FINAL STUDY REPORT
DOWNSTREAM EAV/SAV STUDY
RSP 3.17

CONOWINGO HYDROELECTRIC PROJECT

FERC PROJECT NUMBER 405

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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 Downstream Emergent Aquatic Vegetation (EAV)/Submerged Aquatic Vegetation (SAV) Study. The objectives of this study were to: 1) determine the distribution of and characterize EAV and SAV communities downstream of the Project, both quantitatively and qualitatively, 2) identify potential impacts of Project operations, if any, on downstream EAV- and SAV-associated habitats, and 3) assess the need for enhancement of habitats containing EAV and SAV downstream of Conowingo Dam. The study area for this project encompasses from the downstream end of Rowland Island to the lower end of Spencer Island.

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.

To satisfy the objectives of the project, focused field surveys were conducted at low flow conditions in July and August 2010 to quantify and describe downstream EAV and SAV communities and the various substrate types in the study area. Planning-level transects were established prior to field mobilizing to guide the vegetative survey efforts. While the majority of work was conducted by boat, strict adherence to the transects was not possible in some areas due to very shallow water levels. Surveying of these very shallow areas was conducted on foot or by using range finders to detect vegetative beds. All aquatic vegetative species observed during the surveys were recorded, and a notation was made of the dominant and sub-dominant species. Density of emergent and submergent vegetation beds was qualitatively characterized as sparse, minimal, moderate, or heavy. Survey data were subsequently used to develop maps showing the spatial extent and distribution of the various vegetative species and substrate types.

The results of the July-August 2010 habitat study indicated that SAV communities were primarily localized to areas in the lower part of the study area that are characterized by a greater abundance of fine-grained substrates relative to upstream areas, low water velocities, and limited water level fluctuation. The distribution of SAV observed in the lower portion of the study area within a complex of islands are consistent with that recorded by prior researchers in the late 1990s and early 2000s. Based on the review of historic data of SAV coverage in the lower study area, it is apparent that the extent of SAV is variable from year to year, and is contingent on a variety of natural and anthropogenic factors, including storm events and nutrient levels.

The absence of SAV in the study area upstream of the lower island complex is attributable to the general lack of available sediment substrates and the preponderance of natural bedrock substrates that comprise this portion of the river. The availability of sediment for SAV establishment has historically been limited through the majority of the study area due to naturally high river gradients and turbulent conditions. Although downstream portions of the study area (island complex) may be subject to increased bed sediment mobility with increasing generation flows, moderate to heavy SAV growth has been observed adjacent to the islands historically and during this study. Higher generation flows are therefore not likely to result in effects to the SAV community. The potential for such effects are likely associated with flows exceeding the generation capacity of Conowingo. Species use of SAV-associated habitats is also not expected to be impacted to a significant degree by Project operations.

Emergent vegetation grows opportunistically along river margins and creek mouths containing fine-grained depositional materials, and atop bedrock outcrops containing fine-grained sediment in interstitial spaces within the bedrock. Water willow (*Justicia americana*) was by far the most abundant species observed, comprising 97% of the EAV coverage. Water velocity is not expected to be an important variable in explaining the variability in EAV coverage given that water willow plants have flexible fibrous stems that allow individual plants to withstand high flow events. Available literature indicates that water willow is tolerant to prolonged periods of drought, but is susceptible to extended periods of high water. The presence of water willow in areas where water fluctuations are significant (upper study area) indicate that periods of high water in these areas are of short duration during the water willow growing season. As such, water willow grows opportunistically on marginal substrates with sufficient sediment for seeds to germinate and for roots to gain a foothold. Fluctuating water levels from generation flows temporarily inundate EAV beds, providing needed water and nutrients for growth. Use of emergent habitats by aquatic biota is limited during periods of low flow, which render these habitats inaccessible.

Based on the available information from the 2010 habitat surveys, predictive hydraulic flow modeling, and sediment transport evaluation, it can be concluded that while Project operations are sufficient to alter the downstream flow regime, water levels, and mobility of sediment, aquatic vegetation in the downstream study area grows opportunistically on substrates where sufficient depositional material is present. The distribution of observed vegetation was found to be consistent with an unregulated river system, as operations may serve to attenuate the intensity and duration of high flow events. Limitations to vegetative growth appear to be a function of a lack of suitable substrates resulting from naturally high river gradient and turbulent conditions.

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cfs	cubic feet per second
BMP	Best Management Practice
CBF	Chesapeake Bay Foundation
CBP	Chesapeake Bay Program
EAV	Emergent aquatic vegetation
Exelon	Exelon Generation Company, LLC
FERC	Federal Energy Regulatory Commission
fps	feet per second
MW	Megawatt
Project	Conowingo Hydroelectric Project
ILP	Integrated Licensing Process
PAD	Pre-Application Document
NOI	Notice of Intent
PSP	Proposed Study Plan
MDNR	Maryland Department of Natural Resources
Muddy Run	Muddy Run Pumped Storage Project
NWI	National Wetland Inventory
PaDEP	Pennsylvania Department of Environmental Protection
RSP	Revised Study Plan
SAV	Submerged aquatic vegetation

SRBC	Susquehanna River Basin Commission
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VIMS	Virginia Institute of Marine Science

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 a new license using the FERC's Integrated Licensing Process (ILP). The current license for the Conowingo Project was issued on August 14, 1980 and will expire 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 study of the emergent aquatic vegetation (EAV) and submerged aquatic vegetation (SAV) communities downstream of Conowingo Dam. The study is intended to evaluate the potential impacts from Conowingo Project operations on EAV and SAV communities from Conowingo Dam downstream to the lower end of Spencer Island. The methods applied to conduct that study, the study results, and conclusions based on interpretation of the data from the study are the subject of this report.

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, 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 evaluate the potential impacts from operations at the Conowingo Project to EAV and SAV communities downstream of Conowingo Dam.

In the PSP Study 3.12, Water Level Management (Littoral Zone and Water Level Fluctuation), Exelon proposed to review existing historic and current data on downstream EAV and SAV, and map the presence or absence of downstream EAV and SAV. The field component would entail identifying and describing dominant aquatic and littoral zone plant taxa and density. Additionally, physical data including substrate type, water depth, and water velocity would be recorded. Exelon proposed to compare observed species requirements with existing conditions, and to assess the potential effect of Project operations on EAV and SAV due to downstream velocity and water level changes and sediment trapping by the Conowingo Dam.

In response to the PSP, Exelon was requested to evaluate the potential Project-related effects, including variations in downstream water levels and flows, on downstream SAV and EAV communities. This Downstream EAV/SAV Study Report has been prepared to comply with the agency requests for an ecological characterization of vegetative communities downstream of Conowingo Dam and an evaluation of potential impacts to these communities from operations at the Conowingo Project.

1.2 Study Objectives

The primary objective of this study was to quantify the spatial extent of emergent and submergent vegetation and to evaluate the potential impacts of fluctuating water levels and flows associated with operations of the Conowingo Hydroelectric Project on the downstream vegetative communities. This Downstream EAV/SAV study area was from the downstream end of Rowland Island to the lower end of Spencer Island, a distance of approximately 4.5 miles (Figure 1.2-1). Critical to fulfilling these objectives was the collection of habitat data in the project study area, including extent, composition, and relative density of EAV and SAV, extent and composition of benthic substrate, and water velocity. Information from the Instream Flow Habitat Assessment Below Conowingo Dam (RSP 3.16), the Hydrologic Study of the Lower Susquehanna River (RSP 3.11), and the Sediment Introduction and Transport Study (RSP 3.15) was integrated with the results of the habitat survey to determine the potential for impacts to downstream vegetative communities.

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

1. Determine the distribution of and characterize EAV and SAV communities downstream of the Project, both quantitatively and qualitatively.
2. Identify potential impacts of Project operations, if any, on downstream EAV- and SAV-associated habitats.
3. Assess the need for enhancement of habitats containing EAV and SAV downstream of Conowingo Dam.

1.3 Description of Conowingo Project

The Conowingo Hydroelectric Project has a total drainage area of 27,100 square miles and is the most downstream of five hydroelectric projects on the lower Susquehanna River. The Conowingo Dam is operated in combination with the Muddy Run Pumped Storage Project (Muddy Run). Owing to reservoir size and the requirements of Muddy Run, Conowingo operations result in a relatively small allowable variation in headwater level. Safe Harbor Corporation's operation of Safe Harbor Dam (FERC No. 1025), a peaking facility located 24 miles upstream, primarily determines the operation of the Conowingo Dam in terms of energy generation timing. Maximum hydraulic capacity of Safe Harbor Dam (110,000 cubic feet per second [cfs]) is more than that of the Conowingo Dam (86,000 cfs). There is approximately a two-hour lag time for the arrival of water released at Safe Harbor to reach Conowingo.

The Conowingo Project adheres to a schedule for providing sufficient minimum flows for the maintenance and health of natural resources downstream of Conowingo Dam. The current 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 minimum flow schedule 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

1 As measured at the Susquehanna River at Marietta USGS Gage No. 01576000.

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)

2.0 VEGETATED HABITATS DOWNSTREAM OF CONOWINGO DAM

Aquatic vegetation plays several important roles in aquatic ecosystems, and is often monitored as a biological indicator for detecting changes in various environmental parameters such as nutrient levels, sedimentation rates, contaminant levels, and natural catastrophic events. Emergent vegetation can act as a nutrient buffer by blocking or mitigating input of nutrients that may enter an aquatic system from non-point source runoff, erosion, or point source discharges. EAV communities consisting of deep-rooted plants may also serve to stabilize the shoreline and reduce erosion by locally slowing flow and increasing the rate of deposition of sediment. Desirable varieties of EAV also provide a source of food and habitat for various littoral and riparian organisms (Strakosh et al. 2009). Submergent vegetation also provides a food source for waterfowl and cover habitat for fishes and invertebrates, and can play critical roles in nutrient absorption and oxygenation of surface water. SAV may also facilitate settling of resuspended sediment by mitigating wave action and reducing localized flows (Ward et al. 1987).

Aquatic habitat in the Susquehanna River mainstem below Conowingo Dam consists of shallow waters generally characterized by unvegetated bedrock and boulder substrates. The MDNR has identified Nontidal Wetlands of Special State Concern along Deer Creek and on the main stem shoreline opposite Deer Creek below the Dam. Octoraro Creek, a non-tidal tributary that enters the river approximately 4,500 feet downstream of Conowingo Dam on the river's east side, provides spawning habitat for anadromous species and American eel (*Anguilla rostrata*), and is also potentially influenced at its mouth by fluctuating flows and water levels attributable to Project operations. Spawning by anadromous fish, particularly striped bass (*Morone saxatilis*) and white perch (*M. americana*) occurs in the river main stem below the Dam. Common fish species resident to the area below Conowingo Dam include gizzard shad (*Dorosoma cepedianum*), channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), shorthead redhorse (*Moxostoma macrolepidotum*), quillback (*Carpiodes cyprinus*), brown bullhead (*Ameiurus nebulosus*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), and walleye (*Sander vitreus*).

2.1 Historic Data on Vegetated Habitats

For the Downstream EAV/SAV Study, the study area was focused on the secure area below Conowingo Dam downstream to the lower end of Spencer Island (Figure 1.2-1). There are limited data available regarding the distribution of SAV and EAV in this reach of the river. The majority of the focus on aquatic vegetation communities has been placed on the trends in the density and growth of aquatic vegetation, particularly SAV, in the Chesapeake Bay. Prior to the initiation of the current study, the available information for the reach of the Susquehanna River between Conowingo Dam and the downstream extent of Spencer Island consisted of National Wetland Inventory (NWI) maps for the State of Maryland, an aquatic habitat survey conducted by Exelon in the summer of 2008, and annual surveys conducted by the Chesapeake Bay Program (CBP) of SAV communities in Chesapeake Bay.

Historic data on the distribution of SAV communities in the Susquehanna River mouth portion of the Chesapeake Bay (Susquehanna Flats) indicate that native species such as wild celery (*Vallisneria americana*), Canadian waterweed (*Elodea canadensis*), and waternymph (*Najas* spp.) were largely displaced by the invasive Eurasian watermilfoil (*Myriophyllum spicatum*) in this area in the late 1950s and early 1960s (Davis 1985). Populations of Eurasian watermilfoil subsequently collapsed in the mid-1960s due to disease, enabling native species to recolonize the area (Orth and Moore 1984). A decline of all SAV species which were first observed at some locations in the mid-1960s was a Bay-wide phenomenon in the early 1970s, which was exacerbated by Tropical Storm Agnes in 1972 (Orth and Moore 1984; Orth et al. 2010). SAV populations did not recover immediately after the 1972 tropical storm event, and by 1978, only two species, Eurasian watermilfoil and wild celery, were detected in scattered beds in the Susquehanna Flats (Anderson and Macomber 1980).

2.1.1 National Wetland Inventory Maps

Below Conowingo Dam, Maryland Wetland Inventory maps depict the presence of deciduous broad-leaved forested and scrub-shrub wetlands and persistent emergent wetlands subject to a variety of water regimes (i.e., temporarily flooded, seasonally flooded, seasonally flooded/saturated, semi-permanently flooded, or seasonal tidal). In addition, the localized areas upstream and downstream of Deer Creek are noted by USFWS NWI maps as freshwater forested/shrub wetlands. Forested/shrub wetlands are also identified by the NWI along much of the eastern shoreline from Octoraro Creek downstream to McGibney Island. The eastern margins of Roberts Island and Steel and Wood Islands in their entireties are also mapped as freshwater forested/shrub wetlands.

2.1.2 Exelon's 2008 Study

In 2008, Exelon conducted field surveys below Conowingo Dam to develop a habitat map of the non-tidal portion of the Susquehanna River. The field surveys were conducted from below Conowingo Dam downstream to Deer Creek in August and September under minimum flow generation from one small generating unit discharging approximately 5,700 cfs (United States Geological Survey [USGS] gage at Conowingo Dam). Conducting the field surveys under a minimum flow scenario allowed for maximum safety of the field survey crews while simultaneously enabling the highest potential for detecting habitat features, including aggregations of SAV and conventional channel geomorphic units such as riffle, run, pool, backwater, and side channel areas. Substrate composition and occurrence of SAV within each polygon were visually determined and recorded. Habitat boundaries were recorded as GPS data points and plotted on a habitat map provided in the PAD (Exelon 2009).

Bedrock formations with scattered areas of variable-sized cobble characterized the majority of substrate in the non-tidal habitat area below the tailrace/spillway. Patches of SAV were scarce, and were mainly detected in small habitats near Octoraro Creek (Exelon 2009).

2.1.3 Chesapeake Bay Program SAV Surveys

Since 1984, the Virginia Institute of Marine Science (VIMS) has conducted an annual aerial SAV monitoring program and a bi-monthly to monthly water quality monitoring program for the CBP throughout Chesapeake Bay (e.g., Orth et al. 2002, 2006, 2007, 2008, 2009, 2010). Annual variation in SAV can be significant due to the dynamic ecosystem of the lower Susquehanna River and other Bay tributaries. Annual bay grass acreage estimates are considered by the CBP as a gauge of the water quality in the Bay and its tributaries, and indicate the responses of the Bay to pollution control efforts, such as implementing agricultural best management practices (BMPs), upgrading wastewater treatment plants, installing denitrification systems and phosphorus effluent filters, and reducing non-point source and sewage impacts (CBP 2010, Ruhl and Rybicki 2010).

Annual SAV surveys conducted by VIMS follow fixed flight routes from late spring to early fall to comprehensively record SAV extent and density in shallow waters. The distribution of SAV was mapped from black and white aerial photographs to record percent coverage of vegetative beds. SAV beds less than 1 square meter in area are not included due to the limits of photography and interpretation (VIMS 2011). No surveys were conducted from 1979 to 1983 or in 1988. In years when the Susquehanna River could not be surveyed due to flight restrictions or weather events, acreages in the non-surveyed areas were estimated based on prior years' surveys. Spatial gaps in 1999 occurred due to the inability to photograph SAV occurrences after the disturbance from Hurricane Floyd. Spatial gaps in 2001 occurred due to flight restrictions and again in 2003 due to adverse weather conditions. Community data also included vegetative health, density, and species diversity at select locations throughout the Chesapeake Bay (VIMS 2011).

The uppermost range of the SAV surveys conducted by VIMS extends upstream into the Susquehanna River to approximately the lower ¼ of Roberts Island (see Figure 1.2-1). Therefore, there is a small area of overlap with the geographic range of this Downstream EAV/SAV Study and the VIMS surveys. Based on a review of annual SAV distribution maps available online[2] through VIMS, during the years of 1984 through 1990, SAV was present in limited areas primarily on the downstream ends of Roberts, Steel, Wood, and Spencer Islands. SAV coverage ranged from 10 to 70% where it occurred. The 1990s were associated with a steady increase of SAV populations in the Susquehanna Flats. Orth et al. (2010) cited decreases in nitrogen and phosphorus loading as a primary reason for improved SAV production and growth in several portions of the Chesapeake Bay. Reductions of these nutrients resulted in decreased phytoplankton abundance and corresponding improvements in water clarity, thus allowing for light-dependent submergent species to flourish. The spatial extent of SAV expanded along the shorelines of Spencer, Robert, and Wood Islands, with coverage in these areas ranging from 10 to 100 percent. A period of community fluctuation occurred between 1991 and 1999; SAV ranged from 40 to 100 percent cover through 1994 generally declining in coverage (10 to 40 percent) between 1995 and 1997. A resurgence of SAV growth occurred beginning in 1998 and continued through 1999. SAV extent was greatest in 1999, during which it extended from one bank of the river to the other in the vicinity of the Roberts-Spencer-Wood-Steel Island complex.

In 2000, there were declines in freshwater SAV communities within the lower study area. SAV coverage significantly retracted to the immediate margins along Wood, Roberts, and Spencer Islands, and no SAV was observed along Steel Island. In 2001 and 2002, SAV beds expanded once more to conditions observed in the 1990s. In 2004 and 2005, very little SAV was present in the lower study area, potentially due to extended periods of turbidity (Orth et al. 2005, 2006). In subsequent years, however, SAV coverage and densities once more returned to levels observed in the 1990s (Orth et al. 2007, 2008, 2009). SAV coverage in the lower study area returned to 40 to 70 percent from years 2006 to 2009. Orth et al. (2010) indicates that the SAV species most frequently reported in the Susquehanna Flats portion of the VIMS survey area include Eurasian watermilfoil, wild celery, hydrilla (*Hydrilla verticillata*), coontail (*Ceratophyllum demersum*), water stargrass (*Heteranthera dubia*), and brittle waternymph (*Najas minor*).

Based on the review of historic CBP survey data of SAV coverage in the lower study area, it can be concluded that the extent of submerged vegetation is variable from year to year, and is contingent on a variety of natural environmental and anthropogenic factors. Native SAV abundance appears to be strongly linked to turbidity and nutrient levels, with greater abundance observed during conditions of high water clarity and decreased nutrient input (Kemp et al. 1984; Orth et al. 2010; Ruhl and Rybicki 2010).

[2] http://web.vims.edu/bio/sav/maps.html.

Tropical storms and other severe weather events, in addition to anthropogenic inputs, contribute to reductions in water clarity and subsequent declines in SAV growth and abundance (Orth and Moore 1983; Wang and Linker 2005).

3.0 STUDY METHODS

As noted in Section 1.2, the geographic scope of this Downstream EAV/SAV Study is the lower end of Rowland Island to the downstream end of Spencer Island, a distance of approximately 4.5 miles (Figure 1.2-1). For this study, surveying of vegetative communities in the study area was conducted in late July and late August 2010. To aid in conducting the surveys, transects were established at 500-foot intervals through the study reach (Figure 3.0-1). Transects were used to guide the downstream EAV/SAV survey efforts, though survey efforts were focused in areas where SAV or EAV was observed directly or was suspected to be present.

The surveys were completed by boat and, in some areas, by foot, during the peak vegetative growing season (late July through late August). Surveys were conducted under low flow conditions to maximize visual detection of aquatic vegetative communities and facilitate mapping of habitat features. Data collected from vegetated habitats included detailed grain size characterization of unconsolidated substrates, EAV and SAV composition and relative density, and water velocity. Water velocity less than 0.3 feet per second (fps) is considered lentic, characterized by low-energy environments and still waters; velocities ≥ 0.3 fps indicate lotic conditions, characterized by high-energy environments and flowing waters.

The upper and lower portions of the study area were artificially divided to optimize survey coverage. The lower portion is composed of several large islands with relatively deep water levels. The lower portion of the study area was surveyed primarily by 14-foot flat bottomed boat. The upper portion of the study area, which is generally shallower and higher gradient, was surveyed by kayak. A small boat was also deployed concurrently with the kayaks for safety reasons. Surveying of the lower portion of the study area was conducted from July 26 through July 28, 2010; the survey of the upper portion was conducted on August 23 and August 24, 2010.

Actual surveys generally followed the 500-foot planning transects, with some deviation as conditions warranted. Inaccessibility in some reaches due to very shallow water levels prevented strict adherence to the pre-survey transects. Very shallow areas were surveyed for emergent or submergent vegetation either by walking the area or by far-field visual surveying using a range finder.

3.1 Emergent and Submerged Aquatic Vegetation Mapping and Delineation

Vegetation surveys were conducted for both EAV and SAV communities within the downstream EAV/SAV Study Area. 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). All aquatic vegetative species observed at each survey location were recorded, and a notation was made of the dominant and sub-dominant species. Density of emergent and submergent vegetation beds was qualitatively characterized as sparse, minimal, moderate, or heavy. This density classification was developed in the field by biologists and is described below.

- Sparse: Limited vegetative growth identified by low stem density.
- Minimal: Clusters of vegetation with open space visible.
- Moderate: Majority of the surface covered with vegetation, stems close together.
- Heavy: Complete coverage of the surface by leaves with stems tightly grouped.

To provide a thorough characterization of the SAV community, a Weed Raker™ lake rake was used to collect a representative sample at each survey point (described in Section 4.0). 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. The rake extensions enabled the collection and subsequent characterization of SAV from deeper depths in the study area. 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.

To accurately identify the data positions and vegetated habitats within the river, a handheld Trimble GeoXH 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. 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). Areas of EAV were generally surveyed by walking shoreline or island perimeters and noting taxonomy, species dominance, and density. In addition, the spatial extent of emergent vegetative growth was mapped with the GPS.

Water velocity data were recorded using a Marsh McBirney Flo-Mate 2000 flow meter. As stated above, surveys were conducted primarily during low flow conditions to limit fluctuating water conditions and to maximize visual detection of downstream EAV and SAV communities. The daily range of flow for the survey period of July 26-28, 2010 was between 5,350 cfs (slightly above the minimum flow established for the summer time period [see Section 1.3]) and 25,000 cfs, as determined from USGS Gage No.

01578310[3]. For the survey period of August 23-24, 2010, downstream flow ranged between 5,690 cfs and 19,900 cfs. The majority of the surveying time was conducted at the lower end of these flow ranges. Low flows predominated from morning through mid-afternoon; higher flows generally occurred in the late afternoon.

3.2 Substrate Characterization

To classify the composition of river substrates containing emergent and submergent vegetation, 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 composed 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 provided in Table 3.2-1.

For the purposes of reporting for the Downstream EAV/SAV 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"; 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 grain sizes in the study area (Table 3.2-1). 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).

3.3 Supporting Data from Other Studies

In addition to the vegetated habitat data collected during this study, information from other studies was used to evaluate the potential for impacts to vegetated communities in the downstream study area. Data from the Instream Flow Habitat Assessment Study were used to describe downstream water velocities and

[3] USGS Gage - Susquehanna River at Conowingo, MD (data described is provisional, per USGS)

surface water elevations relative to mean sea level. Historic flow analysis data from the Hydrologic Study of the Lower Susquehanna River (RSP 3.11) were employed to identify the duration of various flow regimes in the downstream study area. Information from the Sediment Introduction and Transport Study (RSP 3.15) is used to characterize the potential for sediment mobility and the stability of habitats in the study area over various operating scenarios.

4.0 2010 STUDY RESULTS

Aquatic vegetation surveys conducted in July and August 2010 were successful in determining the presence or absence of EAV and SAV within the 4.5-mile study area below Conowingo Dam. Appendix A contains photographs of EAV and SAV species observed at various study location points throughout the study area. Survey points at which aquatic vegetation species and abundance, substrate type, and water velocity data were obtained are presented in Figure 4.0-1.

4.1 EAV/SAV Habitat Characteristics

As is typical of large, unregulated river systems, emergent and submergent vegetative communities in the study area generally corresponded to the margins of river or island shorelines and the presence of depositional material, either as fine-grained accretionary sediment (e.g., downstream ends of islands in the lower study area) or intermixed with granules, pebbles, cobbles, or boulders primarily along river and island margins.

River substrates within the study area were found to be composed primarily of bedrock, particularly in offshore areas Figure 4.1-1. The majority of these bedrock-dominated areas are present as unvegetated, exposed outcrops that contain little to no smaller diameter substrates. According to information presented in the Sediment Introduction and Transport Study Report, the area downstream of Conowingo Dam prior to dam construction was composed primarily of bedrock with limited areas of sediment deposition. The report indicates that the lower Susquehanna River was historically a high-energy, steep-gradient environment capable of mobilizing bedload with little sedimentation and deposition until the river mouth was reached.

Sand and sand/gravel substrates, which provide more suitable habitat for SAV/EAV development than bedrock or substrates consisting solely of gravel, were limited in the study area. Gravel-dominated substrates are present sporadically as narrow bands along the eastern and western river margins, at the river confluences of Octoraro Creek and Deer Creek, and along the shorelines of McGibney, Wood, Roberts, and Spencer Islands. Gravel substrates are composed mainly of boulder and cobble; however, pebbles and granules are a large component of the substrate in some areas, particularly near the mouth of Octoraro Creek and within the island complex in the lower study area. Finer grain sediments predominantly consisting of sand are present below Roberts Island and Steel Island, and in a few small reaches along the lower western river shoreline (Figure 4.1-1).

Results from the Instream Flow Habitat Assessment Study generally indicate increased water velocities in most areas with increasing flow (over the range of operating conditions) (Appendix C). In general, higher water velocities were observed in areas associated with the bedrock-dominated channel, and lower velocity conditions were observed along the eastern and western river margins as well as the downstream Roberts-Spencer-Wood-Steel Island complex. The areas of greatest water velocity are the upper portion of the study area along the western shoreline and along the eastern shore of McGibney Island (Appendix C). Modeling data suggest minimal increases in velocity with increasing flows along the lower study area island margins, along portions of the eastern and western river shoreline, and at the mouth of Octoraro Creek.

4.2 EAV/SAV Distribution and Composition

In general, there were few areas of detectable SAV growth in the study area. Dominant SAV observed during the 2010 surveys included Eurasian watermilfoil and hydrilla, with Eurasian watermilfoil accounting for approximately 96% of the dominant SAV (Table 4.2-1 Figure 4.2-1). Submergent plant communities were present only in the areas near the mouth of Octoraro Creek, along the shorelines of Spencer, Roberts, Steel, and Wood Islands, and minimally along the eastern and western river shorelines as narrow bands of vegetation (Figure 4.2-1). Hydrilla was also prominent in some areas, particularly in nearshore areas of Roberts and Spencer Islands. The diversity of SAV was low; only four species were identified during the July/August surveys.

Growth of EAV appeared to be opportunistic throughout the study area, and was concentrated along the river margins or near creek mouths (Figure 4.2-1). Communities were present at the mouth of Octoraro Creek and above the upper limits of McGibney Island and Roberts Island. Commonly observed species of EAV included water willow (*Justicia americana*), water pepper (*Polygonum hydropiper*), and smartweed (*Polygonum* sp.). Water willow had the greatest spatial coverage, and accounted for approximately 97% of the dominant EAV within the study area (Table 4.2-2). Additional species of EAV and SAV observed within the study area are presented in Table 4.2-3.

The following sections provide detailed characterizations of vegetated habitats in various locations of the study area. Appendix A contains photographs of vegetated habitats within each of the areas described below.

4.2.1 Octoraro Creek Confluence Area and Points Downstream

The confluence of Octoraro Creek with the Susquehanna River is located approximately one mile downstream of Conowingo Dam. Prior investigations of this area indicated that it contained diverse habitat types as compared with surrounding downstream locations. Data collected during this survey identified EAV dominated by high-density water willow at the mouth extending riverward, as shown in

Figure 4.2.2-1. Additionally, an area of SAV containing sparsely populated Eurasian watermilfoil was observed extending parallel with the shoreline from below the Dam spillway to the mouth of the creek. Dominant substrate within this area of SAV growth is bedrock, with some areas of intermixed cobble and boulder. Substrate composition at the mouth of the Octoraro Creek transitioned from poorly sorted granular substrate with velocities greater than 0.3 fps to cobble- and boulder-dominated pools with flows less than 0.3 fps.

From Octoraro Creek downstream to the northern tip of McGibney Island, the eastern shoreline is composed primarily of bedrock intermixed with areas of boulder/coarse sand point bars that are exposed during low flow conditions. The species composition of these boulder habitats vary from moderate- to high-density water willow to a dense co-dominant water pepper and smartweed community. No SAV growth was observed along the eastern shoreline between Octoraro Creek and McGibney Island.

4.2.2 McGibney Island Area

McGibney Island is a small island approximately 1,500 feet long located along the eastern shoreline upstream of Smith Falls (Figure 3.0.1). An eastern channel, approximately 250 feet wide, contained extensive EAV growth that varied in density from heavy to moderate. The upstream end of the island and shoreline areas slightly downstream also contained dense EAV growth (Figure 4.2.2-1). Substrate varies from predominantly boulder around the periphery of McGibney Island to predominately bedrock in the lower section of the eastern channel and within the main channel of the Susquehanna River (Figure 4.1-1). Water willow was the dominant EAV species in all areas where EAV was present. Flow within the eastern channel varied as waters moved from steeper gradient boulder channels (higher water velocities) to the bedrock-dominated low gradient pools downstream (lower water velocities). During the July-August 2010 surveys, flow through the eastern channel was minimal. No SAV was observed in the proximity of McGibney Island.

4.2.3 Western Shoreline Area

The western shoreline transitions between high river gradient bedrock- and boulder-dominated margins to lower gradient boulder- and cobble-dominated margins downstream to the confluence of Deer Creek. As with other portions of the study area, mid-river substrate consists almost exclusively of bedrock, with exposed outcrops visible throughout (at low flows). Within the areas of boulder and cobble dominated shoreline, moderate density beds of water willow grew opportunistically in sub-dominant sandy sediment that had settled within the interstitial spaces of the cobbles and boulders (Figure 4.2.3-1). Very little vegetative growth was observed in the mid-channel reach where bedrock dominates the river bottom.

The confluence of Deer Creek on the western shoreline exhibits some alluvial deposition predominately in the form of boulder poorly sorted with cobble and sand. A bedrock outcrop exists upstream of the mouth containing a small high-density water willow community. Riverward, smaller bedrock outcrops lacking vegetation are present, containing water velocities characteristic of lotic conditions (> 2.5 fps) due to the influence of Deer Creek. At the mouth of Deer Creek, a small community of dense water willow is present (Appendix A, Photo 7), similar in size and density to the vegetated area along the river margin upstream of the creek mouth (Figure 4.2.3-1). During the survey period, no SAV was observed in the vicinity of the mouth of Deer Creek.

4.2.4 Lower Study Area Island Complex

The lower extent of the study area contains two large islands, Roberts and Spencer, and two smaller adjacent islands, Wood Island to the west and Steel Island to the east (Figure 3.0-1). River gradient transitions from high gradient exposed bedrock upstream to low gradient open water habitat within this island complex. Substrate composition along the periphery of the islands is variable, shifting from predominantly medium sand between Roberts and Spencer Island (Figure 4.2.4-1) to boulder and bedrock between Roberts Island and Wood Island (Figure 4.2.4-2). Few EAV communities are present within this portion of the study area due to generally deeper water depths and steeper river and island shorelines. A large area of EAV composed of moderate density water willow was identified growing in sediment deposits within bedrock fissures above the upper end of Roberts Island (Figure 4.2-1). A smaller community of water willow is present in association with the upper extent of Steel Island. Dense water willow beds were observed adjacent to a small island to the west of Spencer Island and along the eastern river shoreline below Steel Island.

The SAV community within this reach of the study area was observed to be prolific and dominated by Eurasian watermilfoil. Hydrilla was also prominent in the island complex area, and dominated the SAV community along a portion of the eastern shore of Roberts Island and at the lower end of Spencer Island, where it grew densely as monotypic stands or in association with Eurasian watermilfoil (Figure 4.2-1). A large SAV bed consisting of minimal growth Eurasian watermilfoil and hydrilla is present in a shallow gravel-dominated area between Spencer Island and the western river shoreline (Figure 4.2-1, Appendix A, Photos 1 and 2). As stated in Section 4.1, the lower ends of Roberts Island and Steel Island, as well as a few constricted segments along the western river shoreline, are the only areas identified during the study as containing substrate dominated by sand and not by larger grain sizes. The coverage of SAV communities detected in the lowermost portion of the study area during the July-August 2010 surveys most approximate those identified in the late 1990s and early 2000s by VIMS.

4.3 Effects Related to Project Operations

Communities of emergent and submergent vegetation downstream of Conowingo Dam experience frequent fluctuations in water levels depending on Project generation and discharge levels. As discussed in Section 4.1, the river bottom in the majority of the study area consists of bedrock, as opposed to more suitable substrate such as sand or gravel/sand, thus precluding the growth of emergent and submergent vegetation. Additionally, submerged substrates dominated by bedrock do not permit the colonization of SAV unless sediment is present within crevasses in the bedrock. This condition was not observed in the study area, with the exception of the downstream island complex that contains some areas of bedrock in association with gravel (granules, pebbles, cobble, boulder) and sand.

As part of the Instream Flow Habitat Assessment Below Conowingo Dam, downstream water surface elevations and velocities were quantified using a two-dimensional hydraulic model over a range of operational conditions. Predicted downstream surface water elevations and velocities were generated for flows of 3,500, 5,000, 10,000, 20,000, 40,000, and 86,000 cfs (Appendix B and C). At lower flow scenarios (3,500 and 5,000 cfs), numerous bedrock surfaces are exposed, the majority of which are located within the middle and upper portion of the study area. In addition, a greater proportion of river and island margins are exposed at these lower flow conditions (Appendix B, Map 1 and 2). As flows increase, the proportion of exposed areas decreases, and inundation of bedrock outcrops and shoreline areas increases. At maximum generation capacity (86,000 cfs), relative water elevations increase significantly throughout the study area; the river gradient becomes much greater, and exposed surfaces mid-river and along the margins of the river, islands, and creek mouths are greatly reduced (Appendix B, Map 6).

For the Instream Flow Habitat Assessment Study, the hydraulic modeling results were coupled with habitat suitability information for various fish species and macroinvertebrate orders to evaluate the relationship between habitat and flow. Although habitat suitability index curves are not available for emergent or submergent vegetative species, habitat data obtained from the July-August 2010 surveys and information from the Instream Flow Habitat Assessment Study can be used to make general conclusions concerning the potential effects of Conowingo Dam operations on vegetated habitats.

Modeled river velocities over a range of discharge conditions generally indicate low velocities along the river margins and higher flows with increasing distance from shore (Appendix C). Predicted water velocities vary from 1 to 2 fps at a discharge of 3,500 cfs (Appendix C, Map 1) and from 1 to 5 fps in most areas at a discharge of 40,000 cfs (Appendix C, Map 5). At maximum generation flows, velocities of 6 fps are evident along an approximately 1-mile nearshore reach of the upper western shoreline

(Appendix C, Map 6). Elevated water velocities (~ 6 fps) are also present in much of the eastern channel of McGibney Island (described in Section 4.1.2) and in areas to the east and west of Roberts Island under the maximum generation scenario. Notable is that areas observed to contain SAV during the July-August 2010 habitat surveys contain some of the lowest velocities in the study area, even at maximum generation (Appendix C [Map 6]). Velocities under maximum generation flows are also relatively low (0 to 2 fps) in most areas where EAV growth was observed.

4.3.1 SAV Communities

As described in Section 4.2, SAV communities were present only along the peripheries of Roberts, Spencer, Wood, and Steel Islands, upstream of the mouth of Octoraro Creek, and in minimal reaches along the lower eastern and western river shorelines. Water velocities predicted from hydraulic modeling range between 0 and 2 fps across the majority of the study area at generation flows up to 20,000 cfs. These low velocities are not expected to exert adverse effects on communities of SAV that are established in areas containing sand and silt substrate (including mixed substrates of gravel/sand or gravel/silt). At higher generation flows (40,000 to 86,000 cfs), higher velocity waters (4 to 6 fps) are predicted in some areas; however, the majority of these areas are associated with the bedrock channel that has historically been sediment-limited by naturally turbulent, steep-gradient conditions that were present prior to the construction of the dam. These areas therefore have historically and are currently not suitable for the establishment of aquatic vegetation seed banks or propagules. Even under a full generation regime, low water velocities (0 to 2 fps) are predicted in the areas containing moderate to densely vegetated sediments such as the lower study area island complex shorelines.

The nearshore areas of the lower islands contain sandy and silty sediments co-located with coarser particles such as granule, pebble, cobble, and boulder. These coarse deposits provide some protection of finer sediments, until strong flow events in excess of the generating capacity of the Conowingo Project (86,000 cfs) rearrange the coarse material. Growth of submergent vegetation appears to be limited to areas of alluvium (e.g., the lower ends of the islands) and unconsolidated fine material where stabilized sediments allow colonization of vegetative root material. As described in the Sediment Introduction and Transport Study Report, the potential for bedload mobility generally increases along the peripheries of the islands. Based on that report, the sand and sand/gravel substrates at downstream ends of Roberts Island and Steel Island and pebble/sand substrate mid-channel between Spencer Island and the west shoreline are considered “highly mobile” at full generation. However, each of these areas was observed to contain moderate to heavy growth of SAV during the 2010 surveys, and have historically contained SAV based on the CBP surveys. Reduced water velocities in the lower portion of the study area coupled with the presence of soft sediment allows for the establishment of these SAV communities along the shorelines of these islands. During the growing season, SAV communities may mitigate substrate mobility by binding and trapping sediment grains.

Upstream of the mouth of Octoraro Creek, a significant bed of sparsely populated water milfoil is present growing within mixed gravel/sand substrates. Sediment mobility in this area is minimally affected by various flow releases from Conowingo Dam, as reported in the Sediment Introduction and Transport Study Report. The low water velocities and relative stability of the habitat across the generation range of flows provides suitable conditions for SAV growth in this area.

Water levels in areas containing SAV also remain relatively static, thus submergent communities do not become light-limited as a result of increasing depth. Prolonged periods of high flow are generally associated with turbid conditions that can contribute to sedimentation and lower light availability, thereby reducing the abundance of SAV (Orth et al. 2010). However, significant sedimentation events that may result in burial of SAV are likely to be associated with flows in excess of those resulting from Conowingo operations, based on the available literature (Langland and Hainly 1997).

The assessment of potential operational impacts requires consideration of seasonality. Submerged vegetation species common to the low salinity waters of the upper Chesapeake Bay and tributaries become established generally from July through September (CBF, undated). The presence of these species below Conowingo Dam generally coincides with periods of minimal water level fluctuation and low flows. River flows for the months of July, August, and September exceed a flow equivalent to the maximum generation at Conowingo (86,000 cfs) only 1.0 to 3.5 percent of the time, based on flow duration curves for the USGS Gage at Conowingo Dam (developed as part of the Hydrologic Study of the Lower Susquehanna River). Peaking operations at Conowingo are more infrequent during the summertime growing period than at other times of the year, minimizing the potential for effects associated with elevated generation flows on downstream SAV communities. In contrast, flows at or exceeding 86,000 cfs during the winter and spring seasons (December-May) occur approximately 9.9 to 22.5 percent of the time, based on the results of the Hydrologic Study of the Lower Susquehanna River. As such, although the potential effects of Project operations on downstream SAV communities is likely to be minimal, the likelihood of effects potentially exerted is minimized further by the timing of high flow/high water events, which more often occur during periods when SAV is not present. This is supported from the work of Wang and Linker (2005). Using a three-dimensional model for evaluating the response of SAV to nutrient and sediment loads in Chesapeake Bay, these authors determined that extreme storms can cause substantive damage to SAV communities if the storms occur at times of high

SAV shoot biomass, but have no significant impact on SAV if the storm takes place during periods outside of the SAV growing season (Wang and Linker 2005). The ability of Conowingo Dam to attenuate extreme river flows resulting from storms and natural high water events may enhance SAV growth below the dam.

4.3.2 EAV Communities

Growth of EAV below Conowingo Dam appears to be opportunistic, as would be expected in a natural river system. During the July-August 2010 habitat surveys, EAV was observed within the gravel-sand margins of the river and atop some bedrock and boulder outcrops. Water willow, the dominant EAV species in the study area, produces flexible fibrous stems that allow individual plants to withstand high flow events and scour. Field experiments of water willow in experimental reservoir systems demonstrated that this species is resistant to desiccation (Strakosh et al. 2005). Individual plants were able to tolerate up to 8 weeks of simulated drought conditions due to the water scavenging and storage faculties of this species' system of roots and rhizomes. Conversely, inundation trials from the Strakosh et al. (2005) study indicate that water willow is intolerant of flooding conditions. Mortality of water willow in simulated flooding conditions at 2-, 4-, 6-, and 8-week intervals yielded an overall mortality of 69%, compared to a mortality of 5% from simulated drought experiments over the same study intervals. Additionally, plants growing in controlled conditions (shallow depths) had significantly greater dry weights than plants growing for 4 weeks or more under flooding conditions. Moreover, water willow mortality was significant (40%) even under the shortest inundation duration (2 weeks), presumably due to light limitations resulting from decreased water clarity (Strakosh et al. 2005). Based on these results, the maintenance of EAV communities below Conowingo Dam are likely controlled more by water elevation than by flow intensities. This may explain why significant EAV growth was observed in the eastern channel of McGibney Island (Appendix A, Photos 19, 20, and 22), an area subject to elevated water velocities during periods of higher generation flows (see Appendix C, Map 6).

In the summertime, when generation flows are typically reduced and EAV growth is at its maximum, a greater proportion of the eastern and western river shorelines are exposed. Exposed shorelines containing unconsolidated sediment, either as a homogeneous matrix or in combination with larger diameter particles (e.g., gravel), facilitate root establishment by emergent species. Predicted relative water level rises are minimal in most areas containing EAV, and a higher proportion of bedrock outcrops with sufficient interstitial sediment for EAV colonization are available during this time period. Although water elevation changes in the lower portion of the study area in the vicinity of the island complex are predicted to be minimal and soft-bottom substrate is available for seed germination, greater water depths in these areas do not permit EAV to become established, even during low-flow periods. Notable exceptions are the upstream ends of Roberts Island and Steel Island, and near the mouth of Deer Creek (Figure 4.2-1). Much of these areas become inundated beginning at flows around 40,000 cfs (Appendix B, Map 5), which under prolonged periods (e.g., two weeks based on the Strakosh et al. [2005] study) may result in adverse effects or cause mortality in downstream emergent plants. Prolonged durations of elevated flows of 40,000 cfs are not typical below Conowingo Dam during the time when water willow growth is in full vigor (late spring into fall), and significant beds of this species were observed at locations in the upper study area that experience significant water level rises with incremental increases in generation flows. These areas include the mouth of Octoraro Creek and a densely vegetated ephemeral island located mid-river approximately 2,300 feet below Rowland Island (Figure 4.2-1, Appendix C). Water willow commonly inhabits flood-prone or variably fluctuating lotic waters that experience these conditions in late winter and spring when most vegetative species are still dormant (Haslam 1978, cited in Strakosh et al. 2005). Based on these results, EAV communities below Conowingo Dam are not likely to be impacted to a significant degree by Conowingo operations over the range of generation flows.

4.3.3 Species Use of Vegetated Habitats

Submerged aquatic vegetation provides cover habitat for a variety of macroinvertebrates and fishes, and is a source of forage for waterfowl. As discussed in Section 4.3.1, SAV communities identified and mapped during the July-August 2010 surveys are located in areas of minimal variability in water velocity and surface water elevation. Consequently, epiphytic macroinvertebrates associated with downstream SAV communities are not likely to be significantly affected by varying generation schemes at Conowingo. Fish may also use SAV communities for cover habitat. The overall stability of these communities over the range of generation flows is expected to supply viable habitat to important fish species that prefer sand and gravel substrates, shallow to moderate water depths, and reduced water velocity. Additionally, SAV beds provides stabilization of soft-bottomed substrates and effective buffering against storms, and therefore areas containing dense SAV (lower Roberts Island, upper Spencer Island, lower Steel Island) may serve as refugia for aquatic biota during high flow events.

EAV communities are capable of providing food and refuge for invertebrates and fishes; however, at lower flow conditions, EAV beds are not available to aquatic biota given that the habitat is in an unwetted state. For example, the majority of water willow beds characterized during the July-August 2010 habitat surveys were not inundated during the majority of the surveying period. The low but fluctuating flow conditions during the EAV growing season allow these emergent habitats to be accessed and used by clinging macroinvertebrates and small fish on an intermittent basis.

5.0 SUMMARY AND CONCLUSIONS

The primary objectives of the Downstream EAV/SAV Study were to identify, describe, and map habitats containing emergent and submergent aquatic vegetation from the vicinity of Conowingo Dam downstream to the lower end of Spencer Island, and to determine the extent of impacts to these vegetated habitats from Conowingo Project operations. The results of the July-August 2010 habitat study indicated that SAV communities were found in areas that are characterized by a greater abundance of fine-grained substrates relative to upstream areas, low water velocities, and limited water level fluctuation. The distribution of SAV observed in the lower island complex during the vegetated habitat survey are consistent with that recorded by VIMS in the late 1990s and early 2000s; however, historical SAV abundance in this area is highly variable, and is likely dependent on a number of naturally occurring (e.g., severe weather) and anthropogenic (nutrient input) variables that impact water clarity, an important limiting factor for the health of SAV communities. Based on the available literature, a clear link has been established between water clarity and native SAV abundance. Given that two non-native species (Eurasian watermilfoil, hydrilla) provided nearly all of the spatial coverage of SAV where it occurred, nutrient levels may be the overriding factor in the observed SAV distribution and diversity. Reductions in nutrient levels yield improved water quality and clarity, resulting in increases in native species abundance and diversity, and decreases in the fitness of invasive species (Chadwell and Engelhart 2008; Ruhl and Rybicki 2010).

The absence of SAV in the study area upstream of the lower island complex is attributable to the predominance of natural bedrock substrates that comprise this portion of the river. The exception to this pattern is the mouth of Octoraro Creek, where mixed gravel/sand substrates and low velocity waters facilitate SAV growth. Additionally, the availability of sediment for SAV establishment has historically been limited throughout the majority of the study area due to a naturally high river gradient and naturally turbulent conditions. Consequently, the distribution of SAV in the study area is largely a function of the availability of sediment. Within the range of generation flows, some potential exists for substrate instability within the lower island complex. However, moderate to dense growth of SAV has been observed in these areas historically and during the 2010 surveys. Based on these lines of evidence, the potential for effects related to the SAV community are likely associated with flows exceeding the generation capacity of Conowingo.

EAV communities identified during the 2010 habitat surveys were observed along river margins and creek mouths containing fine-grained depositional materials, and atop bedrock outcrops containing fine-grained sediment in interstitial spaces within the bedrock. The health and abundance of water willow, by far the most abundant EAV species in the study area, is largely a function of duration of inundation, according to the experimental results of Strakosh et al. (2005) and others cited in the Strakosh et al. study. Water velocity is not expected to be an important variable in explaining the variability in EAV coverage. Water willow plants have a sturdy root and creeping rhizomes, enabling the plants to firmly anchor to the substrate even under elevated flow conditions. The rhizomatous extensions enable it to form large colonies that are resistant to drought periods but sensitive to extended periods of inundation. The presence of water willow in areas where water fluctuations are significant (upper study area) indicate that periods of high water in these areas are of short duration during the water willow growing season. Current operational conditions provide frequent inundation of the EAV while limiting the magnitude of duration of inundation. As such, water willow grows opportunistically on substrates with sufficient sediment for seeds to germinate and for roots to gain a foothold. Fluctuating water levels from generation flows temporarily inundate EAV beds, providing needed water and nutrients for growth. Use of emergent habitats by aquatic biota is limited during periods of low flow, which render these habitats inaccessible.

Based on the available information from the 2010 habitat surveys, predictive hydraulic flow modeling, and sediment transport evaluation, it can be concluded that while Project operations are sufficient to alter the downstream flow regime, water levels, and mobility of sediment, aquatic vegetation in the downstream study area grows opportunistically on substrates where sufficient depositional material is present. The distribution of observed vegetation was found to be consistent with an unregulated river system, as operations may serve to attenuate the intensity and duration of high flow events. Limitations to vegetative growth appear to be a function of a lack of suitable substrates resulting from naturally high river gradient and turbulent conditions.

TABLE 3.2-1. SEDIMENT GRAIN SIZES AS DEFINED BY THE WENTWORTH SCALE [4].

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

[4] Leeder, M.R. 1982. Sedimentology: Process and Product. George Allen and Unwin, London.

TABLE 4.2-1. PROPORTION OF DOMINANT SAV SPECIES IN THE STUDY AREA BASED ON 2010 FIELD SURVEYS.

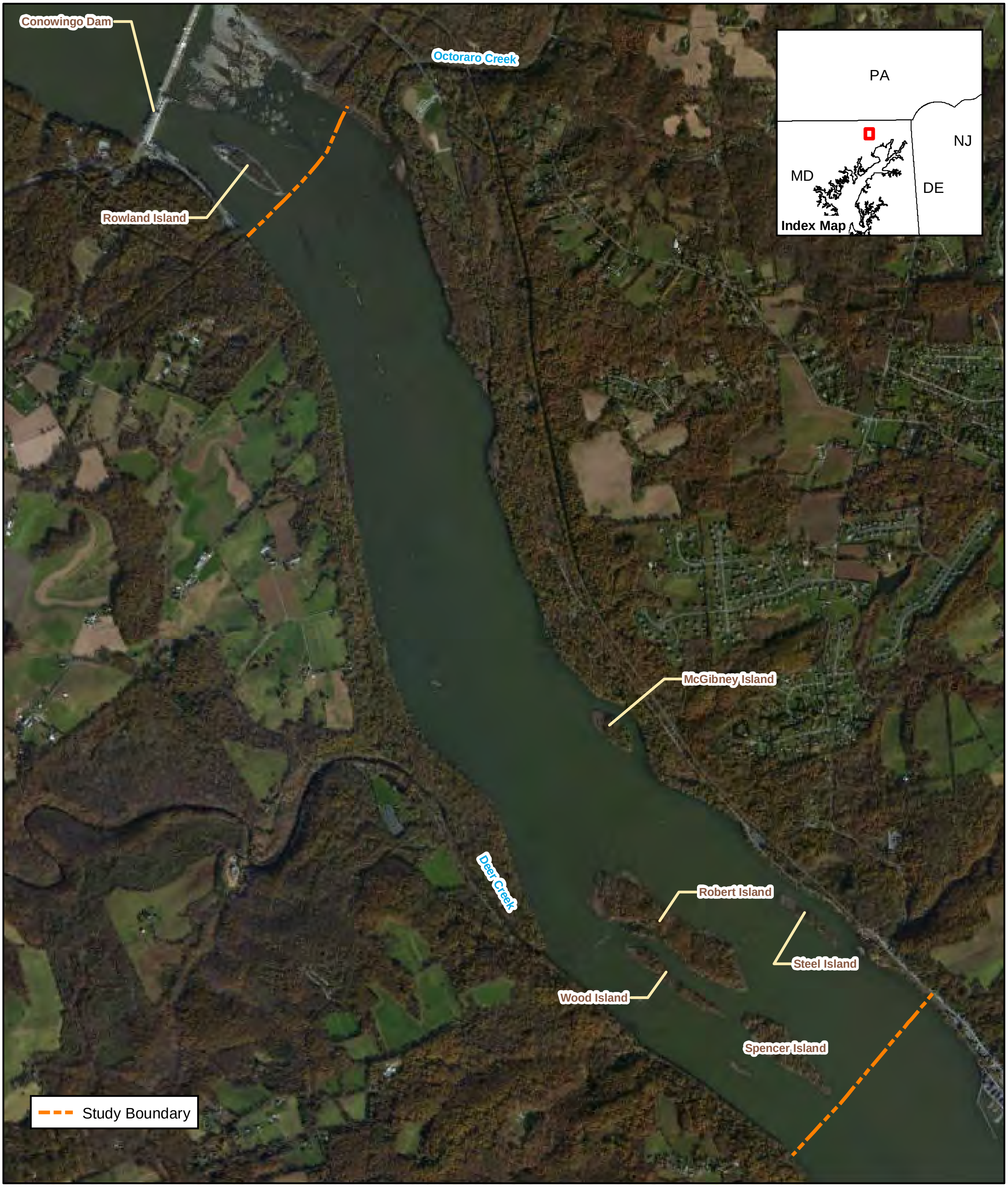
Species	Area (Percent of Total)
Eurasian Watermilfoil / Hydrilla - Heavy	1.38
Hydrilla - Minimal	0.59
Hydrilla - Moderate	0.67
Hydrilla - Heavy	2.51
Eurasian Watermilfoil - Sparse	44.14
Eurasian Watermilfoil - Minimal	8.82
Eurasian Watermilfoil - Moderate	17.78
Eurasian Watermilfoil - Heavy	24.12
Total:	**100**

TABLE 4.2-2. PROPORTION OF DOMINANT EAV SPECIES IN THE STUDY AREA BASED ON 2010 FIELD SURVEYS.

Species	Area (Percent of Total)
Water Pepper/Smartweed - Heavy	3.05
Water Willow - Sparse	3.15
Water Willow - Minimal	0.19
Water Willow - Moderate	57.58
Water Willow - Heavy	36.03
Total:	**100**

TABLE 4.2-3. SPECIES OF EAV AND SAV OBSERVED DURING 2010 FIELD SURVEYS.

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*
Smartweed	*Polygonum pennsylvanicum*	Wild Celery	*Vallisneria americana*
Common Dodder	*Cuscuta gronovii*		
Lady's Thumb	*Persicaria vulgaris*		
False Indigo	*Amorpha fruticosa*		
Water Dock	*Rumex hydrolapathum*		
Marsh Mallow	*Althaea officinalis*		
Stinging Nettle	*Urtica dioica*		



EXELON GENERATION COMPANY, LLC

DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

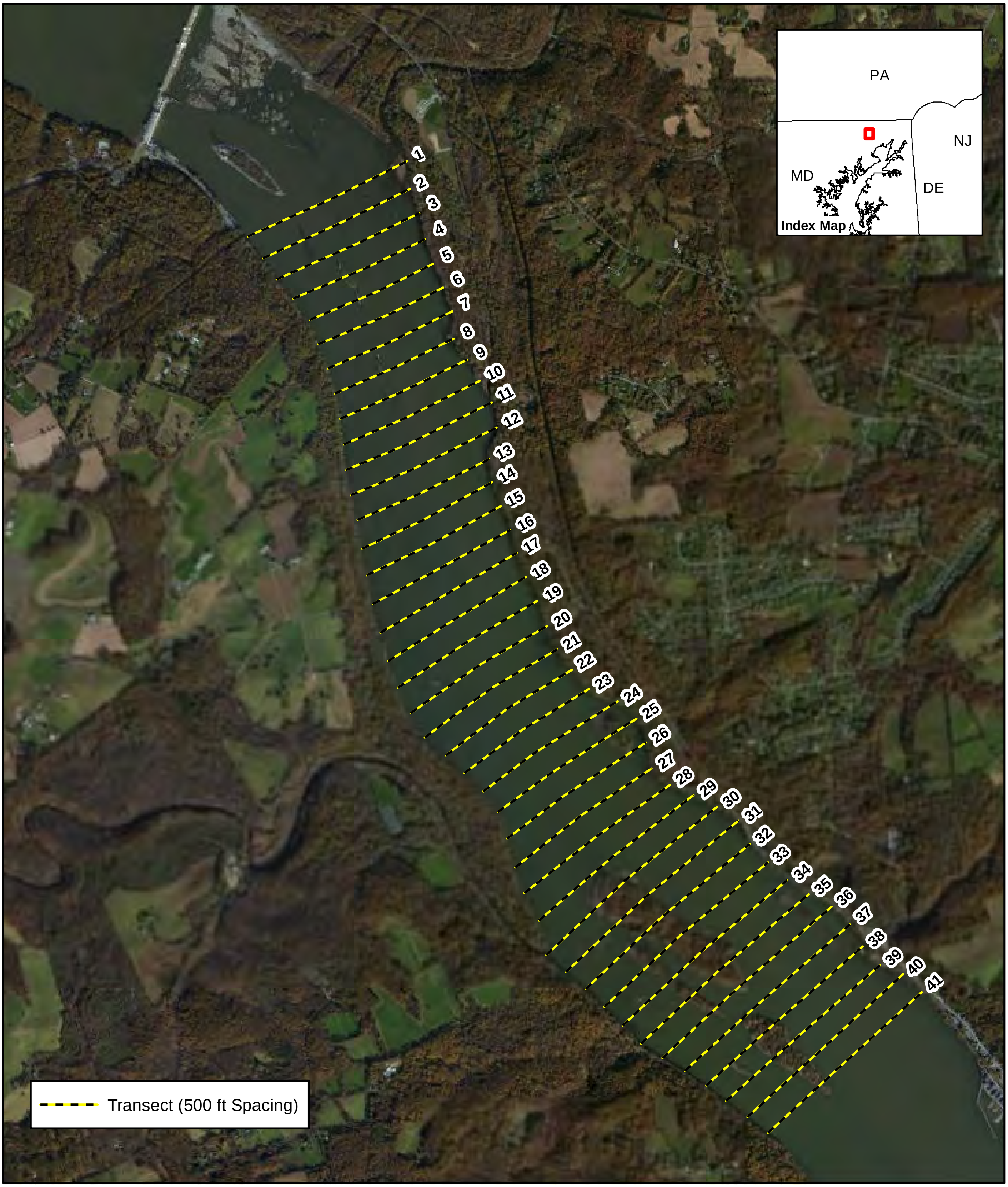
1 inch = 0.5 miles

0 0.25 0.5 1 Miles

N

Figure 1.2-1
Downstream EAV/SAV Study Area

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 1.2-1 Study Area.mxd



Exelon.

N

EXELON GENERATION COMPANY, LLC

DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

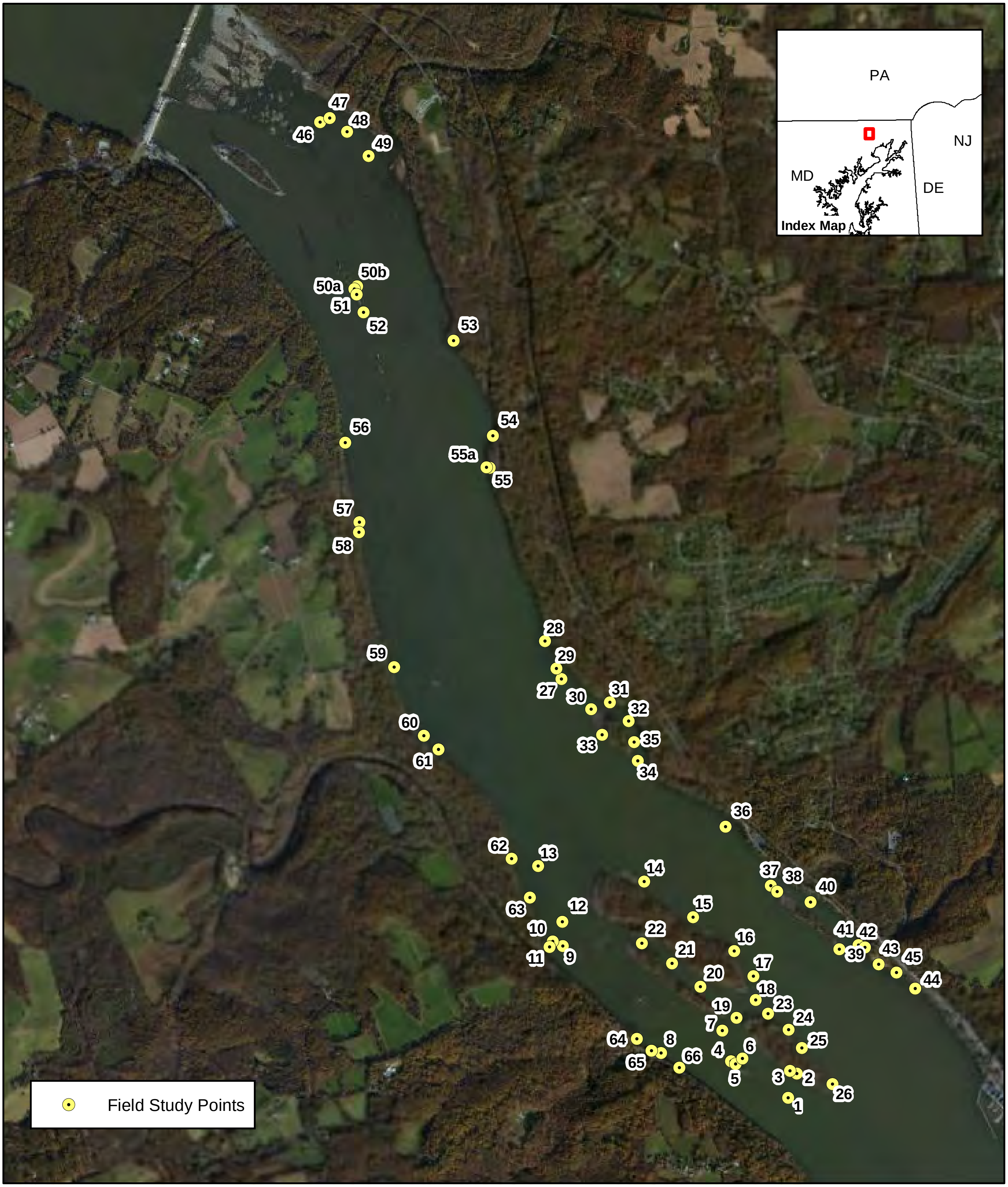
1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Figure 3.0-1
Pre-survey Transect Locations

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 3.0-1 Transects.mxd

FIGURE 3.1-1. WEED RAKE USED TO CHARACTERIZE THE SAV COMMUNITY IN THE PROJECT STUDY AREA.



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EXELON GENERATION COMPANY, LLC

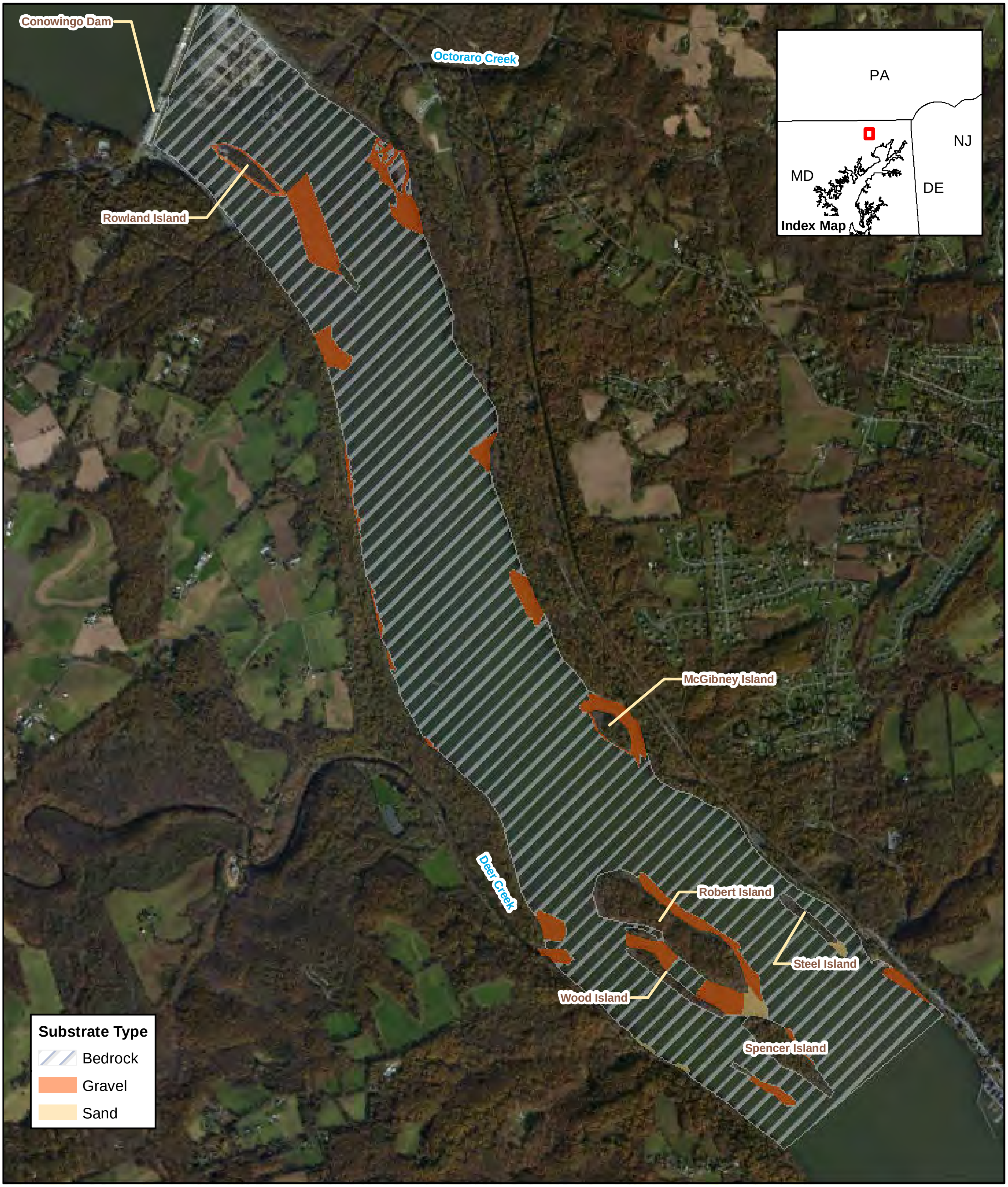
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Figure 4.0-1
Field Study Points Collected During the July-August 2010 Vegetation Surveys

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 4.0-1 StudyPoints.mxd



EXELON GENERATION COMPANY, LLC

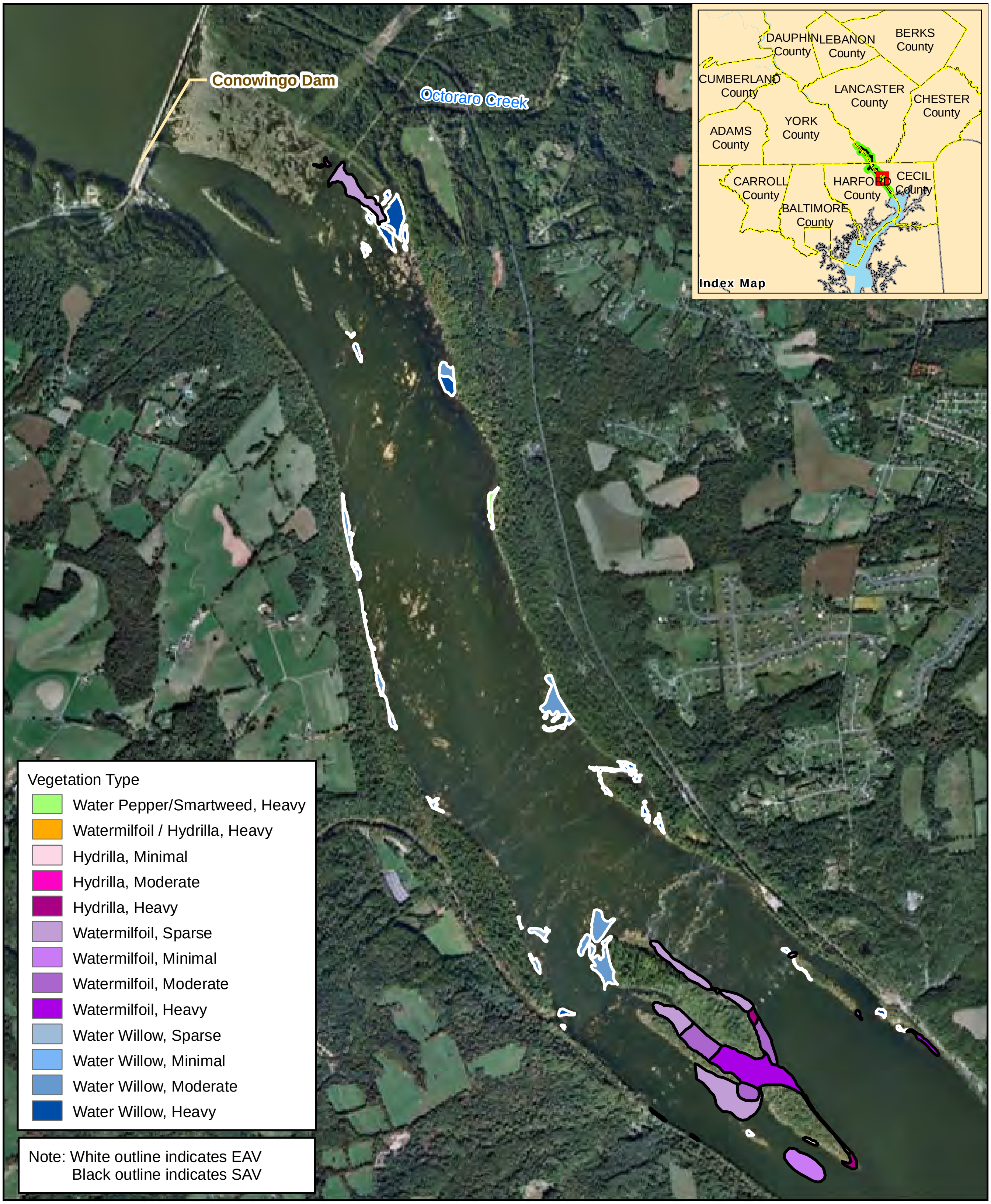
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Figure 4.1-1
Extent of Dominant Substrate Types Within the Study Area

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 4.1-1 Dom Substrate.mxd



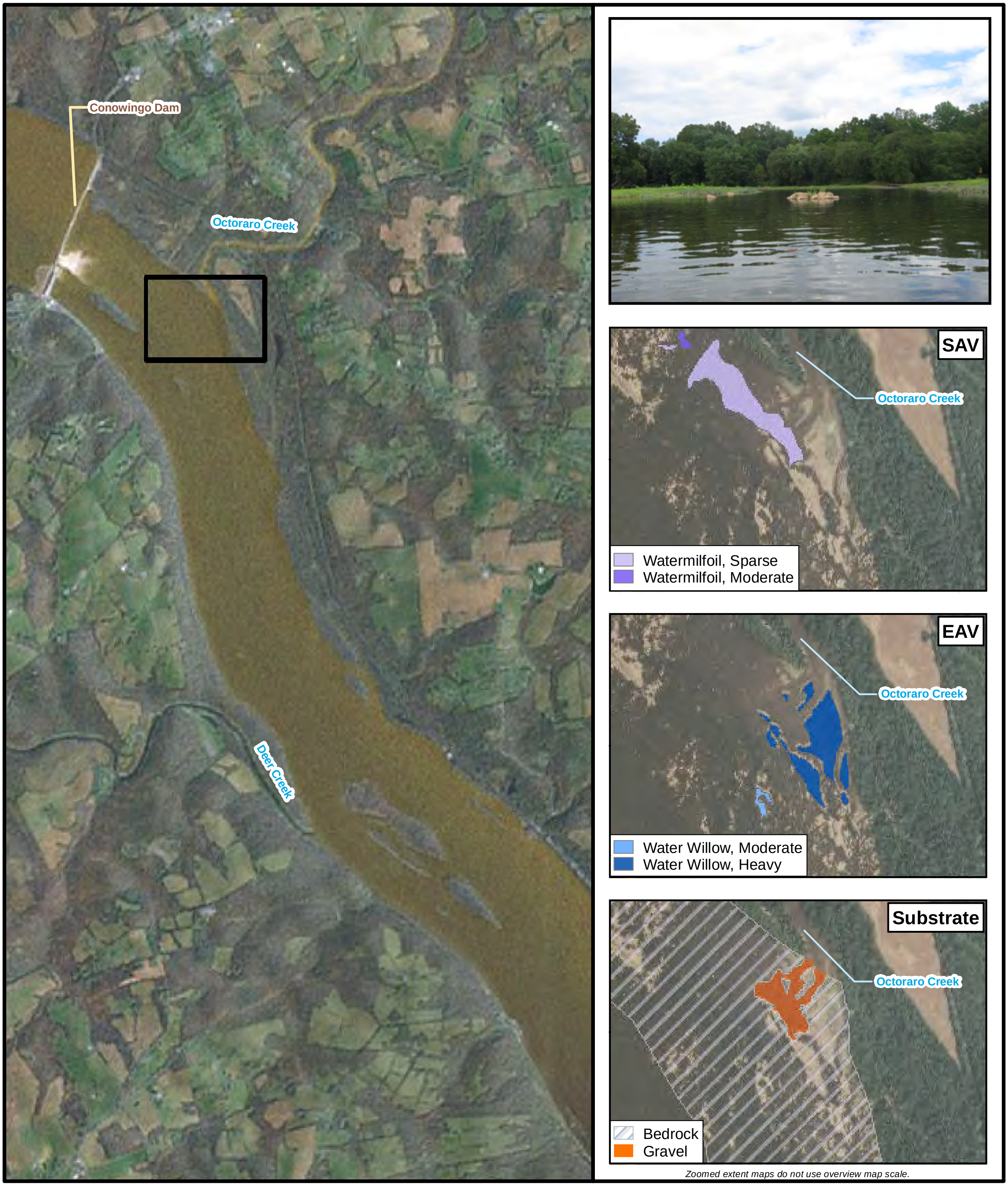
Exelon.

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NO. 405

Figure 4.2-1:
Extent of Dominant EAV & SAV
Within Study Area

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 4.2-1 Dom Vegetation.mxd



EXELON GENERATION COMPANY, LLC

DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

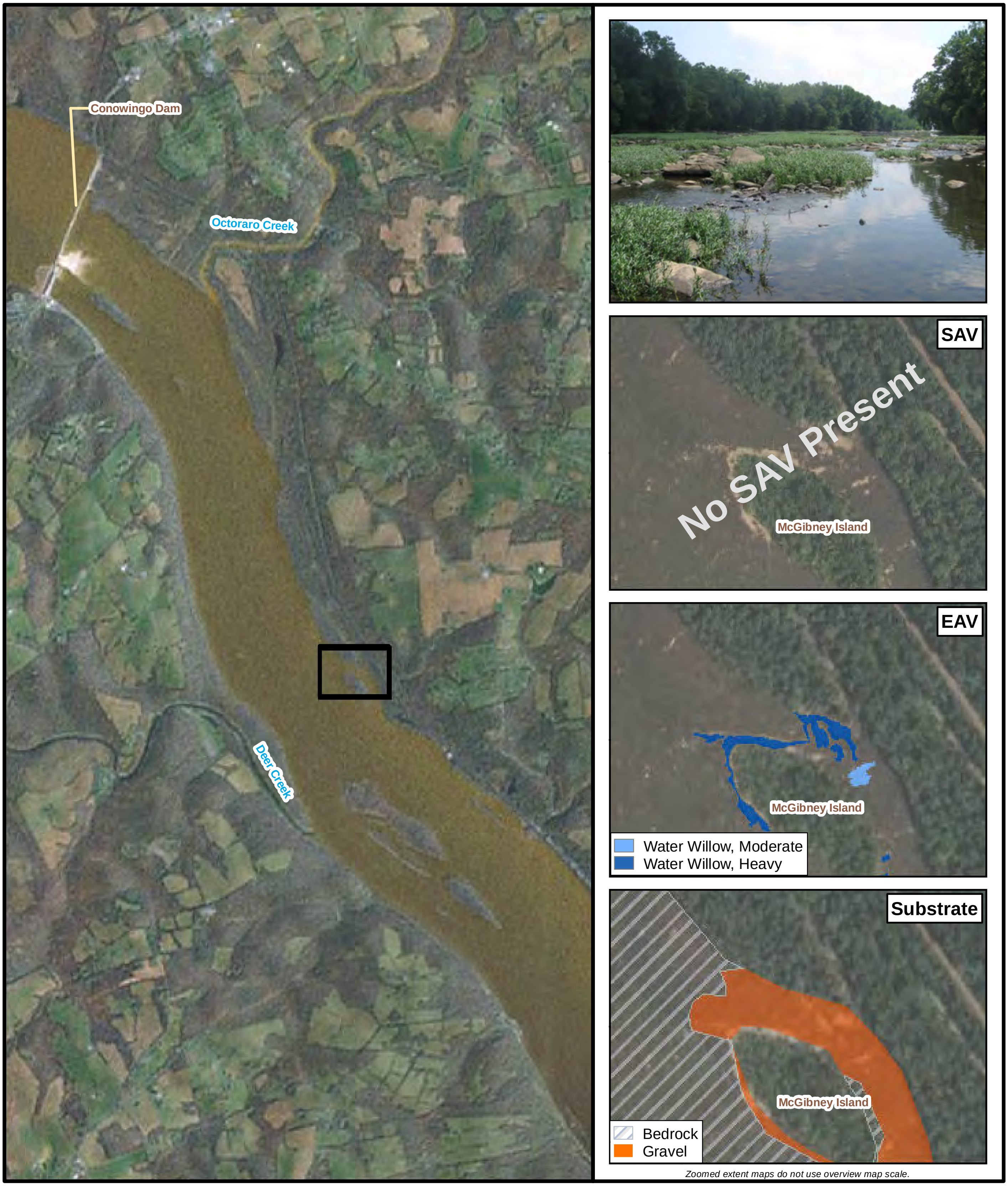
1 inch = 0.75 miles

0 0.25 0.5 1 Miles

N

Figure 4.2.1-1
Habitat Characteristics:
Mouth of Octoraro Creek

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 4.2.1-1 Octoraro Creek.mxd



EXELON GENERATION COMPANY, LLC

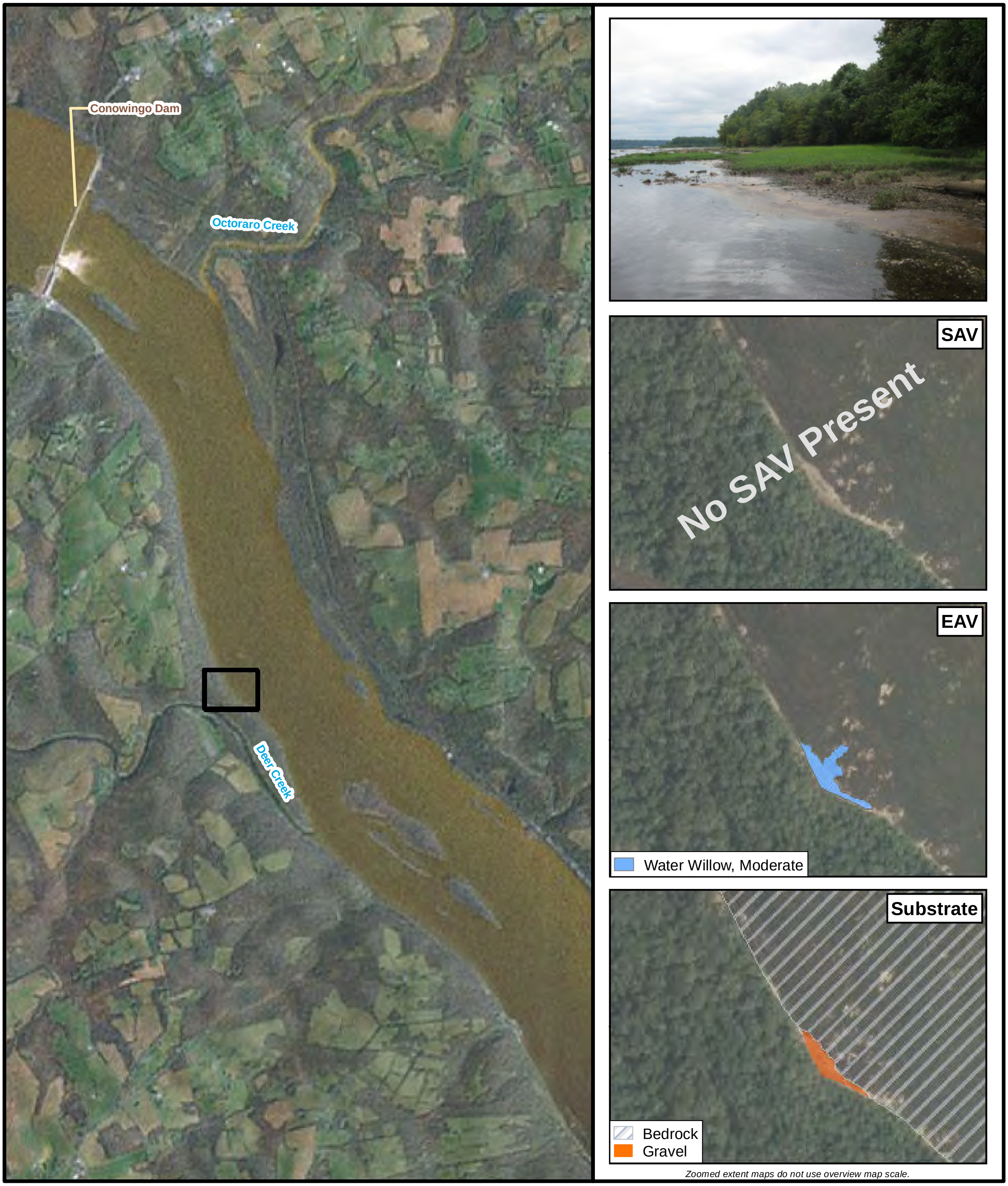
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.75 miles

0 0.25 0.5 1 Miles

Figure 4.2.2-1
Habitat Characteristics:
Eastern Shoreline near McGibney Island

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 4.2.2-1 McGibney.mxd



Exelon.

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EXELON GENERATION COMPANY, LLC

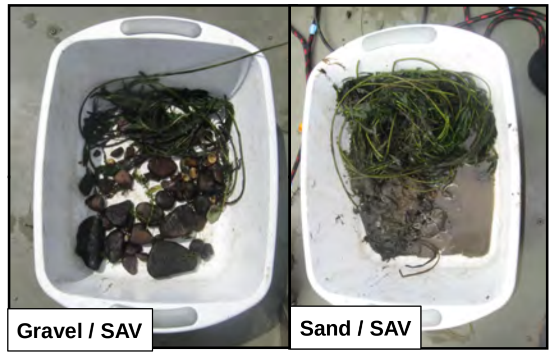
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

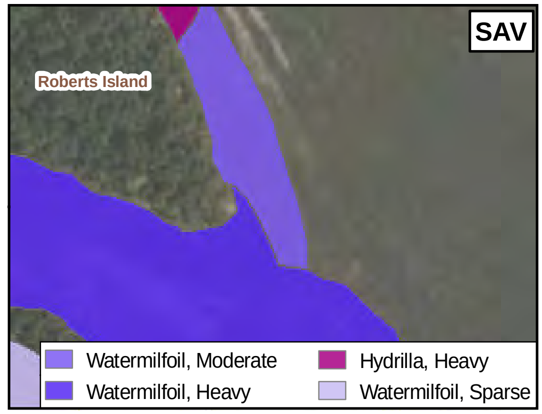
1 inch = 0.75 miles

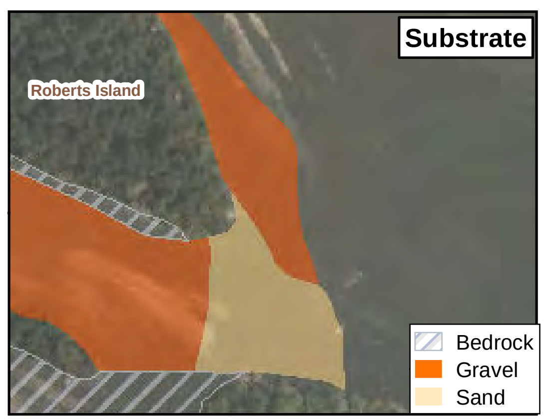
0 0.25 0.5 1
Miles

Figure 4.2.3-1
Habitat Characteristics:
Western Shoreline Above
Deer Creek Confluence

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 4.2.3-1 Deer Creek.mxd







Zoomed extent maps do not use overview map scale.

Exelon.

N

EXELON GENERATION COMPANY, LLC

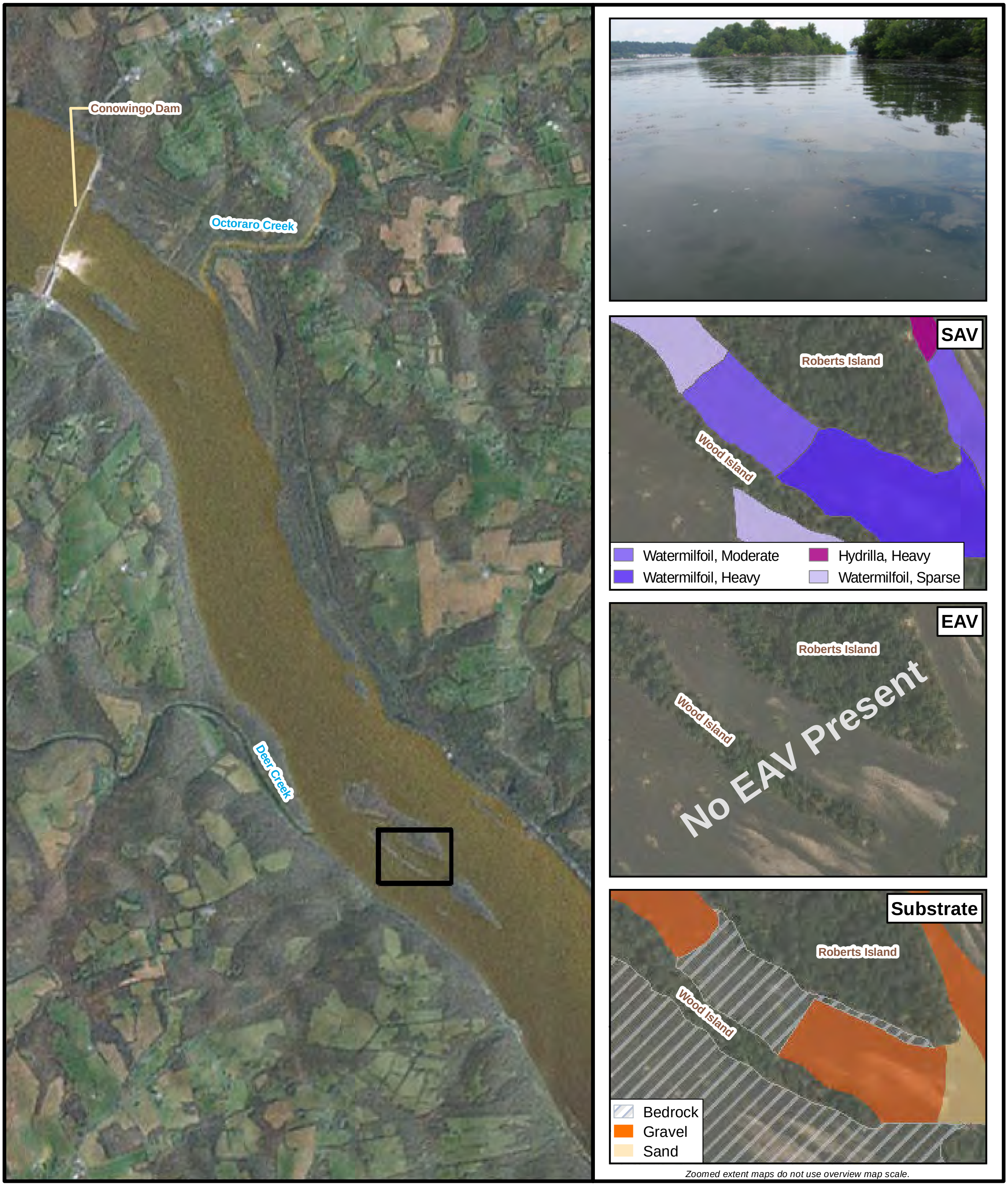
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.75 miles

0 0.25 0.5 1 Miles

Figure 4.2.4-1
Habitat Characteristics:
Lower Study Area Island Complex -
Between Roberts & Spencer Islands

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 4.2.4-1 Roberts_Spencer.mxd



N

1 inch = 0.75 miles

0 0.25 0.5 1 Miles

EXELON GENERATION COMPANY, LLC

DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure 4.2.4-2
Habitat Characteristics:
Lower Study Area Island Complex - between Roberts & Wood Island

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\Figure 4.2.4-2 Roberts_Wood.mxd

6.0 REFERENCES

Anderson, R.R and R.T. Macomber. 1980. Distribution of Submerged Vascular Plants, Chesapeake Bay, Maryland. Final Report. USEPA Chesapeake Bay Program. Cited in Orth, R. J and K.A. Moore (1984).

Chadwell, T.B., and K.A.M. Englehardt. 2008. Effects of pre-existing submersed vegetation and propagule pressure on the invasion success of *Hydrilla verticillata*. Journal of Applied Ecology 45:515-523.

Chesapeake Bay Foundation (CBF). Undated. Chesapeake Bay Foundation Guide to Underwater Grasses. http://www.cbf.org/Document.Doc?id=188.

Chesapeake Bay Program (CBP). 2010. Underwater Bay Grasses Increase 12 Percent in Bay and Rivers in 2009. http://www.chesapeakebay.net/news_savin09.aspx?menuitem=50889. April 2010.

Davis, F.W. 1985. Historical changes in submerged macrophyte communities of the Upper Chesapeake Bay. Ecology 66(3):981-993.

Exelon Generating Company, LLC (Exelon). 2009. Conowingo Project. FERC Project No. 405. Pre-Application Document. March 2009.

Fassett, N.C. 1985. A Manual of Aquatic Plants. 3rd Edition. The University of Wisconsin Press, Madison, WI. 405 pp.

Federal Energy Regulatory Commission (FERC). 1989. Order Approving Settlement Agreement for the Conowingo Hydroelectric Project, Project No. 405-009. Docket No. EL80-38-000. January 24, 1989.

Federal Energy Regulatory Commission (FERC). 2010. Exelon Generation Company, LLC Order Approving Temporary Variance, Project No. 405-074. August 12, 2010.

Haslam, S.M. 1978. River Plants: The Macrophytic Vegetation of Watercourses. Cambridge University Press, Cambridge, U.K.

Kemp, W.M., W.R. Boynton, J.C. Stevenson, J.C. Means, R.R. Twilley, and T.W. Jones. 1984. Submerged Aquatic Vegetation in Upper Chesapeake Bay: Studies Related to Possible Causes of the Recent Decline in Abundance. United States Environmental Protection Agency, Chesapeake Bay Program. EPA-600/S3-84-015. February 1984.

Langland, M.J. and R.A. Hainly. 1997. Changes in Bottom-Surface Elevations in Three Reservoirs on the Lower Susquehanna River, Pennsylvania and Maryland, Following the January 1996 Flood –

Implications for Nutrient and Sediment Loads to Chesapeake Bay. United States Geological Survey Water-Resources Investigations Report 97-4138. 34pp.

Leeder, M.R. 1982. Sedimentology: Process and Product. George Allen and Unwin, London.

Orth, R.J., and K.A. Moore. 1983. Chesapeake Bay: an unprecedented decline in submerged aquatic vegetation. Science 325:1124-1128.

Orth, R.J., and K.A. Moore. 1984. Distribution and abundance of submerged aquatic vegetation in Chesapeake Bay: An historical perspective. Estuaries 7: 531–540.

Orth, R.J., R.A. Batiuk, P.W. Bergstrom, and K.A. Moore. 2002. A perspective on two decades of policies and regulations influencing the protection and restoration of submerged aquatic vegetation in Chesapeake Bay, USA. Bulletin of Marine Science 71:1391-1403.

Orth, R.J., D.J. Wilcox, L.S. Nagey, A.L. Owens, J.R. Whiting, and A. Kenne. 2005. 2004 Distribution of submerged aquatic vegetation in the Chesapeake Bay. VIMS Special Scientific Report Number 146. Final Report to NOAA, Washington, D.C.

Orth, R.J., D.J. Wilcox, L.S. Nagey, A.L. Owens, J.R. Whiting, and A. Kenne. 2006. 2005 Distribution of submerged aquatic vegetation in the Chesapeake Bay. VIMS Special Scientific Report Number 147. Final Report to NOAA, Washington, D.C.

Orth, R.J., D.J. Wilcox, L.S. Nagey, A.L. Owens, J.R. Whiting, and A. Kenne. 2007. 2006 Distribution of submerged aquatic vegetation in the Chesapeake Bay. VIMS Special Scientific Report Number 150. Final Report to NOAA, Washington, D.C.

Orth, R.J., D.J. Wilcox, L.S. Nagey, A.L. Owens, J.R. Whiting, and A. Kenne. 2008. 2007 Distribution of submerged aquatic vegetation in the Chesapeake Bay. VIMS Special Scientific Report Number 151. Final Report to NOAA, Washington, D.C.

Orth, R.J., D.J. Wilcox, L.S. Nagey, A.L. Owens, J.R. Whiting, and A. Kenne. 2009. 2008 Distribution of submerged aquatic vegetation in the Chesapeake Bay. VIMS Special Scientific Report Number 152. Final Report to NOAA, Washington, D.C.

Orth, R.J., M.R. Williams, S.R. Marion, D.J. Wilcox, T.J.B. Carruthers, K.A. Moore, W.M. Kemp, W.C. Dennison, N. Rybicki, P. Bergstrom, and R.A. Batiuk. 2010. Long-term trends in submersed aquatic vegetation (SAV) in Chesapeake Bay, USA, related to water quality. Estuaries and Coasts. DOI 10.1007/s12237-010-9311-4.

Ruhl, H.A., and N.B. Rybicki. 2010. Long-term reductions in anthropogenic nutrients link to improvements in Chesapeake Bay habitat. Proceedings of the National Academy of Sciences 107(38):16566-16570.

Strakosh, T.R., J.L. Eitzmann, K.B. Gido, and C.S. Guy. 2005. The response of water willow *Justicia americana* to different water inundation and desiccation regimes. North American Journal of Fisheries Management 25:1476-1485.

Strakosh, T.R., K.B. Gido, and C.S. Guy. 2009. Effects of water willow establishment on density, growth, diet, and condition of age-0 largemouth bass in Kansas reservoirs. Transactions of the American Fisheries Society 138:269-279.

Trimble. 2010. GeoXH Handheld. http://www.trimble.com/geoxh.shtml.

Virginia Institute of Marine Science (VIMS). 2011. SAV in Chesapeake Bay and Coastal Bays. http://web.vims.edu/bio/sav/index.html.

Wang, P. and L.C. Linker 2005. Effect of timing of extreme storms on Chesapeake Bay submerged aquatic vegetation. In: K.G. Sellner, Ed. Hurricane Isabel in Perspective. vChesapeake Research Consortium, CRC Publication 05-160, Edgewater, MD.

Ward, L.G., W.M. Kemp, and W.R. Boynton. 1984. The influence of waves and seagrass communities in the lower Chesapeake Bay. Marine Geology 59:85-103.

Williams, S.J., M.A. Arsenault, B.J. Buczkowski, J.A. Reid, J.G Flocks, M.A. Kulp, S. Penland, and C.J. Jenkins. 2006. Surficial sediment character of the Louisiana Offshore Continental Shelf Region: a GIS Compilation. U.S. Geological Survey Open-File Report 2006-1195.

APPENDIX A-PHOTOGRAPHIC LOG OF EAV AND SAV COMMUNITIES BELOW CONOWINGO DAM

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 1 **Date:** 7/27/10

Direction Photo Taken:

Description:

Minimal growth of submerged aquatic vegetation (SAV) at Point 1 between Spencer Island and western shoreline of river. Dominant species observed at this location included Eurasian watermilfoil (*Myriophyllum spicatum*) and hydrilla (*Hydrilla verticillata*).

Photo No. 2 **Date:** 7/27/10

Direction Photo Taken:

Description:

River substrate at Point 1. The substrate is comprised predominantly of pebbles. Shells of the invasive Asiatic clam (*Corbicula* sp.) are also present.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No.	Date:
3	7/27/10

Direction Photo Taken:

Description:

Minimal SAV at Point 2 along eastern shoreline of Spencer Island.

Photo No.	Date:
4	7/27/10

Direction Photo Taken:

Description:

River substrate and SAV at Point 2. The substrate here is composed mainly of pebbles poorly sorted with coarse sand. The dominant SAV species is hydrilla, with wild celery (*Vallisneria americana*) secondary in dominance.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 5 | **Date:** 7/27/10

Direction Photo Taken:

Southwest

Description:

Dense bed of emergent aquatic vegetation (EAV) at the eastern shore of small island west of Spencer Island (Point 4). Water willow (*Justicia* sp.) is the dominant EAV species. Note the presence of common dodder (*Cuscuta gronovii*), a parasitic plant growing atop the water willow.

Photo No. 6 | **Date:** 7/27/10

Direction Photo Taken:

Description:

SAV at Point 7 west of upstream tip of Spencer Island. The dominant SAV in this area is Eurasian watermilfoil. Bedrock dominates the river substrate.

URS	PHOTOGRAPHIC LOG	
Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	**Project No.** 19998822.85317

Photo No. 7	**Date:** 7/27/10
Direction Photo Taken: Northwest	
Description: Heavy growth of EAV along the mouth of Deer Creek (Points 9, 10, and 11). Water willow is the dominant species of EAV here.	

Photo No. 8	**Date:** 7/27/10
Direction Photo Taken: Northeast	
Description: Upstream end of Roberts Island. Note the lush growth of water willow within the interstitial spaces of boulders and bedrock.	

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 9 | **Date:** 7/27/10

Direction Photo Taken:

Description:

Sparsely populated SAV is present north of the upstream tip of Roberts Island (Point 14). Eurasian watermilfoil was the only SAV species observed here. Boulder dominates the river bottom.

Photo No. 10 | **Date:** 7/27/10

Direction Photo Taken:

South

Description:

Heavy SAV growth east of lower end of Roberts Island (Point 16). Hydrilla is the primary SAV species at this location. Wild celery is also present.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 11 **Date:** 7/27/10

Direction Photo Taken:

Description:

SAV and river substrate at Point 16. The river bottom is comprised primarily of pebbles poorly sorted with granules and coarse to fine sand. Hydrilla is the SAV species shown in the photograph.

Photo No. 12 **Date:** 7/27/10

Direction Photo Taken:

Description:

SAV and river substrate east of downstream end of Roberts Island (Point 17). Eurasian watermilfoil comprises the majority of the moderate SAV community here. Pebbles are the dominant grain size.

URS	**PHOTOGRAPHIC LOG**

Client Name:	**Project Name/Site Location:**	**Project No.**
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 13 | **Date:** 7/27/10

Direction Photo Taken:

Description:

Substrate and SAV at accretionary area between Spencer Island and Roberts Island (Point 18). Eurasian watermilfoil and, secondarily, hydrilla comprise the majority of the SAV community. The dominant substrate is medium sand poorly sorted with silt.

Photo No. 14 | **Date:** 7/27/10

Direction Photo Taken:

Description:

SAV between Wood Island and Spencer Island (Point 19). Heavy growth of Eurasian watermilfoil is present in this area. Bedrock with lesser amounts of pebbles comprise the river bottom here.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 15 **Date:** 7/27/10

Direction Photo Taken:

Northwest

Description:

SAV between lower portions of Wood Island and Roberts Island (Point 20). Moderate growth of primarily Eurasian watermilfoil is present in this area. Cobbles comprise the majority of the river bottom.

Photo No. 16 **Date:** 7/27/10

Direction Photo Taken:

Description:

SAV and river substrate east of upstream end of Spencer Island (Point 23). Eurasian watermilfoil comprises the majority of the moderate SAV community here. A heavy narrow band of hydrilla is also present along the shoreline. Bedrock is the dominant grain size, followed by pebbles.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 17 **Date:** 7/27/10

Direction Photo Taken:

Description:

SAV east of central portion of Spencer Island (Points 24 and 25). Hydrilla and wild celery occur as co-dominant SAV species in this area. Boulder is the dominant substrate type.

Photo No. 18 **Date:** 7/27/10

Direction Photo Taken:

Description:

SAV east of downstream end of Spencer Island (Point 26). A heavy populated fringe of hydrilla dominates the SAV community along the island shoreline. Eurasian watermilfoil and wild celery become more common with increasing distance from the shoreline. Bedrock is the dominant grain size.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No.	Date:
19	7/28/10

Direction Photo Taken:

Southeast

Description:

Heavy growth of water willow at upper end of McGibney Island (Point 30). Boulders comprise the majority of the river bottom along the island shoreline.

Photo No.	Date:
20	7/28/10

Direction Photo Taken:

Northwest

Description:

Water willow beds east of upper end of McGibney Island (Point 31).

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 21	Date: 7/28/10

Direction Photo Taken:

Northwest

Description:

EAV community along western shoreline of McGibney Island (Point 33). Water willow is the dominant species. This EAV bed extends to the upstream end of the island (Point 30).

Photo No. 22	Date: 7/28/10

Direction Photo Taken:

Description:

Heavy growth of water willow along southern shoreline of McGibney Island. Boulders comprise the majority of the substrate.

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	**Project No.** 19998822.85317

Photo No. 23 | **Date:** 7/28/10

Direction Photo Taken:

West

Description:

Water willow covering the majority of the surface of a small island northwest of Steel Island (Point 37). No SAV was present in the waters surrounding the island.

Photo No. 24 | **Date:** 7/28/10

Direction Photo Taken:

Description:

Sparse SAV is present at Point 38, located between Point 37 (small island) and Steel Island. The SAV here is dominated by Eurasian watermilfoil. Bedrock is the dominant substrate type.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 25

Date: 7/28/10

Direction Photo Taken:

Description:

An accretionary feature is present below the downstream end of Steel Island (Point 39). Moderate growth of SAV occurs here, and is largely comprised of Eurasian watermilfoil. Substrate is comprised of medium sand poorly sorted with fine sand and silt.

Photo No. 26

Date: 7/28/10

Direction Photo Taken:

Southeast

Description:

Small spit of emergent vegetation east of Steel Island (Point 41). Riparian vegetation here includes water willow, purple loosestrife (*Lythrum salicaria*), false indigo (*Amorpha fruticosa*), and water dock (*Rumex hydrolapathum*).

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 27 | **Date:** 7/28/10

Direction Photo Taken:

East

Description:

Water willow beds at Point 43 along eastern river shoreline. Riparian vegetation here is dominated by water willow.

Photo No. 28 | **Date:** 7/28/10

Direction Photo Taken:

Description:

SAV and river substrate along eastern river shoreline (Point 45). Moderate growth of co-dominant Eurasian watermilfoil and hydrilla occurs in this area. Granules poorly sorted with coarse sand and silt comprise the river substrate.

URS **PHOTOGRAPHIC LOG**

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	**Project No.** 19998822.85317

Photo No. 29 | **Date:** 8/23/10

Direction Photo Taken:

Southeast

Description:

Moderate growth of Eurasian watermilfoil at Point 47 below Conowingo Dam spillway. The river bottom in this area is composed mainly of bedrock. Cobbles, granules, and Asiatic clam shells are also common components of the substrate here.

Photo No. 30 | **Date:** 8/23/10

Direction Photo Taken:

Northwest

Description:

Bedrock and boulder islands below Conowingo Dam spillway. Many of the islands here and upstream are covered with emergent vegetation, including water willow and purple loosestrife.

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	**Project No.** 19998822.85317

Photo No. 31 **Date:** 8/23/10

Direction Photo Taken:

Northwest

Description:

Eurasian watermilfoil bed (beyond bedrock "island") at Point 48. Hydrilla and water stargrass (*Heteranthera dubia*) are also present in this area.

Photo No. 32 **Date:** 8/23/10

Direction Photo Taken:

North

Description:

Bedrock/boulder substrate and sparse vegetation at Point 49. Eurasian watermilfoil is the dominant SAV species here, followed by hydrilla.

PHOTOGRAPHIC LOG		
Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	**Project No.** 19998822.85317

Photo No. 33 | **Date:** 8/23/10

Direction Photo Taken:

Description:

Blooming water willow downstream of Point 49.

Photo No. 34 | **Date:** 8/23/10

Direction Photo Taken:

North

Description:

Mouth of Octoraro Creek. This area is characterized by shallow water depths, pebble substrates, and an absence of submerged vegetation.

URS

PHOTOGRAPHIC LOG

Client Name: Gomez & Sullivan	**Project Name/Site Location:** Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	**Project No.** 19998822.85317

Photo No. 35

Date: 8/23/10

Direction Photo Taken:

Northwest

Description:

Water willow-dominated "islands" downstream of Point 49.

Photo No. 36

Date: 8/23/10

Direction Photo Taken:

West

Description:

Heavy growth of water willow at downstream end of Bird Island (Point 50A). The river substrate in this area is characterized by boulder poorly sorted with cobble. Common dodder is also present growing atop the water willow.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 37 **Date:** 8/23/10

Direction Photo Taken:

Northwest

Description:

Downstream end of small unnamed ephemeral island containing a heavy growth of water willow (Point 52). Purple loosestrife is also present on the island.

Photo No. 38 **Date:** 8/23/10

Direction Photo Taken:

Northwest

Description:

Moderate EAV community at Point 53. Water willow is the dominant species. Other emergent species include water pepper (*Polygonum hydropiper*) and marsh mallow (*Althaea officinalis*).

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 39 | **Date:** 8/23/10

Direction Photo Taken:

Northwest

Description:

Water pepper and marsh mallow plants at Point 53.

Photo No. 40 | **Date:** 8/24/10

Direction Photo Taken:

Southeast

Description:

Heavy growth of water pepper along western shore of unnamed island (Point 54). Other emergent species include lady's thumb (*Persicaria vulgaris*) and smartweed (*Polygonum* sp.). The riparian substrate is composed primarily of boulder, with some cobble.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No.	Date:
41	8/24/10

Direction Photo Taken:

South

Description:

Upstream extent of water willow bed along eastern river shoreline (Point 55A). Boulder is the dominant grain size, followed by cobble.

Photo No.	Date:
42	8/24/10

Direction Photo Taken:

South

Description:

Northern extent of water willow bed along western river shoreline (Point 56). The river substrate is comprised predominantly of boulder, with cobble secondary in importance.

PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No.	Date:
43	8/24/10

Direction Photo Taken:

Southeast

Description:

Upstream end of EAV community on western river shoreline (Point 58). Boulder is the dominant substrate type.

Photo No.	Date:
44	8/24/10

Direction Photo Taken:

Southeast

Description:

EAV community dominated by water willow along western river shoreline (Point 60). The substrate is composed of cobble. Pebble is the second most abundant grain size in this area.

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PHOTOGRAPHIC LOG

Client Name:	Project Name/Site Location:	Project No.
Gomez & Sullivan	Exelon Conowingo Hydroelectric Project Relicensing Downstream EAV/SAV Study Cecil and Harford Counties, Maryland	19998822.85317

Photo No. 45 **Date:** 8/24/10

Direction Photo Taken:

Southeast

Description:

Water willow community on western river shoreline (Point 63).

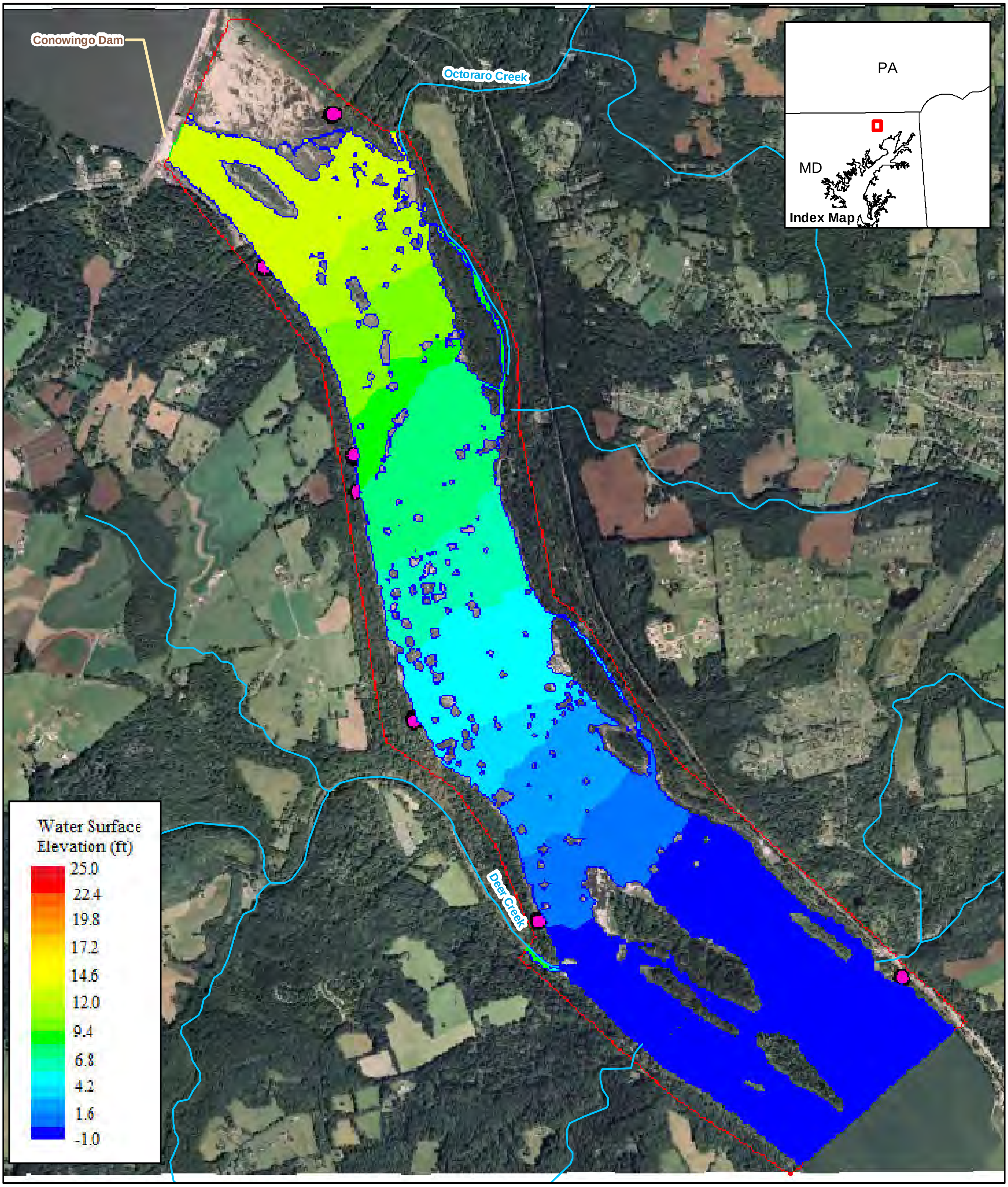
Photo No. 46 **Date:** 8/24/10

Direction Photo Taken:

Description:

Heavy growth of hydrilla along western river shoreline (Point 66). The substrate here is characterized as coarse sand poorly sorted with boulder. Small pockets of silt are also present in this area.

APPENDIX B-WATER ELEVATION DATA BELOW CONOWINGO DAM



EXELON GENERATION COMPANY, LLC

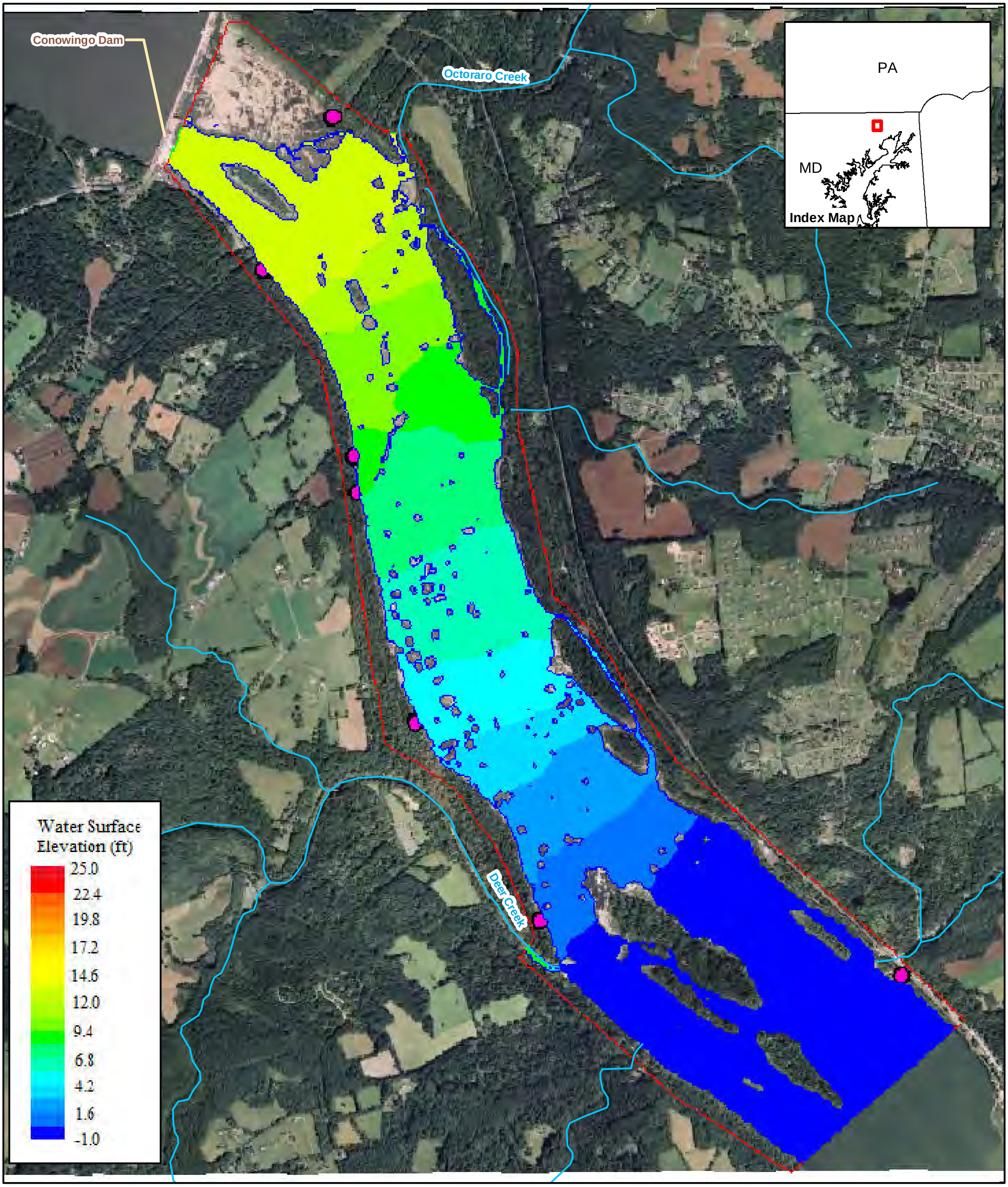
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Appendix B - Map 1
Water Surface Elevation - 3,500

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WSE_3500.mxd



Exelon.

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EXELON GENERATION COMPANY, LLC

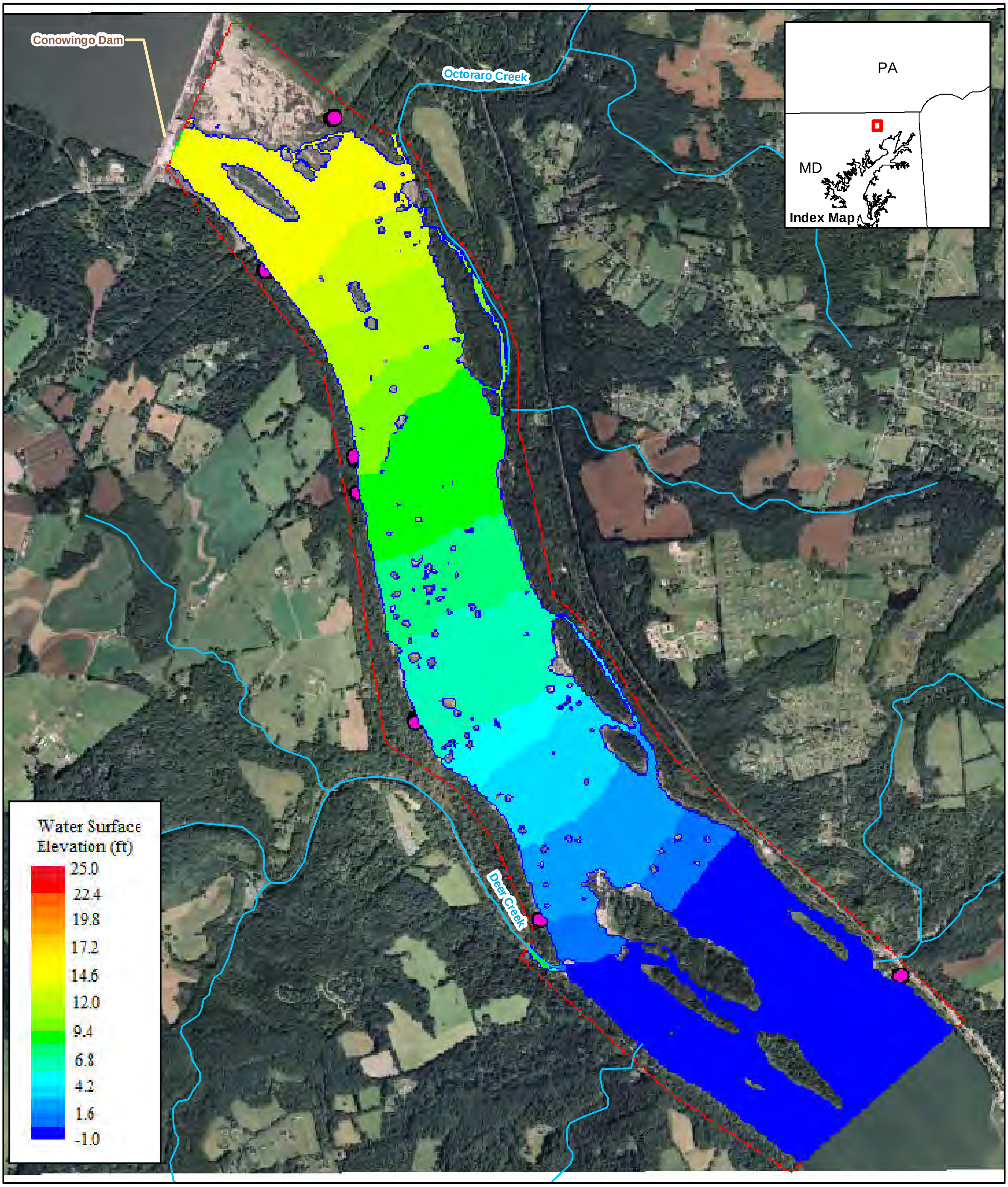
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Appendix B - Map 2
Water Surface Elevation - 5,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WSE_5000.mxd



Exelon

N

EXELON GENERATION COMPANY, LLC

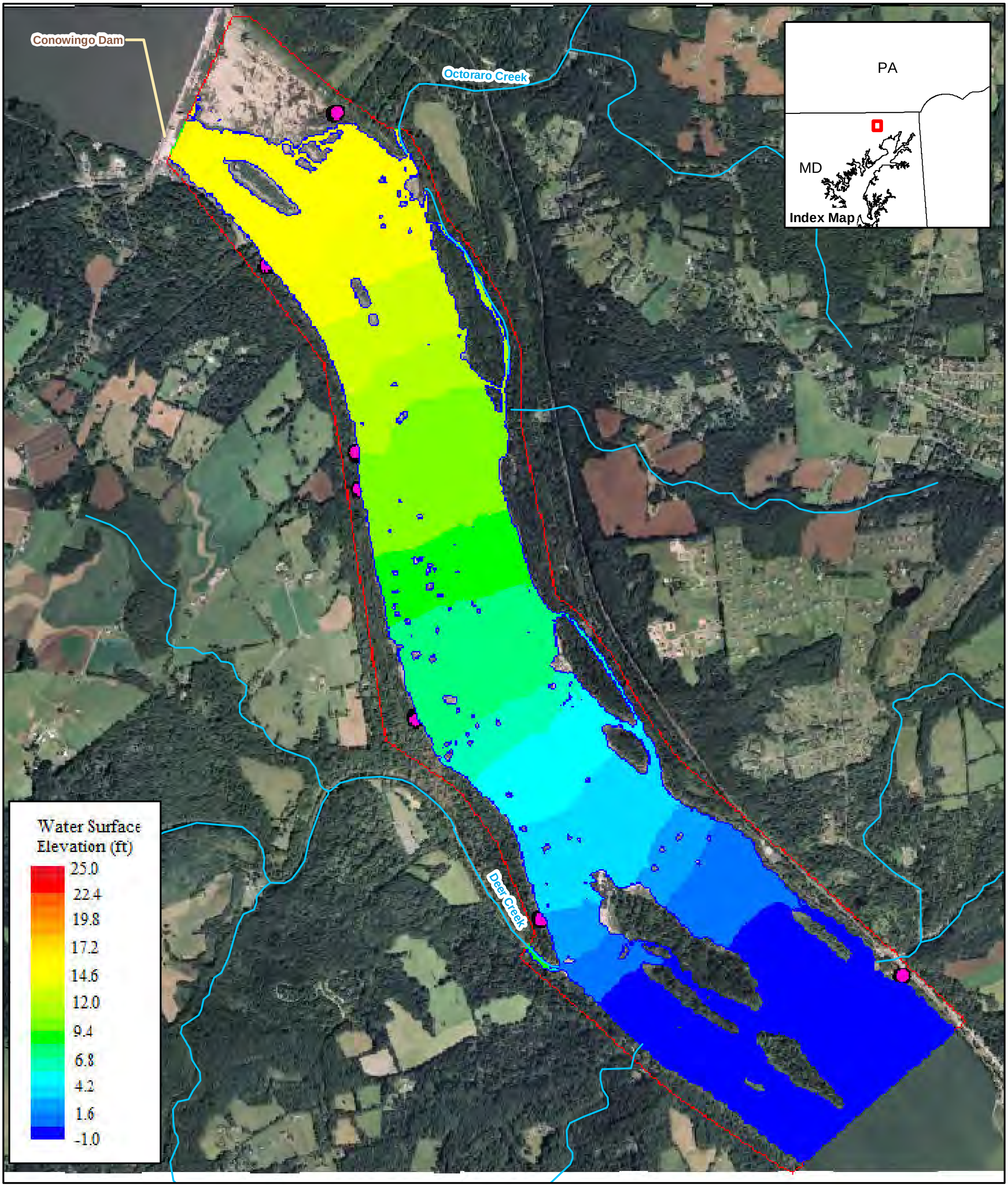
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Appendix B - Map 3
Water Surface Elevation - 10,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WSE_10000.mxd



EXELON GENERATION COMPANY, LLC

DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

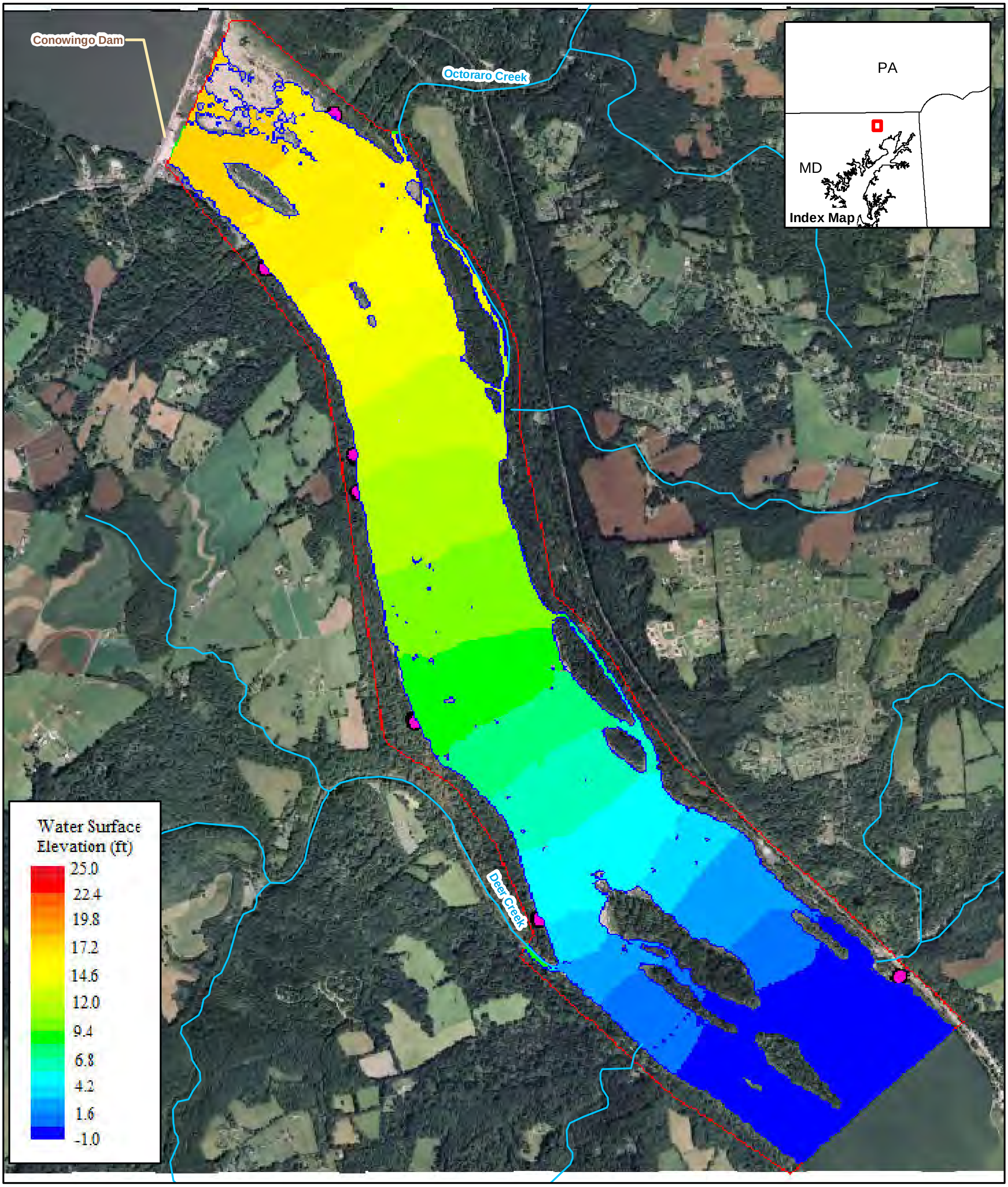
1 inch = 0.5 miles

0 0.25 0.5 1 Miles

N

Appendix B - Map 4
Water Surface Elevation - 20,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WSE_20000.mxd



EXELON GENERATION COMPANY, LLC

DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

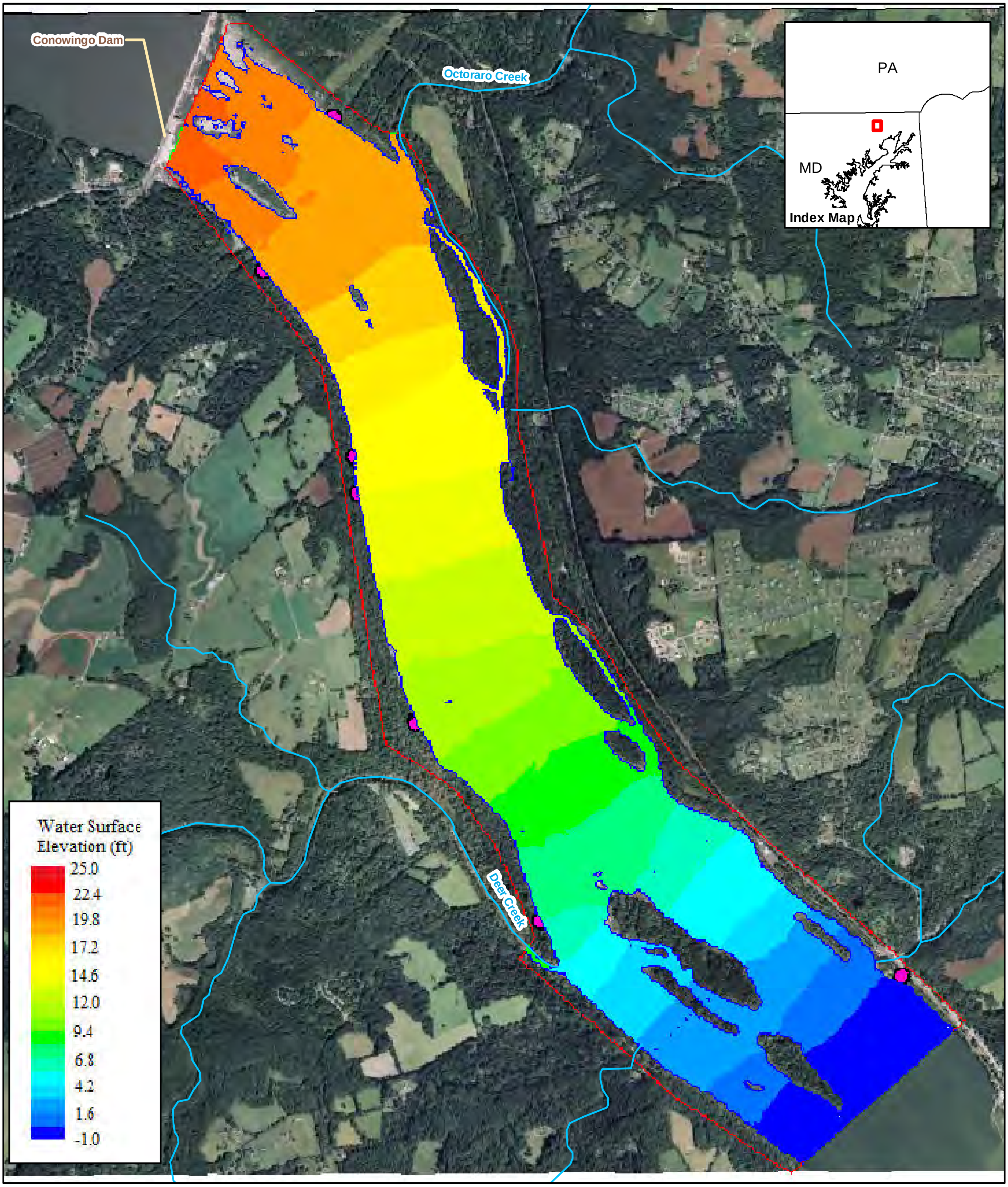
1 inch = 0.5 miles

0 0.25 0.5 1 Miles

N

Appendix B - Map 5
Water Surface Elevation - 40,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WSE_40000.mxd



EXELON GENERATION COMPANY, LLC

DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

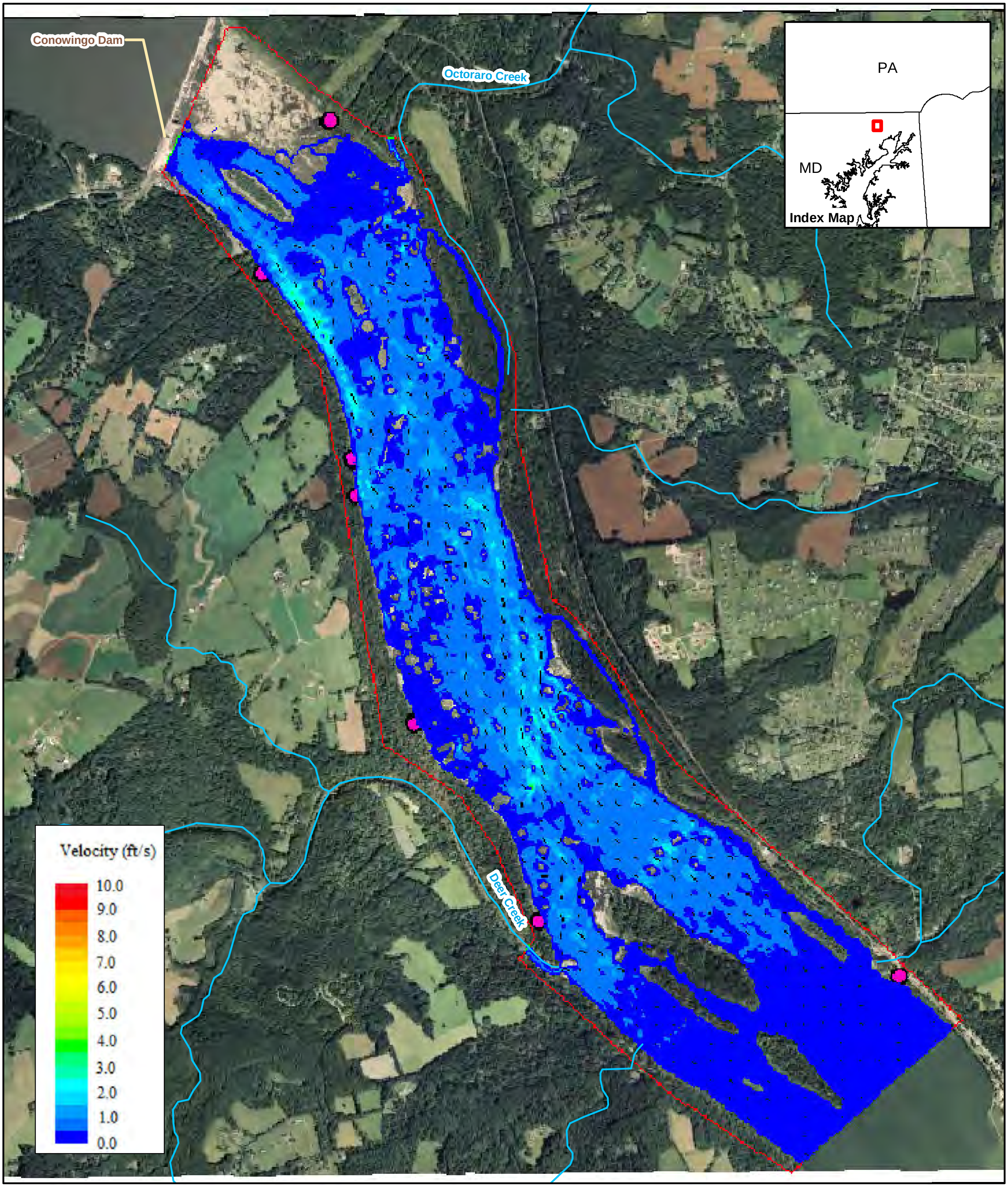
0 0.25 0.5 1 Miles

N

Appendix B - Map 6
Water Surface Elevation - 86,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WSE_86000.mxd

APPENDIX C-WATER VELOCITY DATA BELOW CONOWINGO DAM



N

EXELON GENERATION COMPANY, LLC

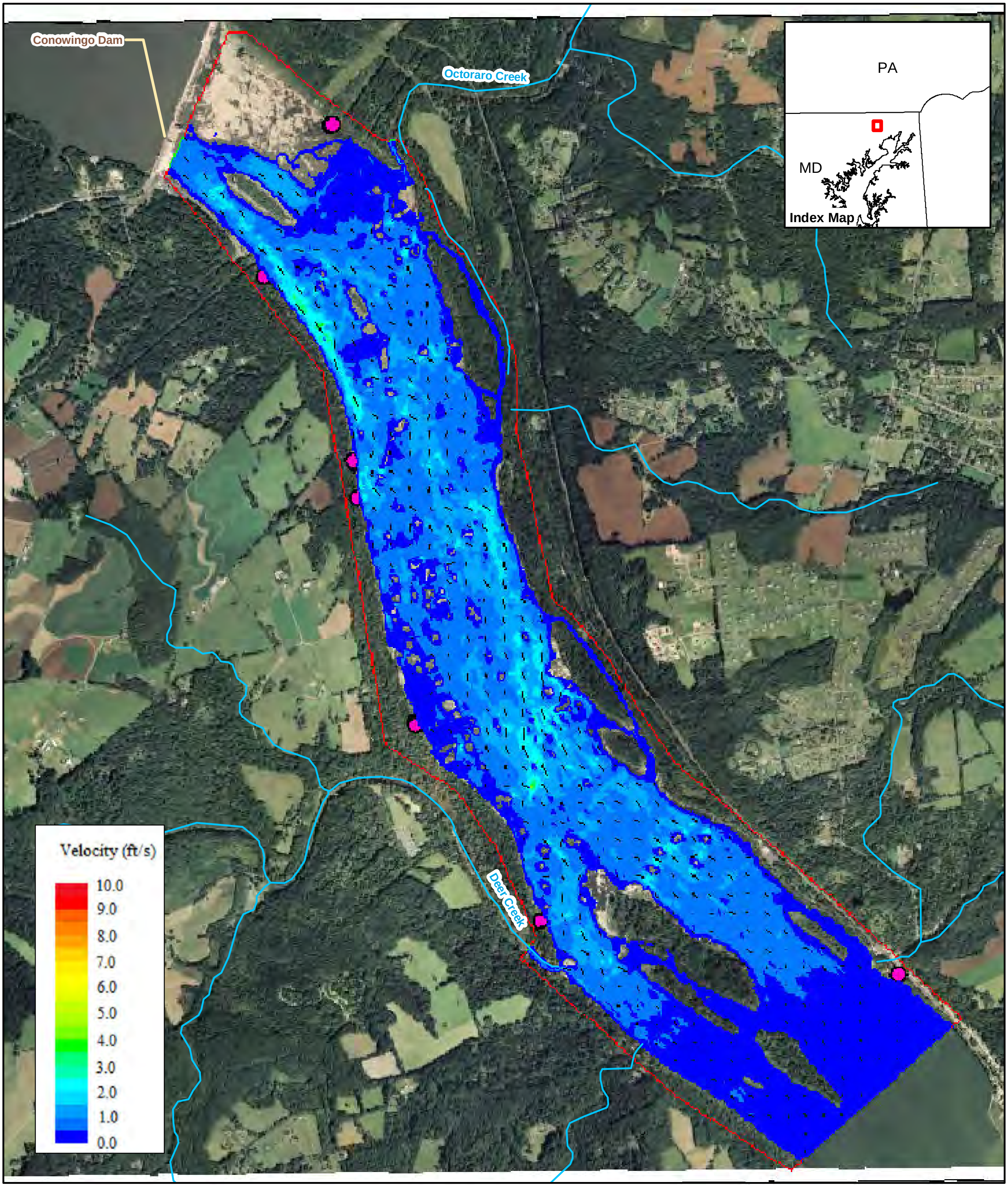
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Appendix C - Map 1
Water Velocity - 3,500

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WV_3500.mxd



Exelon

EXELON GENERATION COMPANY, LLC

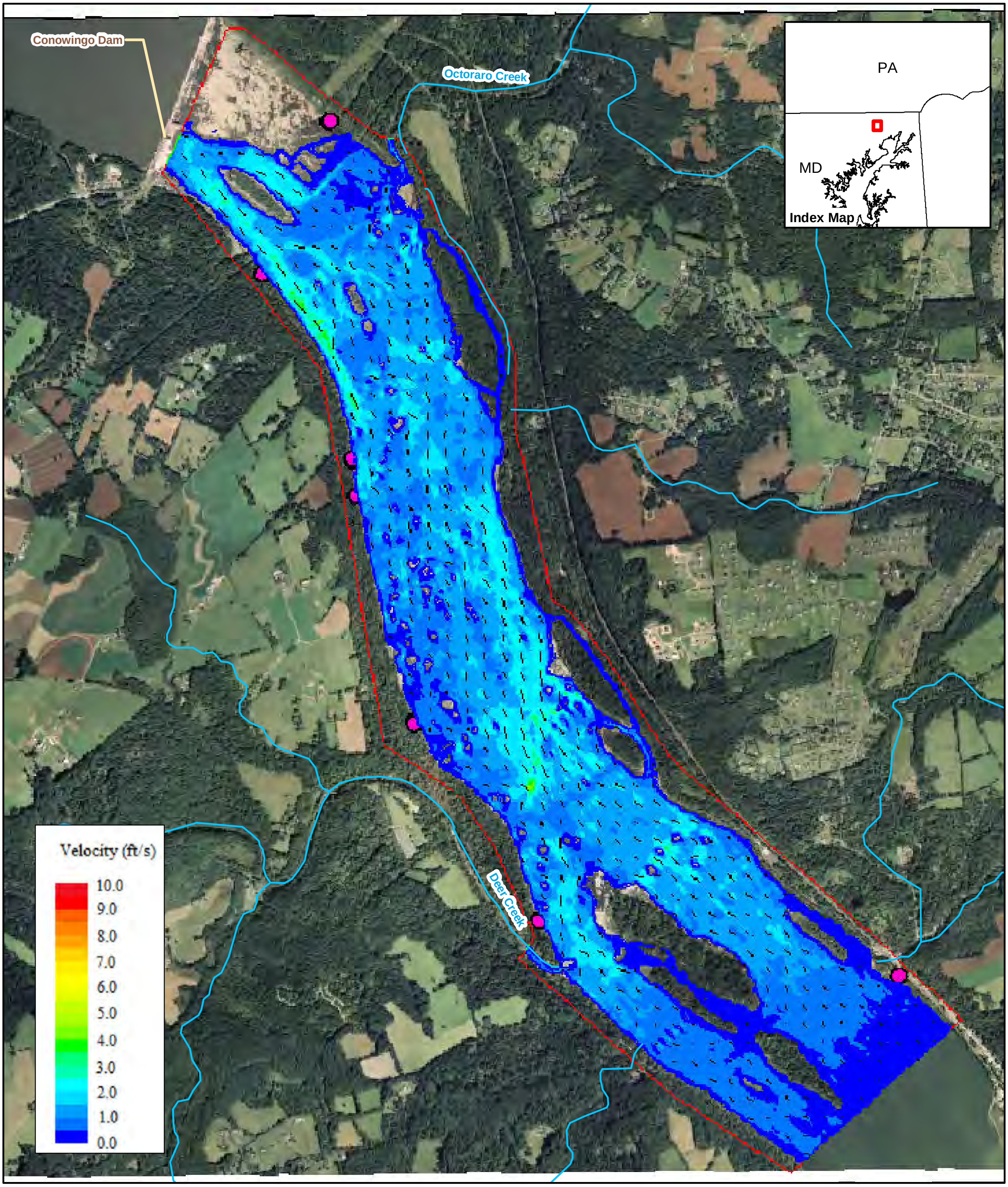
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Appendix C - Map 2
Water Velocity - 5,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WV_5000.mxd



Exelon.

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EXELON GENERATION COMPANY, LLC

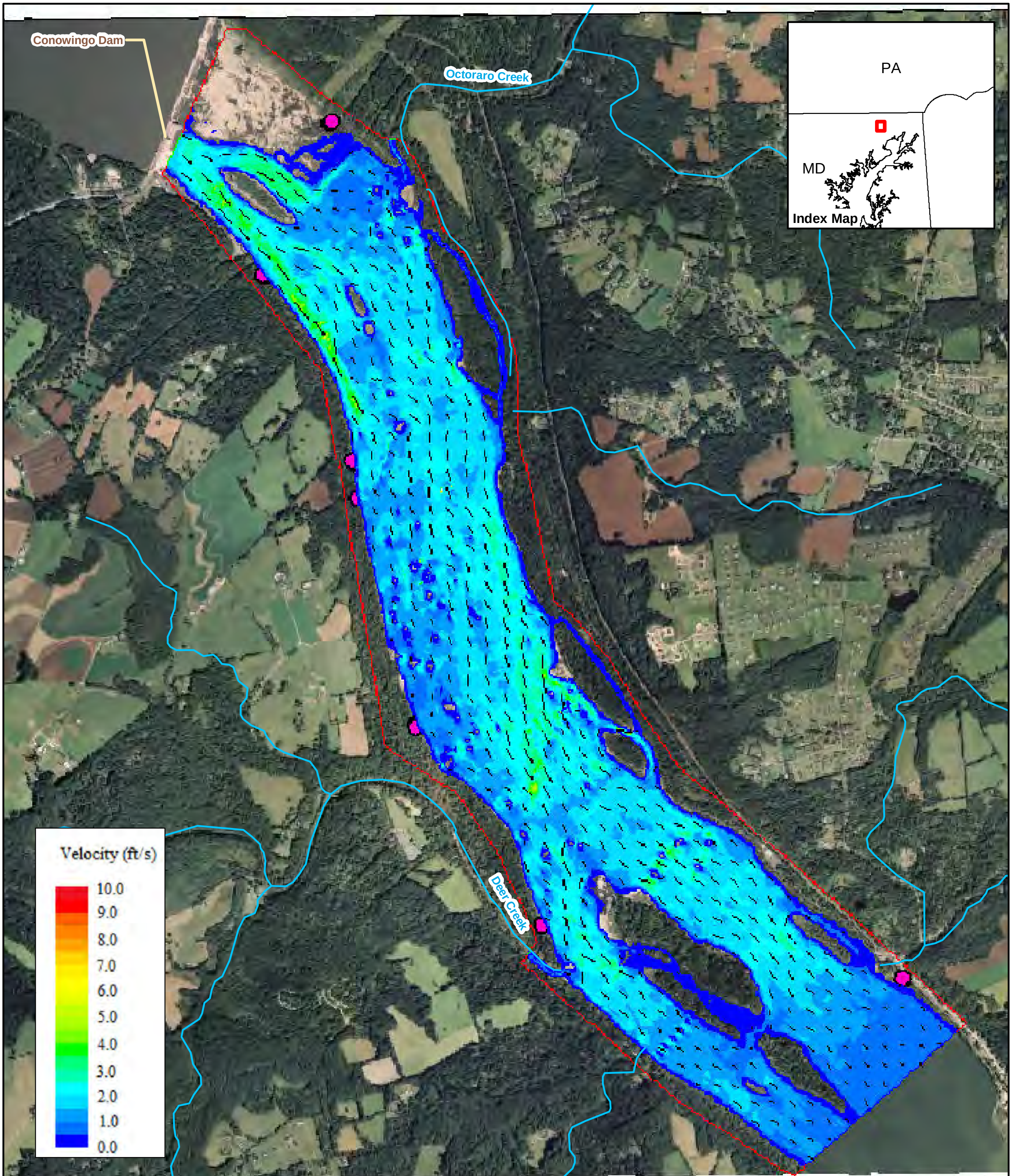
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Appendix C - Map 3
Water Velocity - 10,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WV_10000.mxd



N

0 0.25 0.5 1 Miles

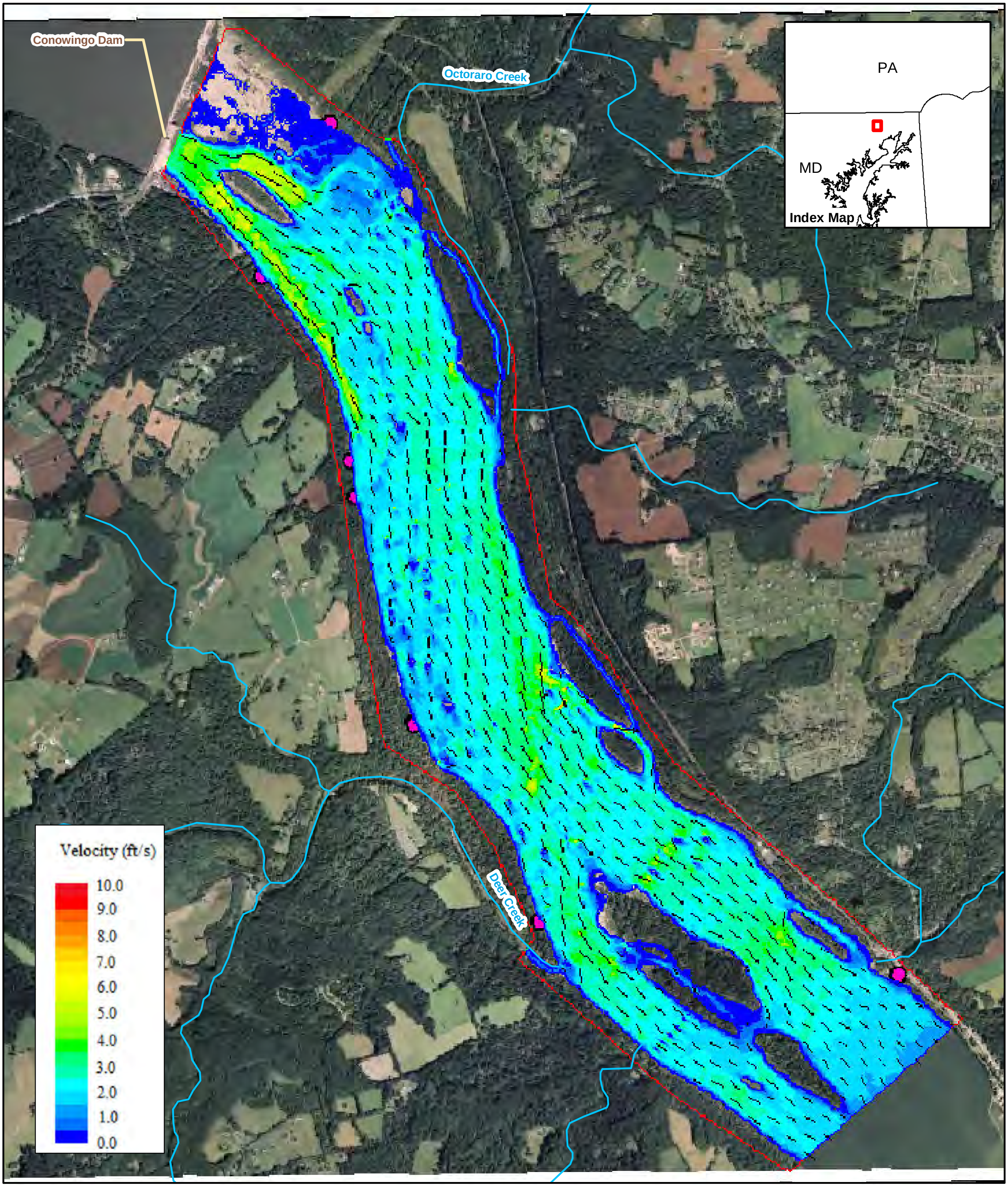
EXELON GENERATION COMPANY, LLC

DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

Appendix C - Map 4
Water Velocity - 20,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WV_20000.mxd



Exelon.

N

EXELON GENERATION COMPANY, LLC

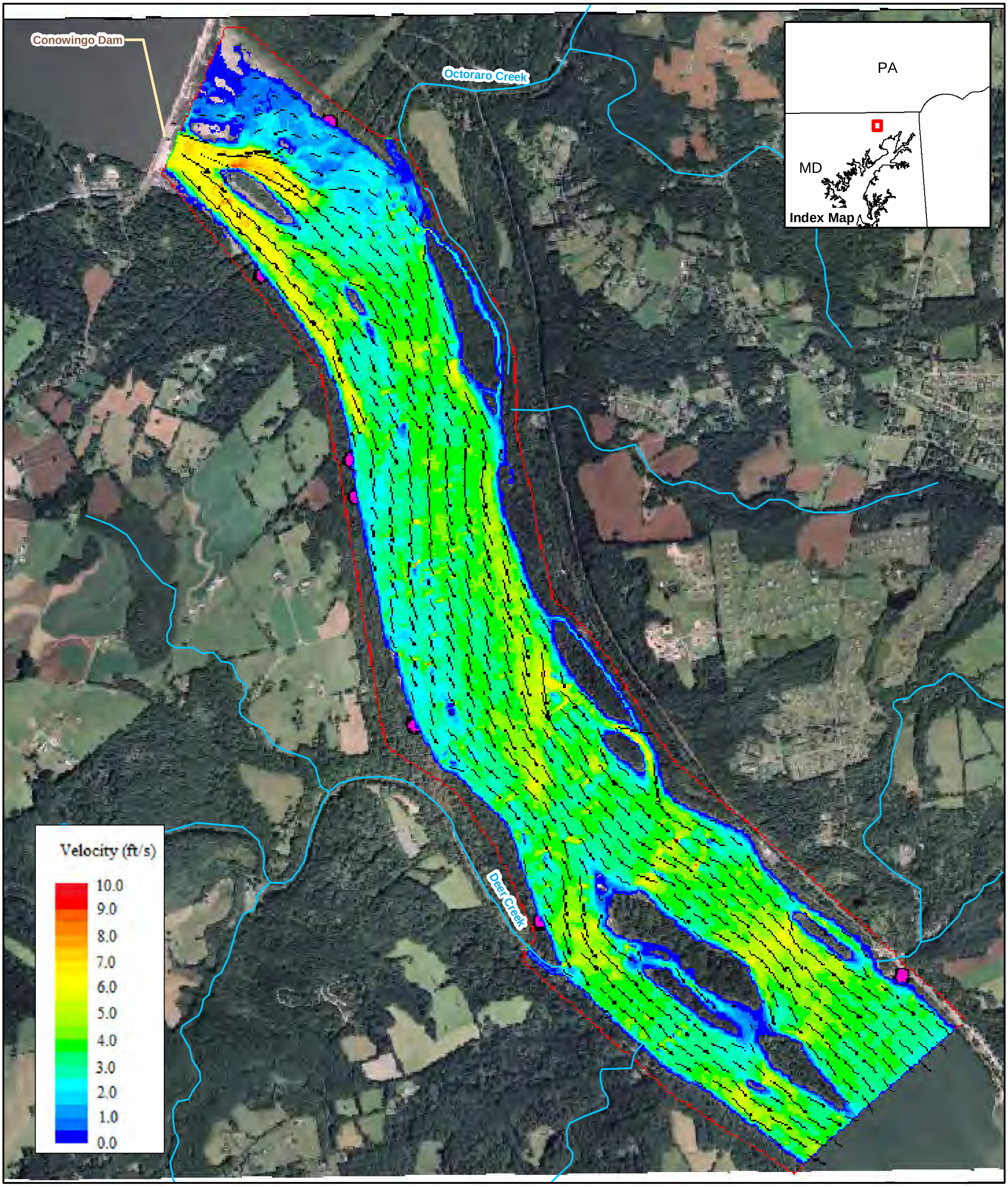
DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

Appendix C - Map 5
Water Velocity - 40,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WV_40000.mxd



N

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

EXELON GENERATION COMPANY, LLC

DOWNSTREAM EAV/SAV STUDY
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Appendix C - Map 6
Water Velocity - 86,000

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.17\EAVSAV_WV_86000.mxd