migrations of American Shad. Fisheries Bulletin 70: 659-670.

Leggett, W.C., Savoy, T.F., and Tomichek, C.A. 2004. The impact of enhancement initiatives on the structure and dynamics of the Connecticut River population of American shad. In the Connecticut River Ecological Study (1965-1973) revisited; ecology of the Lower Connecticut River 1973-2003. Edited by P.M. Jackman, D.A. Dixon, W.C. Leggett, B.C. Macy, and R.R. Massengill.

Machut et al. 2007. Anthropogenic Impacts on American Eel Demographics in Hudson River Tributaries, new Your Trans. Am. Fish. Soc. 136

McCleave, J. D. 2001a. Eels. Pages 800–809 in J. Steele, and C. McNeil, editors. Encyclopedia of Ocean Sciences. Academic Press, London.

McCleave, J. D. 2001b. Simulation of the impact of dams and fishing weirs on reproductive potential of silver-phase American eels in the Kennebec River basin, Maine. North American Journal of Fisheries Management 21(3):592–605.

Mesa, MG, Gee, LP, Weiland, LK and Christansen, HE. 2013. Physiological Responses of Adult Rainbow Trout Experimentally Released through a Unique Fish Conveyance Device. North American Journal of Fisheries Management. 33:6 1179-183.

Quinlan, J. 1873. History of Sullivan County. G.M. Beebe and W.T. Morgan, New York.

Shepard, S.L. 2015. American eel biological species report. U.S. Fish and Wildlife Service, Hadley, Massachusetts. xii +120 pages.

Smith, C.L. 1985. The Inland Fishes of New York. New York State Department of Environmental Conservation. Albany, New York.

St. Pierre, R. A. 1979. Historical review of American shad and river herring fisheries of the Susquehanna River. U.S, Harrisburg, Pennsylvania: Fish and Wildlife Service, Special Report to the Susquehanna River Basin Committee.

Stich, D.S., T.F. Sheehan, and J.D. Zydlewski. 2019. A dam passage performance standard model for American shad. Canadian Journal of Fisheries and Aquatic Sciences, 2019, 76(5): 762-779,

Stier, D. J., and J. H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. U.S. Fish and Wildlife Service Biological Report No. 82(10.88), Washington D.C.

Strassman, S. 2011. Session C2-Thanks for putting in that fish ladder: Can you remove the dam now? American Rivers. International Conference on Engineering and Ecohydrology for Fish Passage 2011.

Summerfelt, S, May, T, Crouse, C, McKnight, J and Bryan III, V. 2015. Novel-Air-Based System Transfers Large Salmon During Harvest. Global Aquaculture Advocate, 71-72

Sweka, J.A., S. Eyler, and M.J. Millard. 2014. An Egg-Per-Recruit Model to Evaluate the Effects of Upstream Transport and Downstream Passage Mortality of American Eel in the Susquehanna River, North American Journal of Fisheries Management, 34:4, 764–773

Tesch, F. W. 2003. The eel. Blackwell. London, England. 408 pages.

Thomas, S., J. Mann. 2018. Fish Passage Devices. Prepared by Steve Thomas (NMFS) and Jonathan Man (CDFW) for consideration of fish passage options for PG&E's Potter Valley Project.

U.S. Fish and Wildlife Service (USFWS). 2019. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, Massachusetts.

Weaver, L. A., Fisher, M. T., Bosher, B. T., Claud, M. L. and Koth, L. J. 2003. “Boshers Dam vertical slot fishway: a useful tool to evaluate American shad recovery efforts in the upper James River”. In Biodiversity, status, and conservation of the world's shads, Edited by: Limburg, K. E. and Waldman, J. R. 339–347. Bethesda, Maryland: American Fisheries Society, Symposium 35.

Whalberg C.H. and P.R. Nichols. 1967. Biology and management of the American Shad and status of the fisheries, Atlantic Coast of the United States. 1960. U.S. Fish and Wildlife Service Special Science Report for Fisheries 550.

Whooshh Innovations. 2017. Video: Sockeye Salmon Over Cle Elum Dam. Online [URL]: https://www.youtube.com/watch?v=uCxNC5cJuOo

Williams, R. O., and G. E. Bruger. 1972. Investigations on American shad in the St. Johns River. Florida Department of Natural Resources Marine Research Laboratory Technical Series 66: 1-49.

Appendix G

Bald Eagle Study

(filed separately as CUI/Privileged)

Appendix H

Updated Special-Status Species Study

(filed separately as CUI/Privileged)