FINAL STUDY REPORT
WATER LEVEL MANAGEMENT STUDY
RSP 3.12

CONOWINGO HYDROELECTRIC PROJECT

FERC PROJECT NUMBER 405

Prepared for:

Exelon

Prepared by:

URS Corporation

Gomez and Sullivan Engineers, P.C.

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EXECUTIVE SUMMARY

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt Conowingo Hydroelectric Project (Conowingo Project). The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014. FERC issued the final study plan determination for the Conowingo Project on February 4, 2010, approving the revised study plan with certain modifications.

The final study plan determination required Exelon to conduct a Water Level Management (WLM) Study. The objectives of this study are to: 1) investigate the potential effect of water level fluctuations on emergent aquatic vegetation (EAV) and submerged aquatic vegetation (SAV) habitat in the littoral zone of the Conowingo Pond; 2) describe and quantify littoral zone habitat; 3) evaluate the potential influence of Conowingo Project drawdown on EAV and SAV habitat in the littoral zone of the Conowingo Pond, and 4) determine whether or not EAV and SAV in Conowingo Pond needs to be enhanced, taking into account necessary limits on pond level fluctuations intended to provide cooling water, drinking water and to limit recreation impacts.

An initial study report (ISR) was filed on April 29, 2011, containing Exelon's 2010 study findings. A meeting was held on August 23 and 24, 2011 with resource agencies and interested members of the public. Formal comments on the ISR including requested study plan modifications were filed with FERC on March 21, 2012 by several resource agencies and interested members of the public. Exelon filed responses to the ISR comments with FERC on April 20, 2012. On May 21, 2012, FERC issued a study plan modification determination order. The order specified what, if any, modifications to the ISR should be made. For this study, FERC's May 21, 2012 order required no modifications to the original study plan. This final study report is being filed with the Final License Application for the Project.

The study area for this project is the Conowingo Pond from the lower end of Hennery Island to the Conowingo Dam, and the lower reaches of Broad Creek and Conowingo Creek. The upper extent of the study area is based on the fact that operations associated with the Conowingo Project on Pond water levels do not extend upstream of Hennery Island. As described in the Revised Study Plan for this study, water elevations above Hennery Island are primarily a function of releases from Holtwood Dam and the Muddy Run Pumped Storage Project.

Bathymetric and LiDAR surveys were conducted along the littoral zone to provide one-foot contour level accuracy within the Project drawdown elevation range of 101.2 to 110.2 feet NGVD 1929. A focused field survey was conducted in August 2010 to quantify the coverage of EAV and SAV and various

substrate types in the littoral zone for each one-foot contour interval within the permitted fluctuation range. Transects were established throughout the littoral zone study area where shifts in substrate composition, SAV and EAV community structure, and water velocity conditions were detected. Hydrographic data from the bathymetry and LiDAR surveys were compiled into a GIS database and integrated with the results of the field-based habitat survey to generate multi-parameter habitat layers for each one-foot contour within the licensed 9-foot Project drawdown range.

The findings of this Study indicate that the presence of SAV generally corresponded with unconsolidated alluvial deposits in the upper portion of the study area, most notably along the eastern shoreline littoral zone and below Mt. Johnson Island. The SAV community was represented by a total of 7 species, but hydrilla (*Hydrilla verticillata*), a tolerant invasive species, dominated the coverage in the majority of locations where SAV was growing. A total of 16 emergent species were identified during the August 2010 habitat survey. EAV growth, however, was confined to point bars in shallow tributaries and to the confluences of tributaries and Conowingo Pond, indicating the observed distribution of EAV is likely a function of the natural geology of Conowingo Pond, and not due to water level fluctuations. Substrate composition in the majority of the Pond was found to be moderately diverse, with a composition that transitions from gravel (mainly cobble and boulder) in the upper range of fluctuation to a gravel and sand mix before becoming silt-dominant in the lower range. In the lower part of the study area along the western shoreline, littoral substrates consist primarily of bedrock due to steeply sloping rock outcroppings in this area. Flow values in the study area generally coincided with a lentic environment (velocity < 0.3 ft/sec).

For the Water Level Management Study, littoral zone substrates were categorized into shallow (0-5 feet) and deep (5-10 feet) for evaluating impacts to habitat from changes in water levels. Based on evaluations of the habitat and bathymetry data, SAV habitat in the littoral zone of the study area would be most affected by drawdown below the 106-foot elevation. Below the 106-foot elevation, the amount of shallow littoral habitat available for SAV growth begins to decrease from its maximum (at 106 feet), and is accompanied by a notable drop in areal coverage of SAV. Sand-dominated substrate, which was often covered by SAV growth, also begins to decline below the 106-foot elevation, and the amount of this substrate type is approximately halved with each successive one-foot reduction in elevation. In parallel with the evaluation of the bathymetry and habitat survey results, historic water elevation data from Conowingo Pond were reviewed and analyzed to determine historical trends in water level fluctuation in the study area. Based on a review and water-level frequency analysis of the Pond elevation data, water level fluctuations are primarily confined to elevations between 107 feet and 109 feet, and rarely fall below 106 feet. Periods at which elevations are lower than 106 feet are infrequent and brief. Therefore, the potential for de-watering of SAV-vegetated habitat in the littoral zone of the study area for extended periods of time is considered minimal.

Based on the results of the Water Level Management Study, water level fluctuations attributable to Project operations do not appear to be impacting littoral habitat in Conowingo Pond.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADR	Alluvial Dominated Reach
BDR	Bedrock Dominated Reach
CFS	Cubic Feet per Second
DEM	Digital ElevationModel
EAV	Emergent Aquatic Vegetation
Exelon	Exelon Generation Company, LLC
FERC	Federal Energy Regulatory Commission
GPS	Global Positioning System
HARN	High Accuracy Reference Network
HGM	Hydrogeomorphic
ILP	Initial Licensing Process
LiDAR	Light Detection and Ranging
MDNR	Maryland Department of Natrual Resources
MGD	Million Gallons Per Day
MPH	Miles per Hour
Muddy Run	Muddy Run Pumped Storage Project
MW	Megawatt
NGS	National Geodetic Survey
NGVD 29	National Geodetic Vertical Datum 1929
NOI	Notice of Intent
NRC	Nuclear Regulatory Commission
PAD	Pre-Application Document
PaDEP	Pennsylvania Department of Environmental Protection
PBAPS	Peach Bottom Atomic Power Station
PFBC	Pennsylvania Fish and Boat Commission
Pond	Conowingo Pond
Project	Conowingo Hydroelectric Project
PSP	Proposed Study Plan
Reservoir	Muddy Run Reservoir
RSP	Revised Study Plan
RTK	Real Time Kinematic
SAV	Submerged Aquatic Vegetation
SRBC	Susquehanna River Basin Commission
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1.0 INTRODUCTION

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt (MW) Conowingo Hydroelectric Project (Project). Exelon is applying for license renewal using the FERC's Integrated Licensing Process (ILP). The current license for the Project was issued on August 14, 1980 and expires on September 1, 2014.

Exelon filed its Pre-Application Document (PAD) and Notice of Intent (NOI) with FERC on March 12, 2009. On June 11 and 12, 2009, a site visit and two scoping meetings were held at the Project for resource agencies and interested members of the public. Following these meetings, formal study requests were filed with FERC by several resource agencies. Many of these study requests were included in Exelon's Proposed Study Plan (PSP), which was filed on August 24, 2009. On September 22 and 23, 2009, Exelon held a meeting with resource agencies and interested members of the public to discuss the PSP.

Formal comments on the PSP were filed with FERC on November 22, 2009 by Commission staff and several resource agencies. Exelon filed a Revised Study Plan (RSP) for the Project on December 22, 2009. FERC issued the final study plan determination for the Project on February 4, 2010, approving the RSP with certain modifications.

The final study plan determination required Exelon to conduct a Water Level Management Study, which is the subject of this report. The study is intended to quantify the extent of littoral zone habitat in the lower 10-mile reach of Conowingo Pond and the potential impacts of fluctuating water levels from Project operations on littoral habitat within the range permitted by the existing license.

An initial study report (ISR) was filed on April 29, 2011, containing Exelon's 2010 study findings. A meeting was held on August 23 and 24, 2011 with resource agencies and interested members of the public. Formal comments on the ISR including requested study plan modifications were filed with FERC on March 21, 2012 by several resource agencies and interested members of the public. Exelon filed responses to the ISR comments with FERC on April 20, 2012. On May 21, 2012, FERC issued a study plan modification determination order. The order specified what, if any, modifications to the ISR should be made. For this study, FERC's May 21, 2012 order required no modifications to the original study plan. This final study report is being filed with the Final License Application for the Project.

1.1 Background

In their study request letters, FERC, Maryland Department of Natural Resources (MDNR), Pennsylvania Department of Environmental Protection (PaDEP), Pennsylvania Fish and Boat Commission (PFBC), Susquehanna River Basin Commission (SRBC), and United States Fish and Wildlife Service (USFWS) requested Exelon conduct a study to quantify impacts of reservoir fluctuation from Project operations on littoral habitat in Conowingo Pond (Pond).

The reservoir known as Conowingo Pond extends approximately 14 miles from Conowingo Dam upstream to the lower end of the Holtwood Project tailrace (Figure 1.3-1). The Pond is formed by the Conowingo Dam and has a design storage capacity of 310,000 acre-feet, of which 71,000 acre-feet are usable storage. The Pond provides water for diverse uses including hydropower generation, water supply, industrial cooling water, recreational activities, and various ecological resources. Relative to hydropower generation, the Pond serves as the lower reservoir for the 800-MW Muddy Run Pumped Storage Project (Muddy Run), located 12 miles upstream of the Conowingo Dam. It also serves as the source of cooling water for the 2,186 MW Peach Bottom Atomic Power Station (PBAPS), located approximately seven miles upstream of Conowingo Dam. The Pond is also a public water supply source for the City of Baltimore, Harford County (MD), and the Chester (PA) Water Authority. In addition, it provides habitat for numerous species of freshwater fishes, benthic macroinvertebrates, and water-dependent wildlife, and is a corridor for anadromous and catadromous fishes to migrate through as they ascend and descend the river.

The permitted range of water level fluctuation in the Pond is 9 feet (Elevation 101.2 to 110.2 National Geodetic Vertical Datum 1929 [NGVD 29]), as established under Article 32 of the existing FERC license for the Conowingo Project. The NGVD 29 Datum is approximately 0.7 feet higher than the Conowingo Datum and is used throughout this document to describe Pond elevations and water fluctuations. Although 9 feet of fluctuation is permitted, Exelon's current operating regime typically restricts fluctuations to approximately 4.5 feet (minimum level at 104.7 NGVD 29) to minimize the potential for intake difficulties at PBAPS and cavitation to the Muddy Run turbines. During summer weekends, the Pond elevation is maintained at 107.2 feet on weekends to provide a water level suitable for summertime recreational use.

Critical water levels for the Conowingo Pond include the following:

- 107.2 feet: The Pond must be maintained at this elevation on weekends between Memorial Day and Labor Day to meet recreational needs;

- 104.7 feet: Below this level, Muddy Run cannot operate its pumps due to cavitation;
- 104.2 feet: PBAPS begins experiencing cooling problems when the elevation of the pool drops to this level;
- 100.5 feet: Below this elevation, the Chester Water Authority is unable to withdraw water from the Pond;
- 99.2 feet: The Nuclear Regulatory Commission (NRC) license for PBAPS requires the plant to shut down completely at this water level; and
- 91.5 feet: The City of Baltimore cannot withdraw water from the Pond below this water elevation.

The influence of Project operations on Pond water levels diminish upstream of Hennery Island where the influences from releases at Holtwood Dam and discharges from Muddy Run are pronounced. The Water Level Management Study encompasses the littoral zone of the Pond from the downstream point of Hennery Island to the Conowingo Dam, and includes the lower reaches of Broad Creek and Conowingo Creek in Maryland (Figure 1.3-1). The Pond as it relates to the Susquehanna River is a bedrock channel with a continuous downstream thickening wedge of alluvial cover. In much of the lower Pond, bedrock dominates the shoreline with steep rock cliffs and sharp elevation changes. Generally, along the eastern shoreline, railroad beds have altered what once was the natural shoreline by carving through much of the bedrock cliffs.

1.2 Study Objectives

The primary objective of this study is to quantify the potential impacts of fluctuating water levels associated with operations of the Conowingo Hydroelectric Project on littoral habitat in Conowingo Pond from Hennery Island to the Conowingo Dam. Central to fulfilling this objective were the collection of littoral habitat data, including benthic substrate, abundance and composition of emergent and submerged aquatic vegetation (EAV and SAV), water velocity, and bathymetric data over one-foot contour intervals from a Project drawdown elevation range of 101.2 to 110.2 feet (NGVD29). The integration of these data in a GIS application is used to define the magnitude of effects on littoral habitat from water level fluctuations within the Project study area.

As presented in the RSP, the specific objectives of this study are as follows:

1. Investigate the potential effect of water level fluctuations on EAV and SAV habitat in the littoral zone of Conowingo Pond.
2. Describe and quantify littoral zone habitat.

3. Evaluate the potential influence of Project drawdown on EAV and SAV habitat in the littoral zone of the Pond.

4. Determine whether or not EAV and SAV in the Pond needs to be enhanced, taking into account necessary limits on Pond levels for providing cooling water, drinking water, and adequate recreational use.

2.0 CONOWINGO POND HABITATS AND WATER LEVELS

The water level of Conowingo Pond at any particular time is a function of: (1) natural flow conditions of the Susquehanna River; (2) the demand imposed by water users, including the Conowingo Project, Muddy Run, PBAPS, City of Baltimore, Harford County, Chester Water Authority; (3) the operation of upstream hydroelectric stations; and (4) FERC requirements for maintaining minimum Pond levels for recreational use during summer weekends and minimum flow releases from the Pond to maintain downstream flows. Pond levels fluctuate within the limits of these constraints.

Water-level fluctuations in impounded and regulated water bodies can affect shallow water aquatic ecosystems and nearshore wetland ecosystems. Terrestrial wildlife and aquatic biota use nearshore and shallow water habitats for breeding, foraging, and cover. These include littoral, wetland, and riparian areas along shoreline margins. Water level fluctuations alternately expose and inundate nearshore areas while continually subjecting submerged areas to changing water depths and abiotic conditions (e.g., temperature, dissolved oxygen, light, water velocity), which, in turn, influences shallow habitats. The magnitude, frequency, duration, rate of change, and timing of water level changes may influence the degree to which species use of a habitat is affected. Additionally, the effect of Pond water level changes on tributary water levels may reduce access and/or use of shallow habitats by certain groups of aquatic organisms (e.g., benthic macroinvertebrates, fishes).

2.1 Historic water level Data

Water elevation data for Conowingo Pond is routinely collected at half-hourly intervals by Exelon at the Conowingo Dam. In addition, Exelon collects elevation data at three locations on its water intake structures at PBAPS. Pond elevation data for both Conowingo Dam and PBAPS are recorded in Conowingo Datum. Elevation data recorded at the Conowingo Dam were available for the period January 2004 through September 2010. These data were used to characterize the magnitudes and durations of recent historical water level fluctuations in Conowingo Pond, and to provide an additional basis for evaluating potential impacts of these fluctuations on littoral zone habitat. Water level data were obtained from PBAPS for the period during which littoral zone habitat surveys were conducted for this study (August 2010). The PBAPS elevation data were used to determine the degree of correlation with water level elevation data recorded at Conowingo Dam (see Section 3.3).

2.2 Historic Bathymetry and Habitat Data

The United States Geological Survey (USGS) has conducted multiple bathymetric surveys of Conowingo Pond. The most recent survey of the Pond was completed in the fall of 2008. Published maps of this survey (Langland 2009) display depths at 10-foot contour intervals. Previous USGS surveys were completed in 1990, 1993, and 1996 to estimate sediment storage capacity and characterize sediment scouring (USGS 1998).

Exelon conducted an assessment of the raw data of the most recent survey provided by USGS to determine if the data were robust enough to accurately provide one-foot contour resolution suitable to address the objectives of this study. The USGS bathymetric data for the Pond were determined to lack sufficient detail of the nearshore and shallow water areas to correlate habitat changes with water level fluctuations. Additionally, existing ecological data were not sufficient to assess the ecological impacts of water level fluctuations. More specifically, nearshore and shallow water habitats along the margins of the entire Pond (and major tributaries potentially susceptible to varying water levels) had not been identified, classified, and mapped. Based on the historical information review, it was determined that additional bathymetric data would need to be collected in order to evaluate potential littoral zone impacts from Pond drawdown on a finer (one-foot contour interval) scale within the permitted fluctuation range.

2.3 Description of Habitats

This Water Level Management Study focuses on nearshore littoral habitats located within the zone of water level fluctuation, and the species that utilize these habitats. The littoral zone is the nearshore area extending from the seasonal high-water level to the deepest extent of rooted aquatic vegetation (Wetzel 1975). However, the lower portions of tributary streams may also be affected by water level fluctuations in the Pond. Additionally, deeper open water habitats can be affected by shifts in species utilization prompted by changes to the littoral habitats.

Nearshore and shallow-water habitats of Conowingo Pond have developed along and adjacent to a shoreline that consists of a discontinuous distribution of the following features:

- Bedrock outcrops;
- Weathered bedrock, fractured and fragmented;
- Alluvium, or material transported and deposited by running water;
- Colluvium, or material mass transported by gravity; and
- Disturbed/artificial areas such as retaining walls, docks, armored shores (e.g., riprap, gabions), canal towpath berm, rail embankment fill, laid rock, industrial structures (e.g., PBAPS), and manicured lawns.

Vegetation in the littoral zone is typically distributed as an upper zone of emergent rooted vegetation, a middle zone of floating-leaved rooted vegetation, and a lower zone of submerged rooted vegetation (Wetzel 1975). The system of habitat classification described in Cowardin et al. (1979) places the deep-water limit of the littoral zone at a depth of 6.6 feet below low water, or the edge of emergent or woody vegetation, whichever is at greater depth. In this study report, a distinction is made between a shallow littoral zone (0 to 5 feet) and deep littoral zone (greater than 5 feet). Littoral habitat can be further categorized as lentic, characterized by low-energy environments and still waters, or lotic, characterized by high-energy environments and flowing waters. This study focused on characterizing and quantifying the littoral habitat in accordance with these descriptions.

A reconnaissance-level survey initiated by Exelon in 2007 characterized vegetated habitats in the littoral zone of Conowingo Pond and associated tributaries. A primary finding from this survey was that major littoral zones occur at areas of alluvial accumulations of sediment at tributary mouths and the downstream end of islands. Vegetation growing within these unconsolidated substrates stabilizes alluvium deposits and promotes a cycle of sediment trapping and accretion. The substrate of the littoral zone in the alluvial areas was determined to be predominantly quartz sand with significant amounts of coal and minor biotite or silt. A large accretionary shoal containing dense stands of invasive Eurasian watermilfoil (*Myriophyllum spicatum*) was identified downstream of Mt. Johnson Island. Accretion was also observed to be prominent at the mouths of Peters Creek and Fishing Creek.

Follow-on surveys were conducted in 2008 to identify wetlands and associated vegetative species and to determine the hydrogeomorphic (HGM) regime in the primarily alluvial-dominated reach downstream of Hennery Island and the major tributaries. Spatial coverage of the 2008 wetland surveys included the margins of Conowingo Pond, as well as Muddy Creek, Robinson Run, Michael Run, Broad Creek, Glen Cove, Hopkins Cove, Policemans Cove, Conowingo Creek, Haines Branch, Peters Creek, Barnes Run, Fishing Creek, and unnamed tributaries. Three major hydrogeomorphic classes were identified during the wetland presence/absence surveys conducted by Exelon in 2008: Pond margin, tributary margin, and pond/tributary margin.

Based on the 2007 and 2008 surveys, it was determined that the character of the littoral zone is distinctly different in the bedrock-dominated reach (BDR) of the Pond (above Hennery Island) and the alluvial-dominated reach (ADR) (below Hennery Island). The BDR is characterized by a higher energy flow regime in its upper reaches and a lower energy flow regime downstream. The higher energy area is comprised of intermittently exposed bedrock with shallow pools at low water. The accumulation of sediment above Hennery Island is minimal because of the high-water velocities associated with releases from the Holtwood Dam, discharges from the Muddy Run facility, and the narrow channel geometry in this section of the Pond. EAV was observed to grow in crevasses on the protected downstream side of rocks. As the energy conditions diminish further downstream in the BDR, the EAV becomes more prominent, growing in small sediment deposits within cracks in the rock surfaces and bedrock islands. Well-established SAV communities were not observed in the BDR.

In the ADR, the bedrock channel bottom is covered with a thickening wedge of sediment that has been accumulating behind the Conowingo Dam since its construction in 1928 (Hainly et al. 1995; Langland and Hainly 1997; Hill et al. 2006). The distribution of aquatic vegetation in the BDR is governed by the presence of silt in rock crevasses and pockets of weathered bedrock and gravel/cobble substrates with a silt matrix. Vegetative communities in the ADR were noted to be present primarily at sites of accumulating sediment, where it covers the hard-bottom substrate. A total of 31 wetlands associated with the ADR of Conowingo Pond were observed, with sizes ranging from under one acre to greater than two acres. The majority of these wetlands were observed along the margins of tributaries associated with the Pond, and not with margins of the Pond itself. Non-native invasive vegetative species observed in the wetlands within the ADR included Japanese knotweed (*Polygonum cuspidatum*), purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), and Eurasian watermilfoil. Transects of bathymetry established at three locations in the Pond indicated a net accumulation of sediment in some channels and the erosion of new channels based on comparisons of cross-sectional data from the 2008 study with data collected by the USGS in 1993 (Reed and Hoffman 1997).

2.4 Factors Affecting Water Level Fluctuation

The flows and water levels of the Lower Susquehanna River are regulated by four conventional hydroelectric stations (York Haven, Safe Harbor, Holtwood, and Conowingo) and one pumped storage project (Muddy Run). River flows in the Lower Basin are highly variable during any given year. Flows and corresponding water levels below each hydroelectric station can fluctuate considerably and are dependent on several variables, the most important of which is natural river flow variations resulting from rainfall events. Other factors include electric power demand, water withdrawal, recreational use, hydropower project-related operational constraints, and point and non-point source discharges. Energy conditions and water levels are factors that influence sediment erosion and deposition in the aquatic environment, at and near the shoreline. These processes, in turn, may influence the availability and distribution of nearshore habitat and the biota capable of utilizing the resources that may be present in these habitats.

The following sections describe the operational and environmental constraints that potentially affect water levels in Conowingo Pond.

2.4.1 Facility Operations

PPL Holtwood Hydroelectric Station

The PPL Holtwood Project includes a 0.5-mile long dam, an 8-mile long reservoir (Lake Aldred) and a 10-unit powerhouse. PPL Holtwood operates to meet peak electrical demand and is currently in the process of increasing the installed capacity from 107 MW to 195.5 MW. The total hydraulic capacity would increase from 31,500 cubic feet per second (cfs) to 61,500 cfs. A 2008 Settlement Agreement between PPL Holtwood, LLC and Exelon Generation Company, LLC states that PPL will provide: (1) a 24-hour continuous minimum flow of 800 cfs, and (2) a daily volumetric flow equivalent to 98.7% of the Conowingo minimum continuous flow requirements aggregated over a 24 hour period (FERC 2008). The Settlement Agreement also states that in the event that the continuous minimum flow requirements for Conowingo are ever modified in the future (e.g., under a new license), PPL's minimum and continuous flows would be similarly adjusted based on the modified flows for Conowingo.

Muddy Run Pumped Storage Station

The Muddy Run Pumped Storage Project (Muddy Run) is located adjacent to Conowingo Pond. The Muddy Run Reservoir (Reservoir) was created by building a rock-filled dam (the main dam) across Muddy Run, a tributary to the Susquehanna River. Muddy Run cycles water in Conowingo Pond to and from the Muddy Run Reservoir for power generation. The facility generates power by pumping Conowingo Pond water to be stored in the Reservoir and released back to the Pond. Conowingo Pond acts as the lower reservoir for the pumped storage facility.

Muddy Run has a total discharge capacity of is 32,000 cfs and a pumping capacity of 28,000 cfs to the Susquehanna River. The total installed capacity of the station is 800 MW. The licensed permitted range of water level fluctuation in the Reservoir is 50 feet (El. 470 to 520 NGVD29). The water level of the Reservoir at any particular time is a function of the demand for power and the ability of the facility to generate electricity (i.e., available storage in Conowingo Pond). Under Article 31 of the current license, Exelon must provide 35,500 acre-feet of pondage weekly to Muddy Run from Conowingo Pond. The actual magnitude and rate of drawdown and pumping varies daily. Typically pumping occurs during low-load periods when energy costs are low and generation occurs during high-load periods.

Conowingo Hydroelectric Project

The Conowingo Hydroelectric Project has a total drainage area of 27,100 square miles and an average annual discharge of 35,500 cfs. The Project is the most downstream of five hydroelectric projects on the lower Susquehanna River. The Conowingo Dam utilizes a limited active storage in combination with the operations of Muddy Run to meet peak electrical demand. Conowingo has a maximum hydraulic capacity of 86,000 cfs and a schedule for providing sufficient minimum flows for the maintenance and health of natural resources downstream of Conowingo Dam. One of the conditions of the 1980 license for the Conowingo Project was to conduct biological studies to determine the minimum flow releases necessary for protecting and enhancing indigenous fish and wildlife resources (Objective 5 of Article 34). Although biological studies were carried out, the results were not used in the licensing process, and a habitat-based study plan using instream flow methodologies was developed to derive an appropriate minimum flow regime, as required by FERC.

Ultimately, the minimum flow regime was established in a Settlement Agreement in 1989 between project owners and several federal and state resource agencies (FERC 1989). The Settlement Agreement specifies that the flows represent turbine releases and excludes gate leakage. These flow values were derived through studies of water quality and benthic macroinvertebrate habitat needs, and are seasonally adjusted. The negotiated minimum flow schedule mutually agreed to by all parties is as follows:

March 1 – March 31	3,500 cfs or natural river flow[1], whichever is less
April 1 – April 30	10,000 cfs or natural river flow, whichever is less
May 1 – May 31	7,500 cfs or natural river flow, whichever is less
June 1 – September 14	5,000 cfs or natural river flow, whichever is less
September 15 – November 30	3,500 cfs or natural river flow, whichever is less
December 1 – February 28	3,500 cfs intermittent (maximum six hours off followed by equal amount on)

Emergency waivers have been granted by FERC to Exelon on four occasions (1999, 2001, 2002, 2005, 2007 and 2010) during summertime drought periods, permitting leakage to be counted toward the minimum flow requirement (FERC 2010).

1 As measured at the Susquehanna River at Marietta USGS Gage No. 0157600.

2.4.2 Consumptive Water Use in the Lower Susquehanna River Basin

Power generation accounts for the largest quantity of water withdrawal in the Lower Susquehanna River (89 percent). Additional water withdrawals applied to other uses include: industrial (4.8 percent), municipal (4.2 percent), agricultural (1.2 percent), and domestic (0.8 percent). Data provided by the SRBC (2008) indicate that surface water users withdraw 454.03 million gallons per day (MGD) (702 cfs) and groundwater users withdraw 78.16 MGD (121 cfs). Consumptive water use in the subbasin is 356.59 MGD (552 cfs) (Exelon 2009).

Power producers rely solely on surface water while non-power users can rely on groundwater in addition to some surface waters. In addition to supplying water for generation by the Conowingo and Muddy Run Projects (Section 2.4.1), the Pond is currently a surface water source for the:

- PBAPS, York County, Pennsylvania;
- City of Baltimore, Maryland, municipal water supply;
- Harford County, Maryland, public water supply (provided by Baltimore's system);
- Chester Water Authority water supply utility, serving areas of southeast Pennsylvania and northern Delaware;
- Recreational uses, including boating and fishing; and
- Sustained stream flows downstream of the dam.

The 2,186 MW PBAPS, located 8 miles upstream of the Conowingo Dam, extracts water from the Pond and uses it as a source of normal cooling water. PBAPS has a maximum withdrawal capacity of 2,230 MGD (3,450 cfs). The Pond is also used as a public water supply source, with the City of Baltimore and Chester Water Authority having permitted withdrawals of 250 MGD (387 cfs) and 30 MGD (46 cfs), respectively. Although permitted for a daily withdrawal of 250 million gallons, Baltimore is currently limited by its pumping capacity to a withdrawal of approximately 137 MGD (212 cfs), depending upon system hydraulics. Baltimore's withdrawal from the Conowingo Pond is done principally during prolonged drought periods or under emergency operating conditions. Increasing water supply demands may lead the Chester Water Authority to request an increase in its maximum withdrawal from 30 MGD to 40 MGD (62 cfs) (Exelon 2009).

A thermoelectric power station (Delta Power Plant Project) has been proposed for construction in Peach Bottom Township, York County, Pennsylvania by Conectiv Mid Merit, LLC, and is currently under review by several regulatory agencies. The proposed project would be located inland approximately 2.5

miles from the Conowingo Pond and would have a maximum capacity of 1,100 MW. The facility would withdraw water from Conowingo Pond to meet its operational needs, with a maximum daily consumptive loss to the Pond of 8.7 MGD (13 cfs) (SRBC 2006).

2.4.3 Releases from Upstream Federal Water Storage Reservoirs

Under contract with the United States Army Corps of Engineers (USACE), the SRBC purchased a combined storage of 30,000 acre-feet water from two reservoirs in the upper Susquehanna River Basin Pennsylvania, the Cowanesque Reservoir in Tioga County, and Curwensville Lake, in Clearfield County (SRBC 2005). The existing capacity for low flow augmentation is approximately 95 million gallons per day (MGD) to the Susquehanna River, but only during conditions of severe low flows when Q7-10[2] events occur. The releases are intended to offset the consumptive use of water by two nuclear power plants (PPL's Susquehanna Steam Electric Station, Berwick, PA, and Exelon's Three Mile Island plant near Harrisburg, PA). As consumptive users require additional water resources during these low flow periods, the SRBC can request the release of a specific amount of water based on consumptive users who are then charged for the water (SRBC, 2008).

As described above, these resources are generally reserved for large nuclear and coal generation facilities; however, in recent years, smaller users have required the release of water from these reservoirs for consumptive use. The Conowingo Project does not directly receive additional water resources from these storage facilities but are afforded a variance during low flows to include leakage from the dam in minimum flow releases.

2.4.4 Natural Processes

Water level fluctuations in Conowingo Pond are mainly controlled by the operational constraints of both the Holtwood Dam and Conowingo Dam, and can also be influenced by natural extremes of low flows during periods of low precipitation and high flows during storm events. The habitats that have developed within the range of water level fluctuations experienced in the Pond are established there because of fluctuating ambient conditions. The species that use them are adapted to fluctuating ambient conditions, including the extremes. The existing habitats provide resources for supporting a variety of aquatic and semi-aquatic species. Additionally, as described above, the Pond is a dynamic system hydrologically, ecologically, and sedimentologically. Change in one element initiates change and adaptation in another.

[2] The low flow expected to occur once in 10 years, on average, for a 7-day duration

Rainfall

Within the watershed of the Pond rainfall has limited effects on water level fluctuations. However, rainfall within the entire drainage can greatly affect water levels. Due to the size of the drainage above Conowingo Dam (27,100 square miles), rainfall can have varying effects on Pond elevations based on how widespread the rain event is as well as the magnitude of the rainfall. Exposure to heavy rainfall by tributaries to Conowingo Pond may result in short-term, localized changes in water levels at their confluence with the Pond. These changes are not likely to exert noticeable prolonged differences in water levels throughout the Pond given that the levels are routinely monitored and maintained.

Wind

Available weather data from a meteorological station established at Route 1 at the Conowingo Dam indicate that prevailing winds at this location are in the north-northeasterly direction. The maximum sustained wind speed over an approximate four-year period from 2007 to 2011 was 21 miles per hour (mph). Wind direction upstream at a river-based station in Peach Bottom (PA) over the same time period was highly variable, with a maximum sustained speed of 26 mph and an average speed of 1.6 mph (Weather Underground 2011). Given the generally broad, open expanse of Conowingo Pond (length: 14 miles, width: 0.5 to 1.3 miles), it is occasionally subject to strong winds during storm events that may result in wind-generated wave action along shorelines of the Pond, islands, and tributaries. If the intensity of these events is sustained over sufficiently long periods, the potential for shoreline erosion increases. However, long-term effects of wind on habitat quality and the vegetative community in the littoral zone are not likely to be significant due to the limited duration and low frequency of high wind events.

2.4.5 Boat Wakes

Given the importance of Conowingo Pond to recreational users, particularly boaters, minor water level fluctuations are occasionally observed stemming from the wakes of larger recreational watercraft. While the objectives of this Water Level Management Study do not include quantification of potential impacts of wake-induced changes in Pond levels on littoral habitat, the potential exists for effects to occur on the littoral habitat from human-induced activities such as boating, particularly during the summer when recreational activities are most prevalent.

3.0 STUDY METHODS

3.1 Littoral Habitat Survey

As described in Section 1.2, the geographic scope of this Water Level Management Study is the downstream end of Hennery Island to the Conowingo Dam. A reconnaissance-level survey was conducted on June 2, 2010 to preliminarily identify areas of observable change in habitat and to document the presence of emerging EAV and SAV beds. The information gathered from the reconnaissance was used to define areas of focus for the August littoral habitat survey. Littoral habitat data were collected from August 9 through August 13, 2010 along the eastern and western shorelines of this section of the Pond, along the shoreline perimeter of Mt. Johnson Island, and in two mid-river reaches with habitat elevations within the permitted fluctuation range. The littoral zones in the portions of Conowingo Creek and Broad Creek potentially affected by fluctuating Pond levels were also surveyed. The survey was completed by boat during the peak vegetative growing season (August) at low flow conditions to maximize visual detection of aquatic vegetative communities and facilitate mapping of habitat features in the littoral zone of the Pond. Data collected from littoral habitats included detailed grain size characterization of unconsolidated substrates, EAV and SAV composition and density, water velocity (lentic, < 0.3 feet per second and lotic, ≥ 0.3 feet per second), and water depth (shallow littoral: 0 to 5 feet, deep littoral: 5 to 10 feet).

To accurately identify locations of survey points and habitat features on the Pond, a Trimble GeoXH Global Positioning System (GPS) unit was used in conjunction with a Zephyr antenna mounted to a fixed pole on the boat. The dual-frequency antenna provides advanced low elevation satellite tracking capability, and sub-millimeter phase center accuracy that permits high-resolution field mapping. All habitat characterization data were collected as close to the GPS antenna as possible to provide the most accurate representation of the habitat. The Trimble GeoXH unit has a stated real-time accuracy of sub-foot (< 30 cm) and decimeter accuracy using an external antenna after post-processing of the data with Trimble Pathfinder Office (Trimble 2010). Water velocity data were recorded using a Marsh McBirney Flo-Mate 2000 flow meter.

A photographic log of habitat survey observations are provided in Appendix A.

3.1.1 Emergent and Submerged Aquatic Vegetation Mapping and Delineation

Vegetation surveys were conducted for both SAV and EAV communities within the Water Level Management study area. During the bathymetric survey (Section 3.2), digitized points where echosounding had recorded SAV as water column interference were used as a preliminary guide for determining the potential presence of SAV beds. A boat-mounted depth finder sonar screen also was used to locate SAV during the littoral zone survey. Species were identified using various sources, including the Chesapeake Bay Foundation (CBF) Guide to Underwater Grasses (CBF, undated) and A Manual of Aquatic Plants (Fassett 1985). To provide a thorough characterization of the SAV community, a Weed Raker™ lake rake was used to collect a representative sample at each point. The rake has a handle capable of being extended to 11 feet and a 3-foot wide rake head with 8-inch soft plastic tines, as shown in Figure 3.1.1-1. The rake extensions enabled the collection and subsequent characterization of SAV from deeper depths within the littoral zone. All aquatic vegetative species observed at each survey location were recorded, and a notation was made of the dominant species. A qualitative assessment of the density of EAV and SAV beds was also conducted where littoral zone vegetation was observed or suspected to be present.

Raking of the river bottom was conducted under two conditions: 1) when water depth inhibited the ability to visually detect the presence of SAV, and/or 2) when it was difficult to determine the species of SAV present. The geographic extent of each SAV bed in the littoral zone was captured and recorded with a GPS unit, as described above. Areas of EAV were generally surveyed by walking the perimeter and noting taxonomy, species dominance, and density. In addition, the spatial extent of emergent vegetative growth was mapped with the GPS.

3.1.2 Substrate Characterization

Transects were established perpendicular to the shoreline to characterize substrate in the littoral zone from the 110.2 foot water elevation to the 101.2 foot elevation at various locations throughout the study area. Bathymetry data collected during a July 2010 survey (see Section 3.2) were used to establish accurate positioning of the survey locations along each of the 1-foot contours. The bathymetric data were layered atop the aerial imagery pre-stored in the field GPS to enable the recording of real-time substrate information at various points along the transect.

Transect locations were based on field observations from the June 2010 reconnaissance and in-situ observations of abrupt changes in littoral zone substrate types. The initial transect assessed was established perpendicular to the eastern shoreline of the Pond at the uppermost portion of the study area (northeast of the downstream end of Hennery Island). From this transect, the survey crew navigated along (parallel to) the shoreline littoral zone, establishing perpendicular transects to the shoreline whenever any changes in vegetative community structure were observed or when changes in the substrate type were detected. Upon detection of a change in habitat (e.g., transition from one substrate type to another), field biologists marked the extent of the change with the GPS unit, while simultaneously establishing a new transect that identified the water elevation at which the change in habitat occurred. This process was repeated until the littoral zones of the eastern and western shorelines of the Pond, the area below Mt. Johnson Island, the two shallow mid-river areas, and the lower sections of Broad Creek and Conowingo Creek were surveyed. Habitat survey points at which aquatic vegetation species and abundance, substrate type, and water velocity data were obtained are presented in Figure 3.1.2-1.

To classify the composition of littoral zone substrates, a Petite Ponar grab sampler was deployed from the side of the boat, and the retrieved material inspected for dominant and sub-dominant substrate types. Substrate samples retrieved via the Ponar sampler were classified according to particle size and consistency. In several instances, substrate particles were too large to permit the collection of an adequate grab sample. In instances where the river substrate was comprised primarily of large diameter particles (e.g., cobble, boulder) or bedrock, an 8-foot long steel rod was used to probe the bottom substrate and subsequently identify substrate particle size. Substrates were classified in the field using the Wentworth scale and a grain size pocket field guide for fine resolution of gravel and sands. The Wentworth scale is a geometric scale of grain sizes which classifies particles of silica-bearing sediment from 0.00006 mm (clay) in size up to 4,096 mm (boulders). Using this scale, substrates were classified as silt, very fine sand, fine sand, medium sand, coarse sand, very coarse sand, granule, pebble, cobble, boulder, or bedrock. The Wentworth particle size classifications are presented in the center column of Table 3.1.2-1.

For the purposes of reporting for the Water Level Management Study, the various fine-scale classifications of particles with a diameter range between 1/16 and 2 mm were consolidated and subsequently classified as “sand”; and unconsolidated particles with a diameter greater than 2 mm were classified as “gravel”. Four major substrate type classifications were therefore defined (silt, sand, gravel, and bedrock), encompassing all grain size subdivisions, and used to characterize littoral zone sediments in the study area (right column of Table 3.1.2-1). Grouping of these substrate types into broad categories allowed for a more cohesive interpretation of the substrate data and less cumbersome presentation of results (e.g., maps).

3.2 Hydrographic Survey (Bathymetry and LiDAR Surveys)

The intent of the hydrographic survey of Conowingo Pond was to develop a one-foot contour plan of the river bottom from the 101.2 feet to 110.2 feet NGVD 1929 contour elevations. In addition to the primary portion of the study area (Pond from Hennery Island to the Dam), key tributaries, including Conowingo Creek and Broad Creek, were surveyed for distances upstream that are potentially influenced by water level fluctuations in the Pond. The tributary surveys were conducted from bank-to-bank.

Two traditional survey methods are often used to capture, process, and generate bathymetric information. The required data can be acquired through an aerial photogrammetric survey when the water level is two or three feet below the required lower contour elevation (in this case, the 101.2 foot elevation). The photogrammetric survey would be conducted during a naturally occurring low water level event or an appropriate season. Alternatively the water level elevation may be artificially drawn down to an acceptable elevation if operationally feasible and practical. The second survey option uses a traditional bathymetric survey with echo sounder or other appropriate technologies to capture elevation data from a boat. This type of survey can be completed when the water level is at an elevation two to three feet higher than the required upper contour interval (in this case, the 110.2-foot interval). This upper-level elevation may be present following a high precipitation event or there may be a natural high elevation season. Both survey methods offer a sound and proven approach to capture the required data, but can be problematic due to logistical planning issues when trying to track precipitation or seasonal events, or operational constraints that may be in place for power generation.

In the case of a hydrographic study for the Conowingo Pond, two primary operational and logistical constraints were present, along with some additional considerations, which made use of a single survey method impractical. These constraints included:

- Exelon is required to keep the Conowingo Pond elevation within certain elevations during the peak summer recreational use time. This made it unacceptable to either artificially raise or lower the Pond elevation to an appropriate level for a single survey method to be used exclusively. Additionally, since the data capture was needed during this peak recreational use time frame it made it impractical to wait for an optimal seasonal event.

- Power plant operational requirements mandate certain water levels are maintained to ensure sufficient elevation level and associated water flow is available to meet generation capacity needs. These operational constraints are required for the Conowingo Project, but also to ensure sufficient water level is available for cooling water supply at the PBAPS.

- Additional constraints included dense vegetation along the shoreline in places that made aerial data capture difficult to achieve, and significant elevation changes along the shoreline causing potential difficulties in bathymetric survey data collection along the nearshore area.

To overcome these constraints, an innovative approach was conceived that allowed for the creation of one-foot contours within the required elevation ranges while minimizing the influences of the operational and logistical constraints. The approach used a traditional bathymetric survey to capture elevation data from the 108-foot to approximately 96-foot level; and a helicopter-mounted LiDAR survey to capture data from the 112-foot to approximately 106-foot level. The data from these two separate surveys were then merged, after appropriate quality checks, to allow generation of a seamless elevation surface for contour generation.

Using these two survey methods allowed for a number of benefits:

- A sufficient elevation data overlap was achieved to allow for excellent data coverage at the upper and lower contour levels and at the interface area between the survey data.

- Helicopter mounted LiDAR allowed for excellent off-nadir data capture along the nearshore area, ensuring full coverage along the shoreline below the tree canopy that would be obscured for traditional aerial surveys.

Increased flexibility in the timing of the data capture and the relatively quick mobilization time for the helicopter LiDAR study were key to minimizing influences of power generation operational constraints on data collection and quality.

3.2.1 Bathymetric and Side Scan Survey

From July 13 through 20, 2010, bathymetric and side scan sonar surveys were performed from a boat throughout the length of the study area. These surveys used a traditional approach for data capture that is consistent with U.S. Army Corps of Engineers standards for hydrographic surveys. The survey was designed with shore-perpendicular lines spaced 200 feet on center that covered the required 110.2 foot to 101.2 foot NGVD29 elevation range. Survey lines were run from the shore out into the Pond until approximately one foot below the target depth of 101.2 feet. Transect spacing for each tributary ranged from 50 feet to 200 feet, and were run bank-to-bank. All transects were digitally created using HYPACK 2010 hydrographic survey software. Background imagery including USGS Topographic Quad maps and orthophotos obtained from Pennsylvania GIS websites were imported into HYPACK to aid in survey design and real-time analysis. A single side scan sonar survey line was run shore-parallel, shoreward of the 101.2 foot contour, as identified in the bathymetric survey. Additional bathymetric data were acquired simultaneously during the side scan sonar survey.

3.2.2 LiDAR Survey

The LiDAR survey was conducted via helicopter on September 18, 2010, and was comprised of two discrete phases: establishing survey ground control and acquisition of airborne data. During the first phase, 23 panels which consisted of either a 4 x 4-foot painted cross on a hard surface or a fabric panel set on a bare earth surface were established. The panels were spread out along the project limits from Muddy Run to the Conowingo Dam. Static baselines were measured to tie most of the panels together and to tie into various control monuments in the area. Real time kinematic (RTK) GPS was then used to locate the remaining panels within the network.

Trimble R8 GNSS Model 3 Receivers with Bluetooth to the Trimble TSC2 data collectors were used to collect all GPS data. Each panel was occupied for a minimum of three (3) minutes collecting 180 epochs of data. After several panels were occupied and initial data collected, they were each revisited for a second observation with a time lapse of at least 45 minutes such that the constellation had changed significantly from the original observation. Each panel was measured using the same method.

The survey also tied into several National Geodetic Survey (NGS) "HARN" (High Accuracy Reference Network) points in the area to check observations, using static baseline observations. The HARN points were: KERR, CASTLEON, MAC, CECIL, MUDDY, M368 and RUN. The GPS data were then downloaded and baselines processed using Trimble Geomatic Office software. The coordinate systems used were NAD 83 Pennsylvania South – 3702, U.S. Survey Feet and NGVD 29, U.S. Survey Feet. The values for each panel were then used in developing the aerial mapping.

Airborne planning was completed with the TrackAir GPS guidance system with flight lines superimposed over quad and orthophotos of the area. Flights were completed with a helicopter elevation of approximately 800 feet outside of the shoreline of the Pond in order to pick up details of the slope of the river bank and overbank area.

3.2.3 Bathymetric Processing Methods

Bathymetric data were processed using the HYPACK Single Beam Processor Module. Components of processing included: removal of outlying soundings associated with water column interference (e.g., fish, vegetation, or mid-water column debris), conversion of soundings to NGVD29 elevations based on water level data recorded by the InSitu depth recorder and measurements from other control points, and adjustments of soundings for variations in sound velocity. After performing data adjustments, the processed bathymetric data were combined into comma-delimited ASCII text files for each survey date including fields for Northing, Easting, and NGVD29 elevation.

During data processing, a series of points were digitized and tabulated where the echosounder had recorded SAV as water column interference. These points were used to guide field personnel in ecological investigations of SAV communities.

The water surface elevation during the bathymetric survey had been maintained at levels ranging from 107.4 to 109.8 feet (NGVD29). The water level was lowered for the LiDAR survey to provide some overlap between the two surveys. This overlap allowed co-located measurements in nearshore areas to be compared, and demonstrated that the two data sets generally agreed to within approximately 0.2 feet vertically.

LiDAR data were provided as comma-delimited ASCII text files that were converted to ESRI SHP format to remove outlying points in the LiDAR data (e.g., elevations reported in deeper waters of the Pond). The edited LiDAR files were re-exported as a single delimited ASCII text file and were combined with bathymetric data to create a master database consisting of 5,052,626 terrestrial and aquatic elevation measurements.

Bathymetric data points were acquired along transects spaced as far as 200 feet apart (although soundings overlapped acoustically along individual transects). Separation between LiDAR topographic points ranged from less than 10 feet to approximately 20 feet. This substantial difference in data distribution patterns dictated use of a non-conventional approach for development of a single seamless digital elevation model (DEM) and contours from the combined elevation database in order to minimize interpolation artifacts while maximizing the resolution of each portion of the database. A DEM limited to the aquatic portion of the database was created using only points with elevations less than 111 feet, from slightly above the shoreline into the Pond. This DEM was created using kriging methods and had a node density of 50 feet. A second DEM was created to best honor dense terrestrial LiDAR data by designating grid search parameters which excluded bathymetric data where the maximum distance between soundings was greater than 30 feet. This effectively excluded all but shallow, nearshore soundings and prevented interference of distant bathymetric data with the topographic DEM. The grid node density of this topographic DEM was set to 10 feet.

Finally, the two DEMs were merged together, with the specification that the denser topographic model would have precedence over the bathymetric portion in shoreline areas where the two models overlapped.

3.3 Water Level Data

Exelon regularly records water levels at Conowingo Dam and at PBAPS for project operations as well as to satisfy regulatory requirements. As such, a robust data set of water elevation data were available (from

Conowingo Dam and PBAPS) for the lower portion of the study area. Given that real time elevation data were not available for the upper portion of the study area (from PBAPS upstream to the lower end of Hennery Island, a distance of approximately 4 miles), a Solinst Levelogger Gold Model 3001 was temporarily installed on the eastern shore as a means to accurately determine changes in water levels during the habitat survey and to determine whether calibration of the elevation data recorded at the Conowingo Dam and/or PBAPS for this upper portion of the study area was necessary. The data logger was suspended in a PVC stilling well via a braided steel cable suspended from the top of the well and spray-painted dull green to minimize the potential for vandalism or theft of the instrument (Figure 3.3-1). This method was adopted from deployment instructions provided by Solinst (Solinst 2010). The data logger has an accuracy of 0.05% with built-in compensation for altitude, water density, temperature, and barometric pressure differences to optimize instrument accuracy.

Elevation data were recorded by the logger at 30-minute intervals, corresponding to the intervals recorded at both Conowingo and PBAPS. To identify any differences in water elevations between the upper portion of the study area and Conowingo Dam or PBAPS, elevation data from each of these three sources were plotted for the survey period. Relative elevation change was compared between the three data sets as presented in Figure 3.3-2. As indicated in the figure, there is excellent agreement between water elevation data recorded at Conowingo Dam, PBAPS, and the upstream level logger. Consequently, facility-recorded elevation data were determined to accurately represent water levels in the upper Pond as well as the lower Pond. Elevation data recorded at the Conowingo Dam were therefore subsequently used to evaluate littoral zone water level fluctuations.

Historic data collected from the Dam between 2004 and 2010 were analyzed to identify operational changes in water elevation. All data were converted from Conowingo Datum to NGVD 29 prior to any analysis. Data were reviewed to identify any outlying data points and the following general rules were set for data analysis:

- Data which showed inconsistent results that are most likely attributable to logger malfunction were removed.

- Data which deviated from the previous and subsequent readings by greater than two feet were removed.[3]

Analysis of the data focused on frequency of water level fluctuations on a weekly, monthly, and annual basis. In addition, half-hourly Pond elevation data for each of the 6+ years were plotted to quantify the magnitudes of water level fluctuations in the Pond and to identify potential trends throughout the year and between years.

Graphical results of the analyses of the 2004-2010 water level data are provided in Appendix B, and discussed further in Section 4.2.

[3] Exclusion of a water level data point that is greater than two feet from prior and subsequent data observations was based on reasonable judgment of water level changes over a ½ hour period. A total of 11 readings from more than 50,000 data points were removed based on this rule, which represents less than 0.01% of the total data.

4.0 STUDY RESULTS

4.1 Analysis of Littoral Habitat Survey Results

Littoral zone habitat data collected during the August 2010 survey included information on nearshore bathymetry, vegetative community composition and abundance, substrate composition, and water velocity. The integration of these data provides insight into the quality of the habitat available within the licensed range of fluctuation within the Pond, and the potential diminution of habitat as a result of drawdown from the Conowingo Project. Throughout Conowingo Pond, littoral habitat varied in substrate composition, bathymetry, and abundance and composition of the aquatic vegetation community. A photographic log of habitat observations (vegetation, substrate type) at various littoral zone survey locations is presented in Appendix A. For this Water Level Management Study, littoral habitat was segregated into shallow (0-5 feet) and deep (5-10 feet) classifications. The scope of the Water Level Management Study focused on the assessment of potential water level fluctuation impacts on littoral zone habitat between elevation 101.2 feet and 110.2 feet. As such, for this study, shallow and deep littoral habitats are defined by the limits of this permitted fluctuation range.

4.1.1 EAV and SAV Community

EAV Community

In general, few areas of EAV were identified in the study area during the August 2010 habitat survey. Common species associated with EAV communities include American water willow (*Justicia americana*), water pepper (*Polygonum hydropiper*), broadleaf cattail (*Typha latifolia*), purple loosestrife, and Japanese stiltgrass (*Microstegium vimineum*). Although water willow was observed at the majority of identified EAV beds, communities were generally represented by more than one dominant EAV species (i.e, co-dominance). These and additional EAV species observed during the habitat survey are presented in Table 4.1.1-1. Figure 4.1.1-1 presents a study area extent map indicating the locations of littoral zone EAV beds. Figures 4.1.1-2 and 4.1.1-3 show the locations of each mapped EAV community and associated dominant EAV species identified within the upper and lower study area extents, respectively.

The presence of EAV was generally accompanied by an alluvial deposit from tributary processes located along the shoreline. Tributaries associated with the Pond appear to have a strong influence on the formation of shallow depositional areas which promote the colonization of these areas by emergent vegetation. For example, three small EAV beds comprised mainly of American water willow and broadleaf cattail are present in shallow sandbars in Conowingo Creek that likely had formed from erosional runoff further upstream in the creek (Figure 4.1.1-3). An EAV bed is also present at the confluence of Fishing Creek and the Pond (Figure 4.1.1-2). Two other water willow-dominated EAV beds were observed slightly downstream of the Muddy Creek confluence on the western shoreline of the Pond (Figure 4.1.1-2).

Appendix A contains photographs of EAV species observed at various locations in the study area.

SAV Community

Submerged aquatic vegetation communities were more extensive in the study area relative to EAV communities. Figure 4.1.1-4 presents a study area extent map indicating locations of littoral zone SAV beds. Figures 4.1.1-5 and 4.1.1-6 show the locations of each mapped SAV community and primary species observed within the upper and lower study area extents, respectively. Generally, these SAV beds were co-located with unconsolidated alluvial deposits in the upper portion of the Pond. Dense beds were observed to be most prevalent in the littoral zone of the eastern shoreline, particularly in the upper portion of the study area (Figure 4.1.1-5). The heaviest concentrations of SAV were present in the "coves" associated with the confluences of Fishing Creek and Peters Creek. In addition, a large SAV bed was observed growing within the accretionary expanse below Mt. Johnson Island (Figure 4.1.1-5). The community of SAV at the Fishing Creek confluence and adjacent areas was dominated by the invasive hydrilla (*Hydrilla verticillata*), but was also comprised of other submergent species including coontail (*Ceratophyllum demersum*), Canadian (or common) waterweed (*Elodea canadensis*), and Eurasian watermilfoil (another invasive species). Hydrilla is also the dominant species throughout the entire expanse of SAV below Mt. Johnson Island, a distance of approximately 1.2 miles. Eurasian watermilfoil was also observed in association with hydrilla below Mt. Johnson Island, but was present in lower densities. As evidenced in Figure 4.1.1-5, hydrilla was the primary SAV species observed in the littoral zone in the vicinity of Peters Creek. Lesser amounts of Eurasian watermilfoil, Canadian waterweed, and coontail are also present in this large SAV bed. In general, steep rock-dominated shorelines limited the growth of SAV in the majority of the remaining areas within the littoral zone of the eastern shoreline.

In contrast with the Pond's eastern shoreline, the spatial coverage and density of the western shoreline SAV community is significantly less. The lower areal coverage of SAV along the western portion of the Pond can be attributed to the sharply sloping shorelines and bedrock-dominated substrates. Narrow bands of SAV composed primarily of Eurasian watermilfoil colonized fine to coarse particle size substrate along the western shoreline north of PBAPS (Figure 4.1.1-5). Sub-dominant species identified during the survey included hydrilla, coontail, Canadian waterweed, and water stargrass (*Heteranthera dubia*). These and other SAV species observed during the August 2010 habitat survey are presented in Table 4.1.1-1. A moderately sized SAV community dominated by hydrilla was also observed growing within silt-dominated substrate at the Pond's confluence with Michael Run (Figure 4.1.1-5).

Submerged vegetation was present along the eastern shoreline of Conowingo Creek and directly above its confluence with Conowingo Pond (Figure 4.1.1-6). These areas are characterized by minimal SAV growth, with hydrilla and Eurasian water milfoil representing the majority of the community. Growth of SAV (mainly hydrilla) in Broad Creek was restricted to a small area along the southern shoreline of the creek below the Route 623 (Flintville Road) bridge (Figure 4.1.1-6). The relatively steep shorelines and deep water depths likely limit the growth of SAV in the surveyed area of Broad Creek.

Appendix A contains photographs of SAV species observed at various locations in the study area.

4.1.2 Substrate Composition

Littoral substrate varied within the study area from alluvial deposits of fine grained sand (including fine coal particles) and silt to bedrock and boulder dominated shorelines. The total area of dominant substrate was grouped in broad categories from field observations made using the modified Wentworth classification system, as indicated in Table 3.1.2-1 and discussed in Section 3.1.2. Figure 4.1.2-1 presents a study area extent map showing the dominant substrate types recorded during the August 2010 habitat survey. Figures 4.1.2-2 and 4.1.2-3 show the locations of primary sediment classifications observed within the upper and lower study area extents, respectively. Figure 4.1.2-4 presents a map indicating the locations of four representative locations (Locations 1-4) in the study area from which detailed habitat maps were created. These detailed habitat maps are discussed below.

The eastern shoreline in the upper portion of the Pond contains large alluvial deposits of sand and silt. Within this area are several "coves" where the river widens and the littoral zone bathymetry is flat, permitting the accumulation of fine-grained sediment. The cove areas associated with the confluences of Fishing Creek and Peters Creek each exhibit these deposits, as does the extensive shallow area downstream of Mt. Johnson Island (Figure 4.1.2-2). However, along the Pond shorelines and the majority of the Mt. Johnson Island perimeter (i.e., at and directly adjacent to the 110.2 foot water elevation), the substrate is composed primarily of larger diameter gravel (primarily cobble). As an example, the substrates present in the littoral zone downstream of the Fishing Creek confluence were cobble in the nearshore littoral areas transitioning to sand and silt in the deeper littoral areas. Primary substrate types, as well as 1-foot bathymetry and dominant SAV species for a portion of this area (Location 1) are presented in Figure 4.1.2-5). The 1-foot topography and bathymetry data collected from boat bathymetry and LiDAR surveys and littoral zone substrate and aquatic vegetation data obtained from the August 2010 habitat survey were also used to construct a three-dimensional cross section of this representative location, as shown in Figure 4.1.2-6. This three-dimensional rendering indicates the substrate types and vegetative extent within and across the 1-foot contour intervals, and includes several of the critical water levels for Conowingo Pond (101.2 and 110.2 foot elevations, summertime weekend water level [107.2 feet]), as discussed in Section 1.1.

Detailed habitat maps and three-dimensional renderings for additional representative locations were created to provide visual depictions of the spatial extent of SAV and dominant substrate types within the permitted fluctuation range in other portions of the study area. These locations and corresponding figures are described below.

- Location 2: This location is along the western shore of the Pond in the upper extent of the study area, and includes nearshore gravel-dominated substrates transitioning riverward to predominantly silt (Figure 4.1.2-7). A small band of EAV (water willow) is present. SAV is represented primarily by Canadian waterweed. The three-dimensional cross section for this area is presented as Figure 4.1.2-8.

- Location 3: This location is on the western shoreline below the confluence of Broad Creek. Figure 4.1.2-9[4] identifies the littoral habitat in this area as lacking both EAV and SAV. Bedrock is the dominant substrate type at this location. As indicated in Figures 4.1.2-9 and 4.1.2-10, this area is characterized by a steeply sloping littoral zone characterized by bedrock-dominated substrates.

- Location 4: This location is along the eastern shoreline of the Pond upstream of the confluence of Conowingo Creek. No EAV or SAV communities were observed in this area, and substrate generally consists of gravel (predominantly cobble), much of which in the area nearest to the shore is comprised of aggregate from the nearby railroad bed (Figure 4.1.2-9). Bathymetry was generally characterized as steeply sloping, as indicated in in the three-dimensional rendering of this location (Figure 4.1.2-11). The littoral zone conditions at Location 4 represent much of the lower eastern shoreline: steep in slope, containing limited vegetation, and dominated by gravel substrate.

[4] No SAV was present at Locations 3 and 4; therefore, Figures 4.1.2-9 through 4.1.2-11 provide substrate and bathymetry information only.

In the middle of Conowingo Pond, disconnected from any noticeable features, an area of accretion was detected northwest of Mt. Johnson Island. The substrate in this shallow offshore area consisted predominately of sand (Appendix A, Photo 27), and its extent within the permitted fluctuation range is depicted in Figure 4.1.2-2. A similar offshore depositional band of sand-dominated substrate is present south of Mt. Johnson Island and east of the PBAPS thermal discharge canal (Figure 4.1.2-2). Along the lower portion of the eastern shore (below the PA/MD state line), littoral substrate transitions to cobble- and boulder-dominated, steeply sloping shorelines, and a general absence of aquatic vegetation. Shallow littoral substrate generally consists of boulder while deeper littoral substrate is dominated by cobble. Substrate found within the littoral zone of Conowingo Creek is mainly limited to fine grained deposits along bedrock-dominated shorelines (Figure 4.1.2-3). Dominant substrate at the mouth of the creek includes silt and very fine sand. Upstream of the creek mouth, littoral substrate generally consists of silt poorly sorted with cobble. Accretion was evident as small coarse sand and cobble point bars in the uppermost extent of Project influence.

The western shoreline contains a variable littoral substrate composition within the upper portion of the Pond. The majority of the littoral shoreline is composed of gravel or bedrock. In some areas, silt is present in deeper water adjacent to the shallow gravel dominated zone (Figure 4.1.2-2). A large portion of anthropogenically altered shoreline is present within the upper portion of the western shoreline, including wooden bulkhead walls along residential communities and rip-rap fill material along the shoreline abutting the PBAPS. Along the lower portion of the western shoreline (below PA/MD state line), littoral substrate consists largely of bedrock formed by steep bedrock outcrops that extend below the water surface (Figure 4.1.2-3). Bedrock substrate generally extends beyond the licensed fluctuation elevation of 101.2 feet. Littoral substrate within Broad Creek was similar to Pond substrates along the lower reach of the western shoreline. Bedrock dominated much of the shoreline extending upstream from the mouth approximately 2,700 feet. Vertical bedrock cliffs were present along the lower shoreline of Broad Creek, where the thalweg elevation averaged approximately 90 feet. Within this transition area of Broad Creek, deep littoral substrate is dominated by silt, while shallow littoral substrate is comprised mainly by bedrock, and secondarily by silt.

4.1.3 Flow Characterization

Water velocity data were collected at the majority of the survey locations during the August 2010 habitat survey. It was determined that the majority of littoral areas of the study area, at conditions experienced during the summer habitat surveys, are best described as lentic environments. Field measurements of water velocity ranged from 0.0 feet/sec to 0.3 feet/sec. However, a small area on the western shore below the PBAPS thermal water discharge canal contained facility-related flows in excess of 1.4 feet/sec during the study period. Following a period of heavy rainfall in the Susquehanna River basin, habitat conditions in the Pond may change from lentic to lotic based on water releases at the Holtwood Dam and incremental flows from tributaries. Increases in water velocities and flows may be especially pronounced in areas at the confluence of tributaries, where flow conditions may alternate rapidly between lentic to lotic due to storm events. However, these weather-induced conditions were not observed while in the field and data suggest a predominantly lentic littoral environment throughout the Pond, as is expected within an impounded reservoir system. For this reason, littoral habitat in the study area is best defined by substrate, water depth, and the presence or absence of aquatic vegetation, rather than by water velocity.

4.2 Analysis of Bathymetric Data

Appendix C provides a series of figures presenting the 1-foot bathymetric contours of the study area littoral zone. The study area bathymetry within the permitted fluctuation range of 110.2 feet to 101.2 feet was variable throughout the study area. The upper portion of the eastern shoreline and the accretionary area downstream of Mt. Johnson Island were characterized by a shallow sloped littoral zone extending to over 700 feet from the shoreline. Along the western shoreline, littoral bathymetry was less variable but generally contained steeper slopes than those on the eastern shore. In the downstream reach of the study area, littoral bathymetry is much steeper in slope. Along both shorelines below the PA/MD state line, the littoral zone within the permitted fluctuation range extends approximately 20-50 feet. A few isolated areas in the downstream reach, including the mouth of Michael Run (Appendix C, Map 6) and a small cove-like area on the eastern shoreline (Appendix C, Map 7), have gently sloping littoral zone bathymetry.

4.3 Analysis of Water Level Data

Water level elevation data extracted from the temporary level logger data suggested the relative change in elevation was consistent with the data collected at both PBAPS and the Conowingo Dam (Figure 3.3-2). Data trended similarly throughout the week of study with variation in data limited in magnitude and short in duration. Generally, the greatest variations between collection locations occurred during the maximum and minimum water elevations observed each day. Based on these results, it was determined that the data loggers at Conowingo Dam and at PBAPS would provide accurate pond elevation data for analysis of water level fluctuations in the Conowingo Pond littoral zone. Total daily fluctuation of water levels in the Pond during the August 2010 habitat survey recorded at Conowingo Dam ranged from 0.7 feet (on August 12, 2010) and 1.5 feet (on August 9, 2010). Water level elevations recorded at Conowingo Dam during the period of study were used to identify the water level elevation at any particular moment during the habitat survey.

Water elevation data collected at half-hourly intervals for Conowingo Pond from January 2004 to September 2010 revealed that water levels were maintained between elevation 109.5 and 106.2 feet 90% of the time based on monthly averages (Figure 4.3-1). In addition, overall monthly average water levels range from 107.9 to 108.4 feet, annually averaging 108.1 feet for the period. Maximum and minimum observed water levels from the entire data set of 30-minute water elevations were 110.1 feet and 104.7 feet, respectively. Additional historic annual water elevation data from 2004 through 2010 are presented in Appendix B. This appendix provides graphical depictions of: 1) individual 30-minute water level elevations recorded at the Conowingo Dam for each year from 2004 to 2010, and 2) a frequency distribution for each month (across years) of Pond water elevation data. An evaluation of the monthly elevation frequency data indicates that water levels were between 108 and 109 feet 56.4 to 67.9% of the time. Monthly frequency of water levels at or below elevation 106.0 feet ranged from a high of 4% in March to a low of 0.01% in June.

Weekly average data also indicate general trends in Pond water elevations. For the 6+ years of data analyzed, fluctuations are generally limited to between 107 feet and 109 feet (Figure 4.3-2). In general, during the first quarter of the year and last quarter of the year, the greatest variation in water level occurs. During summer months, weekly average fluctuations are highly limited, with water elevations between 108.8 feet and 107.5 feet.

4.4 Quantification of Water Level Fluctuation Impacts to Littoral Habitat

4.4.1 Assessment of Habitat Quantity

Littoral habitat quantified within the permitted range of fluctuation included areal habitat coverage (as determined by wetted area), spatial extent and composition of substrates, and spatial extent and species abundance of emergent and submerged vegetative communities. Total wetted area associated with each contour interval in the littoral zone were determined using GIS by first quantifying the total area of the study area and then determining the acreage remaining from successive reductions in water levels. The wetted area within the upper range of permitted water level fluctuation suggests that the Conowingo Pond contains generally steep shorelines with minimal wetted area. The acreage of littoral habitat between water elevations 110.2 feet and 107 feet is approximately 34 acres, or 0.5% of the available aquatic habitat in the Pond (Table 4.4.1-1). Within the lower limits of the permitted fluctuation range (elevations between 107 feet and 101.2 feet), the amount of wetted area is reduced 432 acres, or 5.8% of the total study area. The loss of total wetted area within the entire 9-foot permitted fluctuation range is approximately 6.4 percent of the Pond within the study area. The amount of wetted area associated with each one-foot contour interval is presented in Table 4.4.1-1.

Substrate composition was variable throughout the littoral zone of Conowingo Pond, particularly in the upper portion where depositional areas and fine-grained sediments were more prominent. Composition of littoral zone substrates at each one-foot contour interval, on an aerial basis, is provided in Table 4.4.1-2. As evidenced from the table, bedrock and gravel (primarily boulder) comprise the majority of the littoral habitat in the upper range of the fluctuation range (110.2 feet to 106 feet). However, this range of elevations comprises only 73.7 acres (16.2%) of the total littoral habitat (453.48 acres) within the permitted fluctuation range in the study area. The relative proportions of sand and silt increase substantially over the lower (106 feet to 101.2 feet) elevation range, which comprises 379.8 acres, or 83.8% of the total littoral habitat. The greatest amount of available habitat (98.3 acres) is in the 104-105 foot elevation range (Table 4.4.1-2). Approximately 60% of the littoral habitat within this interval is composed of sand. Bedrock habitat was generally consistent in extent throughout the range of fluctuation, comprising between 0.5 and 5.0 acres. The areal coverage of various substrate types in the littoral zone is also presented graphically in Figure 4.4.1-1.

For this study, littoral zone substrates were also categorized into shallow (0-5 feet) and deep (5-10 feet) for evaluating impacts to habitat from changes in water levels. Shallow and deep habitat zonation is relative to water level at any moment in time. Thus, as the water elevation changes, the shallow and deep habitat zonation changes accordingly. River bottom data collection focused on substrates within the permitted fluctuation range of 101.2 feet to 110.2 feet. Accordingly, the potential reduction of shallow and deep littoral zone habitat was confined to the limits of this range. The total shallow and deep habitat based on field characterizations of substrates within the permitted fluctuation range is presented in Table 4.4.1-3. The data shows that a water surface elevation of 106 feet provides the greatest quantity of shallow habitat (379.8 acres) within the fluctuation range, habitat that is comprised mainly of sand (152.7 acres, or 40.2% of the total shallow littoral habitat). Silt also comprised a high proportion of shallow habitat at the 106-foot elevation (100.9 acres, or 26.6% of the total shallow habitat). A water elevation of 107 feet provides the second highest quantity of shallow habitat in the littoral zone (364.5 acres). Approximately equal amounts of gravel and sand make up the majority of the shallow habitat at this elevation (Table 4.4.1-3). At an elevation of 108 feet, available shallow habitat decreases to approximately 298.0 acres with substrate dominated by gravel and sand. Composition of dominant substrate transitions from gravel to a gravel/sand mix before becoming silt dominated from 103 to 101.2 feet.

At full Pond elevation (110.2 feet), the quantity of deep littoral habitat is 316.6 acres, and is comprised primarily of sand (115.5 acres) (Table 4.4.1-3). The availability of deeper littoral habitat is generally unaffected until water levels approach 109 feet, where the amount of gravel and sand are roughly halved.

Deep littoral habitat is not present at an elevation below 106 feet, given that by definition within this study, only deep habitat within the permitted fluctuation range was identified.

The extent and coverage of SAV within the study area was broad, particularly in areas of unconsolidated substrates in the upper portion of the study area (e.g., near Fishing Creek and Peters Creek, and below Mt. Johnson Island) (Figure 4.1.1-4). The five dominant SAV species observed within the study area of the Pond covered 320.8 total acres, with hydrilla identified as the dominant species in 292.0 acres of the total SAV cover (91%). Changes in water levels have the potential to decrease the extent of or dewater SAV beds. Figure 4.4.1-2 depicts the relationship between water level and total area of SAV. Limited decreases in SAV extent are apparent between elevation 110.2 and 106 feet. Consistent declines in the extent of SAV can be observed beginning at a water surface elevation of approximately 106 feet. The loss of SAV cover continues to elevation 102, with a less pronounced rate of decrease to elevation 101.2. Coverage of SAV is greatest at Pond elevations between 104 feet and 105 feet, with total coverage of approximately 86 acres of the 98 total acres of littoral habitat available in this interval.

Growth of SAV within specific substrate categories throughout the fluctuation range showed a preference for sand, as evidenced in Table 4.4.1-4. Gravel and silt also provided substantive habitat for SAV growth, but to a lesser degree than sand. Between water surface elevation 110.2 feet and 105 feet, sand accounts for 46-50% of the substrate type containing SAV growth. Reductions in water level below these elevations reduce the amount of SAV in sand, from 18-32%. Between elevations 110.2 feet and 104 feet, SAV coverage at each water elevation is highly consistent (26-30%). Growth of SAV in silt is also consistent across surface water elevations between 110.2 feet and 105 feet (21-28%). At lower elevations, silt is the primary substrate for SAV growth (e.g., 77% of SAV growth in the study area at elevation 102 feet was in silt).

Based on the results above, vegetated habitat in the littoral zone of the study area would be most affected by drawdown below the 106-foot elevation. Below this elevation, the amount of shallow littoral available for SAV growth begins to decrease from its maximum (at 106 feet) and is accompanied by a notable drop in areal coverage of SAV. The quantity of sand substrate, which is conducive for SAV growth, also begins to decline below elevation 106 feet, and is approximately halved with each successive one-foot reduction in elevation. Analyses conducted over varying temporal scales of historic water level elevation data collected for Conowingo Pond indicate that water level fluctuations are primarily confined to water elevations between 107 feet and 109 feet, and rarely fall below 106 feet. Water level elevations below 106 feet typically occur over brief periods that do not overlap with the optimal timing of year for SAV growth (summer). Fluctuations are minimized the most during the summer months of June, July, and

August. This is likely attributable, in part, to the current license requirement for maintaining a minimum summertime surface water level elevation of 107.2 feet to satisfy recreational needs. As such, the potential for dewatering of SAV-vegetated habitat in the littoral zone of the study area to the point where adverse effects could occur is considered minimal.

Habitat for growth of EAV appears to be limited in the study area. Growth of EAV was minimal, and was primarily confined to point bars in shallow tributaries and to the confluences of tributaries and Conowingo Pond. Water willow, a common EAV species in the lower Susquehanna River basin, was shown to be highly resistant to desiccation but sensitive to inundation (Strakosh et al. 2005). Much of the shoreline at nominal Pond elevations is comprised of steeply sloping shorelines and boulder substrates that do not provide suitable substrates for EAV growth. The minimal presence of EAV in the study area is thus likely a function of the natural geology of the Susquehanna River in the general area, and not due to water level fluctuations. Surveys conducted by Exelon in 2007 and 2008 identified 31 wetlands in the alluvial reach of Conowingo Pond, but 21 of these wetlands were not in the Pond itself, but in tributaries that contain a higher incidence of emergent, depositional features for colonization by emergent species.

4.4.2 Assessment of Habitat Quality

Substrate is fairly generally diverse throughout the littoral habitat of Conowingo Pond; however, higher quality habitat is present in the upper portion of the study area. Gravel and sand comprise a majority of the littoral habitat in the upper study area. Bedrock and silt are present to a lesser extent. Vegetative growth of primarily SAV generally coincided with the presence of sand, although growth also occurred within gravel and silt substrates. Littoral habitat in much of the lower portion of the study area is characterized by bedrock substrates and steeply sloping shorelines, limiting the quality of the habitat for vegetative growth in this reach of the Pond.

The SAV community was comprised of a total of seven species based on the observations taken during the August 2010 habitat survey. Although hydrilla was the dominant species in the majority of areas where SAV was observed, it was common to see the hydrilla interspersed with other SAV species. Of the species identified, three are non-native (hydrilla, Eurasian watermilfoil, and brittle waternymph [*Najas minor*]), two of which (hydrilla, Eurasian watermilfoil) were most prominent in the study area. The large SAV beds associated with the confluences of Fishing Creek and Peters Creek were populated with high densities of hydrilla, a hardy tolerant aquatic plant that often forms monotypic stands by outcompeting native submergent species. The benefit provided by SAV communities in the majority of the study area of providing potential cover and foraging habitat for fishes and waterfowl, therefore, is somewhat offset by the dominance of the community by invasive species (i.e., hydrilla, and secondarily Eurasian watermilfoil). Given the general stasis of water levels in Conowingo Pond and the hardiness of the numerically dominant species, it is unlikely that fluctuations in water levels affect habitat quality in the study area.

4.4.3 Habitat Use

The littoral habitat of the Pond is used by various aquatic and terrestrial organisms. Bird species observed during ecological surveys from multiple studies on Conowingo Pond in 2010 included great blue heron *(Ardea herodias)*, green heron (*Butorides virescens)*, tern sp., gull sp., double crested cormorant (*Phalacrocorax auritus)*, spotted sandpiper (*Actitis macularia),* belted kingfisher (*Ceryle alcyon*), bald eagle (*Haliaeetus leucocephalus)*, and osprey (*Pandion haliaetus)*. In addition, a large nest was observed during the Black Crowned Night Heron Survey (RSP 3.31) in an ash tree along the eastern shoreline upstream of Mt. Johnson Island that may have been constructed by an osprey or bald eagle. Many of these species observed in the Pond were found to be interacting with littoral habitat, foraging at various depths of the littoral habitat. Foraging opportunities may increase at lower elevations for wading birds such as herons and egrets that stalk fish, amphibian, or macroinvertebrate prey in very shallow water. At higher surface water elevations, foraging opportunities may be reduced for these species but may be augmented for ducks or cormorants, birds that dive for their prey, and for belted kingfishers, an open water foraging species.

The principal resident fish species identified in the PAD from previous studies were used to assess potential utilization of littoral habitat during adult and spawning lifestages. Principal resident species included gizzard shad (*Dorosoma punctatus*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), channel catfish (*Ictalurus punctatus*), and minnows (Cyprinidae), including spotfin shiner (*Cyprinella spilopterus*), spottail shiner (*Notropis hudsonius*), and bluntnose minnow (*Pimephalus notatus*). Table 4.4.3-1 presents the optimal habitat preferences during specific lifestages for each resident species. Optimal spawning habitat for the majority of species occurs over shallow vegetated and unvegetated gravel substrates. Gizzard shad and channel catfish will also spawn over shallow sandy habitat. Shallow unvegetated gravel substrates and shallow vegetated sand substrates are preferred environments for the adult lifestage of the majority of principal fish species. Adult gizzard shad, largemouth bass, channel catfish, and minnows also prefer shallow silt substrates containing vegetation. These habitat types are well represented in the littoral zone of the study, providing generally good quality habitat for recreationally and ecologically important fish species in the Susquehanna River. Shifts in surface water elevations within the permitted fluctuation range, particularly within the range most often observed, are unlikely to result in a decrease in habitat utilization by resident fish species.

5.0 SUMMARY AND CONCLUSIONS

This Water Level Management Study integrated the results of field-derived habitat data, including emergent and submergent aquatic vegetation diversity and abundance, substrate composition and spatial extent, and flow characteristics, with river bottom bathymetry to evaluate the potential effects of Project induced surface water fluctuations on littoral zone habitat. Mapping of habitat and bathymetric data indicated that the littoral zone in the study area consists of a variety of substrate types including bedrock, gravel (primarily cobble and boulder), sand, and silt. Habitats containing primarily sand substrates are closely associated with the confluences of Fishing Creek and Peters Creek and a large depositional area downstream of Mt. Johnson Island. The majority of sand- and silt-dominated substrate within the fluctuation range contains extensive SAV communities that are typical of a lentic littoral zone. Species composition consisted primarily of hydrilla, a perennial tolerant invasive plant. Much of the littoral habitat in the lower portion of the study area is dominated by steep, bedrock outcroppings along the shorelines. In addition, well-sorted gravel (primarily cobble and boulder) substrates are also present in many nearshore areas. These areas of bedrock and well-sorted bedrock and boulder provide unfavorable conditions for the establishment of vegetative communities in the Pond. The lower portion of Conowingo Creek contains emergent soft-bottomed substrates that provide suitable habitat for SAV growth. Emergent vegetative growth in the study area is minimal, and is likely restricted by the general absence of emergent depositional environments and by the natural geology of the Pond.

Historic water elevation data indicate that project fluctuations, in excess of 110 feet or below 105 feet, are highly infrequent, and the typical elevation range is between 107 feet and 109 feet. During the summer when aquatic vegetation is present and most likely to be impacted, water level fluctuations are even further minimized. Vegetated habitat in the littoral zone of the study area would be affected most by a reduction in water levels below 106 feet. Below 106 feet, the amount of shallow littoral habitat available for SAV growth decreases from its maximum; accordingly, the amount of SAV begins to decrease significantly below this elevation. Given that Pond levels are rarely below this elevation, impacts to vegetated littoral habitat from water level fluctuations are unlikely. Of importance to the assessment is that the aquatic vegetation and fish species within the Pond are relatively robust taxa that are adapted to fluctuating ambient conditions, including shifts in water levels.

Based on the results of this study, existing short-term water level fluctuations attributable to Project operations do not appear to be impacting littoral habitat in Conowingo Pond.

TABLE 3.1.2-1. SEDIMENT GRAIN SIZES AS DEFINED BY THE WENTWORTH SCALE[5].

Table 4.1 Summary of the Udden–Wentworth size classification for sediment grains (after Pettijohn *et al.* 1972). This grade scale is now in almost universal use amongst sedimentologists. Estimation of grain size in the field is aided by small samples of the main classes stuck on perspex.

	US Standard sieve mesh	*Millimeters*		*Phi (ϕ) units*	*Wentworth size class*
GRAVEL	*Use wire*	4096		−12	
GRAVEL	*squares*	1024		−10	boulder
GRAVEL		256	256	− 8	
GRAVEL		64	64	− 6	cobble
GRAVEL		16		− 4	pebble
GRAVEL	5	4	4	− 2	
GRAVEL	6	3.36		− 1.75	
GRAVEL	7	2.83		− 1.5	granule
GRAVEL	8	2.38		− 1.25	
GRAVEL	10	2.00	2	− 1.0	
SAND	12	1.68		− 0.75	
SAND	14	1.41		− 0.5	very coarse sand
SAND	16	1.19		− 0.25	
SAND	18	1.00	1	0.0	
SAND	20	0.84		0.25	
SAND	25	0.71		0.5	coarse sand
SAND	30	0.59		0.75	
SAND	35	0.50	1/2	1.0	
SAND	40	0.42		1.25	
SAND	45	0.35		1.5	medium sand
SAND	50	0.30		1.75	
SAND	60	0.25	1/4	2.0	
SAND	70	0.210		2.25	
SAND	80	0.177		2.5	fine sand
SAND	100	0.149		2.75	
SAND	120	0.125	1/8	3.0	
SAND	140	0.105		3.25	
SAND	170	0.088		3.5	very fine sand
SAND	200	0.074		3.75	
SAND	230	0.0625	1/16	4.0	
SILT	270	0.053		4.25	
SILT	325	0.044		4.5	coarse silt
SILT		0.037		4.75	
SILT		0.031	1/32	5.0	
SILT		0.0156	1/64	6.0	medium silt
SILT	*Use*	0.0078	1/128	7.0	fine silt
SILT	*pipette*	0.0039	1/256	8.0	very fine silt
CLAY	*or*	0.0020		9.0	
CLAY	*hydro-*	0.00098		10.0	clay
CLAY	*meter*	0.00049		11.0	
CLAY		0.00024		12.0	
CLAY		0.00012		13.0	
CLAY		0.00006		14.0	

5 Leeder, M.R. 1982. Sedimentology: Process and Product. George Allen and Unwin, Ltd. UK. 344p.

TABLE 4.1.1-1. SAV AND EAV OBSERVED DURING THE AUGUST 2010 HABITAT SURVEY.

Common Name	Scientific Name	Common Name	Scientific Name
EAV		SAV	
Purple Loosestrife	*Lythrum salicaria*	Eurasian Watermilfoil	*Myriophyllum spicatum*
Water Willow	*Justicia americana*	Hydrilla	*Hydrilla verticillata*
Water Pepper	*Polygonum hydropiper*	Water Stargrass	*Heteranthera dubia*
Japanese Stiltgrass	*Microstegium vimineum*	Canadian Waterweed	*Elodea canadensis*
Broadleaf Cattail	*Typha latifolia*	Brittle Waternymph	*Najas minor*
Arrow Arum	*Peltandra virginica*	Coontail	*Ceratophyllum demersum*
Smartweed	*Polygonum pennsylvanicum*	Wild Celery	*Vallisneria americana*
Swamp Milkweed	*Asclepias incarnata*		
Common Dodder	*Cuscuta gronovii*		
Lady's Thumb	*Polygonum persicaria*		
False Indigo	*Amorpha fruticosa*		
Nightshade	*Solanum* sp.		
False Loosestrife	*Ludwigia* sp.		
Common Reed	*Phragmites australis*		
Soft Rush	*Juncus effusus*		
Spotted Joe-Pye Weed	*Eupatorium maculatum*		

TABLE 4.4.1-1. TOTAL WETTED AREA OF AQUATIC HABITAT IN THE STUDY AREA.

Elevation	Total Wetted Area (acres)	Change in Wetted Area (acres)
110.2	7,484.2	--
110	7,482.3	1.9
109	7,473.0	9.3
108	7,463.6	9.4
107	7,449.7	13.9
106	7,413.6	36.2
105	7,351.3	62.3
104	7,255.4	95.8
103	7,172.1	83.3
102	7,089.4	82.7
101.2	7,017.3	72.2

TABLE 4.4.1-2. LITTORAL SUBSTRATE COMPOSITION AT 1-FOOT INTERVALS THROUGHOUT THE PERMITTED FLUCTUATION RANGE.

Water Elevation	Littoral Habitat Coverage (acres)				Total Acres
	Bedrock	Gravel	Sand	Silt	
110-110.2	0.50	1.27	0.00	0.02	1.78
109-110	2.64	7.15	0.13	0.15	10.07
108-109	2.68	6.68	0.16	0.48	10.00
107-108	3.21	10.51	0.30	0.56	14.59
106-107	3.99	29.70	2.77	0.77	37.23
105-106	4.97	19.33	37.18	1.68	63.16
104-105	4.05	28.40	60.80	5.04	98.28
103-104	4.19	41.56	25.89	13.05	84.69
102-103	3.12	11.51	16.57	49.90	81.09
101.2-102	2.46	6.68	12.24	31.18	52.56
Total	**31.79**	**162.80**	**156.05**	**102.84**	**453.48**

TABLE 4.4.1-3. QUANTIFICATION OF SUBSTRATE IN SHALLOW AND DEEP LITTORAL HABITAT WITHIN PERMITTED FLUCTUATION RANGE.

Elevation (ft)	Elevation Range (ft)		Bedrock (acres)		Gravel (acres)		Sand (acres)		Silt (acres)	
	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
110.2	110.2-105	105-101.2	17.98	13.82	74.65	88.15	40.56	115.49	3.66	99.17
110	110-105	104-101.2	17.48	13.82	73.38	88.15	40.56	115.49	3.65	99.17
109	109-104	103-101.2	18.89	9.77	94.63	59.75	101.22	54.69	8.54	94.13
108	108-103	102-101.2	20.40	5.58	129.51	18.19	126.94	28.81	21.11	81.08
107	107-102	101.2	20.31	2.46	130.51	6.68	143.20	12.24	70.44	31.18
106	106-101.2	*	18.78	-	107.48	-	152.67	-	100.85	-
105	105-101.2	*	13.82	-	88.15	-	115.49	-	99.17	-
104	104-101.2	*	9.77	-	59.75	-	54.69	-	94.13	-
103	103-101.2	*	5.58	-	18.19	-	28.81	-	81.08	-
102	102-101.2	*	2.46	-	6.68	-	12.24	-	31.18	-
101.2	*	*	-	-	-	-	-	-	-	-

Note: Shallow (0-5 ft). Deep (5+ft)

* Elevation at which shallow or deep habitat no longer exists within the fluctuation range as defined by the study scope.

TABLE 4.4.1-4. SAV GROWTH ASSOCIATED WITH SUBSTRATE TYPES IN CONOWINGO POND.

Water Elevation (ft) (NGVD 1929)	Total Submerged Aquatic Vegetation (acres)				
	Bedrock	Gravel	Sand	Silt	Unidentified
110.2	1.24	96.10	147.42	66.03	1.46
110	1.24	96.01	147.41	66.03	1.46
109	1.24	95.48	147.31	66.03	1.46
108	1.23	94.60	147.17	66.03	1.46
107	1.23	92.47	146.88	66.02	1.46
106	1.20	73.12	144.11	65.85	1.46
105	1.05	59.85	107.36	64.40	1.44
104	0.70	39.04	46.85	59.92	1.34
103	0.19	4.84	13.97	56.93	0.11
102	0.04	0.52	3.92	15.15	0.01
101.2	-	-	-	-	-

Note: Unidentified vegetative bed found during side scan sonar survey

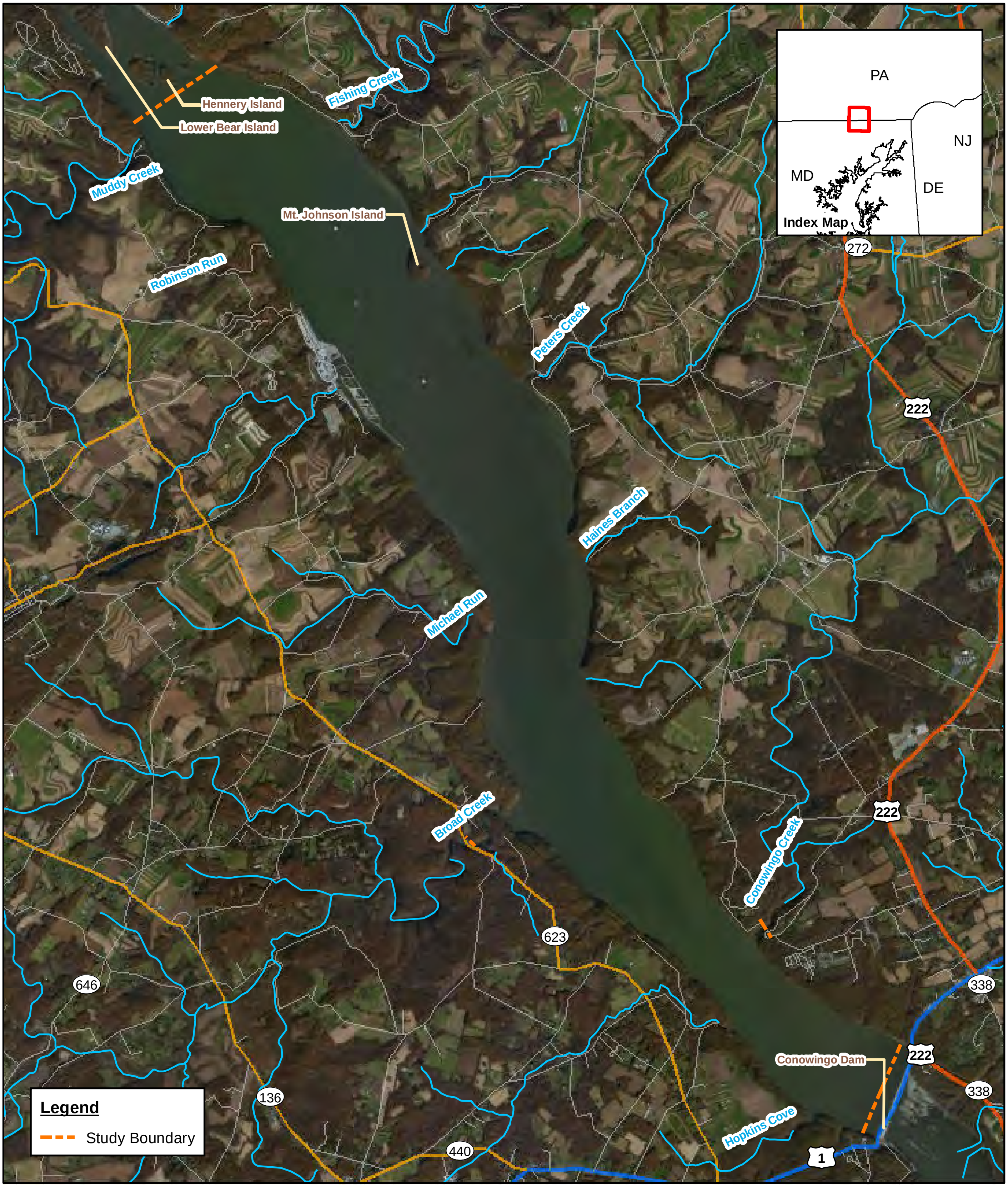
TABLE 4.4.3-1. PRINCIPAL RESIDENT FISH SPECIES OPTIMAL HABITAT UTILIZATION FOR ADULT AND SPAWNING LIFESTAGES.

		Habitat Type													
Species	Lifestage	Shallow Bedrock	Deep Bedrock	Shallow Gravel Unveg.	Shallow Gravel Veg.	Deep Gravel Unveg.	Deep Gravel Veg.	Shallow Sand Unveg.	Shallow Sand Veg.	Deep Sand Unveg.	Deep Sand Veg.	Shallow Silt Unveg.	Shallow Silt Veg.	Deep Silt Unveg.	Deep Silt Veg.
Gizzard shad	Spawning			O	O			O	O						
	Adult							O	O	O	O	O	O	O	O
Largemouth Bass	Spawning			O	O	O	O								
	Adult								O				O		
Smallmouth Bass	Spawning			O											
	Adult			O		O									
Walleye	Spawning			O				O							
	Adult			O		O	O								
Channel Catfish	Spawning			O		O									
	Adult			O	O	O	O		O		O		O		O
Cyprinidae[1]	Spawning				O				O						
	Adult			O	O				O				O		

O Represents optimal habitat for a specific lifestage

[1] Includes spotfin shiner, spottail shiner, and bluntnose minnow

<u>*Sources*</u>: Becker, G.C. 1983. Fishes of Wisconsin. The University of Wisconsin Press.
USGS. 2011. Habitat Suitability Index Models. http://www.nwrc.usgs.gov/wdb/pub/hsi/hsiindex.htm.



EXELON GENERATION COMPANY, LLC

WATER LEVEL MANAGEMENT STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

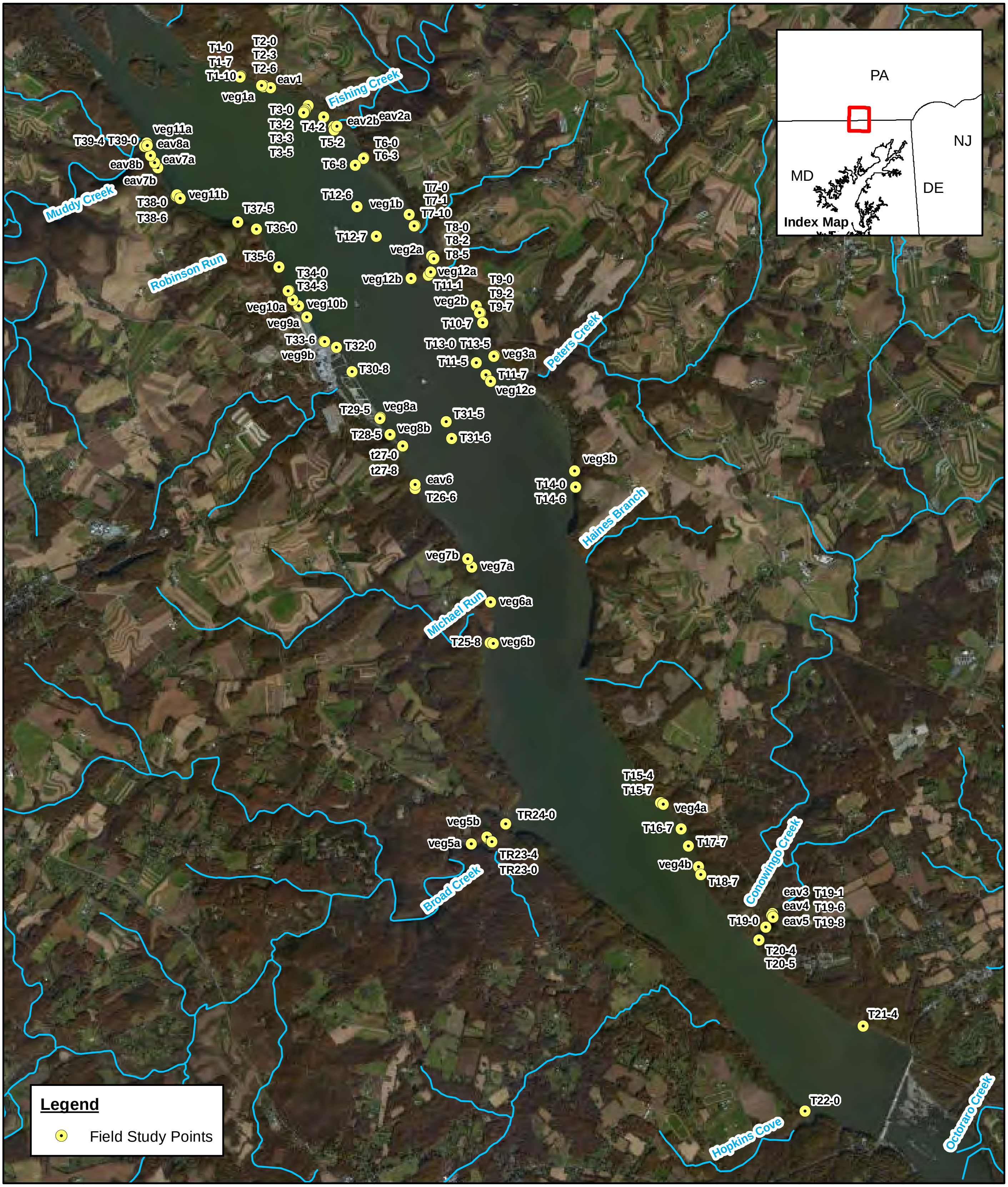
1 inch = 1.25 miles

0 0.5 1 2 Miles

Figure 1.3-1
Conowingo Pond Water Level Management Study Area

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 1.3-1.mxd

FIGURE 3.1.1-1. WEED RAKE USED TO CHARACTERIZE SAV COMMUNITY IN THE STUDY AREA.



N

EXELON GENERATION COMPANY, LLC

WATER LEVEL MANAGEMENT STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 1.25 miles

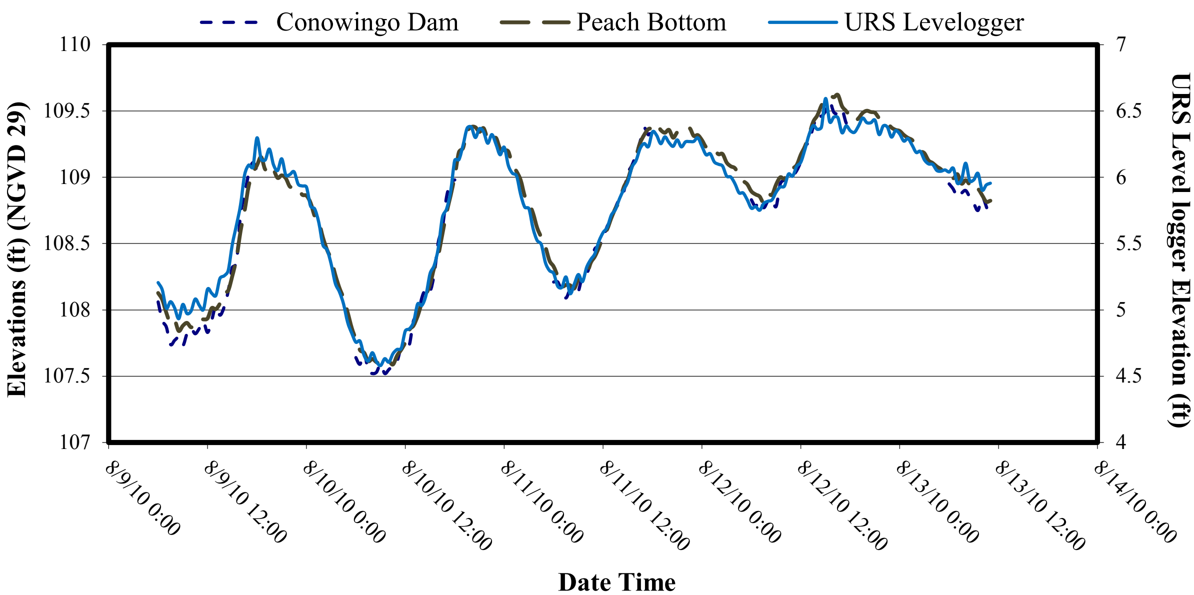
0 0.5 1 2 Miles

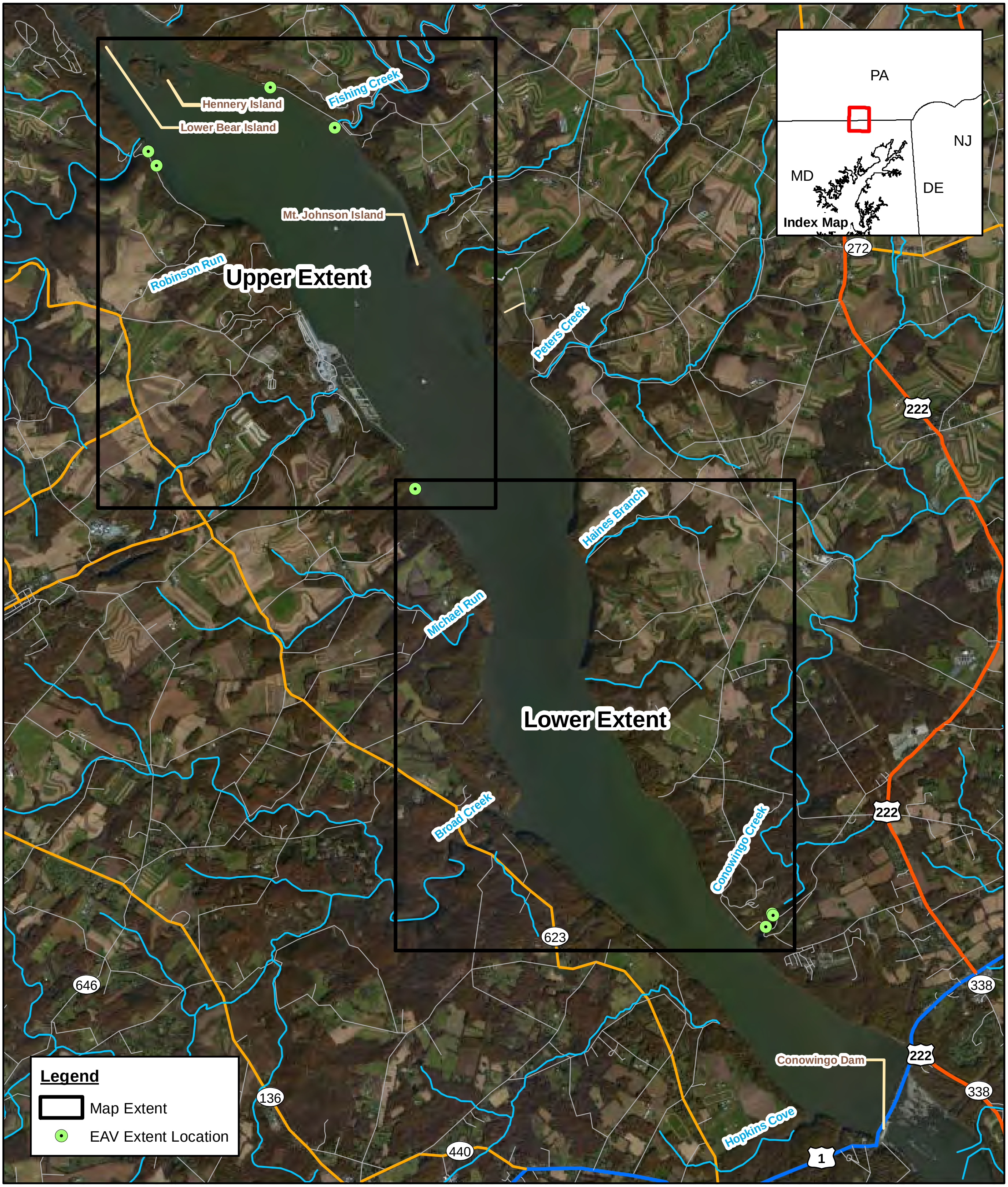
Figure 3.1.2-1
Habitat Survey Points Collected During the 2010 Water Level Management Study

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 3.1.2-1.mxd

FIGURE 3.3-1. WATER LEVEL DATA LOGGER INSTALLED IN A PVC STILLING WELL.

FIGURE 3.3-2. WATER LEVEL DATA COLLECTED IN THE CONOWINGO POND – AUGUST 9-13, 2010.





N

EXELON GENERATION COMPANY, LLC

WATER LEVEL MANAGEMENT STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 1.25 miles

0 0.5 1 2 Miles

Figure 4.1.1-1
EAV Community Extent Map

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.1-1.mxd

EXELON GENERATION COMPANY, LLC

WATER LEVEL MANAGEMENT STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

N

1 inch = 1 miles

0 0.25 0.5 1 Miles

Figure 4.1.1-2
EAV Community Map
Upper Extent

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.1-2.mxd

Exelon.

N

EXELON GENERATION COMPANY, LLC

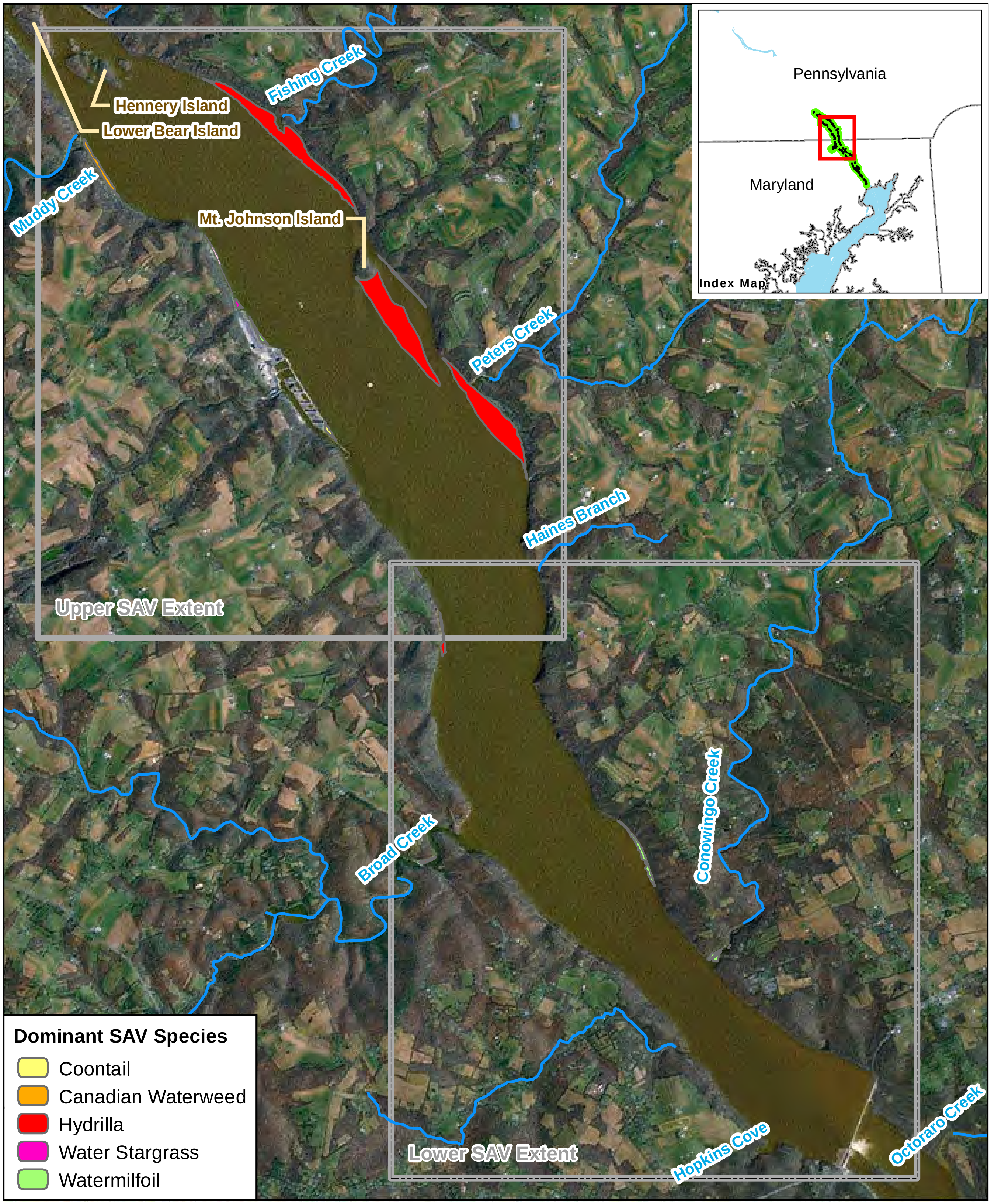
WATER LEVEL MANAGEMENT STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 1 miles

0 0.25 0.5 1 Miles

Figure 4.1.1-3
EAV Community Map
Lower Extent

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.1-3.mxd



N

1 inch = 1.25 miles

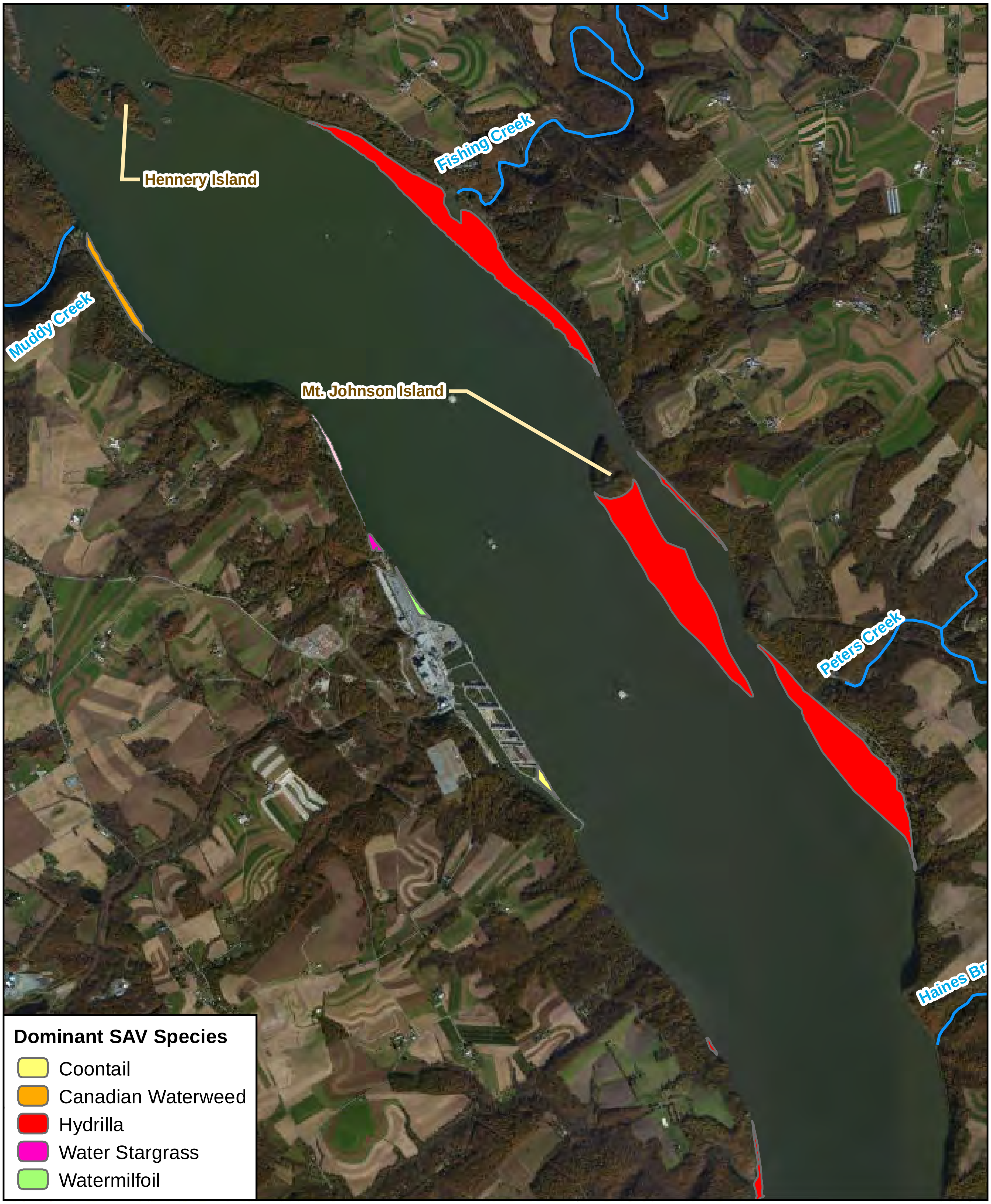
0 0.625 1.25 2.5 Miles

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NO. 405

Figure 4.1.1-4:
SAV Community Extent Map

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.1-4.mxd



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CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NO. 405

Figure 4.1.1-5:
SAV Community Extent Map
Upper Extent

N

0 0.25 0.5 1 Miles

Exelon.

N

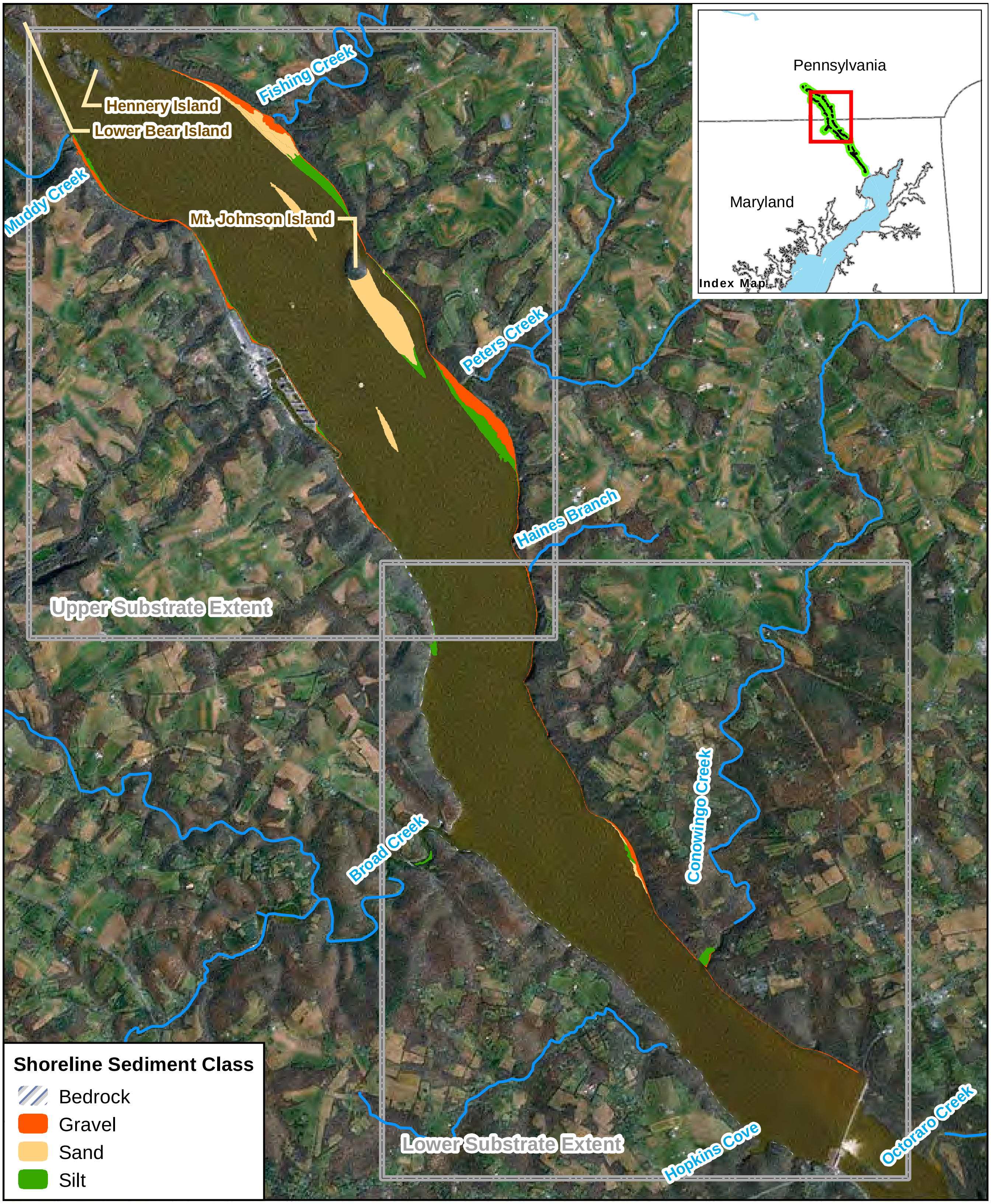
EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NO. 405

Figure 4.1.1-6:
SAV Community Extent Map
Lower Extent

0 0.25 0.5 1
Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.1-6.mxd



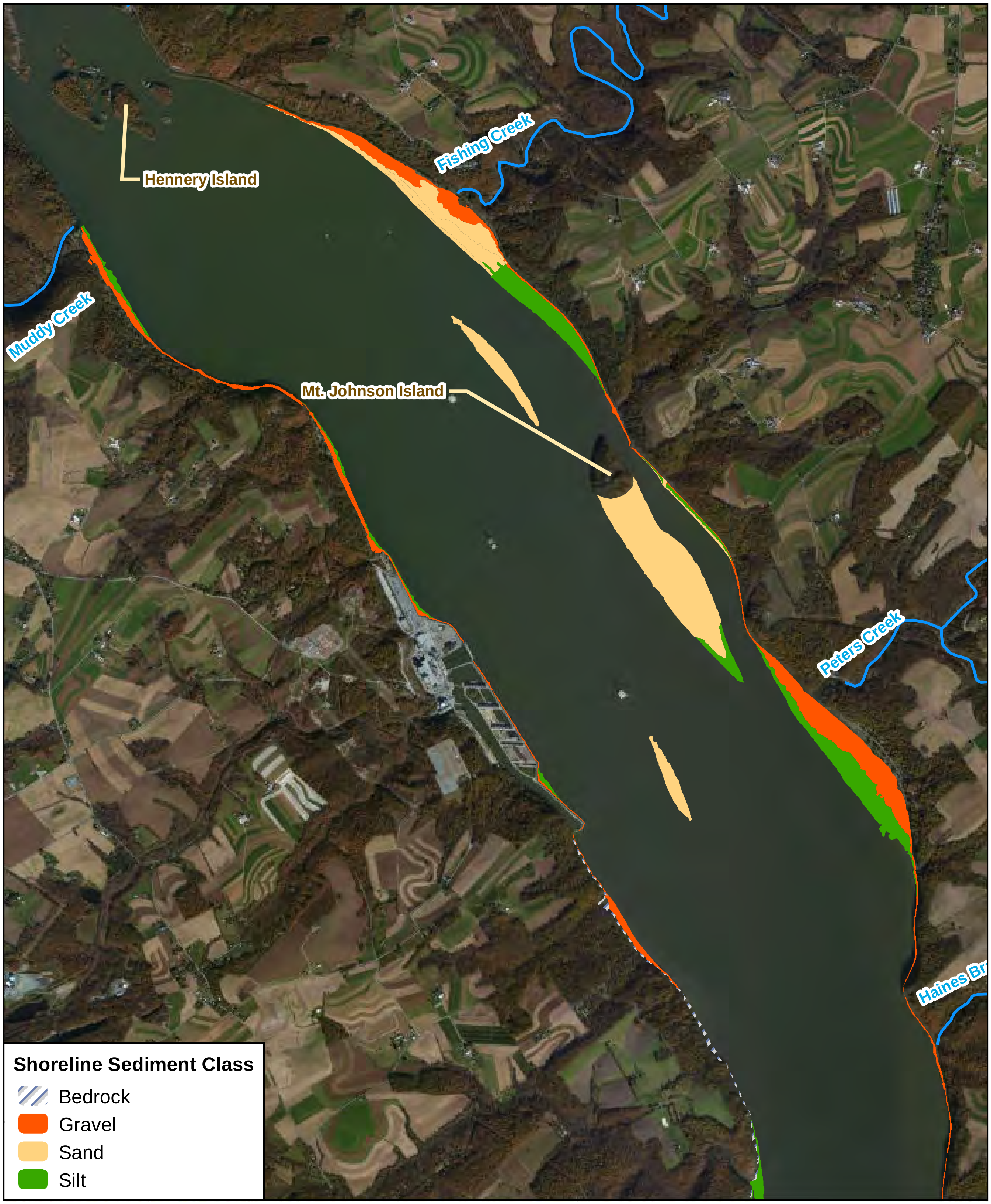
EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NO. 405

Figure 4.1.2-1:
Substrate Extent Map

1 inch = 1.25 miles
0 0.625 1.25 2.5 Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.2-1.mxd



N

0 0.25 0.5 1 Miles

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NO. 405

Figure 4.1.2-2:
Substrate Upper Extent Map

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.2-2.mxd

N

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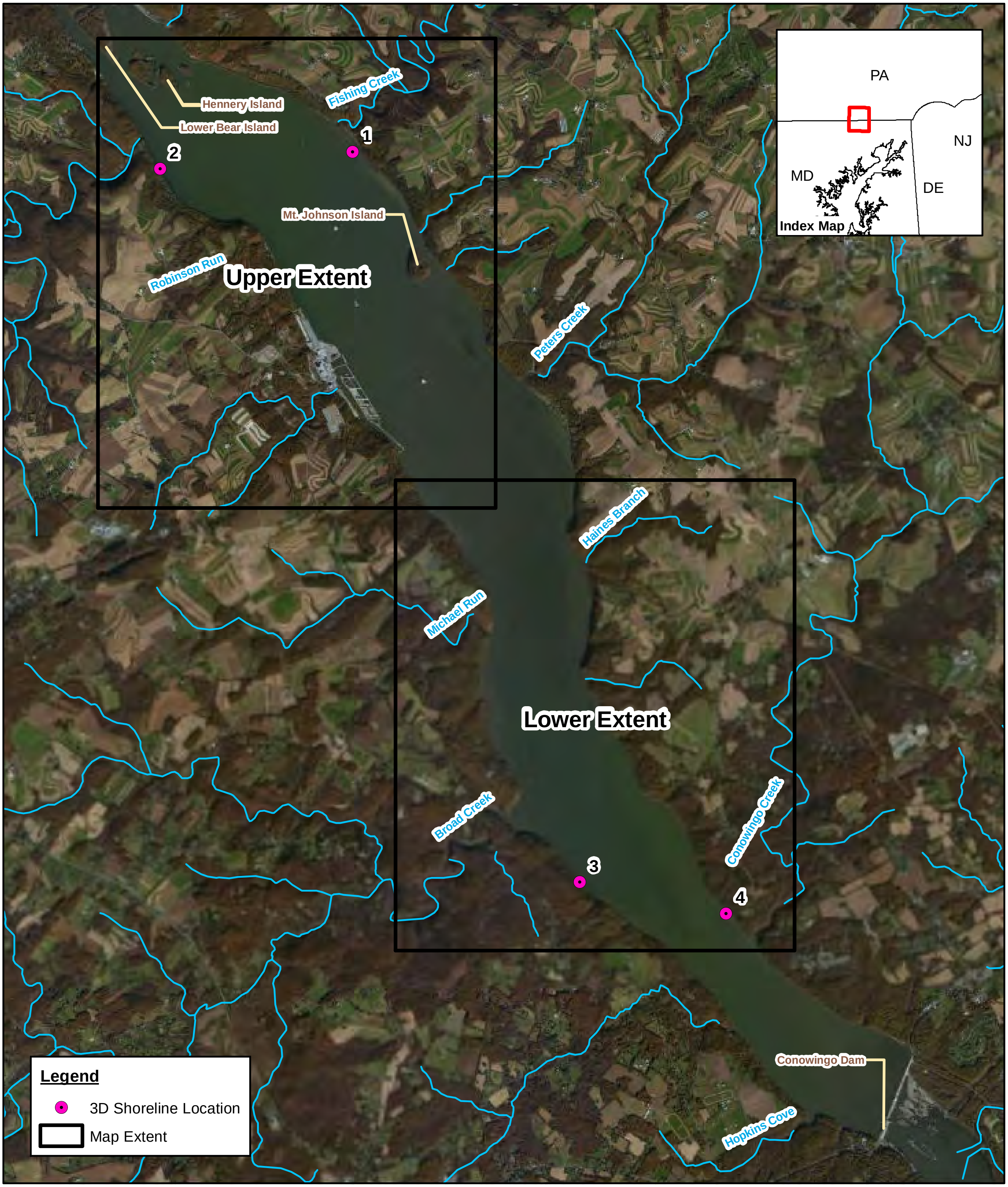
FERC PROJECT NO. 405

Figure 4.1.2-3:
Substrate Lower Extent Map

0 0.25 0.5 1
Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.2-3.mxd



Exelon

N

EXELON GENERATION COMPANY, LLC

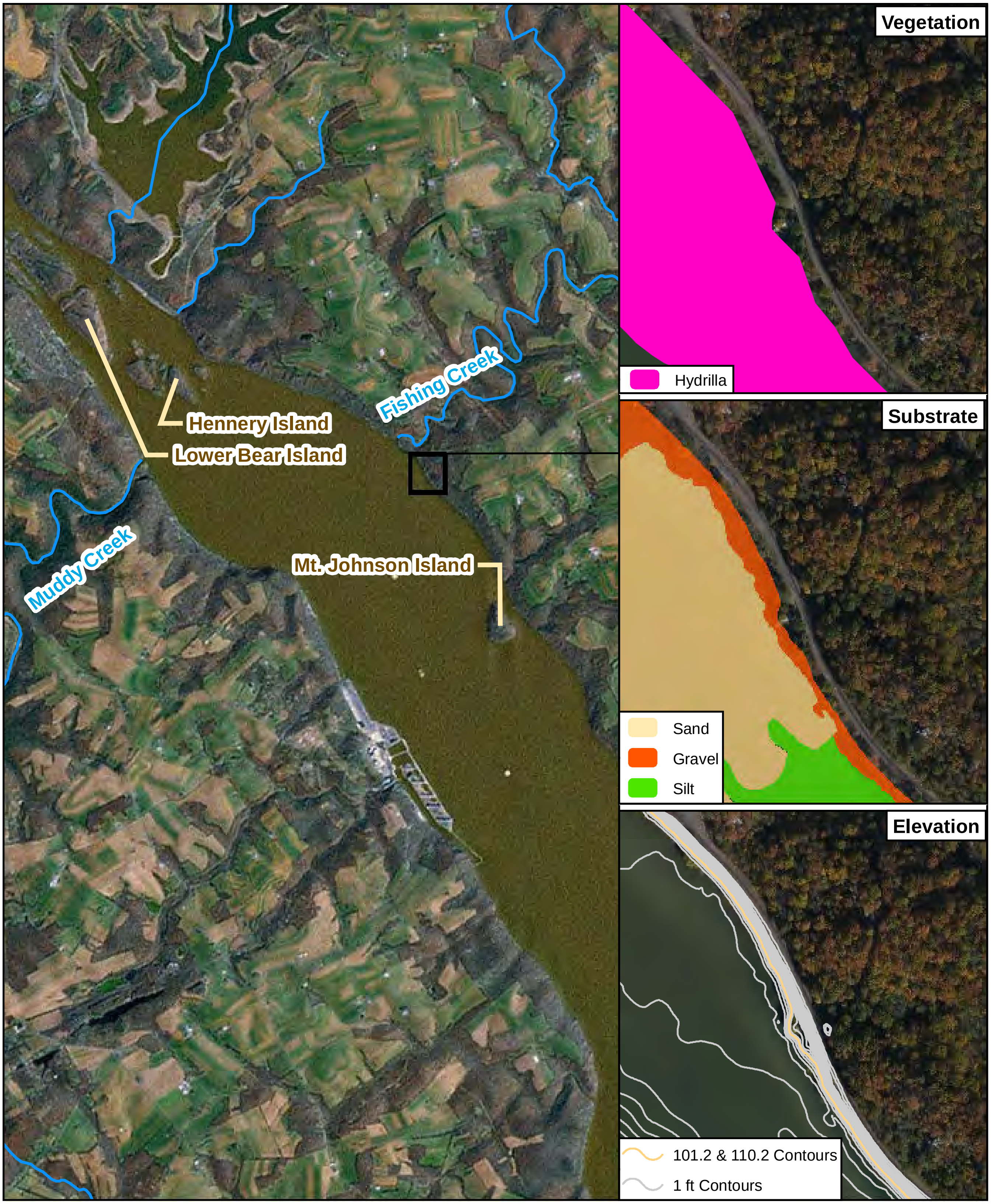
WATER LEVEL MANAGEMENT STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 1.25 miles

0 0.5 1 2 Miles

Figure 4.1.2-4
Representative Habitat Map Locations

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.2-4.mxd



EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NO. 405

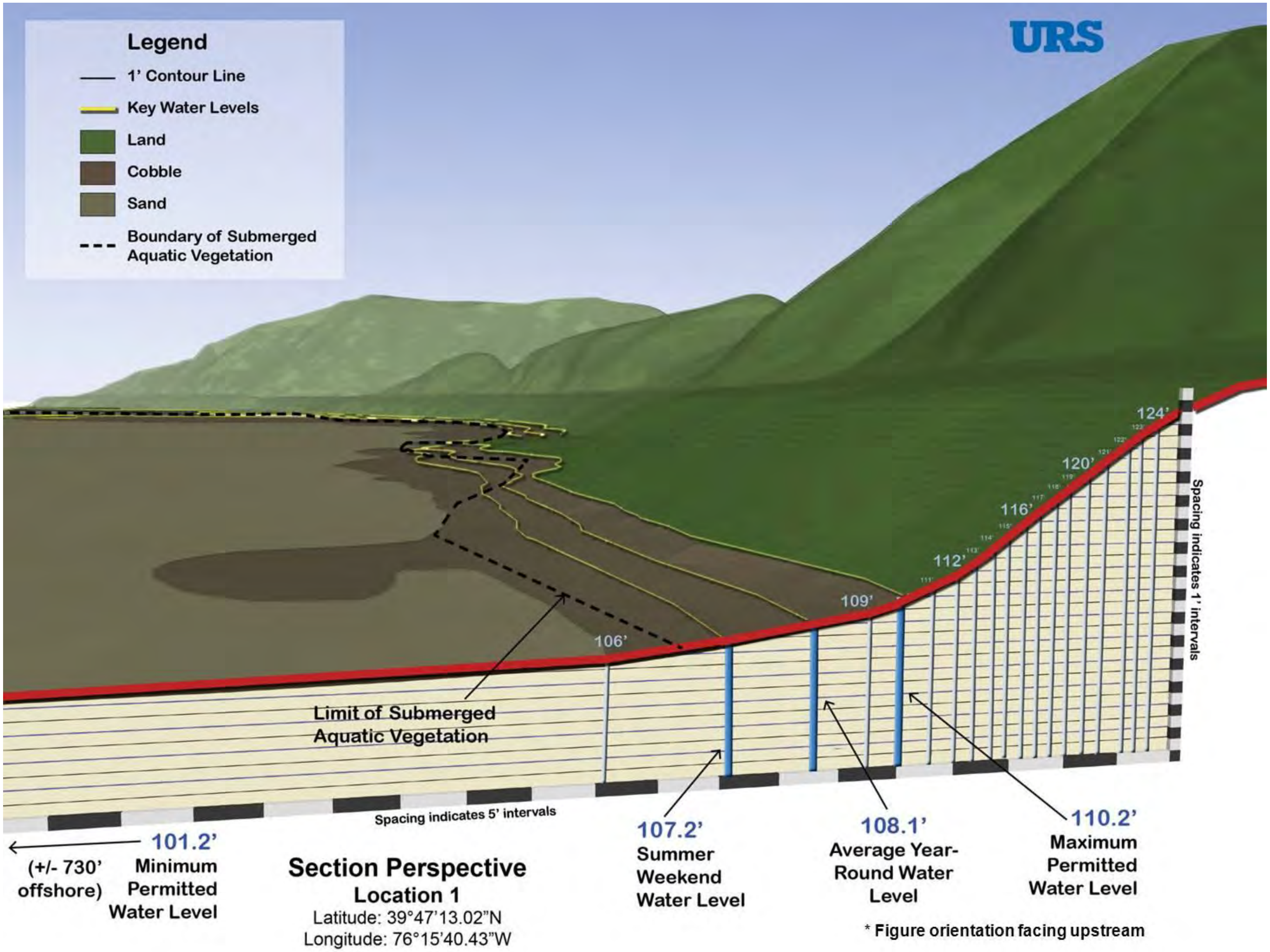
N

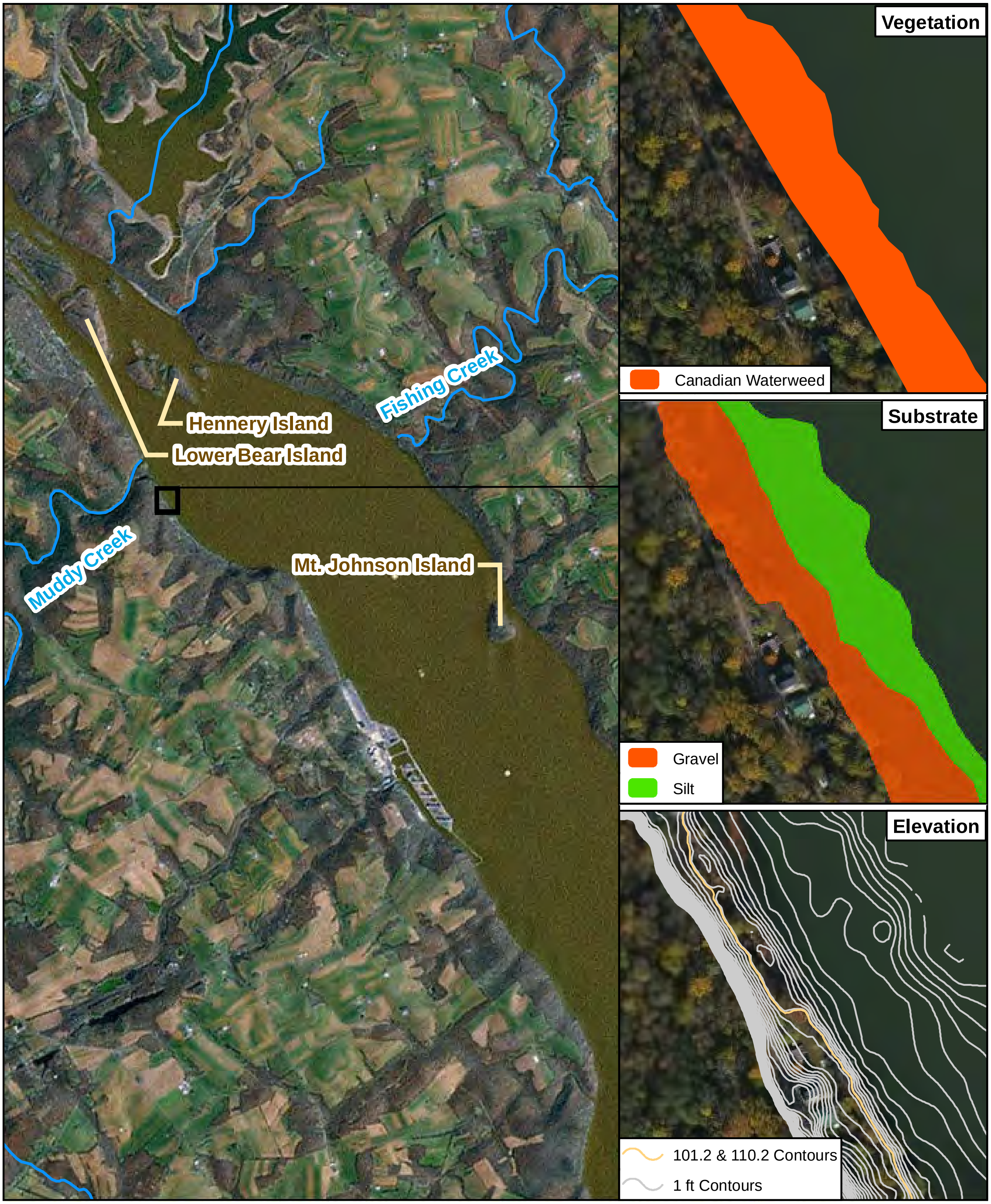
1 inch = 1 miles
0 0.5 1 2 Miles

Figure 3.3.4.1.4-6:
Conowingo Pond
Sumberged Aquatic Wetland Habitat
Location 1

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.2-5.mxd

FIGURE 4.1.2-6. 3D CROSS SECTION OF LOCATION 1 INDICATING BATHYMETRY, SUBSTRATE, AND LIMITS OF SAV.





N

1 inch = 1 miles

0 0.5 1 2 Miles

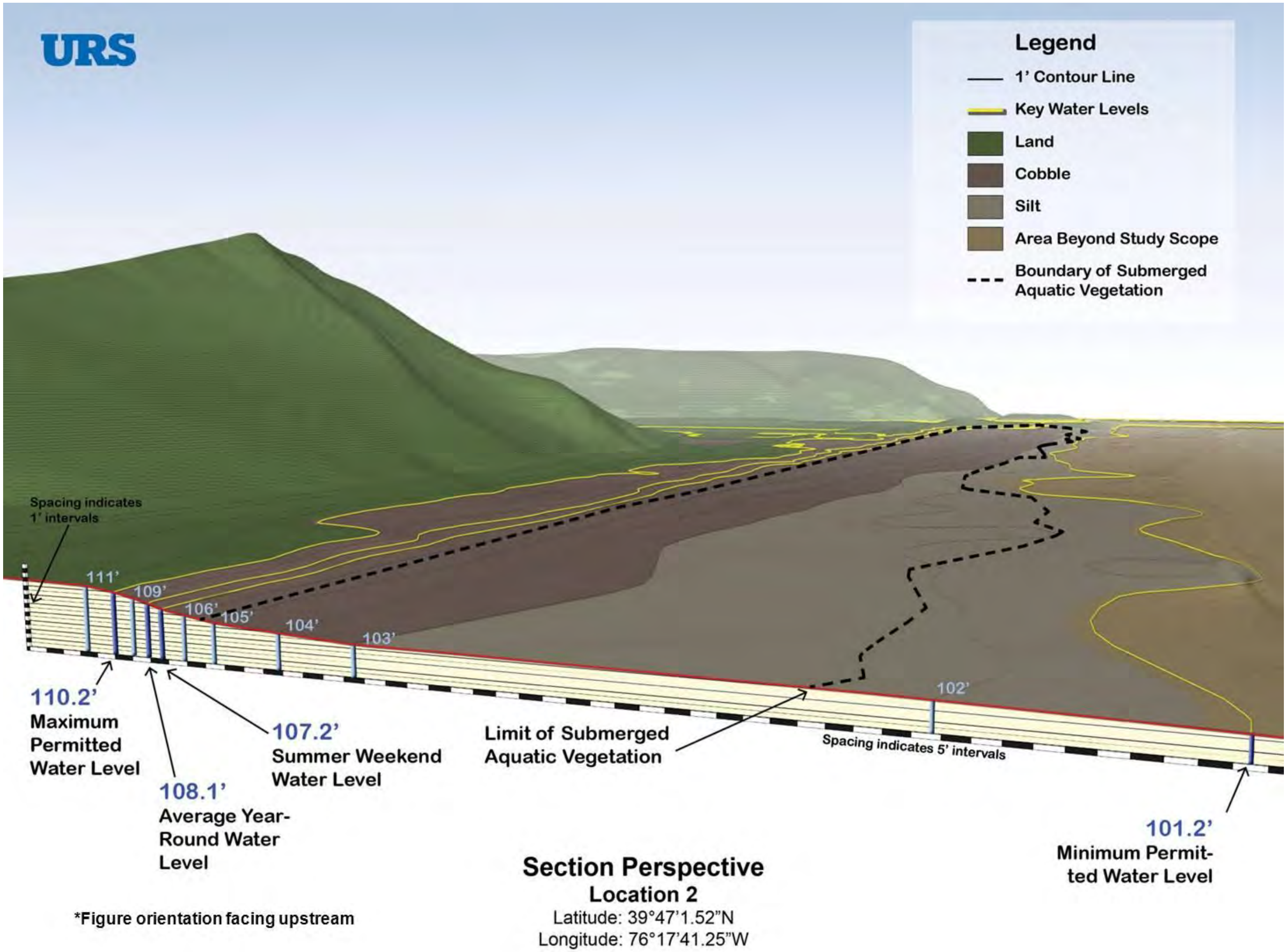
EXELON GENERATION COMPANY, LLC

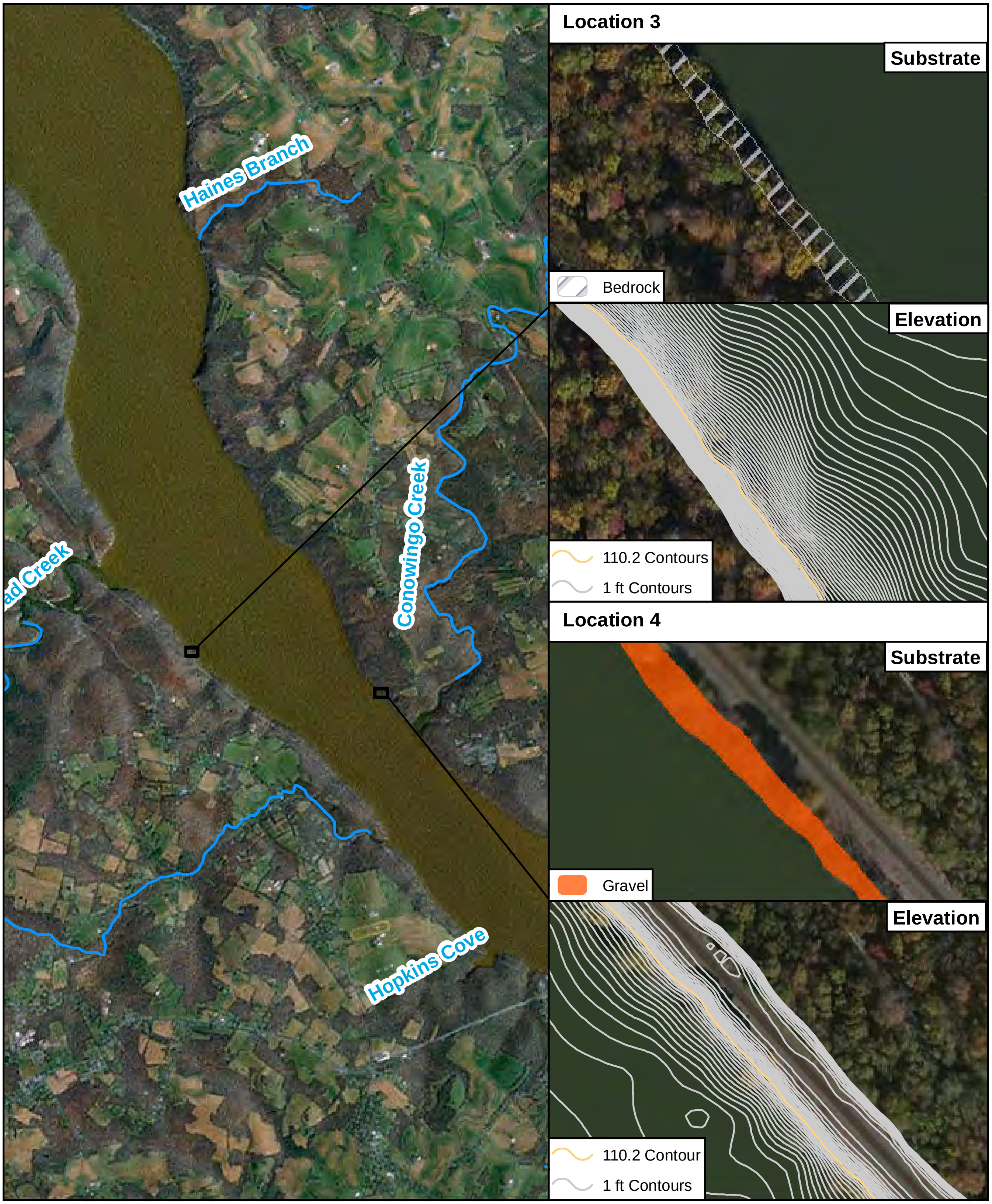
CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NO. 405

Figure 4.1.2-7:
Habitat Map
Location 2

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.2-7.mxd

FIGURE 4.1.2-8. 3D CROSS SECTION OF LOCATION 2 INDICATING BATHYMETRY, SUBSTRATE, AND LIMITS OF SAV.





EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NO. 405

Figure 4.1.2-9:
Habitat Map
Locations 3 and 4

N

1 inch = 1 miles

0 0.5 1 2 Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\WLM Figure 4.1.2-9.mxd

FIGURE 4.1.2-10. 3D CROSS SECTION OF LOCATION 3 INDICATING BATHYMETRY, SUBSTRATE, AND LIMITS OF SAV.

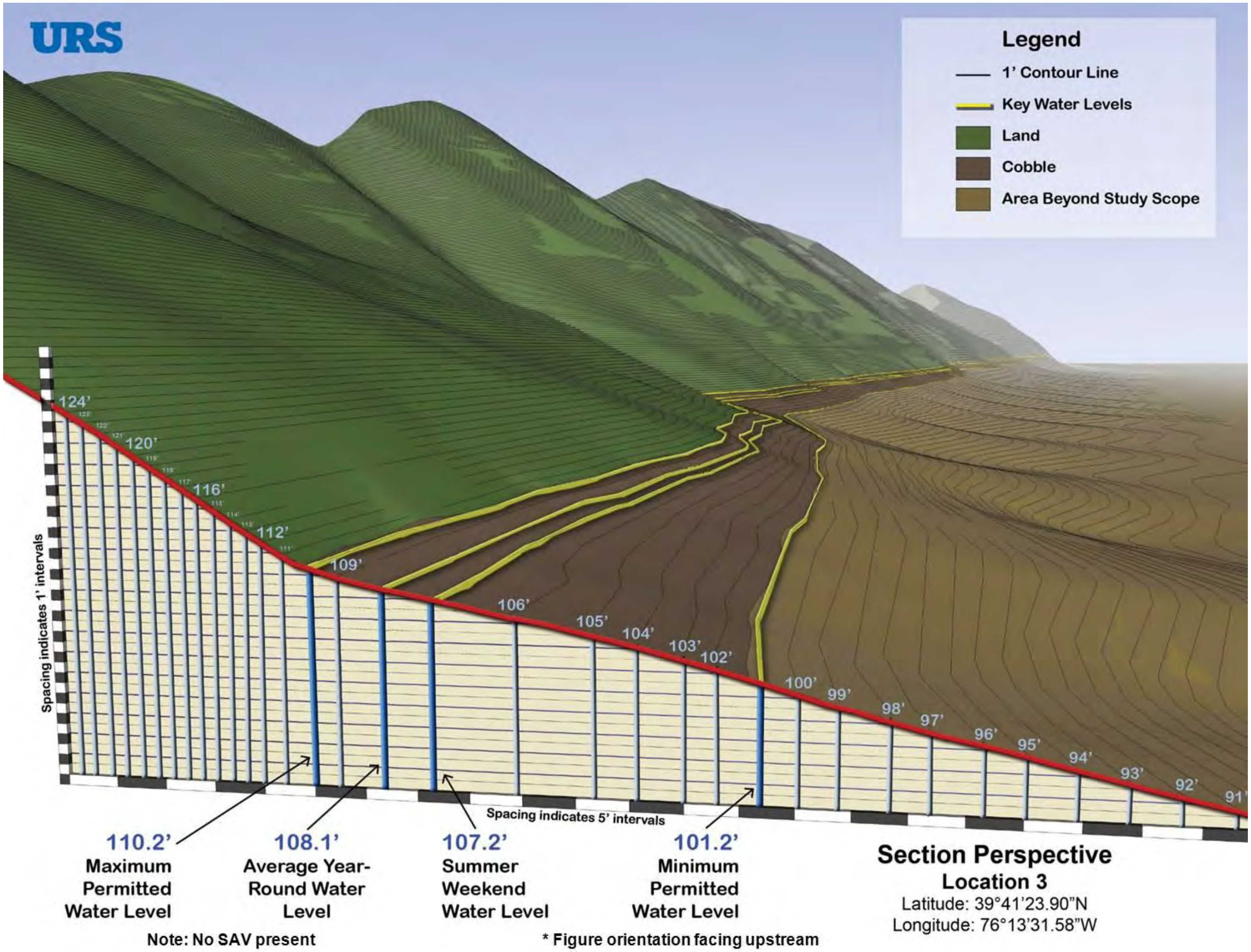


FIGURE 4.1.2-11. 3D CROSS SECTION OF LOCATION 4 INDICATING BATHYMETRY, SUBSTRATE, AND LIMITS OF SAV.

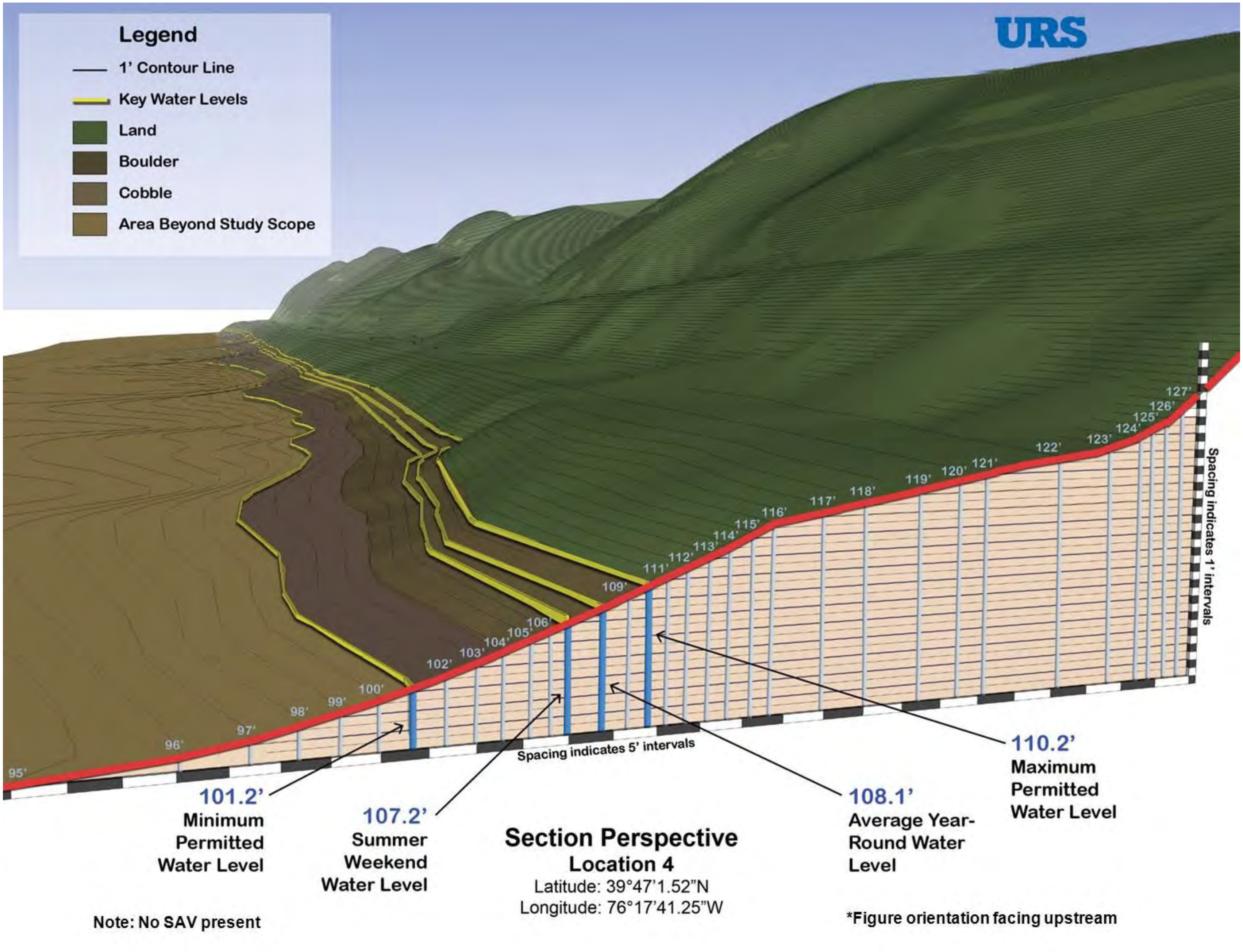


FIGURE 4.3-1. MONTHLY SUMMARY OF CONOWINGO POND ELEVATION DATA – JANUARY 2004 THROUGH SEPTEMBER 2010.

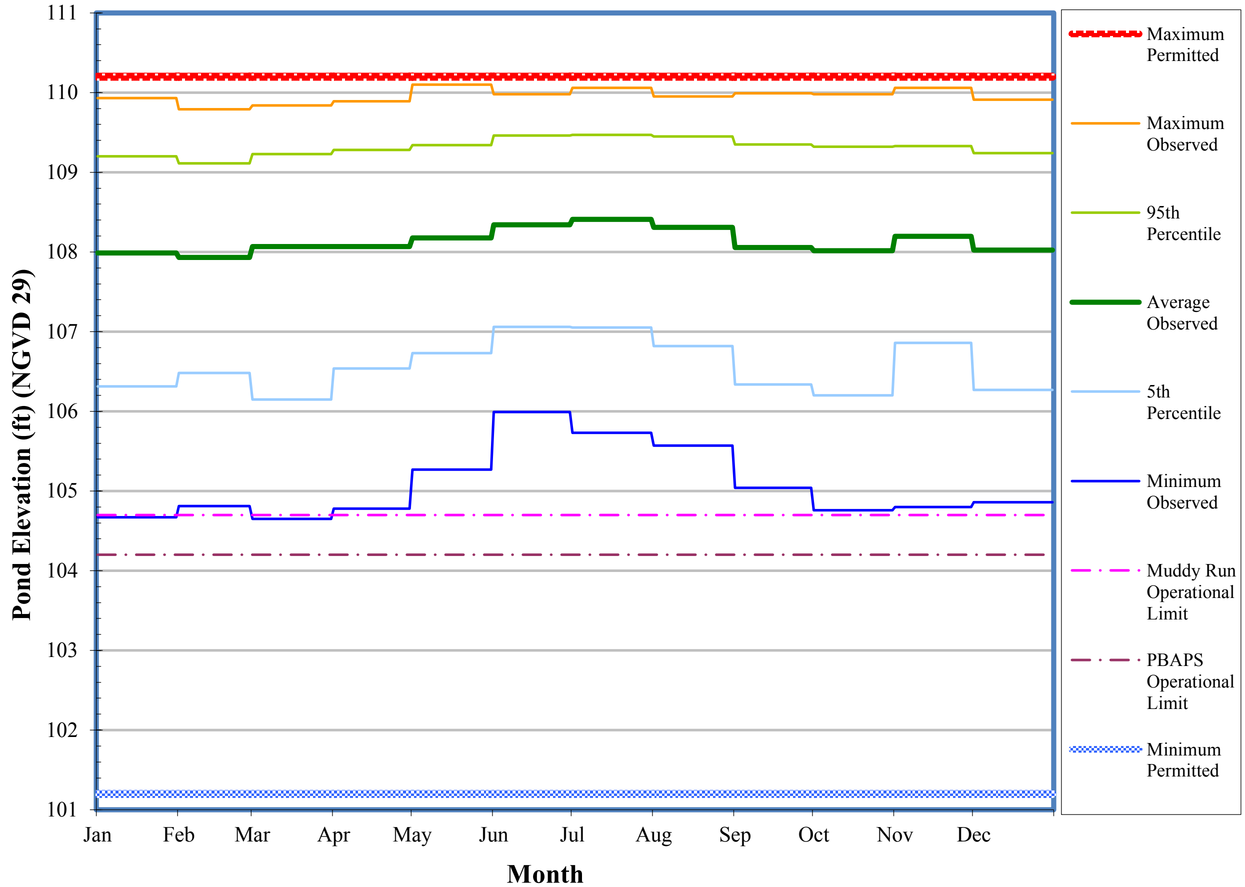


FIGURE 4.3-2. WEEKLY AVERAGE WATER LEVEL FLUCTUATION DATA IN CONOWINGO POND – JANUARY 2004 THROUGH SEPTEMBER 2010.

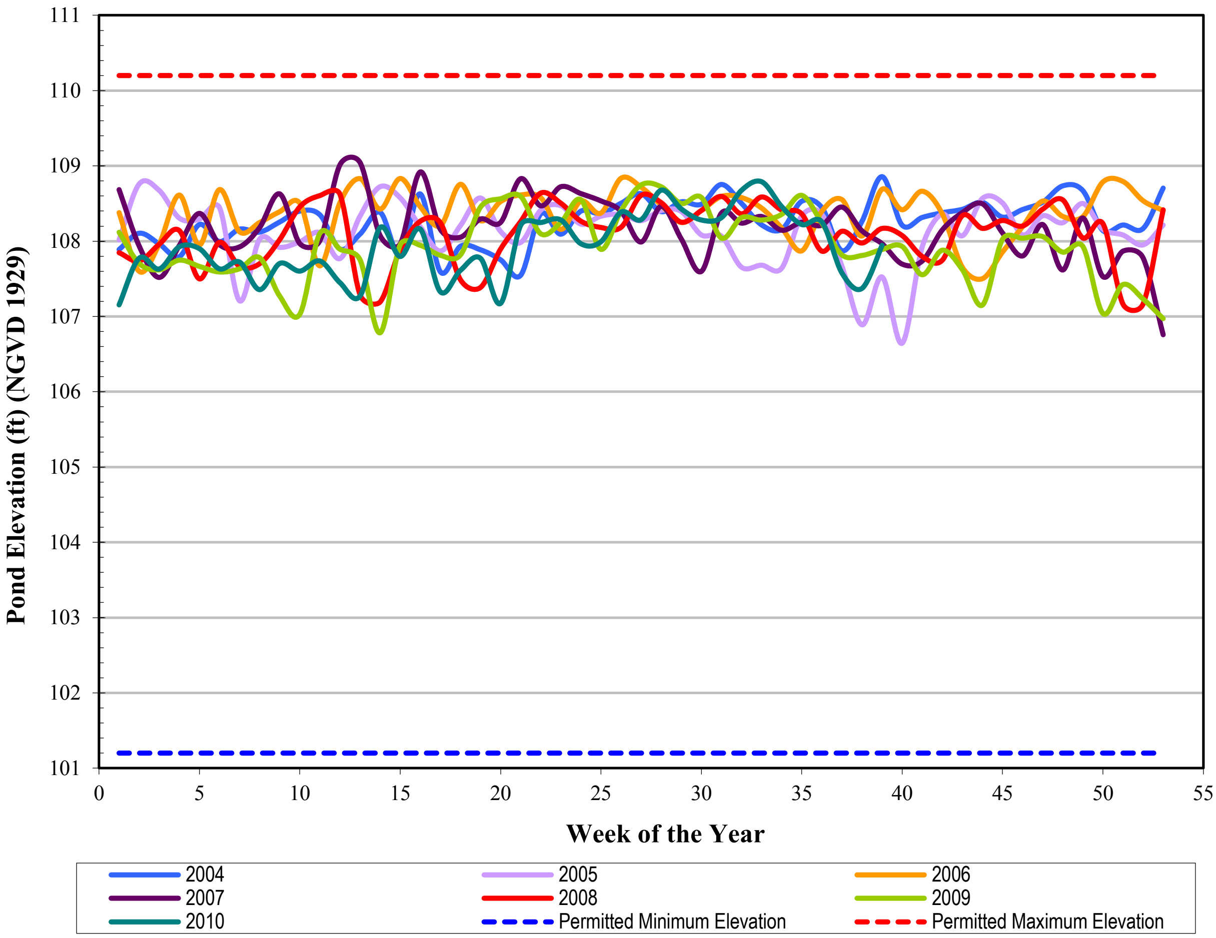


FIGURE 4.4.1-1. SPATIAL COVERAGE OF SUBSTRATE TYPES IN EACH 1-FOOT CONTOUR INTERVAL

.

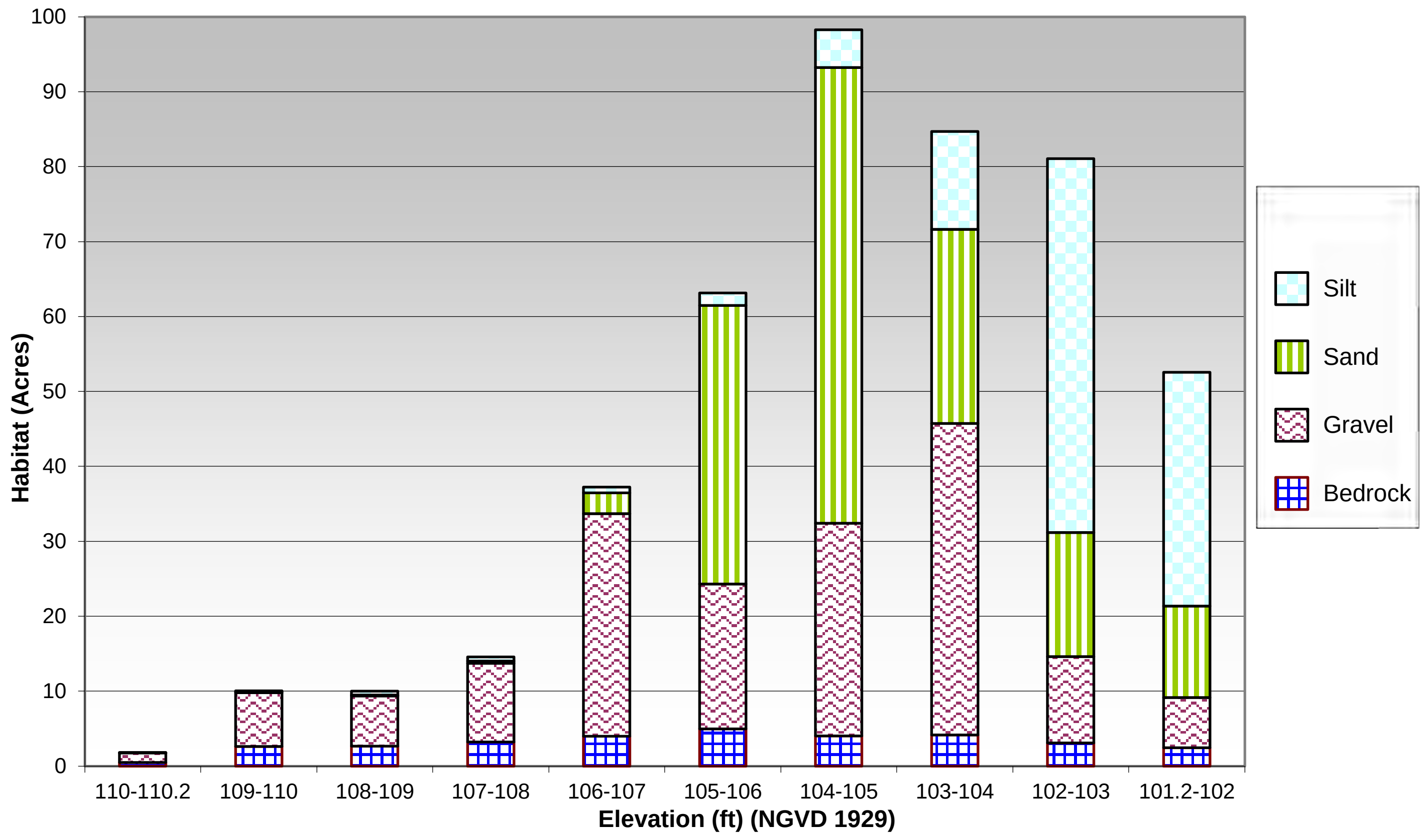
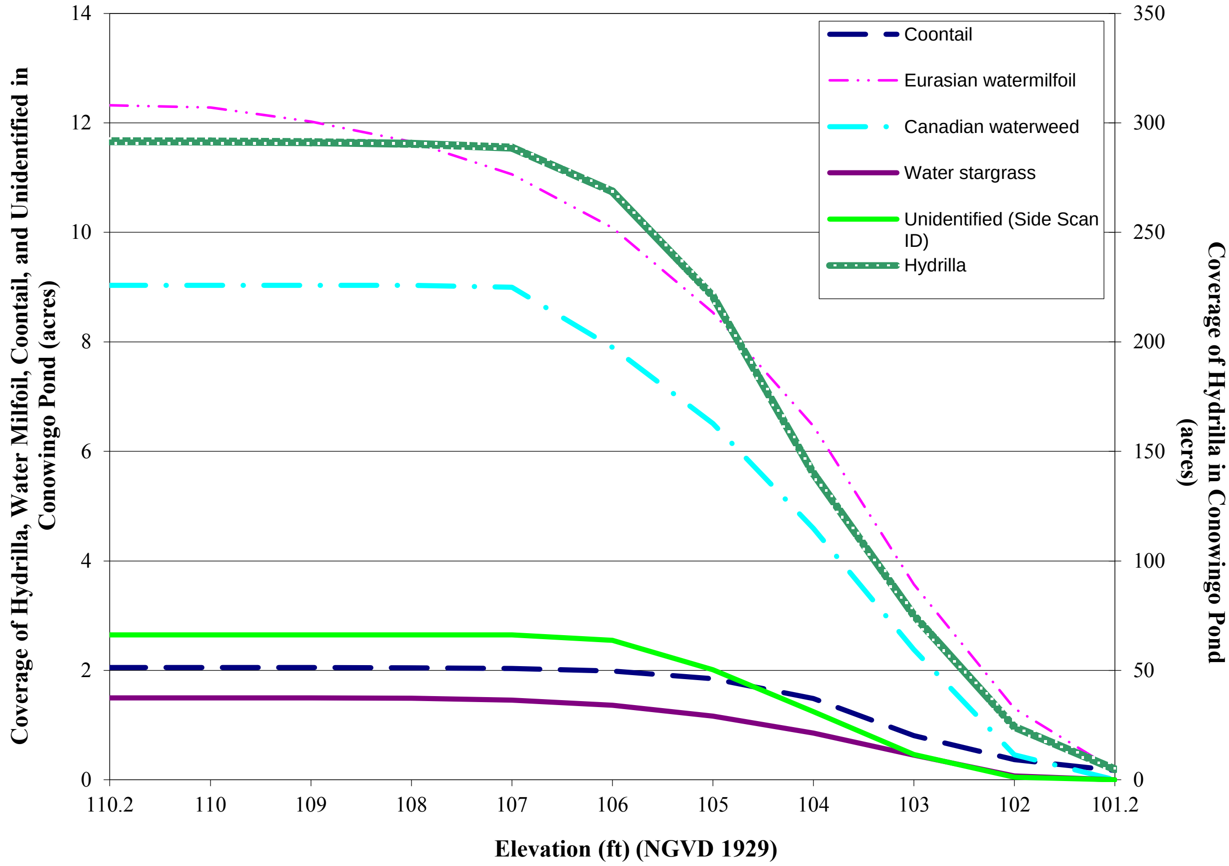


FIGURE 4.4.1-2. RELATIONSHIP BETWEEN WATER LEVELS AND SAV COVER.



Note: The abundance of hydrilla necessitated the inclusion of a secondary y-axis on a greater scale.

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APPENDIX A-PHOTOGRAPHIC LOG

URS

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 1 **Date:** 8/9/10

Direction Photo Taken:

Description:

River substrate at T1-7.5 along eastern river shoreline. The dominant sediment grain size at this location is medium sand, followed by fine sand and silt. No submerged aquatic vegetation (SAV) or emergent aquatic vegetation (EAV) is present in this area.

Photo No. 2 **Date:** 8/9/10

Direction Photo Taken:

Description:

Coarse sand substrate at T1-10. Pebble, silt, and boulders are also present in this area. No SAV or EAV is present in this area.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 3 **Date:** 8/9/10

Direction Photo Taken:

Description:

Eastern river shoreline substrate along Transect 2 (T2-0). Cobble comprises the majority of the substrate at the shoreline, followed by boulder. SAV and EAV are absent in this area.

Photo No. 4 **Date:** 8/9/10

Direction Photo Taken:

Description:

River substrate at T2-3. The substrate here is composed mainly of fine sand poorly sorted with silt. SAV is present along this transect from the water depth at this location (3 feet) out to 6 feet.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. **5** | **Date:** 8/9/10

Direction Photo Taken:

Northwest

Description:

Heavy growth of Eurasian watermilfoil (*Myriophyllum spicatum*) at T2-3. Other SAV species observed in this area were hydrilla (*Hydrilla verticillata*) and water stargrass (*Heteranthera dubia*).

Photo No. **6** | **Date:** 8/9/10

Direction Photo Taken:

East

Description:

Bed of emergent vegetation (EAV-1) downstream of Transect 2. Water willow (*Justicia* sp.) is the dominant species in this area. Common dodder (*Cuscuta gronovii*), a parasitic species, is also observable growing atop the water willow.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. **7** | **Date:** 8/9/10

Direction Photo Taken:

Description:

Substrate and SAV at T3-2 along eastern river shoreline. The dominant grain size at this location is very fine sand, followed by silt. Canadian waterweed (*Elodea canadensis*) was the primary SAV species observed here. Eurasian watermilfoil, hydrilla, and brittle water nymph (*Najas minor*) are also present in this area.

Photo No. **8** | **Date:** 8/9/10

Direction Photo Taken:

Southwest

Description:

SAV community at T3-2.

URS	**PHOTOGRAPHIC LOG**

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 9 | **Date:** 8/9/10

Direction Photo Taken:

Description:

Sediment and SAV at T3-3. The sediment is characterized as fine sand poorly sorted with medium sand and silt. Hydrilla is the dominant SAV species at this location, followed by Canadian waterweed.

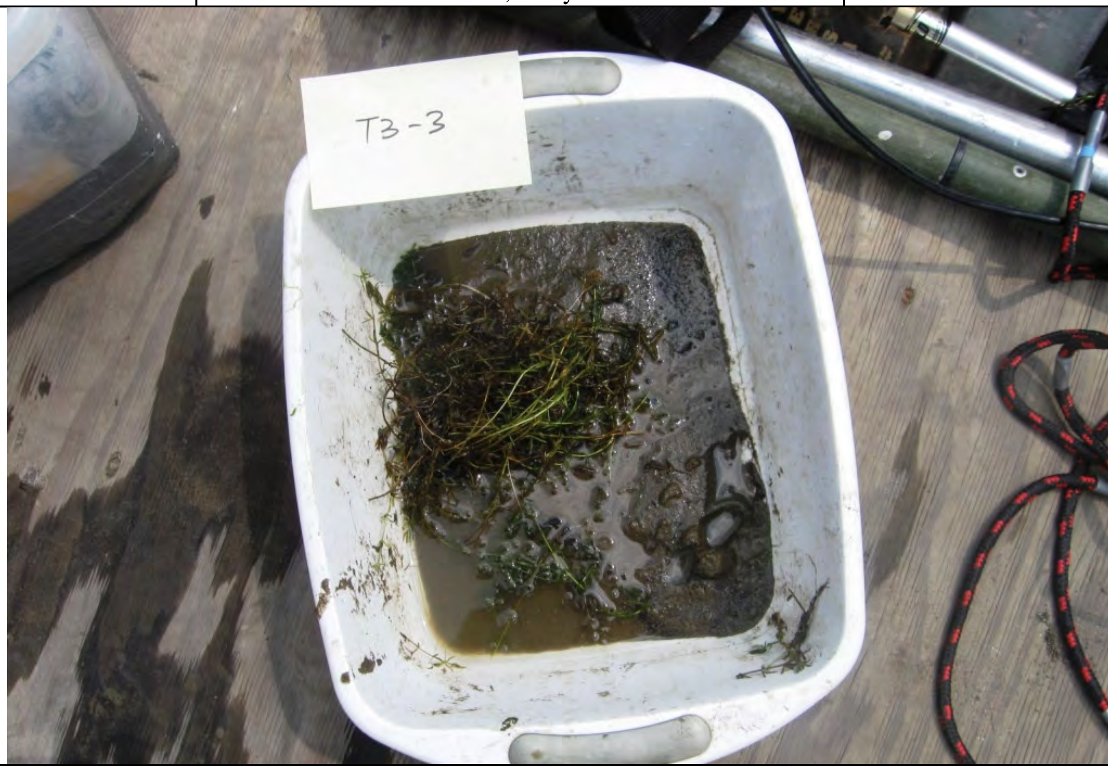


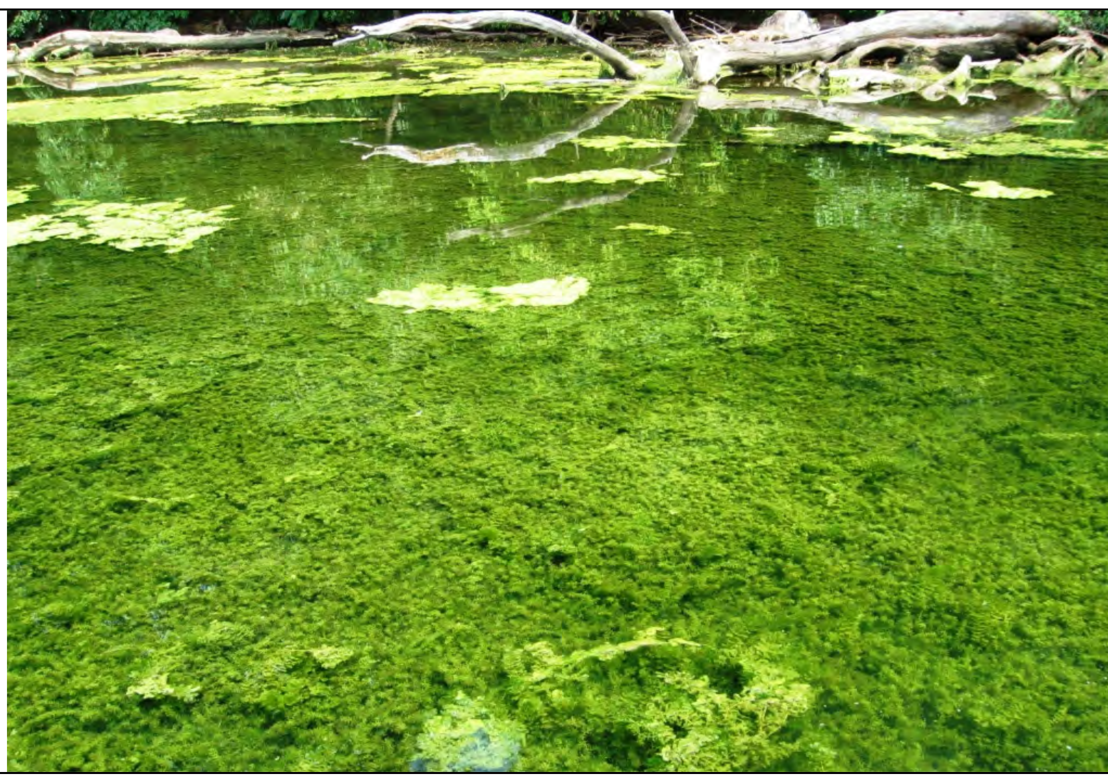
Photo No. 10 | **Date:** 8/9/10

Direction Photo Taken:

Northwest

Description:

Heavy growth of hydrilla at T3-3.



PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 11 **Date:** 8/9/10

Direction Photo Taken:

Description:

SAV and river substrate at T3-5. The river bottom is comprised primarily of very coarse sand poorly sorted with coarse sand and silt. Coal fines (see concentration in upper left corner of pan) are also present. The SAV community is comprised mainly of Eurasian watermilfoil, with some water stargrass.

Photo No. 12 **Date:** 8/9/10

Direction Photo Taken:

Description:

SAV and river substrate at T4-2 along eastern river shoreline. Coontail (*Ceratophyllum demersum*) comprises the majority of the SAV community here. Wild celery (*Vallisneria americana*) is also present in lesser abundance. Silt is the dominant grain size.

URS

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 13

Date: 8/9/10

Direction Photo Taken:

North

Description:

Depositional area below mouth of Fishing Creek (EAV-2). The beach area contains several plant species, including water willow, purple loosestrife (*Lythrum salicaria*), lady's thumb (*Persicaria vulgaris*), smartweed (*Polygonum* sp.), false indigo (*Amorpha fruticosa*), nightshade (*Solanum* sp.), and false loosestrife (*Ludwigia* sp.).

Photo No. 14

Date: 8/9/10

Direction Photo Taken:

Description:

Substrate material at Transect 5 (T5-2). Medium sand is the primary component of the sediment here, followed by silt. Although Eurasian watermilfoil appears in the photograph, it occurred only as part of the drift. No SAV was observed at this location.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No.	Date:
15	8/9/10

Direction Photo Taken:

Description:

Cobble with bedrock and occasional boulders at shoreline location of Transect 6 (T6-0). No SAV is present at this location.

Photo No.	Date:
16	8/9/10

Direction Photo Taken:

Description:

SAV and river substrate at T6-3. Coontail comprises the majority of the SAV community here. Eurasian watermilfoil and hydrilla are also present. Well-sorted silt comprises the substrate.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 17 **Date:** 8/9/10

Direction Photo Taken:

Description:

SAV and substrate at 8-foot depth along Transect 6 (T6-8). Coontail is the most abundant SAV species, followed by hydrilla. Very coarse sand is the dominant grain size. Medium sand and silt are also present at this location.

Photo No. 18 **Date:** 8/10/10

Direction Photo Taken:

Description:

Cobble-dominated shoreline at Transect 7 (T7-0). No SAV is present at this location.

URS

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	Project Name/Site Location: Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	Project No. 19998822.85312

Photo No. 19 | **Date:** 8/10/10

Direction Photo Taken:

Description:

SAV and river substrate at T8-2 (east of Mt. Johnson Island). Hydrilla and to a lesser extent coontail occur in this area. The substrate is comprised of well sorted silt.

Photo No. 20 | **Date:** 8/10/10

Direction Photo Taken:

Northeast

Description:

SAV community at T8-5. Eurasian watermilfoil and brittle water nymph are co-dominant species at this location.

URS	**PHOTOGRAPHIC LOG**

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 21 | **Date:** 8/10/10

Direction Photo Taken:

Description:

The river substrate at T8-5 is characterized as fine sand poorly sorted with very fine sand and silt. Note Eurasian watermilfoil and brittle water nymph in the photo.

Photo No. 22 | **Date:** 8/10/10

Direction Photo Taken:

Description:

Well-sorted silt comprises the substrate at a river depth of 7 feet along Transect 9 (T9-7). No SAV is present at this location.

URS

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 23 **Date:** 8/10/10

Direction Photo Taken:

Description:

River substrate and submergent vegetation at T11-1, near the southeast point of Mt. Johnson Island. The substrate is composed of well-sorted fine sand. Hydrilla is the most abundant SAV species here, followed by Canadian waterweed.

Photo No. 24 **Date:** 8/10/10

Direction Photo Taken:

West

Description:

Heavy growth of submerged vegetation below Mt. Johnson Island. Alluvial deposition has resulted in sediment accretion downstream of the island. Hydrilla and silt are the dominant SAV species and substrate type, respectively, throughout the length of this acccretionary feature.

URS

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 25

Date: 8/10/10

Direction Photo Taken:

North

Description:

Heavy SAV growth (see lower part of photograph) within area of sediment accretion approximately 1.2 miles downstream of Mt. Johnson Island. The island is the land mass in the center of the photograph.

Photo No. 26

Date: 8/10/10

Direction Photo Taken:

North

Description:

Western shoreline of Mt. Johnson Island. This area is characterized by steep banks, bedrock and cobble substrate, and lack of submergent and emergent vegetation.

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	Project Name/Site Location: Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	Project No. 19998822.85312

Photo No. 27 | **Date:** 8/10/10

Direction Photo Taken:

Description:

River substrate at 7-foot depth along Transect 12 (northwest of Mt. Johnson Island in middle of river). The substrate is composed predominantly of fine sand. Note the concentration of coal fines on right side of pan.

Photo No. 28 | **Date:** 8/10/10

Direction Photo Taken:

Description:

Cobble-dominated substrate along the eastern river shoreline at Transect 13 (T13-0).

URS	PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 29	**Date:** 8/10/10

Direction Photo Taken:

Southeast

Description:

SAV and substrate at T13-5, upstream of the river's confluence with Peters Creek. Hydrilla is the dominant SAV species. Eurasian watermilfoil, Canadian waterweed, and coontail are also present at this location. Silt is the dominant grain size. Very fine sand is also present.

Photo No. 30	**Date:** 8/10/10

Direction Photo Taken:

Northwest

Description:

Heavy growth of hydrilla near Peters Creek confluence. These waters are characterized by silty depositional sediments and dense submergent vegetation.

URS	PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 31

Date: 8/10/10

Direction Photo Taken:

Southeast

Description:

Floating large woody debris near Transect 15 along eastern river shoreline. The debris was also present on the river bottom. Nearshore (0-6 foot depth) substrate is comprised primarily of cobble, while sandy substrates are present further offshore (> 7 feet). A small bed of submergent vegetation is present slightly downstream of this area.

Photo No. 32

Date: 8/10/10

Direction Photo Taken:

Description:

Well sorted silt substrate at T16-7 along the eastern river shoreline. No aquatic vegetation is present in this area.

PHOTOGRAPHIC LOG		
Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 33

Date: 8/10/10

Direction Photo Taken:

Description:

SAV and substrate observed at 7-foot depth along Transect 17 (T17-7). SAV growth is minimal at this location, and consists of Eurasian watermilfoil. The substrate is comprised of medium sand poorly sorted with silt.

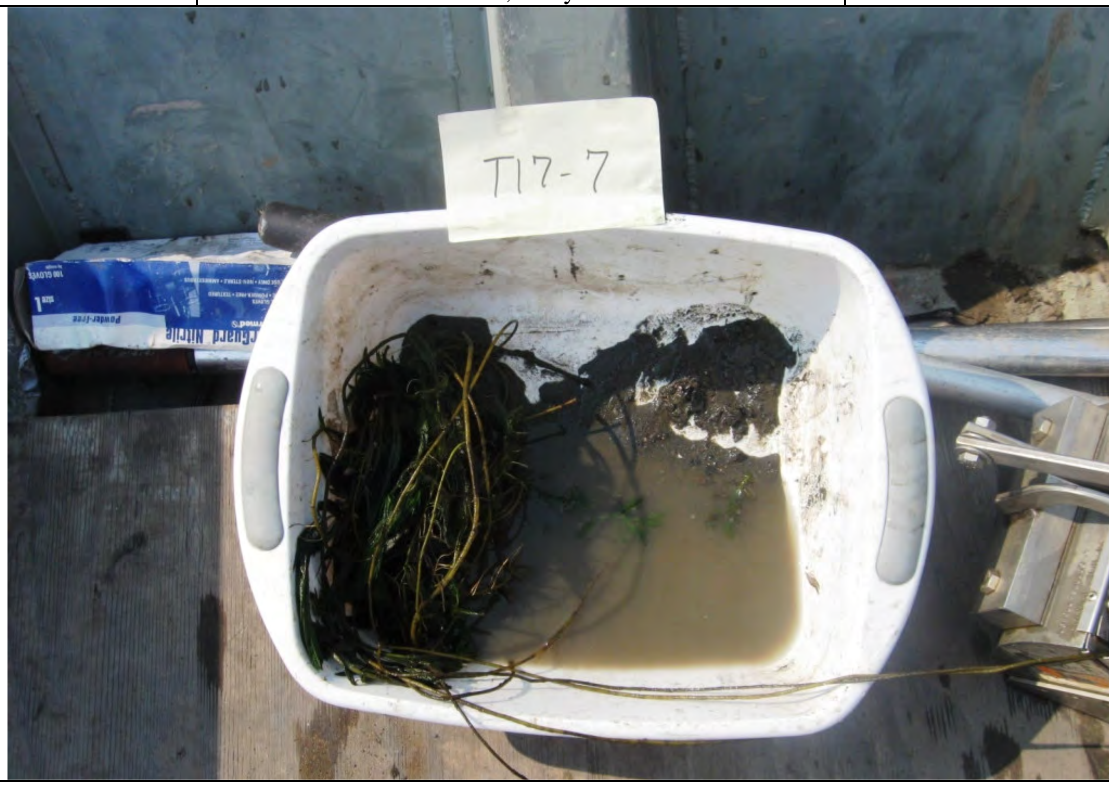


Photo No. 34

Date: 8/11/10

Direction Photo Taken:

East

Description:

EAV bed on eastern shoreline of Conowingo Creek (EAV-3). Dominant emergent species included water willow (background) and arrow arum (*Peltandra virginica*) (foreground). Substrate at this location in the creek is primarily silt, with some very fine sand.

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	Project Name/Site Location: Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	Project No. 19998822.85312

Photo No. 35 **Date:** 8/11/10

Direction Photo Taken:

East

Description:

Small EAV community near western shoreline of Conowingo Creek (EAV-4). The community is composed of water willow and water pepper (*Polygonum hydropiper*). The sediment at this location consists mainly of silt. Boulders are also present.

Photo No. 36 **Date:** 8/11/10

Direction Photo Taken:

Description:

Sediment and SAV at T19-1 along eastern shoreline of Conowingo Creek. The substrate at this location consists of poorly sorted silt with very fine sand. The SAV is composed predominantly of hydrilla (lower right of photograph), and secondarily of coontail (upper right of photograph).

URS

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 37 **Date:** 8/11/10

Direction Photo Taken:

Description:

The river substrate at T19-6 is characterized by poorly sorted silt with cobble. SAV was not observed at this location.

Photo No. 38 **Date:** 8/11/10

Direction Photo Taken:

Southwest

Description:

SAV community in the lower portion of Conowingo Creek. SAV was observed throughout the lower creek, however growth was minimal. Eurasian watermilfoil is common in this area. Canadian waterweed and hydrilla are also present in lesser abundance.

URS	**PHOTOGRAPHIC LOG**

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 39 **Date:** 8/11/10

Direction Photo Taken:

West

Description:

Small EAV community on northern shoreline of Conowingo Creek (EAV-5). The EAV extends further to the east as a fringe shoreline community, and is largely comprised of broad-leaved cattail (*Typha latifolia*) and Japanese stiltgrass (*Microstegium vimineum*). Arrow arum and swamp milkweed (*Asclepias incarnata*) are also present.

Photo No. 40 **Date:** 8/11/10

Direction Photo Taken:

Description:

Well sorted silt and Eurasian watermilfoil at T20-5 just upstream of the mouth of Conowingo Creek. Silt was the dominant substrate across the width of the creek in this area.

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	Project Name/Site Location: Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	Project No. 19998822.85312

Photo No. 41 | **Date:** 8/11/10

Direction Photo Taken:

Description:

Flowering water stargrass in the lower section of Conowingo Creek.

Photo No. 42 | **Date:** 8/11/10

Direction Photo Taken:

South

Description:

SAV bed downstream of Flintville Road bridge in Broad Creek (Veg-5A/B). The aquatic vegetation community here is comprised mainly of hydrilla.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 43 **Date:** 8/11/10

Direction Photo Taken:

Description:

Substrate at TL23-4 in Broad Creek. The substrate is composed of well sorted silt, with some detritus from decaying leaves and small woody debris. No SAV is present in this area.

Photo No. 44 **Date:** 8/11/10

Direction Photo Taken:

Description:

Well-sorted silt substrate at 8-foot depth along Transect 25 (T25-8) near Michael Run. No SAV is present in this area.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 45 **Date:** 8/11/10

Direction Photo Taken:

North

Description:

SAV bed at confluence of Michael Run and Conowingo Pond (Veg-6A/B). The dominant plant species in this area is hydrilla. River substrate is composed mainly of silt.

Photo No. 46 **Date:** 8/11/10

Direction Photo Taken:

Southeast

Description:

Heavy growth of hydrilla at river confluence with Michael Run near downstream extent of SAV bed (Veg-6B).

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	Project Name/Site Location: Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	Project No. 19998822.85312

Photo No. 47 **Date:** 8/11/10

Direction Photo Taken:

West

Description:

Small emergent vegetation bed on western river shoreline (EAV-6). EAV species include water willow, purple loosestrife, common reed (*Phragmites australis*), soft rush (*Juncus effusus*), and spotted joe-pye weed (*Eupatorium maculatum*).

Photo No. 48 **Date:** 8/11/10

Direction Photo Taken:

Description:

River substrate at 6-foot depth along Transect 26, downstream of the below Peach Bottom Atomic Power Station (PBAPS) thermal discharge canal. Substrate at this location is characterized as granules poorly sorted with pebble, very coarse sand, and silt. No SAV is present in this area.

URS	**PHOTOGRAPHIC LOG**

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 49 | **Date:** 8/12/10

Direction Photo Taken:

Northwest

Description:

Shoreline near Transect 27 adjacent to PBAPS thermal discharge canal (T27-0). The substrate consists of well sorted boulder. No SAV or EAV is present in this area.

Photo No. 50 | **Date:** 8/12/10

Direction Photo Taken:

Description:

Silt substrate at T28-5 (photo incorrectly labeled) adjacent to PBAPS discharge canal. Medium sand and detrital matter also comprise lesser proportions of the sediment matrix. SAV is absent in this area.

URS	**PHOTOGRAPHIC LOG**

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 51 **Date:** 8/12/10

Direction Photo Taken:

Description:

Submergent vegetation from small SAV bed adjacent to the PBAPS discharge canal. Coontail is the dominant SAV species at this location, followed by hydrilla and water stargrass.

Photo No. 52 **Date:** 8/12/10

Direction Photo Taken:

Description:

River substrate at 8-foot depth along Transect 30 (T30-8). Granules are the most abundant substrate type. Pebbles are also prominent at this location. No aquatic vegetation is present in this area.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 53 **Date:** 8/12/10

Direction Photo Taken:

Description:

SAV and river substrate at T33-6 adjacent to PBAPS. Silt is the dominant sediment grain size at this location. Eurasian watermilfoil is the primary SAV species in this area, followed by coontail. A Chinese mystery snail (*Cipangopaludina chinensis*), an invasive mollusk, was collected at this location, and is shown at the right part of the photograph.

Photo No. 54 **Date:** 8/12/10

Direction Photo Taken:

West

Description:

Lower extent of SAV bed above PBAPS boat launch (Veg-10B). Species in this vegetated area include water stargrass, Eurasian watermilfoil, and wild celery.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	19998822.85312

Photo No. 55 **Date:** 8/12/10

Direction Photo Taken:

Description:

River substrate at 3-foot depth along Transect 34 (T34-3). The primary grain size at this location is cobble, followed by pebble. SAV did not occur in this area.

Photo No. 56 **Date:** 8/9/10

Direction Photo Taken:

Description:

Substrate comprised of silt poorly sorted with very fine sand at T35-6. No SAV was observed in this area.

URS

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	Project Name/Site Location: Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	Project No. 19998822.85312

Photo No. 57 **Date:** 8/12/10

Direction Photo Taken:

Description:

SAV and river substrate at T38-6. The dominant sediment grain size at this location is silt, with lesser amounts of very fine sand. Eurasian watermilfoil is the most abundant SAV species here, followed by coontail.

Photo No. 58 **Date:** 8/12/10

Direction Photo Taken:

Northwest

Description:

Lower extent of water willow bed downstream of the confluence of Muddy Creek and Conowingo Pond. A recent water release from the Hotwood Project had resulted in inundation of the majority of emergent vegetation in this area.

URS

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Water Level Management Study Lancaster and York Counties, Pennsylvania Cecil and Harford Counties, Maryland	**Project No.** 19998822.85312

Photo No. 59	**Date:** 8/12/10

Direction Photo Taken:

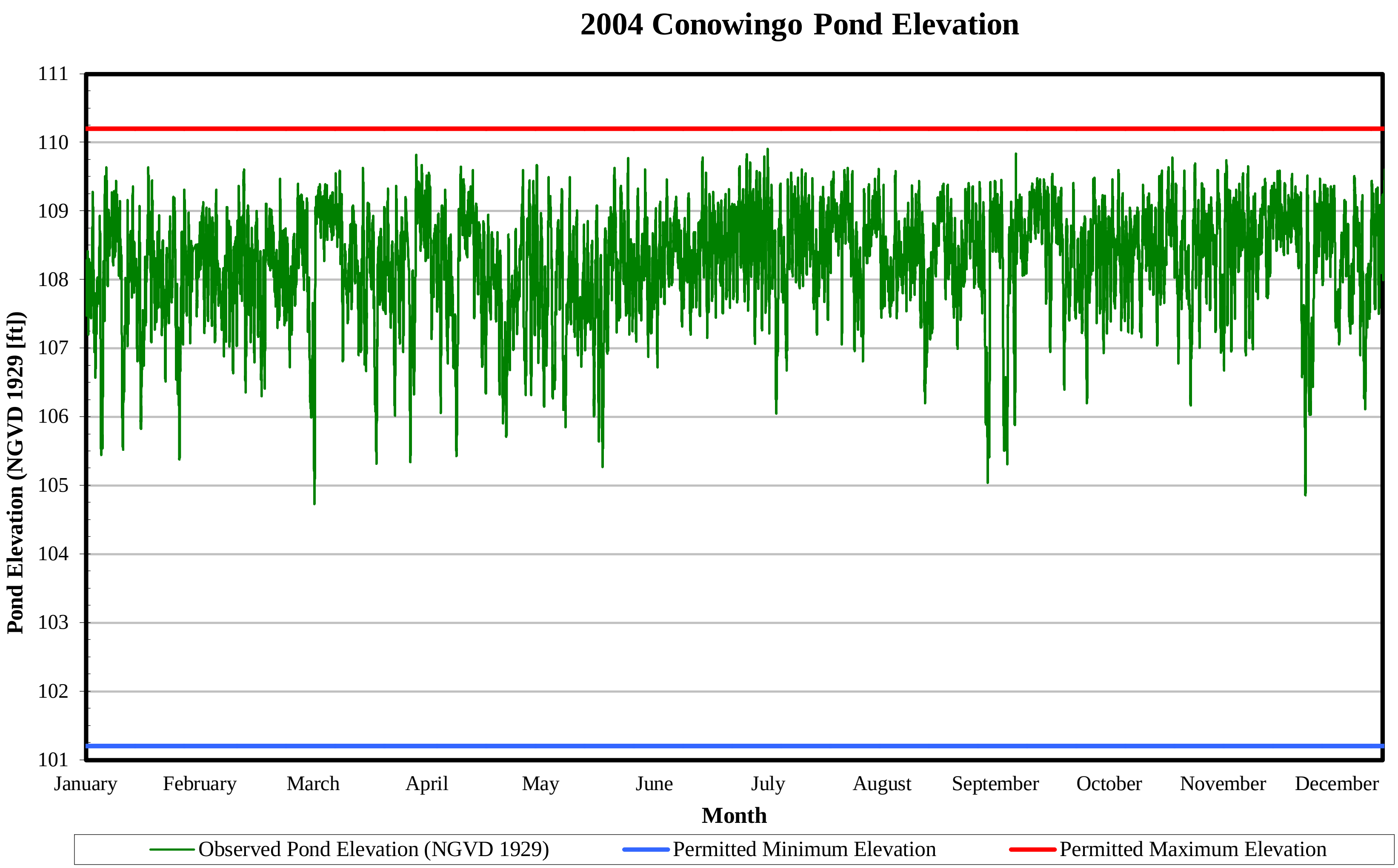
Description:

SAV and river substrate at T39-4 slightly downstream of Muddy Creek confluence. Canadian waterweed comprises the majority of the SAV community at this location. Other SAV species observed include Eurasian watermilfoil and brittle water nymph. The substrate is characterized as poorly sorted silt with fine sand.

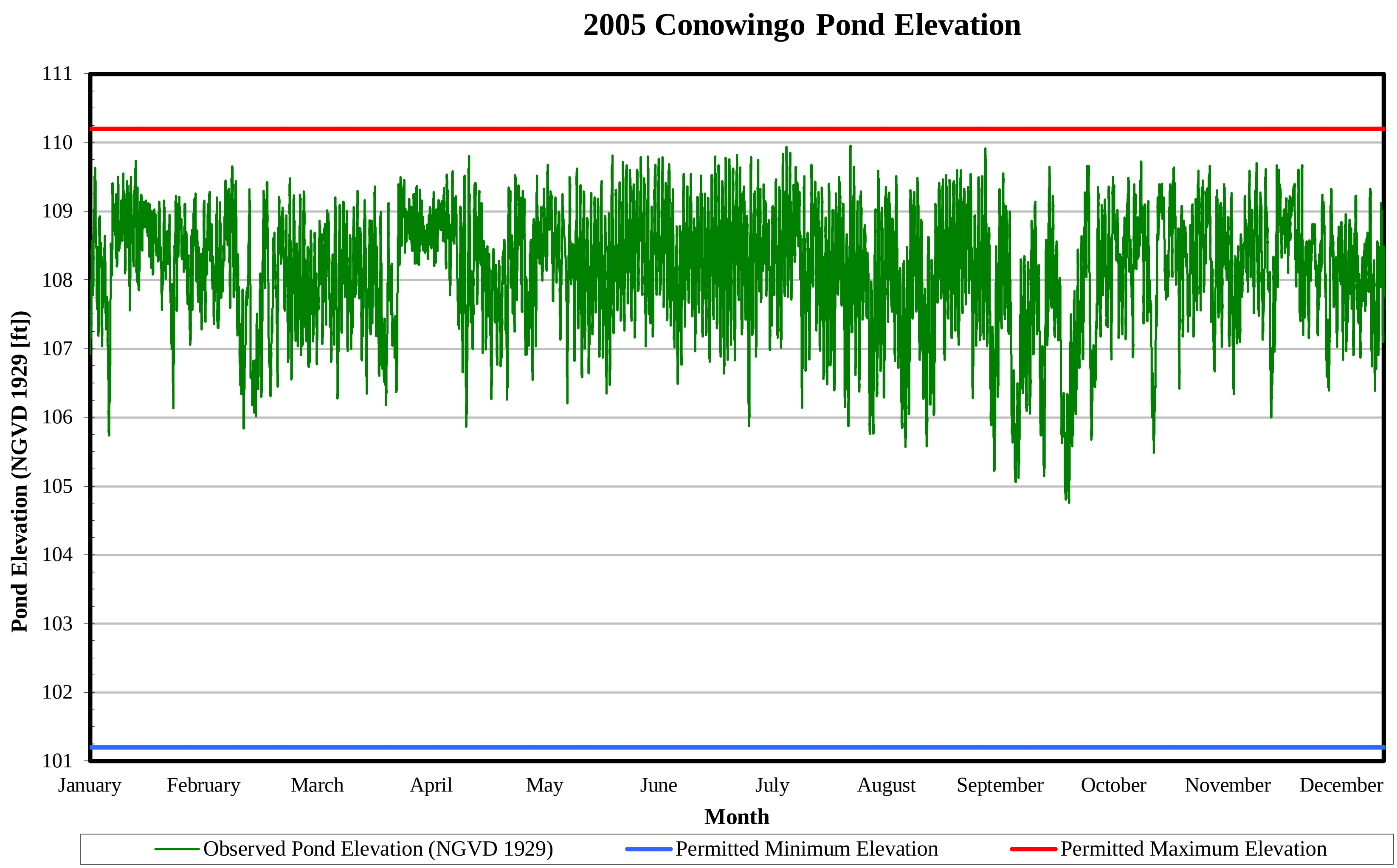
APPENDIX B-2004-2010 WATER LEVEL PLOTS

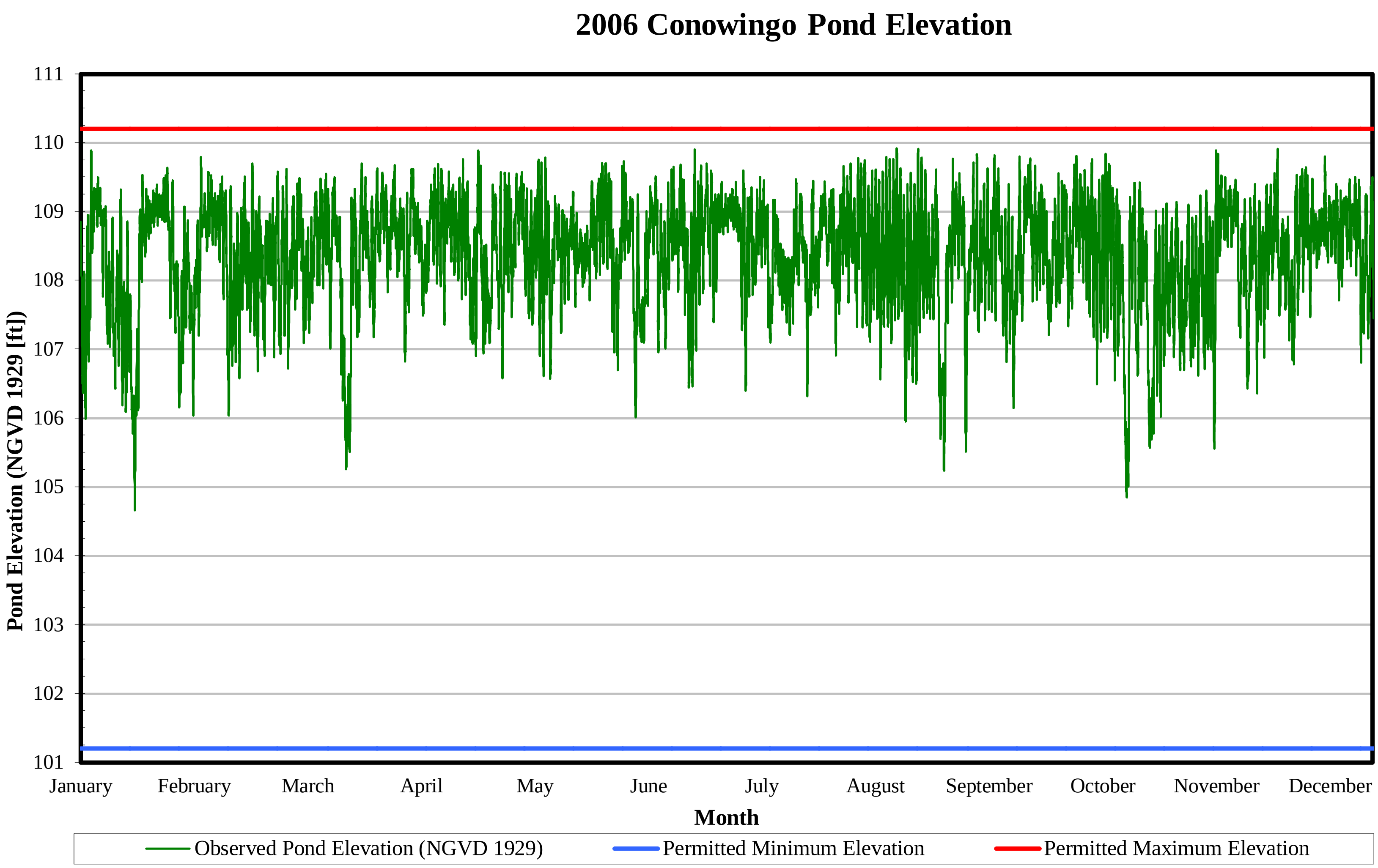
Historic Annual Conowingo Pond Water Level Fluctuations

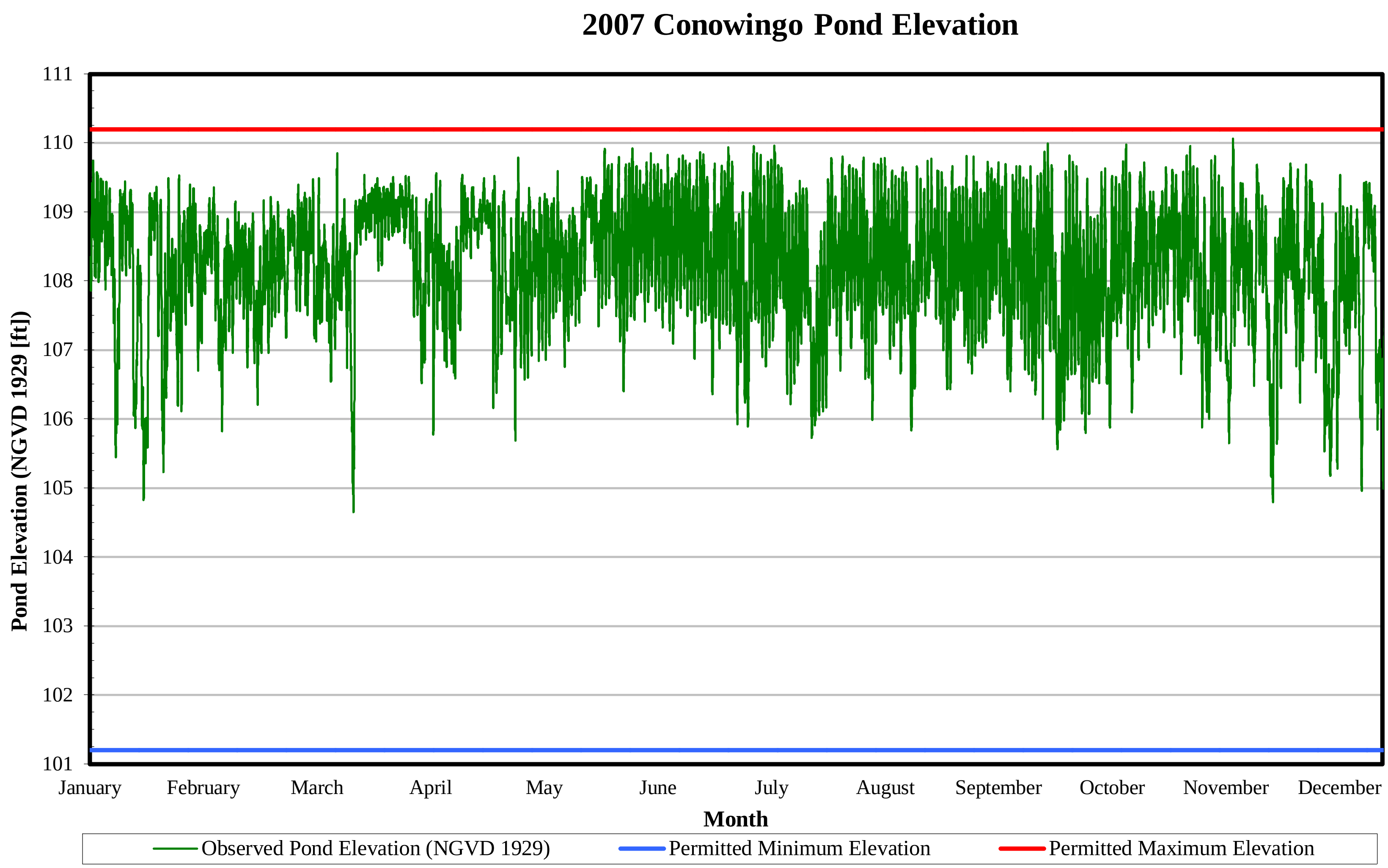
January 2004 – September 2010

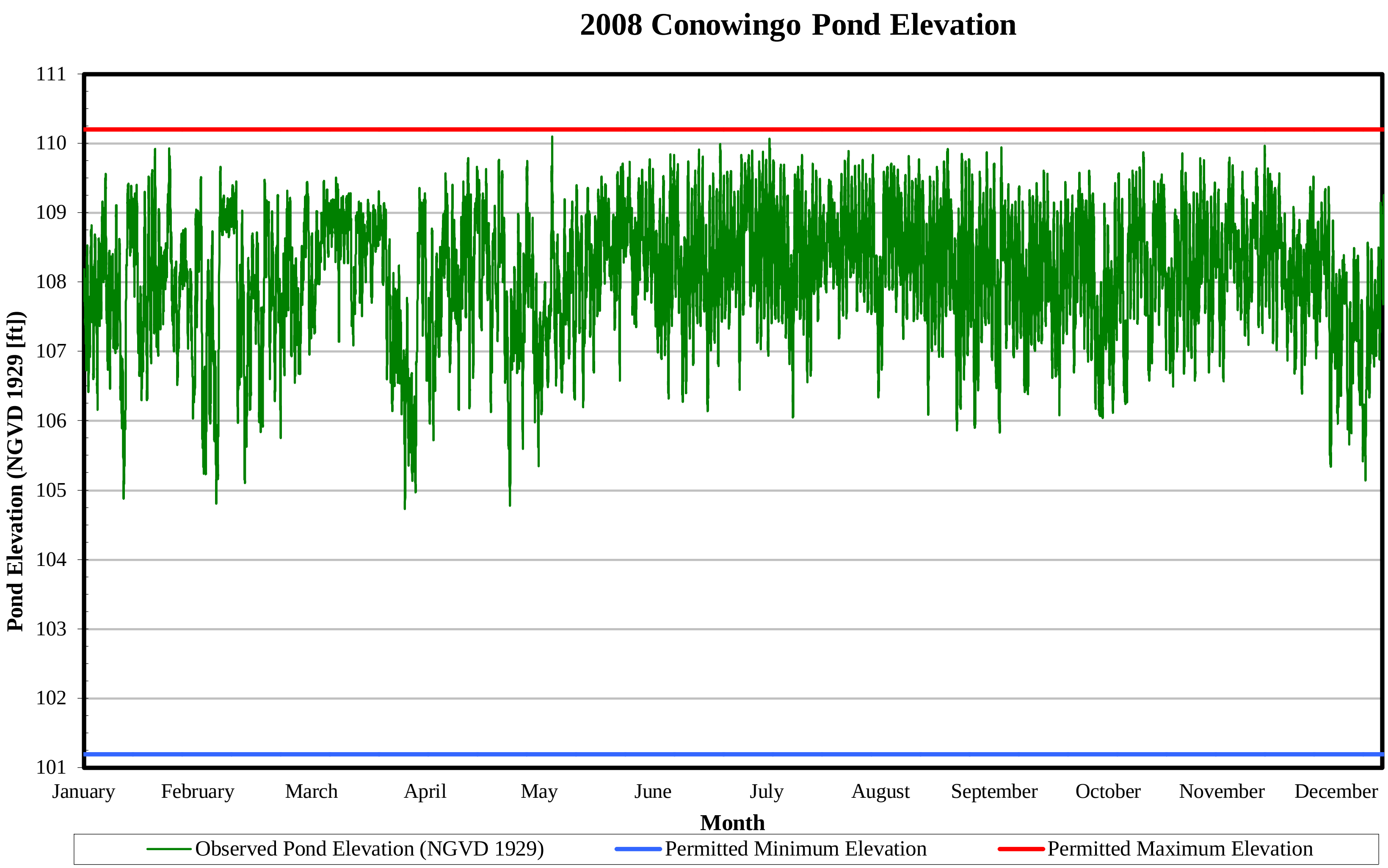


2004 Conowingo Pond Elevation
Pond Elevation (NGVD 1929 [ft])
111
110
109
108
107
106
105
104
103
102
101
January
February
March
April
May
June
July
August
September
October
November
December
Month
Observed Pond Elevation (NGVD 1929)
Permitted Minimum Elevation
Permitted Maximum Elevation


2005 Conowingo Pond Elevation
111
110
109
108
107
106
105
104
103
102
101
Pond Elevation (NGVD 1929 [ft])
January
February
March
April
May
June
July
August
September
October
November
December
Month
Observed Pond Elevation (NGVD 1929)
Permitted Minimum Elevation
Permitted Maximum Elevation

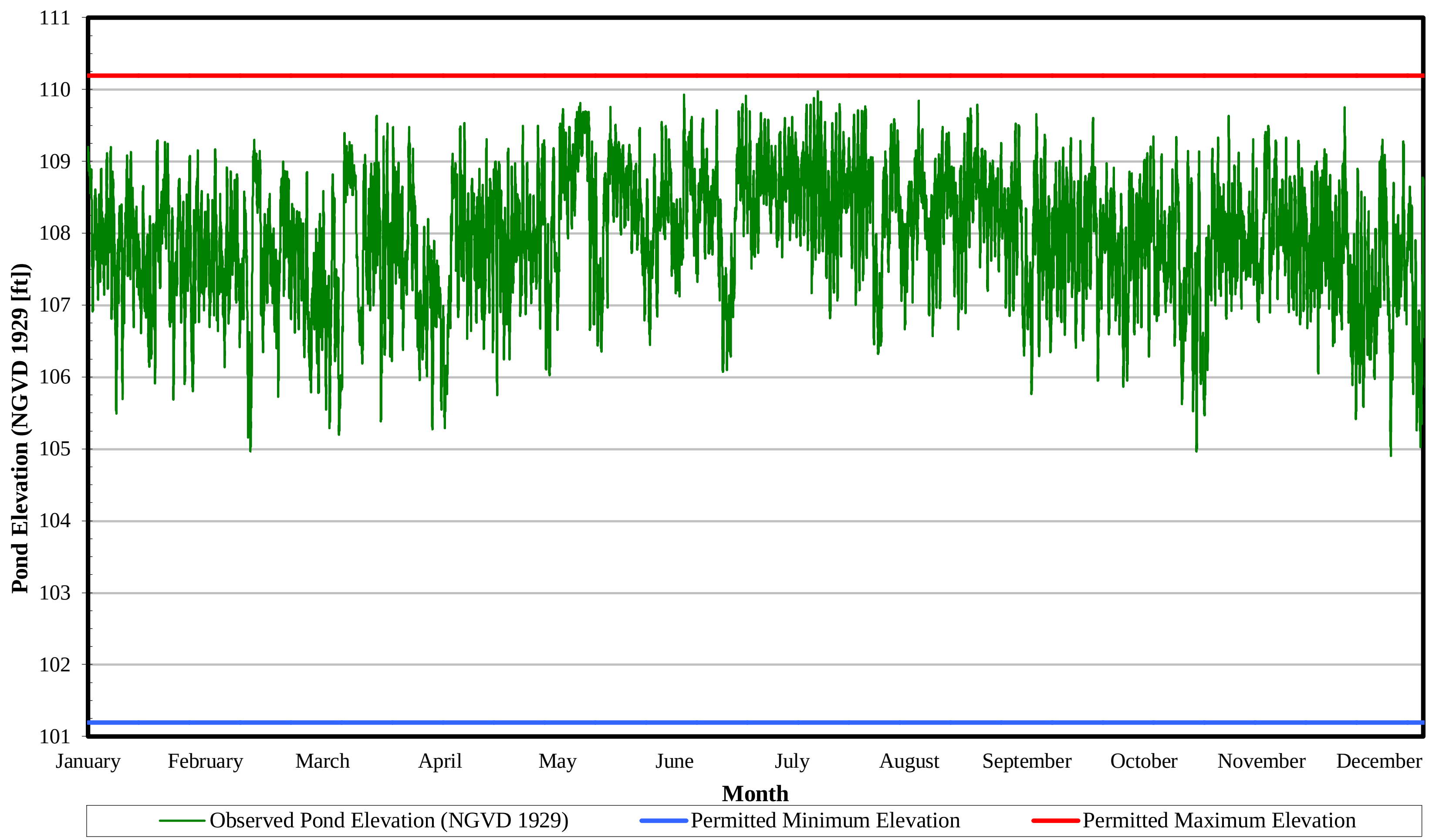

2006 Conowingo Pond Elevation
111
110
109
108
107
106
105
104
103
102
101
Pond Elevation (NGVD 1929 [ft])
January
February
March
April
May
June
July
August
September
October
November
December
Month
Observed Pond Elevation (NGVD 1929)
Permitted Minimum Elevation
Permitted Maximum Elevation

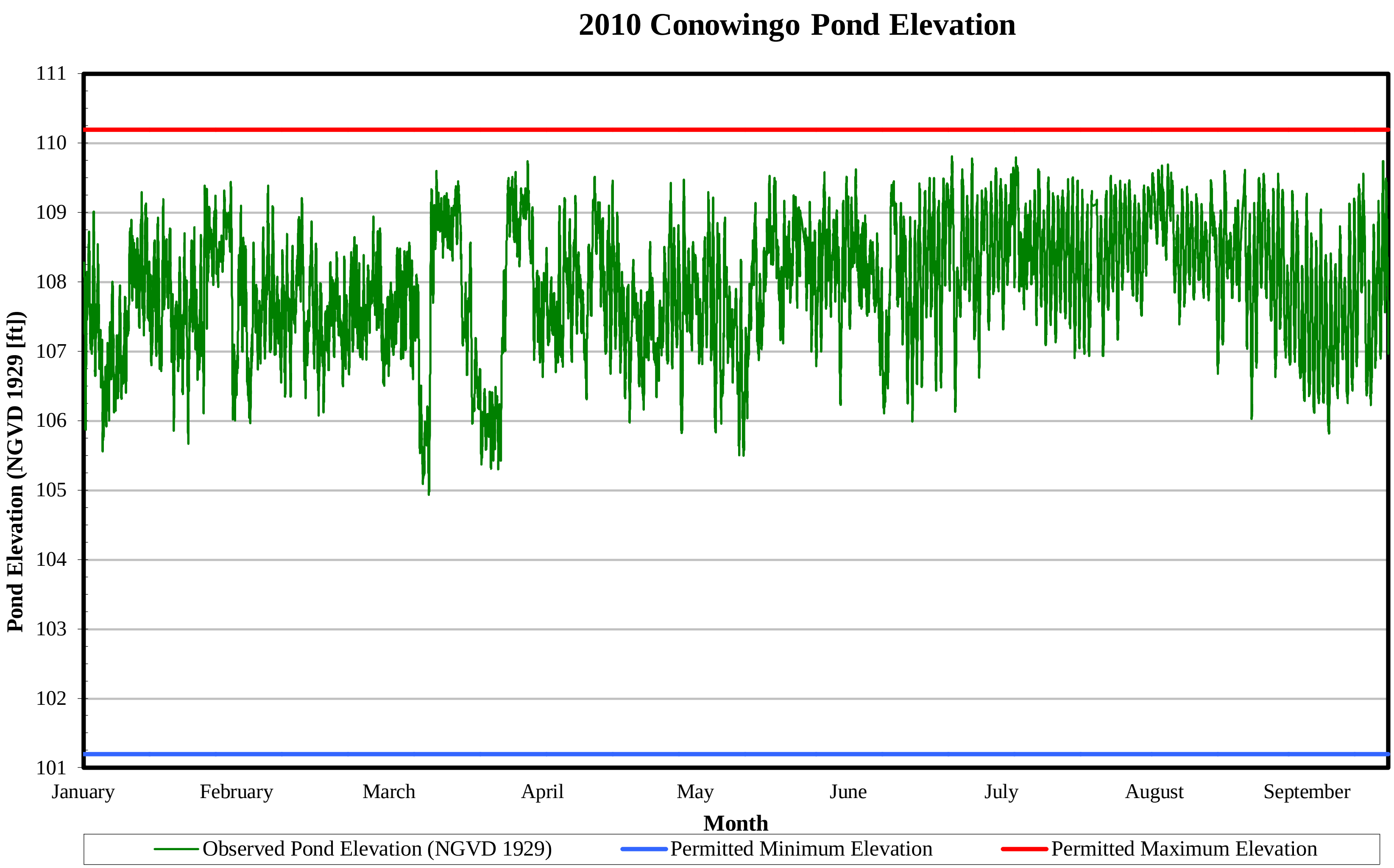

2007 Conowingo Pond Elevation
Pond Elevation (NGVD 1929 [ft])
111
110
109
108
107
106
105
104
103
102
101
January
February
March
April
May
June
July
August
September
October
November
December
Month
Observed Pond Elevation (NGVD 1929)
Permitted Minimum Elevation
Permitted Maximum Elevation



2008 Conowingo Pond Elevation
Pond Elevation (NGVD 1929 [ft])
111
110
109
108
107
106
105
104
103
102
101
January
February
March
April
May
June
July
August
September
October
November
December
Month
Observed Pond Elevation (NGVD 1929)
Permitted Minimum Elevation
Permitted Maximum Elevation

2009 Conowingo Pond Elevation

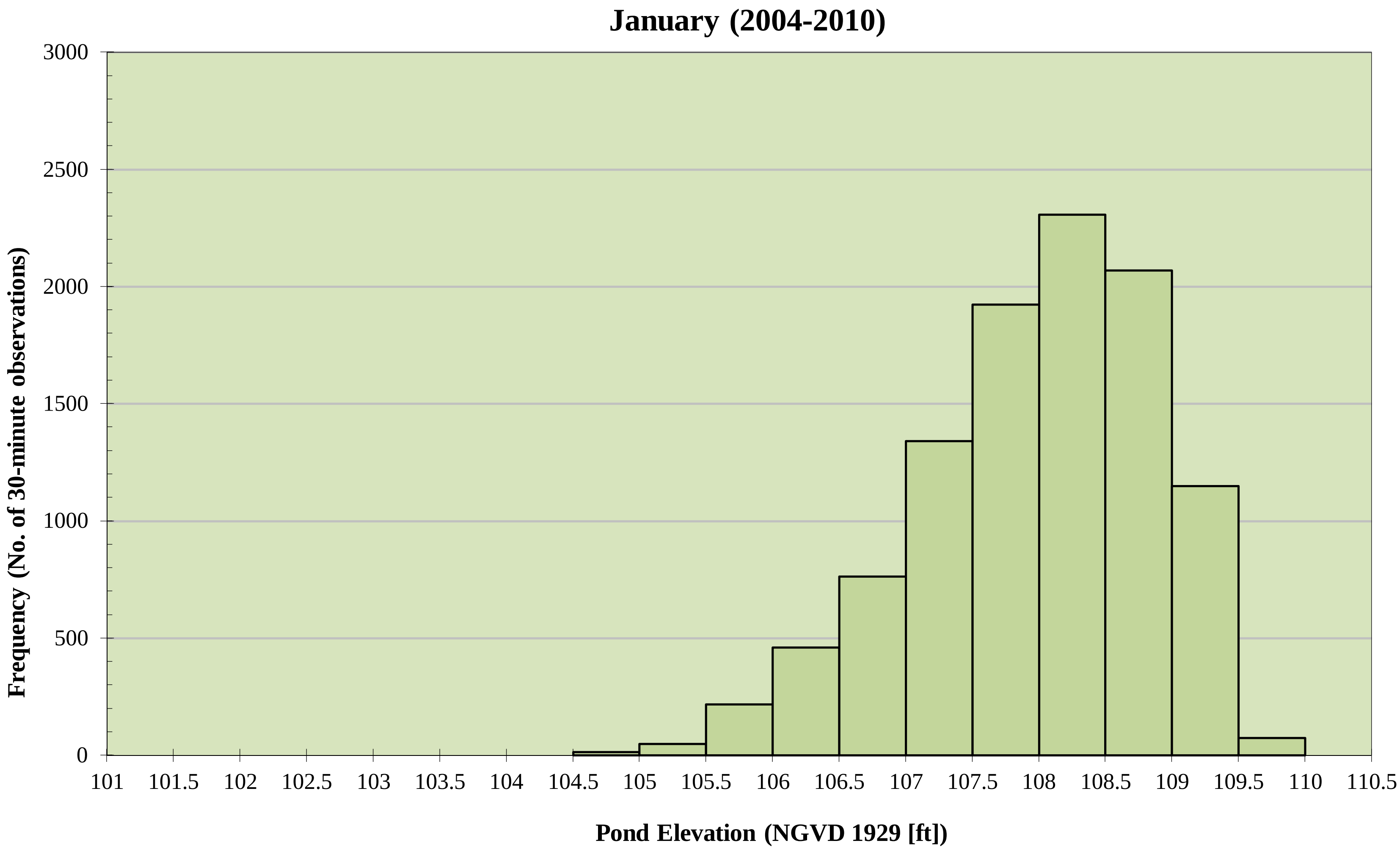


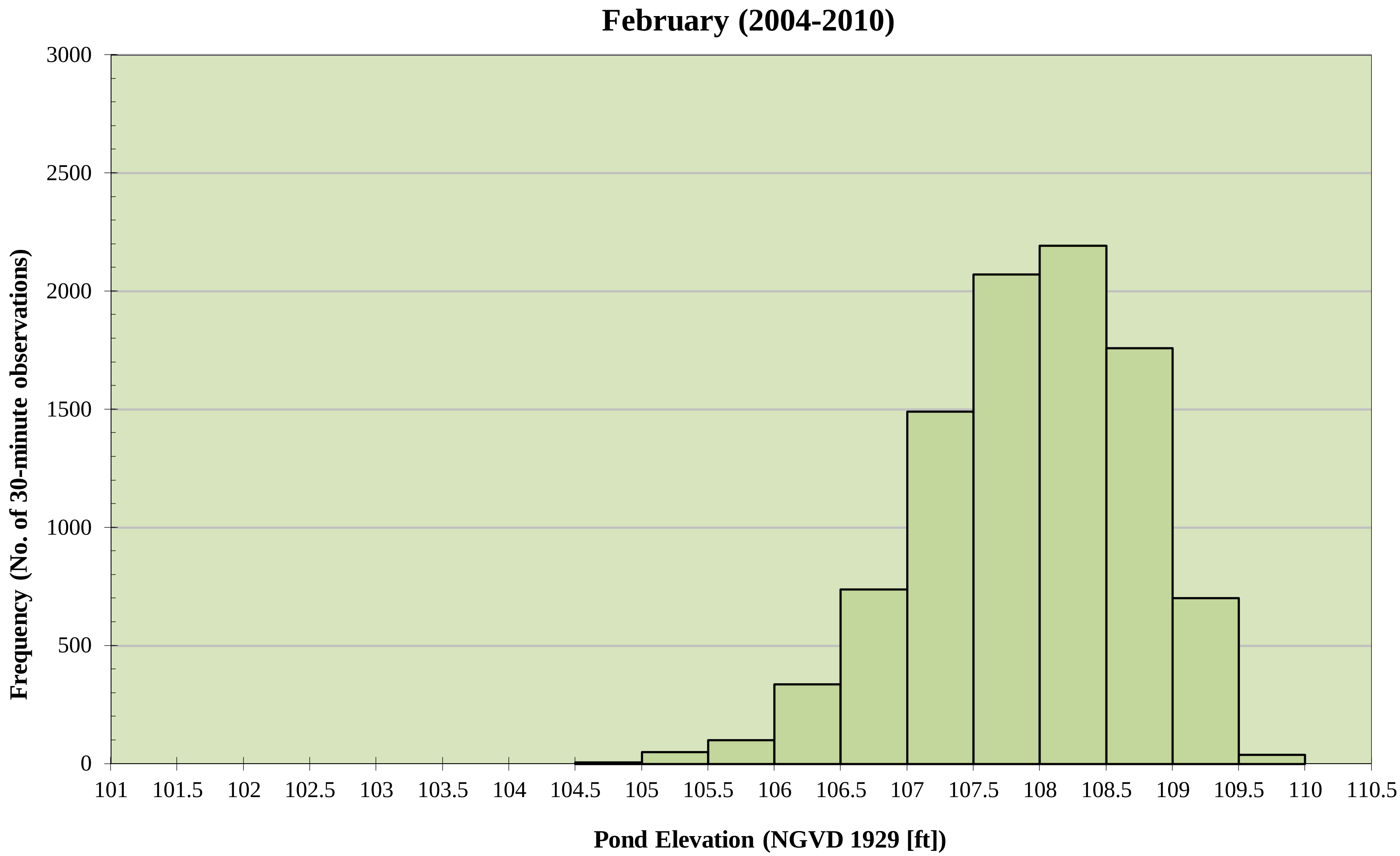


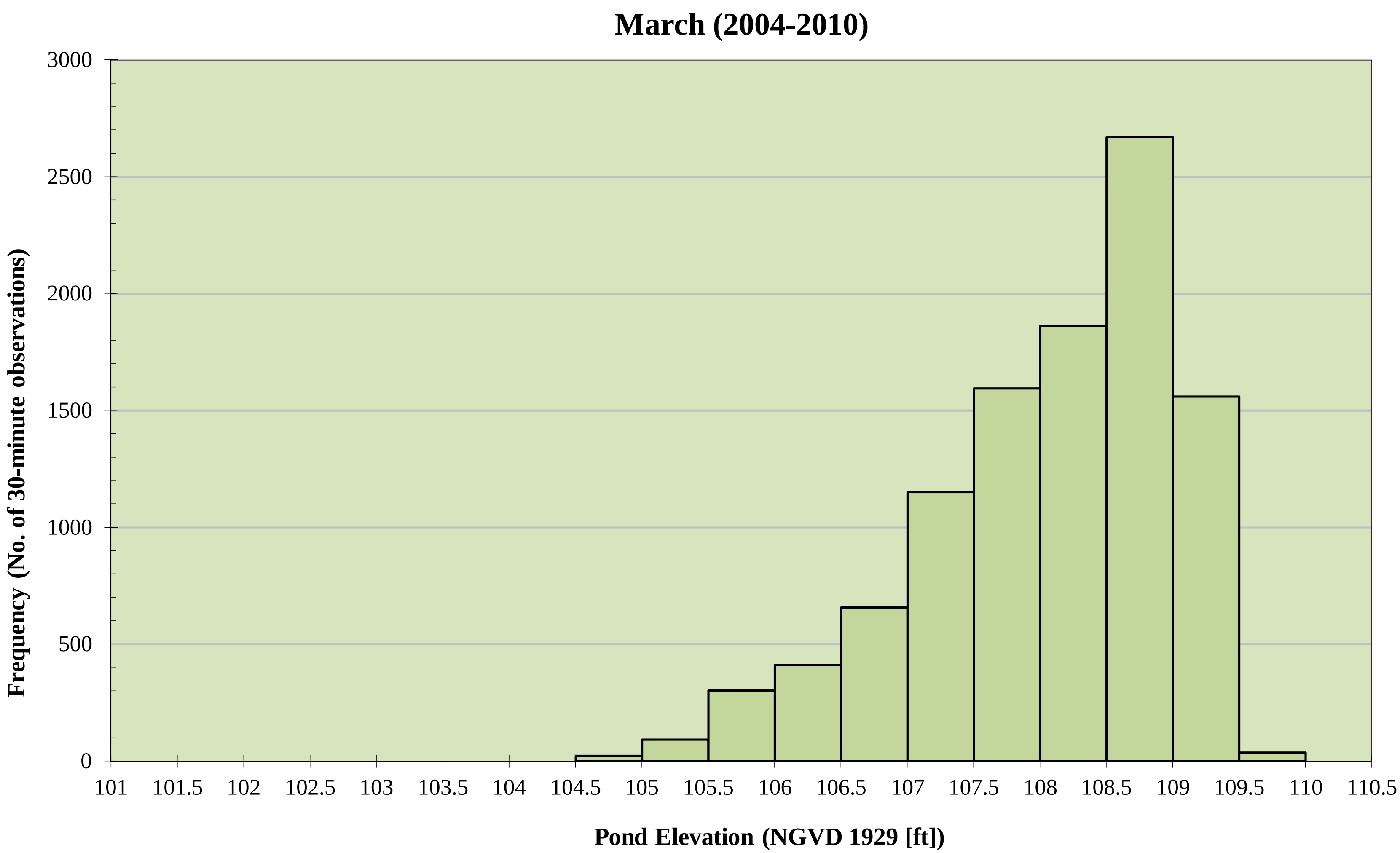
2010 Conowingo Pond Elevation
111
110
109
108
107
106
105
104
103
102
101
Pond Elevation (NGVD 1929 [ft])
January
February
March
April
May
June
July
August
September
Month
Observed Pond Elevation (NGVD 1929)
Permitted Minimum Elevation
Permitted Maximum Elevation

Historic Monthly Conowingo Pond Water Level Frequency

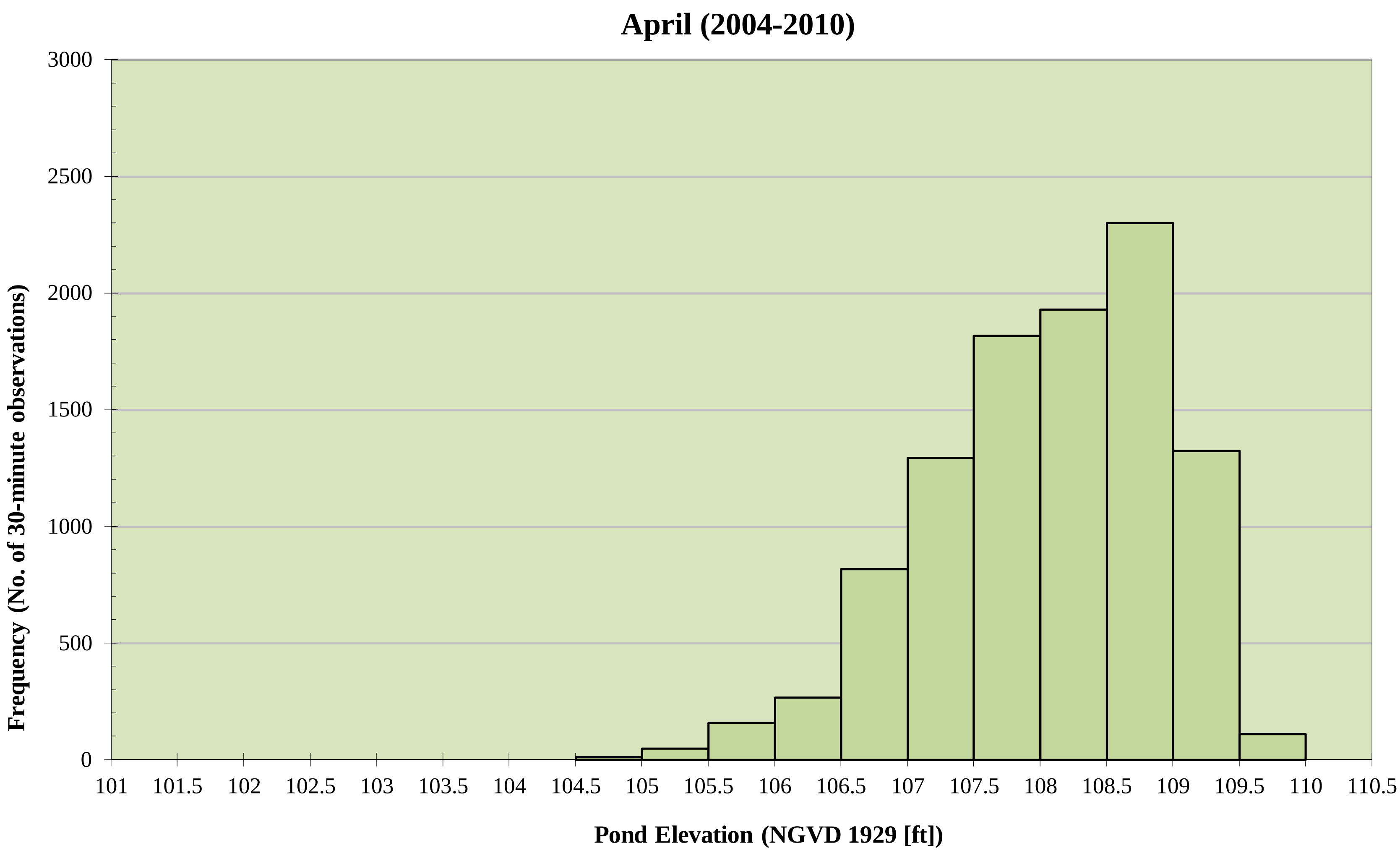
January 2004 – September 2010

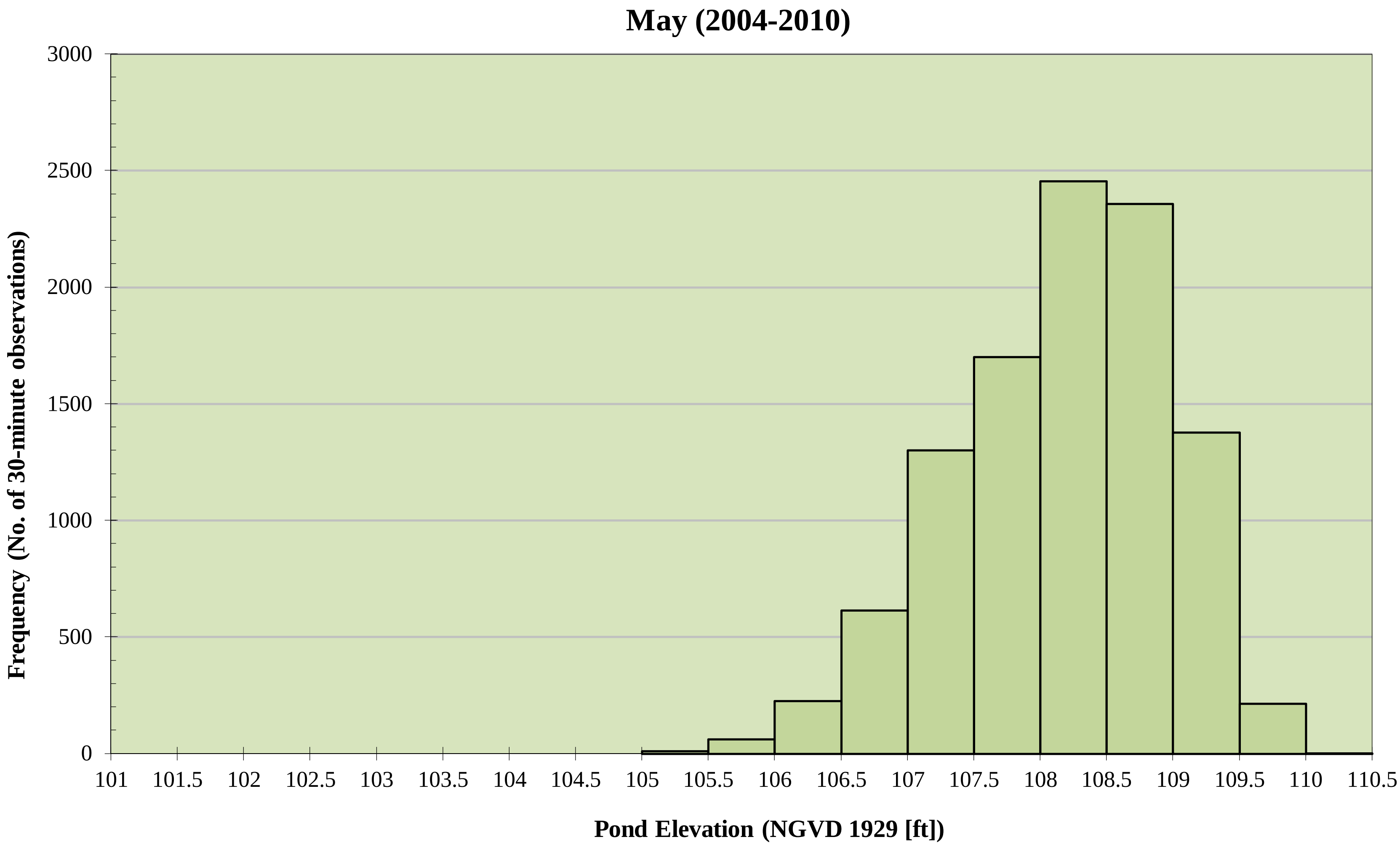

January (2004-2010)
Frequency (No. of 30-minute observations)
0
500
1000
1500
2000
2500
3000
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])


February (2004-2010)
Frequency (No. of 30-minute observations)
3000
2500
2000
1500
1000
500
0
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])

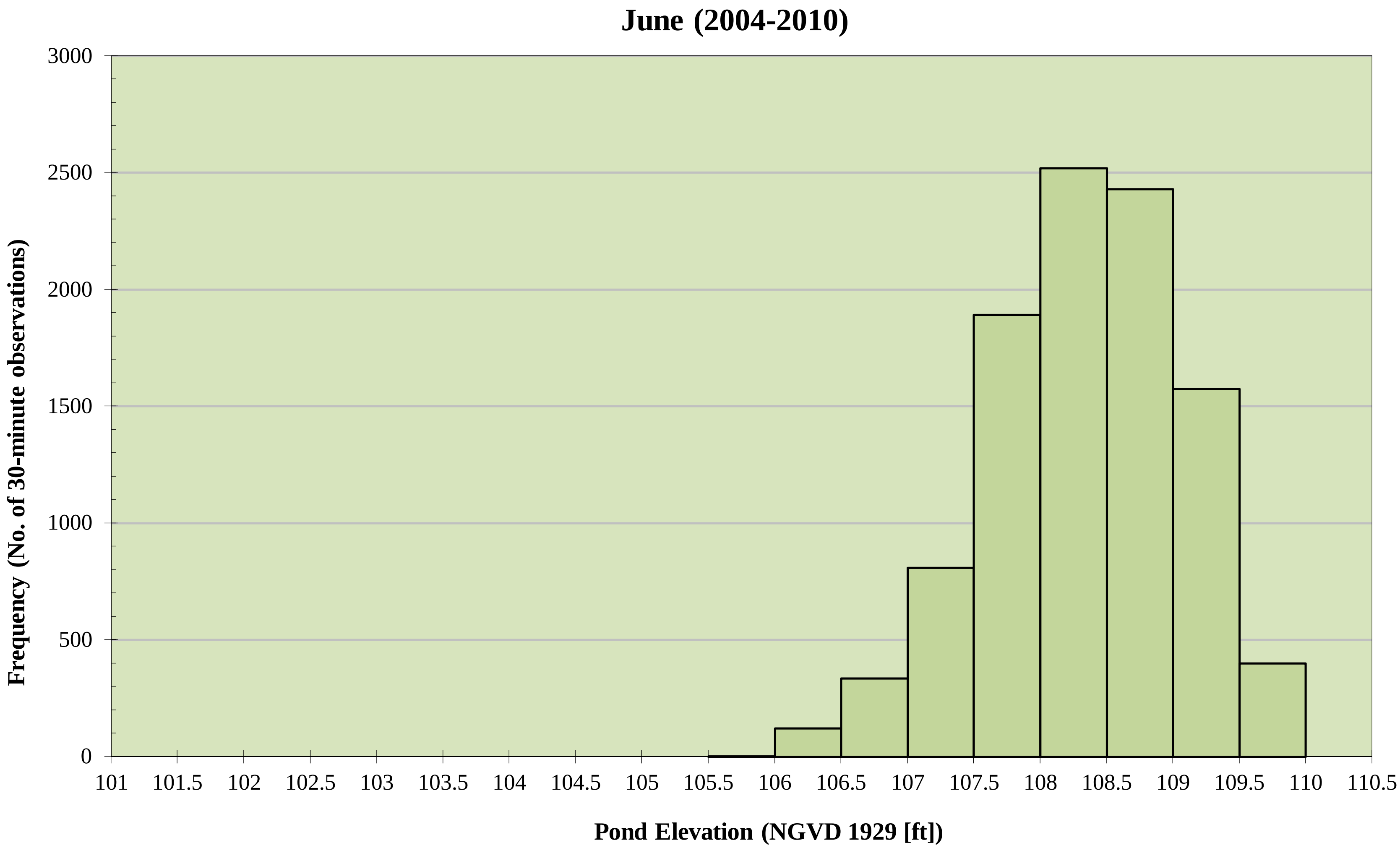


March (2004-2010)
Frequency (No. of 30-minute observations)
0
500
1000
1500
2000
2500
3000
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])

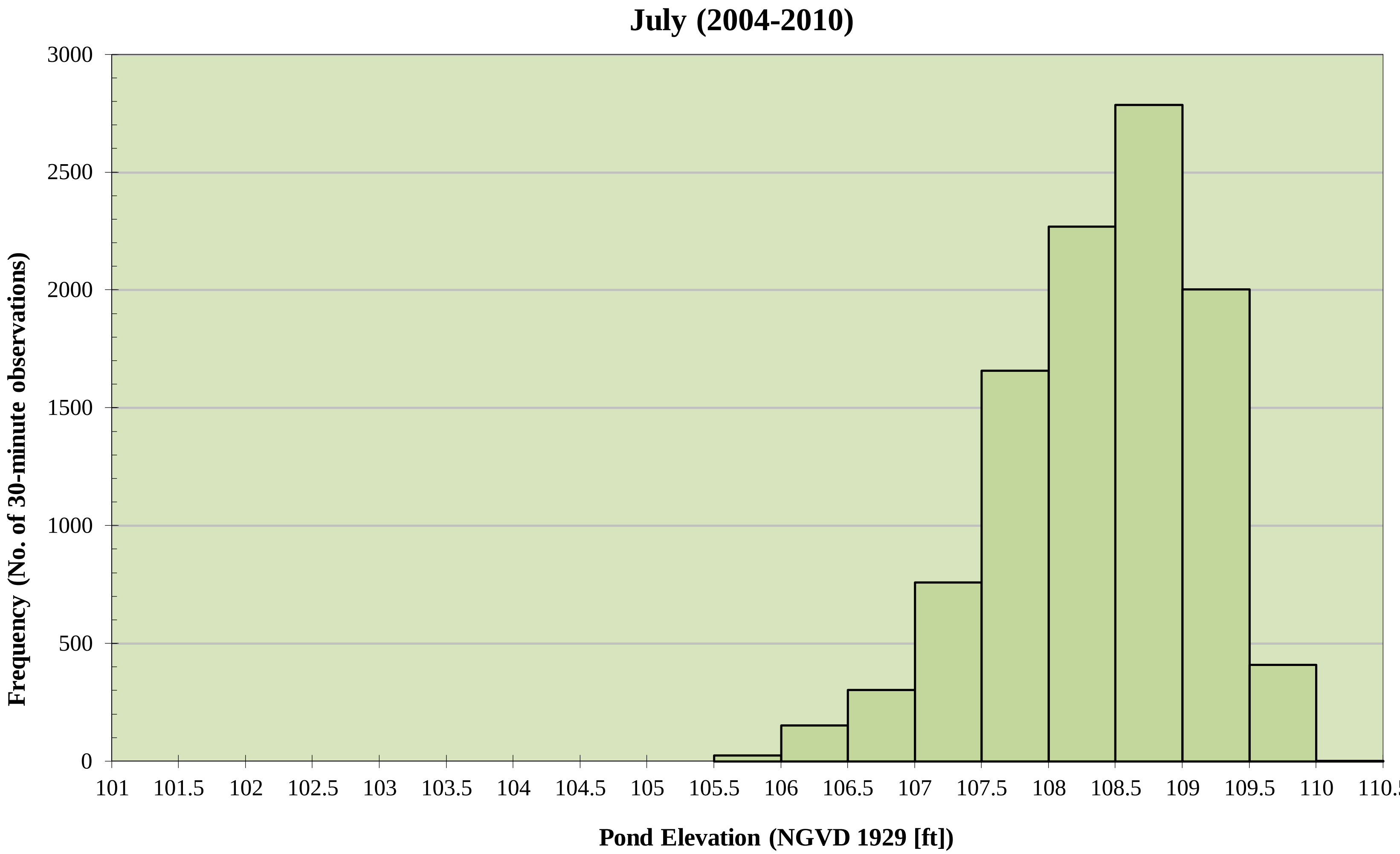

April (2004-2010)
Frequency (No. of 30-minute observations)
0
500
1000
1500
2000
2500
3000
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])



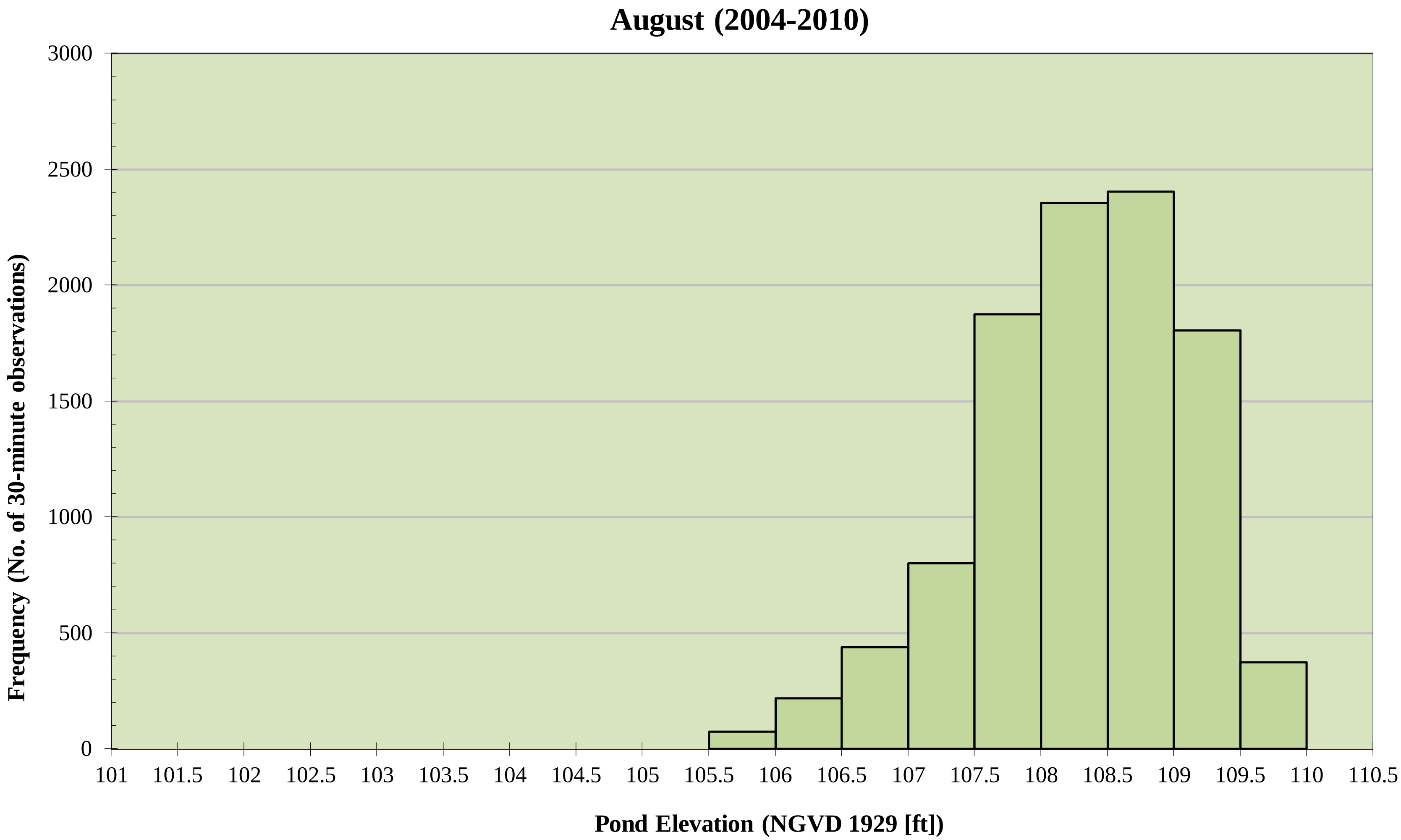
May (2004-2010)
Frequency (No. of 30-minute observations)
3000
2500
2000
1500
1000
500
0
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])



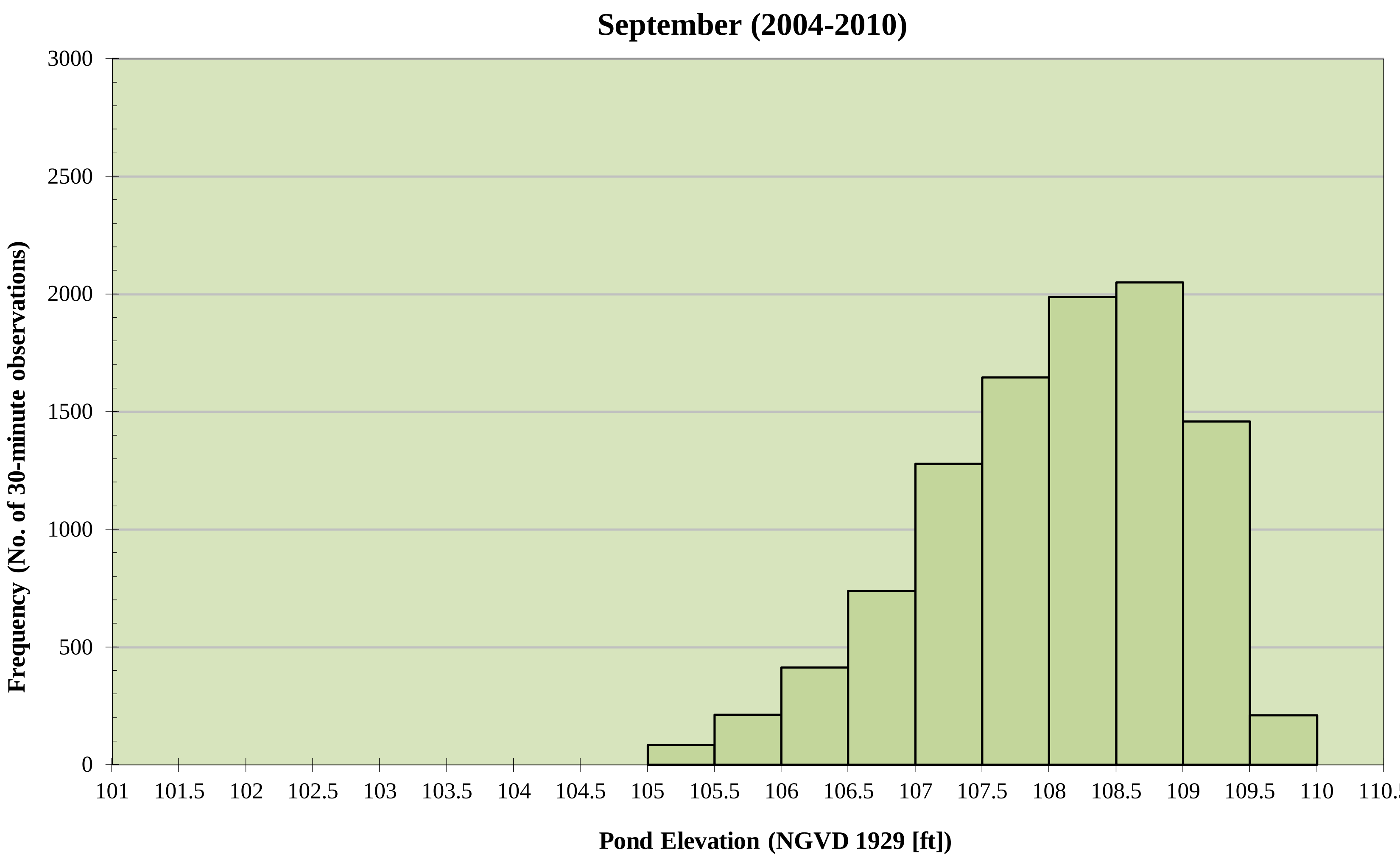
June (2004-2010)
Frequency (No. of 30-minute observations)
3000
2500
2000
1500
1000
500
0
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])

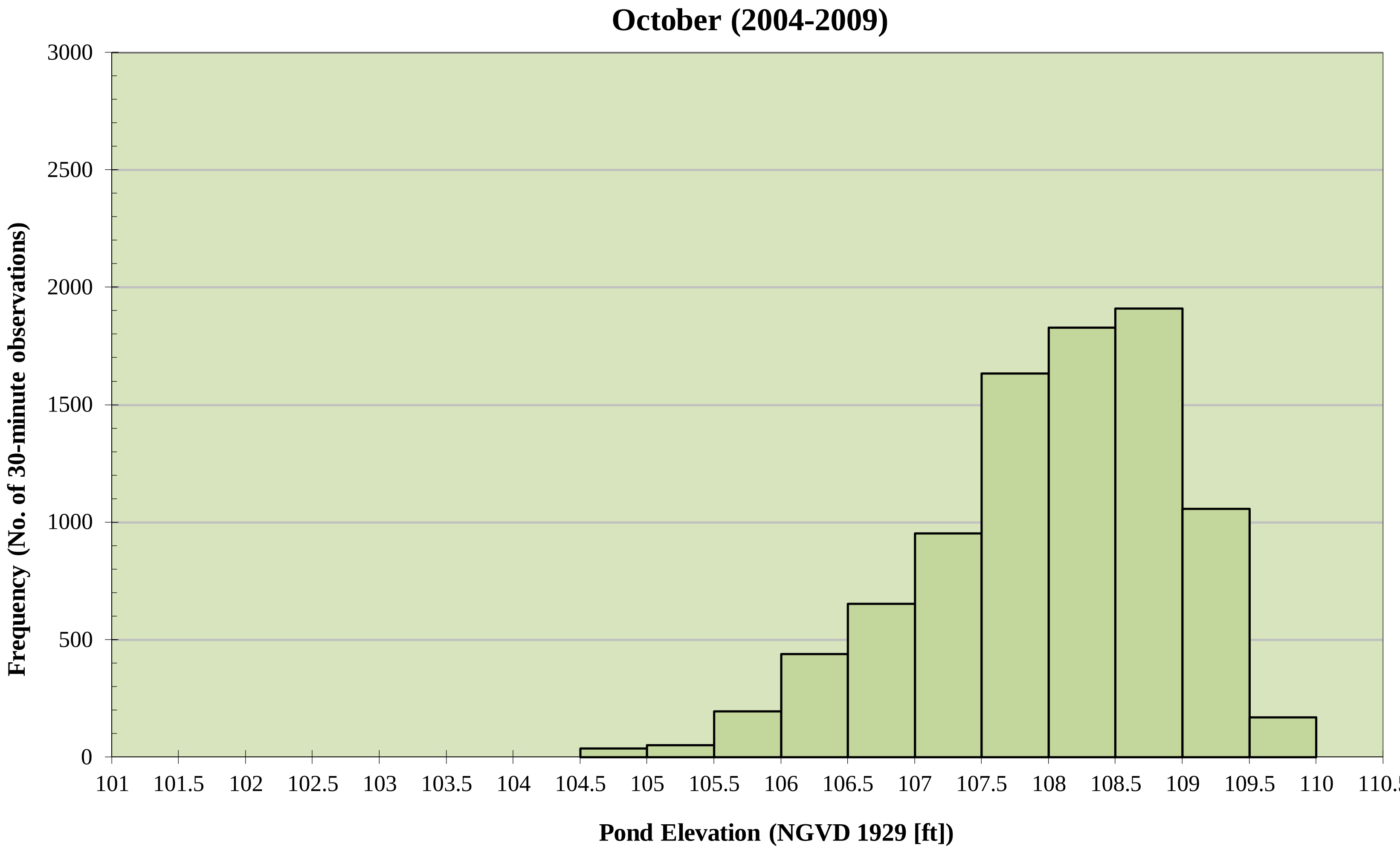


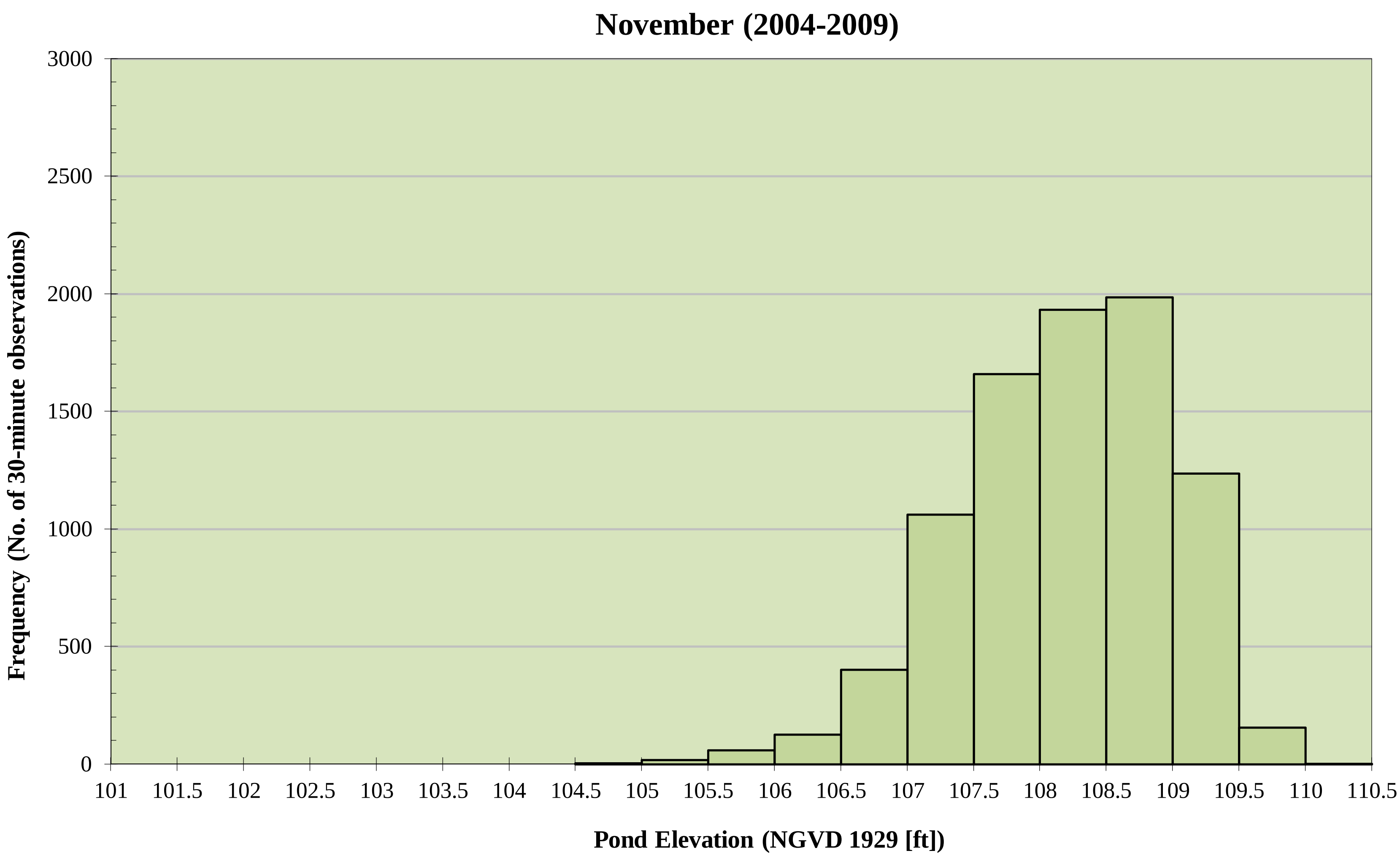
July (2004-2010)
3000
2500
2000
1500
1000
500
0
Frequency (No. of 30-minute observations)
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])



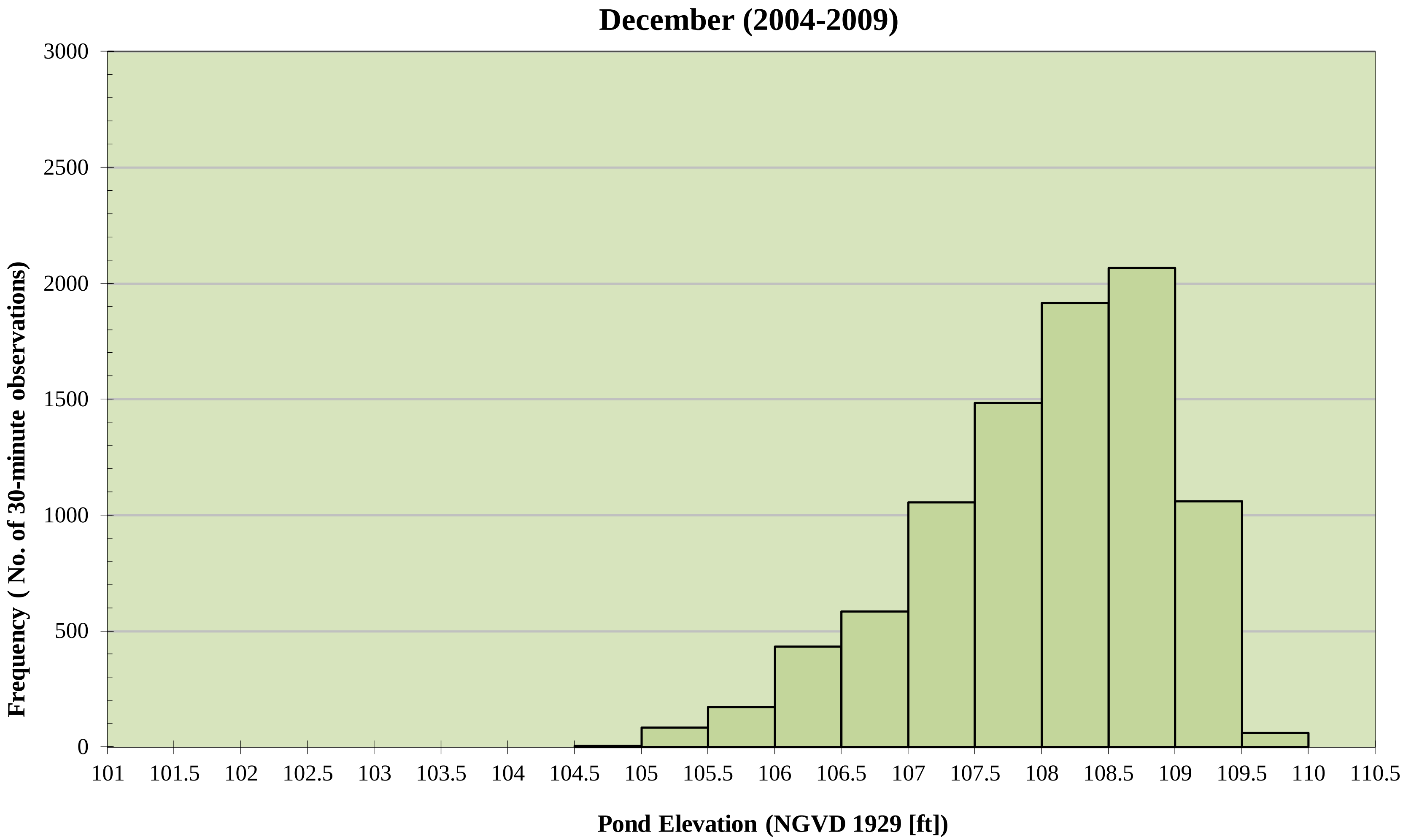
August (2004-2010)
Frequency (No. of 30-minute observations)
3000
2500
2000
1500
1000
500
0
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])


September (2004-2010)
Frequency (No. of 30-minute observations)
3000
2500
2000
1500
1000
500
0
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])


October (2004-2009)
Frequency (No. of 30-minute observations)
0
500
1000
1500
2000
2500
3000
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])

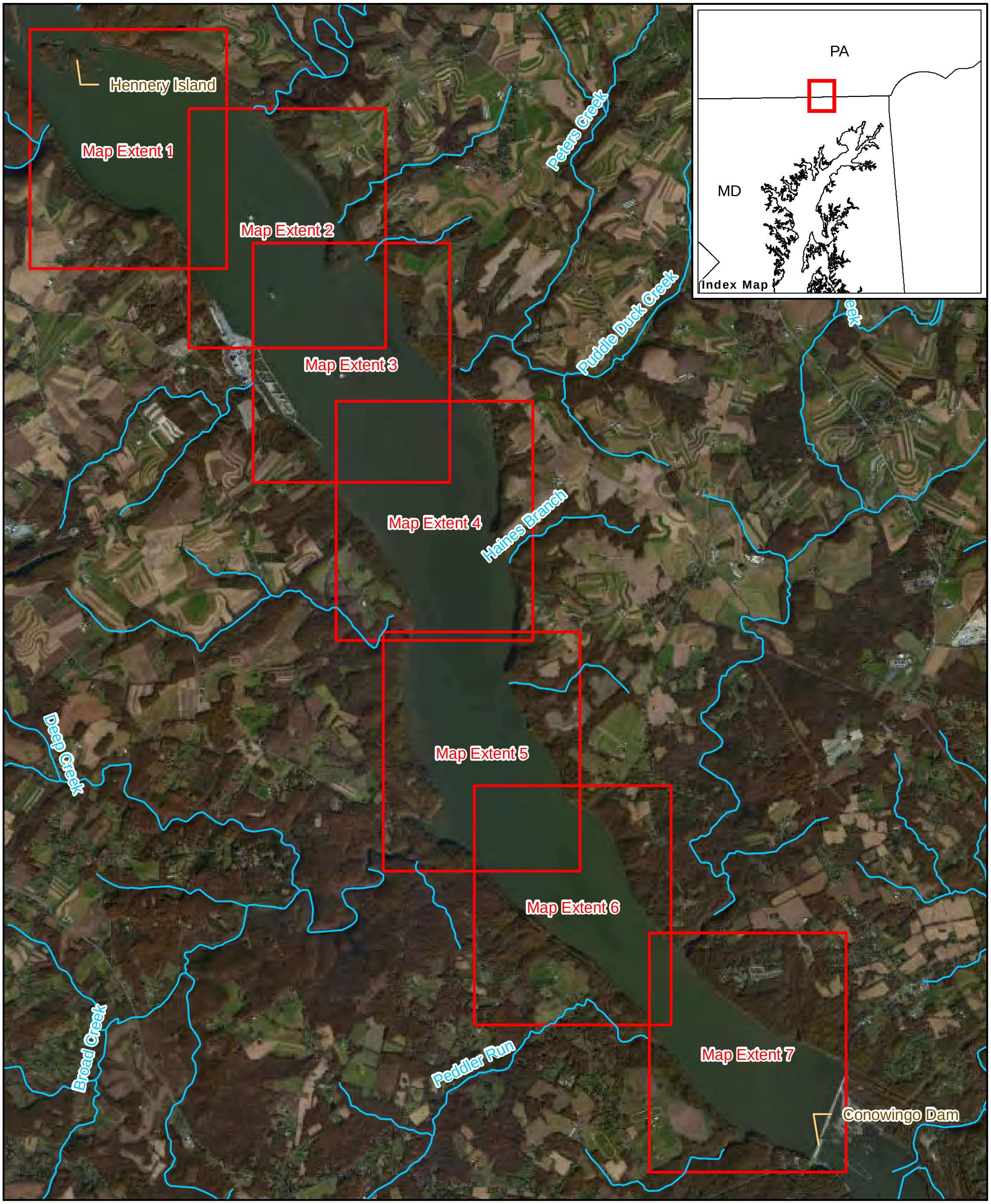


November (2004-2009)
Frequency (No. of 30-minute observations)
3000
2500
2000
1500
1000
500
0
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])



December (2004-2009)
Frequency (No. of 30-minute observations)
3000
2500
2000
1500
1000
500
0
101
101.5
102
102.5
103
103.5
104
104.5
105
105.5
106
106.5
107
107.5
108
108.5
109
109.5
110
110.5
Pond Elevation (NGVD 1929 [ft])

APPENDIX C-BATHYMETRIC MAPS



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Appendix C - Map 1
Bathymetry Map Extent Overview

Exelon

N

1 inch = 1.25 miles

0 0.625 1.25 2.5 Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\appendix_c_bathymetry_index.mxd

N

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PROJECT NO. 405

Appendix C - Map 2
Bathymetry Map Extent 1

1 inch = 0.25 miles

0 0.125 0.25 0.5 Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\appendix_c_bathymetry.mxd

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Appendix C - Map 3
Bathymetry Map Extent 2

1 inch = 0.25 miles

0 0.125 0.25 0.5 Miles

N

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\appendix_c_bathymetry.mxd

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Appendix C - Map 4
Bathymetry Map Extent 3

1 inch = 0.25 miles

0 0.125 0.25 0.5 Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\appendix_c_bathymetry.mxd

Exelon

N

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Appendix C - Map 5
Bathymetry Map Extent 4

1 inch = 0.25 miles

0 0.125 0.25 0.5 Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\appendix_c_bathymetry.mxd

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Appendix C - Map 6
Bathymetry Map Extent 5

1 inch = 0.25 miles

0 0.125 0.25 0.5 Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\appendix_c_bathymetry.mxd

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Appendix C - Map 7
Bathymetry Map Extent 6

N

1 inch = 0.25 miles

0 0.125 0.25 0.5 Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\appendix_c_bathymetry.mxd

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Appendix C - Map 8
Bathymetry Map Extent 7

1 inch = 0.25 miles
0 0.125 0.25 0.5 Miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\Study_3.12\appendix_c_bathymetry.mxd