FINAL STUDY REPORT
DOWNSTREAM FLOW RAMPING AND STRANDING STUDY
RSP 3.8

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 Flow Ramping and Fish Stranding Study. The objectives of this study were: 1) evaluate specific locations/habitats below Conowingo Dam where stranding potential exists, catalog the sites evaluated, and document the numbers, species affected, and their condition; 2) describe project operations during the survey periods and the effects on water levels both near-field (i.e., tailrace-spillway) and far-field (i.e., flow attenuation); and 3) relate stranding to seasonal variability and other characteristics of impacted species and populations.

An initial study report (ISR) was filed on February 22, 2011, containing Exelon's 2010 study findings. An initial study report meeting was held on March 9, 10 and 11, 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 April 27, 2011 by Commission Staff, several resource agencies and interested members of the public. Exelon filed responses to the ISR comments with FERC on May 27, 2011. On June 24, 2011, FERC issued a study plan modification determination order. The order specified what, if any, modifications to the ISRs should be made. For this study, FERC's June 24, 2011 order required no modifications to the original study plan. An updated study report (USR) was filed on January 23, 2012 addressing comments from stakeholders received at the March ISR meeting, those comments addressed by Exelon in the May 27, 2011 responses to ISR comments, as well as editorial and minor text changes. This final study report is being filed with the Final License Application for the Project.

Rapid declines in downstream water level following peaking generation (down-ramping) when hydro station load is reduced to the prevailing minimum flow release are believed to increase fish stranding potential in certain aquatic habitats, such as the spillway reach below Conowingo Dam and possibly other shallow habitats downstream.

Stranding surveys below Conowingo Dam consisted of observations by a biologist equipped with binoculars and spotting scope positioned at the exit trough level of the East Fish Lift (EFL) paired with on-ground surveys of the spillway reach conducted by two 2-person teams. Twelve stranding surveys

were conducted. The observer on the EFL recorded pertinent observations of avian predator activity. The on-ground teams traversed the east and west sides of the spillway reach and observed fish in and along attainable pools that remained at the prevailing minimum flow. Fish observations were recorded along with position, as determined by a hand-held global positioning system (GPS). Hydraulic data in the tailrace and downstream locations were obtained from the USGS gage at Conowingo Dam and a system of water level recorders.

The four stranding surveys conducted during the summer of 2010 documented the most stranded fish (10,308) in the spillway study reach. Fewer stranded fish occurred in spring surveys (5,030) and in fall surveys (1,779). In each season, non-migratory resident fish species such as gizzard shad and common carp formed 90% or more of stranded fish. Low numbers of anadromous fish species such as American shad, river herring, and white perch were documented only in spring and early summer. Resident fish composition in all seasons was relatively consistent. Young of many species, particularly of gizzard shad (57% of the total), accounted for the high fish abundance in the summer surveys. The numbers of dead fish documented were highest in spring (18% of the total) and less than 4% of the total in other seasons. Dead fish found in all seasons were primarily gizzard shad. Predation by several bird species on many fish species occurred each season. Most fish consumed appeared to be gizzard shad.

Stranded fish in spring were more common in the west side of the tailrace and were mostly adult-sized. Stranded fish, mostly small or juveniles, were documented primarily in east-side pools in summer and fall. Any larger individuals stranded in fall occurred mostly in west-side pools proximal to the tailrace.

The main consequences to fish of stranding in the spillway reach below Conowingo Dam during the spring are suffocation and desiccation following station discharge reduction to minimum flow. Given the composition of the fishes documented in the spillway during spring, the impacts to the populations of non-migratory and anadromous species affected are minor. The species affected in spring likely reflect the temporal abundance patterns and behavior of these fishes. Minimum flow periods in spring during daylight are usually more limited than in other seasons, which may reduce risk of predation on stranded fish.

Stranding is high in summer due to gizzard shad juveniles in the spillway reach. However, the consequences of stranding in the spillway reach in summer were inconsequential and likely benefit fish populations. In fact, the spillway reach represents an important habitat area used by numerous resident fish species in summer and into fall for rearing and growth. Although stranding in fall is low, the risk of those larger stranded individuals dying due to predation is high due to abundant birds, particularly bald eagles. In addition, predation appears to be heightened by twice-daily peaking patterns that reflect fall power demand and which expose stranded fish to sight predators in daylight.

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LIST OF ABBREVIATIONS

cfs	cubic feet per second
DO	dissolved oxygen
EAV	emergent aquatic vegetation
EFL	East Fish Lift
Exelon	Exelon Generation Company, LLC
ft	feet
FERC	Federal Energy Regulatory Commission
GPS	Global Positioning System
ILP	Integrated Licensing Process
MW	Megawatt
NOI	Notice of Intent
PAD	Pre-Application Document
PJM	PJM Interconnection
Project	Conowingo Hydroelectric Project
PSP	Proposed Study Plan
RSP	Revised Study Plan
USGS	United States Geological Survey
WLR	Water Level Recorder

1.0 INTRODUCTION

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

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

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

The final study plan determination required Exelon to conduct a Flow Ramping and Fish Stranding Study, which is the subject of this report. The objectives of this study are to: 1) evaluate specific locations/habitats below Conowingo Dam where stranding potential exists, catalog the sites evaluated, and document the numbers, species affected, and their condition; 2) describe Project operations during the survey periods and the effects on water levels both near-field (*i.e.*, tailrace-spillway) and far-field (*i.e.*, flow attenuation); and 3) relate stranding potential and stranding consequences to the impacted fish populations.

An initial study report (ISR) was filed on February 22, 2011, containing Exelon's 2010 study findings. An initial study report meeting was held on March 9, 10 and 11, 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 April 27, 2011 by Commission Staff, several resource agencies and interested members of the public. Exelon filed responses to the ISR comments with FERC on May 27, 2011. On June 24, 2011, FERC issued a study plan modification determination order. The order specified what, if any, modifications to the ISRs should be made. For this study, FERC's June 24, 2011 order required no modifications to the original study plan. An updated study report (USR) was filed on January 23, 2012 addressing comments from stakeholders received at the March ISR meeting, those comments addressed by Exelon in the May 27, 2011 responses to ISR comments, as well as editorial and minor text changes. This final study report is being filed with the Final License Application for the Project.

2.0 BACKGROUND

The Susquehanna River below Conowingo Dam flows approximately 10 miles before entering Chesapeake Bay. The non-tidal portion of the Susquehanna River encompasses approximately four miles of river length from Conowingo Dam downstream to the mouth of Deer Creek (a west-bank tributary). Non-tidal habitats were mapped and described in 2008 at summer minimum flow levels (Figure 2-1). The largest amounts of aquatic habitat below the tailrace in the non-tidal reach were not isolated, but contiguous flowing reaches of variable depth (Exelon 2009-PAD). A network of interconnected and isolated shallow pools occurred near the mouth of Octoraro Creek. Isolated back channel habitats were also identified below the mouth of Octoraro Creek and further downstream. The 2008 study also identified but did not assess the extensive “boulder field” below the Conowingo Dam spillway (spillway reach; (Figure 2-1). This reach is east of and adjacent to the tailrace with surface area estimated at 106.1 acres.

The Conowingo Project uses limited active storage within Conowingo Pond for generation purposes. Maximum hydraulic capacity of the Conowingo powerhouse is 86,000 cfs. The current minimum flow regime below Conowingo Dam was formally established with the signing of a settlement agreement in 1989 between the project owners and several federal and state resource agencies (46 FERC ¶61,063) (FERC 1989). The established minimum flow regime below Conowingo Dam is the following:

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

The downstream discharge must equal these values or the discharge measured at the Susquehanna River at the Marietta United States Geological Survey (USGS) gage (No. 01576000), whichever is less. The Marietta USGS gage is located approximately 35 miles upstream of Conowingo Dam above the Safe

Harbor Dam. Downstream stage and discharge is gaged at the Conowingo Dam tailrace by USGS gage No. 01578310.

Stranding occurs when fish are separated from flowing water by declining river stages following rapid decreases in river flow or discharge (PacifiCorp 2004). Stranding potential exists in river reaches with low gradient or where rugged substrate topography creates pockets or isolated pooled areas as water levels decline. The spillway reach below Conowingo Dam and possibly other shallow areas further downstream represent aquatic habitats with stranding potential. Rapid declines in downstream water level following peaking generation (down-ramping) when hydro station load is reduced to the prevailing minimum flow release are believed to increase fish stranding in certain aquatic habitats with stranding potential. Operational factors that can affect the risks of stranding in river reaches with stranding potential include: 1) down-ramping rate, 2) seasonal and diurnal timing, 3) frequency of occurrence (e.g., once or twice daily), and 4) magnitude of the flow change (PacifiCorp 2003). Biological factors include behavioral characteristics of fish species affected, life history stage, and seasonality of a species occurrence (Hunter 1992).

Below Conowingo Dam, the spillway reach is overall a low gradient, off-channel habitat that contains areas with both low-relief substrate and areas with extremely rugged, high-relief substrate. Substrate in low-relief areas is a mix of gravel, cobbles, and small boulders (Figure 2-2). The more rugged areas feature very large boulders and/or bedrock outcrops (Figure 2-3). At prevailing minimum flows, the low-relief areas retain pools of various size that are generally shallow and wadeable, whereas the high-relief areas retain pools also variable in size but which can be deep and not wadeable.

The spillway reach is watered by daily generation to a level that depends on natural river inflow, operations of upstream hydro stations, and electricity load demand. When station load is reduced (down-ramping) and river stage declines, the spillway reach begins to drain downstream (longitudinally) and laterally towards the tailrace. The most conspicuous drainage occurs as a large pooled area immediately below the spillway structure flows rapidly toward the tailrace past the concrete wing wall adjacent to the East Fish Lift (EFL). Drainage laterally toward and into the tailrace also occurs at several locations approximately 400-800 m below the dam. Spillway-reach stage generally declines most rapidly in the first hour following station load reduction, although the rate of decline varies with the number of generating units taken off line.

3.0 METHODS

3.1 Field Surveys

The following methods were used to meet the study objectives. Stranding surveys consisted of observations by a biologist equipped with binoculars and spotting scope positioned at the exit trough level of the EFL paired with on-ground surveys of the spillway reach conducted by two 2-person teams. Twelve stranding surveys were scheduled from April 2010 through November 2010. The EFL afforded an elevated vantage point from which to observe the spillway reach, areas associated with the mouth of Octoraro Creek, and the main river channel below the tailrace.

The observer on the EFL coordinated the movements of the on-ground teams during the duration of the survey and recorded pertinent observations of avian predator activity. The observer was normally in place before the on-ground teams began their survey to view and document bird behavior, unaffected by the teams. Prior to the on-ground activity, the observer made a systematic count of major avian predators. These always included bald eagles and great blue herons, but could also include double-crested cormorants and various gull species, and occasionally black vultures, a prominent scavenger. A systematic count of bald eagles or great blue herons involved a lateral sweep across the spillway reach through binoculars that included counts of eagles on transmission line towers at the head of Rowland Island and at the east edge of the spillway reach, and herons in east-edge spillway trees near the tower. The count typically took 2-3 minutes. The count thus represented individual birds in a short time interval and was a good indicator of abundance.

The on-ground teams traversed the spillway reach and observed fish in and along attainable pools of various dimensions that remained at the prevailing minimum flow. The spatial coverage achieved by the on-ground teams for the twelve studies was generally consistent among studies and is shown in Appendix A for Studies 1-6 and 7-12. Each team covered approximately one-half of the spillway reach. Team observations and their associated data were classified either "east" or "west" as appropriate. The east team also covered the area at and below the mouth of Octoraro Creek on foot and by canoe as needed.

Fish observations were recorded along with position of the siting by hand-held GPS and, in summer, water temperatures in many of the pools. Stranded fish in de-watered areas were identified to species. Fish in pooled areas were identified to species, if possible, by observation made possible by normally high water clarity, clear weather, and little or no wind. Small fishes not identifiable to species were grouped as darters, minnows, and young sunfish (*Lepomis spp.*) as appropriate. Efforts were also made to collect specimens with small-mesh nets, particularly in summer, for identification of the species classified as darters, minnows, and sunfishes, plus young of larger fishes. These efforts were mostly unsuccessful.

The spillway reach surveys were supplemented by occasional on-ground surveys of the east shore side channels below Octoraro Creek. The three side channels investigated were habitat areas P14, P13, and P12 (Figure 2-1). Little was known about the stranding potential of these three isolated side channels but they are subject to the same water level fluctuations as the spillwy reach. At least one side channel survey accompanied each minimum flow level investigated, including 10,000 cfs, 7,500 cfs, 5,000 cfs, and 3,500 cfs. All side channels were accessed from the hiking trail below Octoraro Creek or from US Rt. 222.

Surveys were conducted four times each during spring, summer, and fall at the prevailing minimum flow release (see above). Survey days in spring and summer began after first light and after crew transport across the tailrace. Start time of observations was typically near 0700 h, which allowed for sufficient light levels to permit safe walking on slippery substrate and count and identify fish in the pools. Surveys lasted 5-6 h, and typically followed a period of generation the previous day, although this was not always the case (i.e., peaking flow levels were not arranged but rather those dispatched by PJM Interconnection, the regional transmission organization). However, in fall twice-daily generation peaks occurred in the early morning and evening. As a result, fall surveys typically began near 1100h, following the morning peak release. In spring, the weekly coordinated ground surveys were supplemented by an additional visual-only survey that same week from the EFL observation site (total of four).

Time series plots for each survey were used to describe water level fluctuations in the tailrace (proxy for the west side of the spillway reach), east side of the spillway, and at selected locations downstream. The USGS Conowingo gage stage and discharge data were used to describe tailrace and west-side spillway reach fluctuations. A series of water level recorders provided temporal stage data to describe water level changes in the spillway reach far-east side and at locations downstream below the tailrace.

All field data were reviewed and entered into EXCEL spreadsheets for analysis. Observed fish numbers and species were paired with GPS coordinates to facilitate plotting the spatial coverage for individual surveys and preparation of summary plots to describe sites of fish abundance and/or spatial trends for particular fish species of interest.

Hydraulic data used for this study included USGS Conowingo Dam tailrace stage and discharge gage and stage data recorded at several water level recorders (WLR), either In Situ Vented Level TROLL 500, Model No. 0089010 or In Situ Vented Aqua TROLL 200, Model No. 0056010. Recorders were sited at the eastern edge of the spillway reach (Site 1) and at several downstream west shore locations above Deer Creek including the Exelon dissolved oxygen (DO) shed (Site 2), near Reuben Island (Site 4), and just above Deer Creek (Site 5). Each WLR provided data at 15-min intervals. The water level recording sites are shown in Figure 3-1.

Hydraulic Modeling Analysis

Results from a modified version of the two-dimensional hydraulic model originally created for and described in Conowingo Study RSP 3.16: Instream Flow Habitat Assessment Below Conowingo Dam were used to quantify Conowingo spillway channel wetted area changes. This hydraulic model used in this study (the Spillway channel model) had two primary differences from the original model:

- The Spillway channel model's input elevation data were increased in the Conowingo spillway channel area, relative to the original model. The same input data were used in both models, but the Spillway channel model simply had a much greater number of input nodes in the Conowingo spillway channel area; and

- The Spillway channel model's computational mesh was rebuilt, with the purpose of increasing mesh density in the spillway channel area and areas that may hydraulically influence the spillway channel area, relative to the original hydraulic model. As a result of computational resource limitations, mesh density in areas of less interest (i.e., in the lower portion of the river near and in the tidal area) was reduced relative to the original hydraulic model.

We attempted to use the Spillway channel model as a tool to delineate areas and locations that were dewatered by examining various minimum and generation flow pairs' steady state water depths.

4.0 RESULTS

4.1 Spring Surveys

The spring stranding surveys were timed to occur during the principal period of the anadromous fish spawning migration. Surveys combining on-ground crews and a visual observer occurred on April 29, May 6, 13, and 18, 2010. These studies are herein referred to consecutively as Studies 1, 2, 3, and 4. Visual-only surveys from the EFL observation site occurred on April 27, May 5, 10, and 20, 2010. Weather conditions were favorable for all surveys except Study 4 on May 18 when showers and overcast, breezy conditions affected the on-ground teams, limiting both mobility through the spillway reach and visibility into the accessible pools.

4.1.1 Hydraulic Conditions

Each early morning spring stranding survey was preceded by generation from Conowingo Station that varied in maximum discharge attained and duration (Figures 4.1.1-1 to 4.1.1-4). Daily peak discharge the prior day varied from 36,500 cfs for Study 1 to 80,900 cfs for Study 3. Duration of peaking releases preceding the study day ranged from approximately 13-h for Study 2 to 21-h for Study 3. The timing of the onset of daily peaking (station discharge > minimum flow requirement) varied, as did the release volume during generation. The peaking curve shape also varied among studies. A uni-modal peak occurred prior to Studies 1, 2, and 4, whereas a bi-modal peak preceded Study 3.

The decline in tailwater elevation measured by the USGS tailrace gage prior to each stranding survey varied with peak discharge attained and the shape of the discharge curve (Figures 4.1.1-1 to 4.4.1-4). The net (total) decline in tailwater elevation was 2.4 ft (13.2 ft to 10.8 ft) prior to Study 1, 5.2 ft (15.2 ft to 10.0 ft) prior to Study 2, 6.0 ft (16.1 ft to 10.1 ft) prior to Study 3, and 5.5 ft (15.6 ft to 10.1 ft) prior to Study 4. Net tailwater elevation decline typically took 4 h or more but, depending on the shape of the declining leg of the discharge curve, could be rapid over briefer periods. For example, tailwater elevation, as measured at the USGS Conowingo gage, declined 3.7 ft (16.1 ft to 12.4 ft) and 3.9 ft (14.0 ft to 10.1 ft) in approximately 2 h prior to Studies 3 and 4, respectively. Temporally, the tailwater elevation decline for the spring studies occurred after dark and was usually dependent on when load reduction to the prevailing minimum flow occurred

Water level elevation throughout the spillway reach declined largely in parallel with that in the tailrace. The water level at WLR Site 1 on the east bank of the spillway reach began to fall within minutes of that in the tailrace (Figure 4.1.1-5). Water levels also declined but more gradually downstream at WLR Sites 4 and 5, and also lagged temporally but by less than 30 minutes.

Spillway reach pools remaining after drainage of generation flows ranged from large to small and deep to shallow at either spring minimum flow volume (7500 or 10,000 cfs). Numerous deeper pools were clearly isolated by large boulders; shallower pools typically were found within expanses of lower-relief large cobble or gravel. Numerous pools were also interconnected by water flow even after hours of drainage. Spillway pools of either type (isolated or flow-connected, including those that drained to the tailrace), however, retained live fish after water level stage approached minimum tailrace stage indicated by the USGS gage.

4.1.2 Fish Observations

More than 5,000 fish of at least 14 taxa were identified in spillway reach pools during the four surveys (Table 4.1.2-1). Study 2 accounted for 54% of all fishes observed and more than 75% of all fish observed were noted during the two initial spring surveys. As noted above, poor weather hampered biologists' mobility and vision during Study 4 on May 18, 2010. Crews could see fish activity in isolated pools but were largely unable to identify species or estimate numbers.

Gizzard shad (*Dorosoma cepedianum)* (59%) and common carp (*Cyprinus carpio)* (26%) accounted for the most fish identified. White perch (*Morone americana)* (7%) ranked third in abundance. All other taxa identified represented less than 9% of all fishes observed in the pools. Anadromous river herring *Alosa* spp. and American shad (*Alosa sapidissima)* formed 3% of fish identified. American shad abundance in spillway pools was highest during the May 6, 2010 survey, similar to both gizzard shad and common carp. Resident game fish species such as smallmouth bass (*Micropterus dolomieu*), largemouth bass (*M. salmoides*), and walleye (*Sander vitreus*), plus striped bass (*Morone saxatilis*) were noted but scarce in all four surveys.

Most fishes (82%) observed in either isolated or interconnected spillway pools were alive and actively swimming. A total of 900 fish (18%) of at least eight taxa was recorded as either freshly or recently dead, decomposed but identifiable, or the remains of fish apparently eaten by birds (Table 4.1.2-1). Carcasses/remains were frequently noted on top of large or small boulders or had been clearly dragged some distance from a pool. Gizzard shad formed the largest proportion (75%) of the dead fish counted, followed by carp and catfishes (channel catfish *Ictalurus punctatus* and flathead catfish *Pylodictis olivaris*). A total of 46 dead American shad was counted among 108 total shad observed within the spillway reach. Most American shad (60 were found in a single, large pool on May 6, 2010 (Study 2); 30 shad were live and 30 were dead.

Most (88%) of the fish observed were in pools in the western portion of the spillway reach (Table 4.1.2-1). This spatial trend was consistent for all four spring surveys. Pools retaining the largest numbers of fish in the four spring surveys are shown in Figure 4.1.2-1. Pools in the western one-third of the spillway reach and approximately even with the upper one-half of Rowland Island consistently retained the most fish.

The spatial distribution of six selected species and their live/dead status, regardless of the number estimated, is shown in Figure 4.1.2-2. Virtually all of the American shad, river herring, striped bass, white perch, and walleye were located in the western portion of the spillway reach where the overall number of fish was highest. In contrast, largemouth bass and smallmouth bass (shown as "black bass") clearly favored pools in the east side of the spillway. All bass were alive (Table 4.1.2-1).

Observations during the spring surveys in the three principal side channels along the east shoreline yielded no observable, stranded fish. The side channel immediately below Octoraro Creek (Side Channel P14 in Figure 2-1) was watered by combined river and Octoraro Creek flow for several hundred yards. At both 10,000 cfs and 7,500 cfs minimum flow releases, much of the water in the upper portion of the side channel exited to the main channel via a cut at the head of Mud Island. In the side channel below this exit-flow cut (i.e., behind Mud Island) water of variable depth remained. No fish were visible in the lower portion or exit of side channel P14. Similarly, no stranded fish were observed in side channels P13 and P12 further downriver. Access to view channel P13 is difficult, but channel P12 was an easily accessed, wide, open side channel and much more an integral part of riverine habitat than either P13 or P14.

The upper tidal reach along the east shoreline was also viewed from several vantage points during Surveys 1 and 2 at the two minimum flows. No stranded fish or evidence of previously stranded fish in near-shore shallow habitats were noted. These observations, at opposite tidal stage (Study 1 low and flooding; Study 2 high and ebbing) were sufficient to note the habitat connectivity along the upper west shore of the tidal zone and, as a result, further visits to the upper tidal reach were curtailed.

4.1.3 Spring Bird Observations

The observer documented significant feeding on stranded fish in the pools within the study area. The average bird count during spring study events (visual-only and visual plus on-ground) was 35-45 bald eagles, 50-60 great blue herons and approximately 100 double-crested cormorants. Bald eagles and great blue herons caught carp, catfishes, gizzard shad and white perch in numerous pools, notably one termed the "Crescent Pool". The Crescent Pool was consistently the area of greatest feeding activity and extends from near the east side of the tailrace below the powerhouse, about 1,500 ft south of the dam, arcs counterclockwise to the northeast into the center of the spillway reach and ends about 1,300 ft south of the dam (Figure 4.1.3-1). Several small pools north of the Crescent Pool and five or six pools southwest of the crescent pool (just east of an island with high rocks and trees; "Tree Island") were also significant feeding areas. Cormorants favored the western edges of the spillway reach and areas near the EFL below the wing wall and generally did not feed in the isolated pools within the spillway reach.

During visual-only surveys (no on-ground disturbance) on May 11, 2010 and May 20, 2010, higher numbers of birds were observed. A systematic count of individual birds on May 11, 2010 noted 60-70 bald eagles, 125 great blue herons and flocks of 30-40 herring gulls and ring bill gulls feeding in the spillway reach. On May 20, 2010 during a two-minute search at the beginning of the survey day at 0615 h a total of 135 bald eagles and 150 great blue herons were observed. Approximately 100 great blue herons and 30 bald eagles were feeding in the crescent pool alone; 10-20 additional bald eagles perched around the pool edges.

4.2 Summer Surveys

Four summer stranding surveys were scheduled at three to five week intervals on June 11, 2010, July 7, 2010, August 11, 2010, and September 1, 2010, referenced hereafter as Studies 5, 6, 7, and 8. Surveys included both on-ground and visual methods; no visual-only surveys occurred. Weather conditions were favorable which enhanced crew mobility and fish observations in shallow pools.

4.2.1 Hydraulic Conditions

Three of four summer surveys followed some amount of peaking generation the previous day (Figures 4.2.1-1 to 4.2.1-4). Studies 6 and 8 followed a typically short summer afternoon period of generation that ended by early evening. Study 5 followed two generation peaks the day prior; station discharge was ultimately reduced to summer minimum flow at 2200 h. Net tailwater elevation decline for Studies 5, 6, and 8 was 4.3 ft (13.8 ft to 9.5 ft), 5.5 ft (14.9 ft to 9.4 ft) and 3.6 ft (13.1 ft to 9.5 ft), respectively. In contrast, Study 7 followed seven consecutive days without daily peaking releases due to low natural river flows (< 6,800 cfs for August 6-11, USGS Marietta gage). Prior to Study 7, peaking of about 3.25 h duration last occurred on August 4, 2010.

In comparison to the tailrace, water levels downstream of the tailrace (Sites 4 and 5) declined more slowly after peak generation ceased and also displayed a short temporal lag (Figure 4.2.1-5). The east spillway reach WLR (Site 1) malfunctioned and was unable to provide summer data for comparison to the tailrace. With only minimum flows released from upstream for several days, the WLR at Site 5 during Study 7 (August 10, 2010) clearly depicted tidal effects.

4.2.2 Fish Observations

The spillway reach in summer displayed a completely different character than in the spring. There were extensive areas of terrestrial vegetation growing among the rocks and much filamentous algal growth and emergent aquatic vegetation (EAV) associated with the pooled areas. Additionally, the pools were much smaller and fewer than noted during the spring studies.

The four summer surveys documented more than 10,300 fishes of at least 13 taxa plus blue crabs (*Callinectes sapidus*) residing in spillway reach pools (Table 4.2.2-1). Surveys 7 and 8 in late summer contributed 54% and 43% of the total number of fishes estimated. Three taxa (gizzard shad, banded killifish (*Fundulus diaphanous*), and *Lepomis* spp.) formed 91% of the fishes observed. The *Lepomis* group consisted of mostly bluegill, but also redbreast sunfish (*L. auritus*) and green sunfish (*L. cyanellus*). A high proportion of fish observed were young-of-the-year. No anadromous species such as alosids were noted. White perch were observed mainly to Survey 5 in June. Smallmouth bass and, particularly, largemouth bass were common; most were young-of-the year. Overall, an estimated 4% of all fish noted in spillway pools were largemouth bass. One pool during Survey 5 on June 11 contained two adult largemouth bass and a school of bass fry, suggesting possible spawning occurred in the pool. Walleye occurred only during Study 5 in June and consisted of a single individual.

Water temperatures in numerous spillway reach pools were taken during Studies 6 and 7 in July and August, respectively. Water temperatures ranged from 26.0°C to 30.7°C at 32 sites in Study 6 and from 25.0°C to 33.7°C at 30 sites in Study 7. Water temperatures in pools on the east side of the spillway reach typically were several degrees cooler than those in pools on the west side. Diurnal warming in isolated pools was noted during both surveys but did not appear responsible for any of the few dead fish observed. Schools of banded killifish, largemouth bass, and gizzard shad were all observed swimming actively in pools up to 33.7°C as Study 7 concluded at noon.

More than 99% of fishes observed in spillway reach pools were alive; most dead fish (40 of 73 total) were gizzard shad (Table 4.2.2-1). Dead largemouth bass and *Lepomis* sunfish were mostly young of the year. Catfishes, particularly flathead catfish, were found away from water, suggesting transport and consumption by birds. Dead fish that were found were typically fresh or day-old specimens. There was little evidence of piles of dry skeletons or other remains during any of the summer surveys.

Spatially, 67% of all fishes in summer were observed in pools in the eastern side of the spillway reach, opposite that in spring (Table 4.2.2-1). Sites with at least 100 individuals of the three most common species residing in spillway pools during Studies 7 and 8 are shown in Figure 4.2.2-1. Gizzard shad and banded killifish were generally distributed across the spillway whereas *Lepomis* spp. favored east-side pools. White perch and smallmouth bass, primarily noted in spillway pools in early summer, were the only species that appeared mostly in west-side spillway pools (Figure 4.2.2-2). Largemouth bass young-of-the-year were abundant during Studies 7 and 8 and distributed in pools throughout the spillway reach (Figure 4.2.2-2).

The upper east bank side channel area below Octoraro Creek (Habitat P14; Figure 2-1) was visited to evaluate stranding at summer minimum flow in all studies. Prevailing Octoraro Creek flow split so that both the side channel leading to Mud Island and the main river channel received some creek flow. Water flowed slowly down the side channel and exited the side channel towards the main channel after several hundred yards through the small rocky cut at the head of Mud Island. The side channel behind Mud Island retained water intermittently. No fish were noted in the upper flowing portion of this side channel or in the intermittently-watered lower section. During Study 6, crews noted that black vultures were feeding on a very few dead carp and channel catfish in the rocky cut where side channel flows rejoin the main river channel.

4.2.3 Bird Observations

The bird count in summer was noticeably reduced from the spring. Summer was characterized by increased great blue heron activity and decreased bald eagle activity. There was a high of 85 bald eagles and 100 great blue herons counted (individual birds) during Study 5 and a low of 15 bald eagles and 5 great blue herons for Study 7. Most of the bald eagles as well as many of the great blue herons moved onto the exposed rocks of the river channel downstream of the spillway reach in areas below Rowland Island and the mouth of Octoraro Creek. By Study 8 (September 1, 2010), the piscivorous birds started moving back to the spillway study area. Numerous bald eagles and great blue herons as well as several (2-3 immature) black crowned night herons were observed scattered over the study area during Study 8.

Generally there appeared a lack of large fish in the pools as suggested by what the great blue herons were observed eating. Most of the fish were of the minnow or fingerling size. Thus it was impossible to identify any fish species eaten because they were eaten quickly in one bite. During spring surveys, birds were eating larger fish; consuming larger fish was time consuming and this longer time allowed the observer to identify these fish.

4.3 Fall Surveys

Four fall stranding surveys were scheduled at one-week intervals on October 27, November 3, 10, and 17, 2010, referenced hereafter as Studies 9, 10, 11, and 12. Surveys included both on-ground and visual methods; no visual-only surveys occurred. Weather conditions were mostly favorable which enhanced investigator mobility and fish observations in shallow pools.

4.3.1 Hydraulic Conditions

The four fall surveys were preceded by a high flow event with spillage during the first week of October. Conowingo Dam discharge reached 141,000 cfs on October 3, 2010. Natural river flows and dam discharges returned to more normal levels by the end of October and during November. Spillage at Conowingo Dam had last occurred during the first week of April, 2010 prior to the start of any stranding studies.

The typical fall generation pattern of twice-daily discharge peaks characterized hydraulic conditions below Conowingo Dam for each of the October-November stranding studies. The bi-modal peaking regime not only increased the number of daily flow up-ramp and down-ramp events but also changed the timing of the fish stranding evaluations (Figures 4.3.1-1 to 4.3.1-4). Whereas all spring and summer surveys occurred in the early morning to about noon, the fall surveys all occurred mid-day from approximately 1100-1500 h. The morning generation peak typically occurred from 0600-0900 h prevailing time, followed by down-ramp to the minimum flow of 3,500 cfs. The afternoon peak often did not occur until several hours after the on-ground survey concluded.

The morning peak discharge prior to the onset of three studies (9, 10, and 12) ranged from 26,100 cfs for Study 9 to 46,200 cfs for Study 10 (Figures 4.3.1-1, 4.3.1-2 and 4.3.1-4). Morning station discharge reached 80,000 cfs prior to the start of Study 11 (Figure 4.3.1-3). The down-ramp rate prior to each fall study was rapid. During the initial one-hour following reduction to minimum flow prior to each study, the spillway reach stage as measured by the USGS tailrace gage declined 2.8 ft (12.3 ft to 9.5 ft) for Study 9, 4.2 ft (13.8 ft to 9.6 ft) for Study 10, 5.6 ft (16.0 ft to 10.4 ft) for Study 11, and 3.1 ft (13.0 ft to 9.9 ft) for Study 12. Water level recorders that provided data on stage changes downstream in spring and summer had either malfunctioned or been removed prior to fall surveys.

4.3.2 Fish Observations

The spill event in early October altered the spillway pools by eradicating much of the emergent vegetation that had flourished in the spillway reach during the summer, as well as the heavy growths of filamentous algae noted in some pools. Many of the pools during Study 9 appeared scoured. Additionally, the lower minimum flow in fall (3,500 cfs) meant fewer and smaller pools remained after peaking generation ceased.

An estimated 1,779 fishes of at least 12 taxa were observed during the four studies (Table 4.3.2-1). Based on the lower numbers of fish seen in the pools, relative to spring and especially summer, many fish were probably transported out of the study area to downstream habitats by the high flows. More than 82% of the total fish were observed during Studies 9 and 10. The low numbers of fishes observed during Study 12 may have been exacerbated by high winds which rippled pool surfaces and reduced the visibility needed to identify and enumerate fishes, particularly smaller individuals. Three taxa, including banded killifish, cyprinid minnows, and sunfishes (*Lepomis* spp.) formed 82% of all fishes documented. Gizzard shad and several darter species (percids) combined formed an additional 13% of the total. Banded killifish were the most abundant species and favored east-side pools. Other abundant taxa such as minnows, *Lepomis* spp., gizzard shad, and darters favored west-side pools (Table 4.3.2-1). No emigrating juvenile American shad were documented in the spillway reach.

Dead fish were few (70), forming 4% of the fishes documented. Most were gizzard shad and catfishes, mainly channel catfish (Table 4.3.2-1). However, investigators also noted numerous piles of scales on spillway rocks during most surveys, suggesting that the number of fish that died due to consumption by birds, especially bald eagles, in the spillway reach during fall studies was higher. Scale piles appeared to be remains of gizzard shad.

The composition of dead fishes noted during the fall surveys suggests size plays a major role in predation by birds and particularly by bald eagles. Gizzard shad found dead were mostly 8-10 inches long; the remains of channel catfish, walleye, and carp were larger. Investigators noted that remains of each of these species, as well as lacerations on several live, swimming specimens, bore evidence of talon wounds likely inflicted by bald eagles (Figure 4.3.2-1).

4.3.3 Bird Observations

Although fall on-ground surveys usually started around 1100 h after allowing for adequate drainage of the spillway reach, the bird observations started at 0800-0830 h, before down-ramping occurred and several hours prior to disturbance of the birds in the study area by the on-ground field crews. The larger, more numerous specimens of gizzard shad (relative to the small juveniles noted in summer), and, although far fewer, adult walleye, catfishes and carp noted by on-ground investigators, apparently attracted larger number of birds. Studies 9 and 10 each recorded 93 bald eagles during a single systematic count. Fifteen great blue herons were observed during Study 9 and 35 during Study 10. During the initial systematic count prior to study 11 there were 129 bald eagles (about 70 were mature) and 25 great blue herons on and around the study site. Study 12, following a morning storm and with high winds, documented approximately 40 bald eagles.

The observer documented intense, almost frenzied feeding by the bald eagles in fall beginning about 15 or 20 min after station shutdown to minimum flow and continuing for 20 or 30 minutes. This behavior was most notable during studies 9 and 10. Bald eagles would capture a fish or engage in fighting and steal fish from other eagles, eat it quickly, then fish and eat some more. When this feeding period ended suddenly, the eagles perched on rocks in the area or moved down river to the rocks below Rowland Island to resume feeding. Fall migrations of bald eagles probably played a part in the large number of bald eagles in the spillway reach each week.

The most intense fishing activity during the fall studies was concentrated around the Crescent Pool and the delta-like outflow area of the Crescent Pool draining to the west into the main river channel (Figure 4.1.3-1). Other principal fall feeding locations included the five or six small pools just west of Tree Island and the extremely coarse rocky area just below the end of the concrete training wall below the EFL. This latter area was normally not used by piscivorous birds other than cormorants (mostly for loafing) during other seasons and stretches for several hundred yards south almost to the outflow of the Crescent Pool. Bald eagles, great blue herons and black vultures would scour this area looking for fish in and among the rocks.

4.4 Hydraulic Modeling Analysis

The results of the hydraulic modeling analysis did not match well with actual site photos taken during ramping survey events. In general, the model underpredicted wetted areas within the spillway area for lower flows. This was primarily due to the model's handling of river bed transmissivity and groundwater/hyporheic exchange.

The River2D model assumes a fixed riverbed transmissivity throughout the entire study reach. While this assumed value can be changed and has a negligible effect on the main river hydraulics, it is necessary to maintain a certain amount of groundwater transmission for model stability. However, this groundwater modeling routine, when used in a steady state solution, as was the case for this analysis, results in any "perched" or isolated pools that are above the surrounding river level to slowly drain until the groundwater level matches the overall surrounding river level. There were numerous such pools found in the Conowingo Spillway.

As a result of the model's groundwater routine, the model drained all of the Conowingo spillway pools which were above the river's water surface elevation in the process of reaching a true steady-state solution. However, in reality the spillway's bedrock formation tends to hold water indefinitely in several pools as described above (Figure 4.4-1). Thus, it was determined that use of the River2D model was not an appropriate tool for modeling specific wetted pools or other locations in the spillway.

5.0 CONCLUSION

Stranding, and therefore stranding potential (the likelihood of stranding) appears highest in summer based on the number of fishes documented in spillway reach pools. However, the consequences of stranding for the species found in summer are negligible. Less than 1.0% of more than 10,000 fish observed in spillway reach pools in summer were dead. Rather, either due to their small size (e.g., minnows or darters) or early life stage (young-of-year), stranding left these fishes in ideal, off-channel rearing habitats. The vegetation and coarse substrate provided cover and some protection from predation by birds, in summer primarily by great blue herons. Stranding in summer was twice as prevalent in east-side spillway pools as in west-side pools nearest the tailrace.

Stranding and stranding potential relative to summer is more moderate in spring and substantially lower in fall. Spatially, stranded fish in spring occur mainly in west-side pools, those closest to the tailrace and near Rowland Island. Stranded fish in fall occur primarily in east-side pools, similar to summer. The consequences of stranding also distinguish these seasons. In spring, suffocation and desiccation appeared responsible for most fishes found dead, although apparent predation or scavenging was not insignificant based on skeletal and partially-eaten remains. Perhaps most important, the consequences in spring appear highest for gizzard shad, carp, and catfishes, all non-migratory species attaining high abundance in the Conowingo tailrace in spring. Stranding of these abundant species provides abundant forage for numerous bald eagles and great blue herons when nesting and rearing young. Further, at least for carp, stranding leads to substantial spawning activity in many spillway reach pools.

Spring stranding of migratory fishes such as American shad, river herring, and white perch was minor compared to stranding of gizzard shad and other species. Along with a very few striped bass, these migratory species formed 10% of stranded fish in spring. The migratory species and gizzard shad tend to travel in schools as they move upstream, thus increasing the potential risk to these species in times of high abundance. The abundance of gizzard shad and occurrence of other species in the spillway reach in spring, including migratory species, reflects their abundance during upstream migration.

In fall the principal consequence of stranding of adult fish is death by predation. A large number of bald eagles utilize the river below Conowingo Dam in fall and take advantage of medium-sized or larger gizzard shad and large individuals of other species such as catfishes and carp. Any small or young fish that remains in spillway pools in fall either continues rearing or is transported downstream by fall spillage. The large decrease in the number of small fish observed in spillway reach pools during the fall was likely the result of the spillage that occurred in early October.

The risk of consumption by birds in fall is enhanced by the twice-daily peaks of generation that characterize station load demand in fall. Occurrence of the minimum flow period at mid-day between peaks as noted in the fall studies (also typical of non-study days) facilitates visually-oriented predation by birds such as bald eagles. Thus, the diurnal generation patterns provide the increased frequency and temporal aspects that increase the risk to fish from stranding. Fish that might otherwise escape from pooled areas as the west edge of the spillway drains to the tailrace are also subject to predation by the abundance of piscivorous birds.

Seasonal patterns of fish abundance and movement appear to be more important than Project operations in stranding fish below Conowingo Dam. Any influence on stranding potential due to the peak flow amplitude on a given day or the particular down-ramp rate used as station load is decreased are less significant. For example, the initial two spring stranding studies resulted in the two highest spillway fish counts in spring yet followed two distinctly different generation patterns. Study 2 in early May experienced the sharpest down-ramp rate among spring studies but also corresponded to the peak tailrace abundance of gizzard shad and common carp and likely other species.

Fish stranding in areas downstream of the spillway reach is possible in selected areas such as the side channel near Octoraro Creek, but such incidents were limited to one occurrence. Fish stranding in other side channels did not occur and is unlikely due to the muted down-ramp rate (e.g., Steele and Smokorowski 2000) several miles downstream.

6.0 REFERENCES

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TABLE 4.1.2-1: FISHES OBSERVED DURING FOUR SPRING STRANDING STUDIES WITHIN AND JUST DOWNSTREAM OF THE SPILLWAY REACH BELOW CONOWINGO DAM.

	29-Apr		6-May		13-May		18-May		Spring Total				Dead Fish Observed	
Species	East	West	East	West	East	West	East	West	East	West	All	Percent	No.	Percent
River herring		1		8		21			0	30	30	0.6	1	3.3
American shad		6		81		21			0	108	108	2.1	46	42.6
Gizzard shad	45	915	79	1,298	27	348	3	230	154	2,791	2,945	58.5	675	22.9
Carp	35	68	220	722	129	47	8	53	392	890	1,282	25.5	80	6.2
Quillback		2	3	34	18	72		2	21	110	131	2.6	2	1.5
Shorthead redhorse	1		2	4			4		7	4	11	0.2	1	9.1
Catfishes	5	17	9	56	7	17		4	21	94	115	2.3	75	65.2
White perch				168	20	168		10	20	346	366	7.3		
Striped bass		1		3		2			0	6	6	0.1	1	16.7
Smallmouth bass			2		*				2	0	2	0.0		
Largemouth bass			1		4				5	0	5	0.1		
Sunfish (*Lepomis*)					*				0	0	0	0.0		
Walleye				3					0	3	3	0.1		0.0
Darters				*					0	0	0	0.0		
Unidentified	7	18	1						8	18	26	0.5	19	73.1
Totals	**93**	**1,028**	**317**	**2,377**	**205**	**696**	**15**	**299**	**630**	**4,400**	**5,030**	**100**	**900**	**17.9**

*Observed, no estimate made.

Table Notes: Individual survey totals represent live and dead individuals. The percentages of dead fish are species specific, except for total.

TABLE 4.2.2-1: FISHES OBSERVED DURING FOUR SUMMER STRANDING STUDIES WITHIN AND JUST DOWNSTREAM OF THE SPILLWAY REACH BELOW CONOWINGO DAM.

	11-Jun		7-Jul		11-Aug		1-Sep		Summer Total		Season		Dead Fish Observed	
Species	**East**	**West**	**East**	**West**	**East**	**West**	**East**	**West**	**East**	**West**	**Total**	**Percent**	**No.**	**Percent**
American eel						2				2	2	0.0	1	50.0
Gizzard shad		43		22	2,570	579	1,583	1,073	4,153	1,717	5,870	56.9	40	0.7
Carp	*	8	13		5				18	8	26	0.3	4	15.4
Minnows[1]	8		34	*	28			8	70	8	78	0.8		
Quillback		9	*	1	80	49	25	3	105	62	167	1.6		
Catfishes[2]		10	1	3	1		1	2	3	15	18	0.2	7	38.9
Banded killifish				2	590	702	716	341	1,306	1045	2,351	22.8		
White perch		51		1						52	52	0.5	1	1.9
Smallmouth bass				28	2	5		7	2	40	42	0.4	2	4.8
Largemouth bass		2	1	7	119	86	123	82	243	177	420	4.1	9	2.1
Micropterus spp.						20			0	20	20	0.2		
Sunfish (*Lepomis*)[3]	*	2	8	*	639	75	271	148	918	225	1143	11.1	4	0.3
Walleye		1								1	1	0.0	1	100.0
Darters[4]			47	*	21	25			68	25	93	0.9	3	3.2
Blue crabs							10	5	10	5	15	0.1	1	6.7
Unidentified						10				10	10	0.1		
Totals	**8**	**126**	**104**	**64**	**4,055**	**1,553**	**2,729**	**1,669**	**6,896**	**3,412**	**10,308**	**100**	**73**	**0.7**

*Observed, no estimate made.

Table Notes: Individual survey totals represent live and dead individuals. The percentages of dead fish are species specific, except for total.

[1] Minnows include: spotfin shiner *Cyprinells spiloptera*; comely shiner *Notropis amenus*; bluntnose minnow *Pimephales notatus*.

[2] Catfishes include: channel catfish *Ictalurus punctatus*; flathead catfish *Pylodictis olivaris*.

[3] Sunfish includes: *Lepomis auritus;* green sunfish *L. cyanellus*; bluegill *L. macrochirus*.

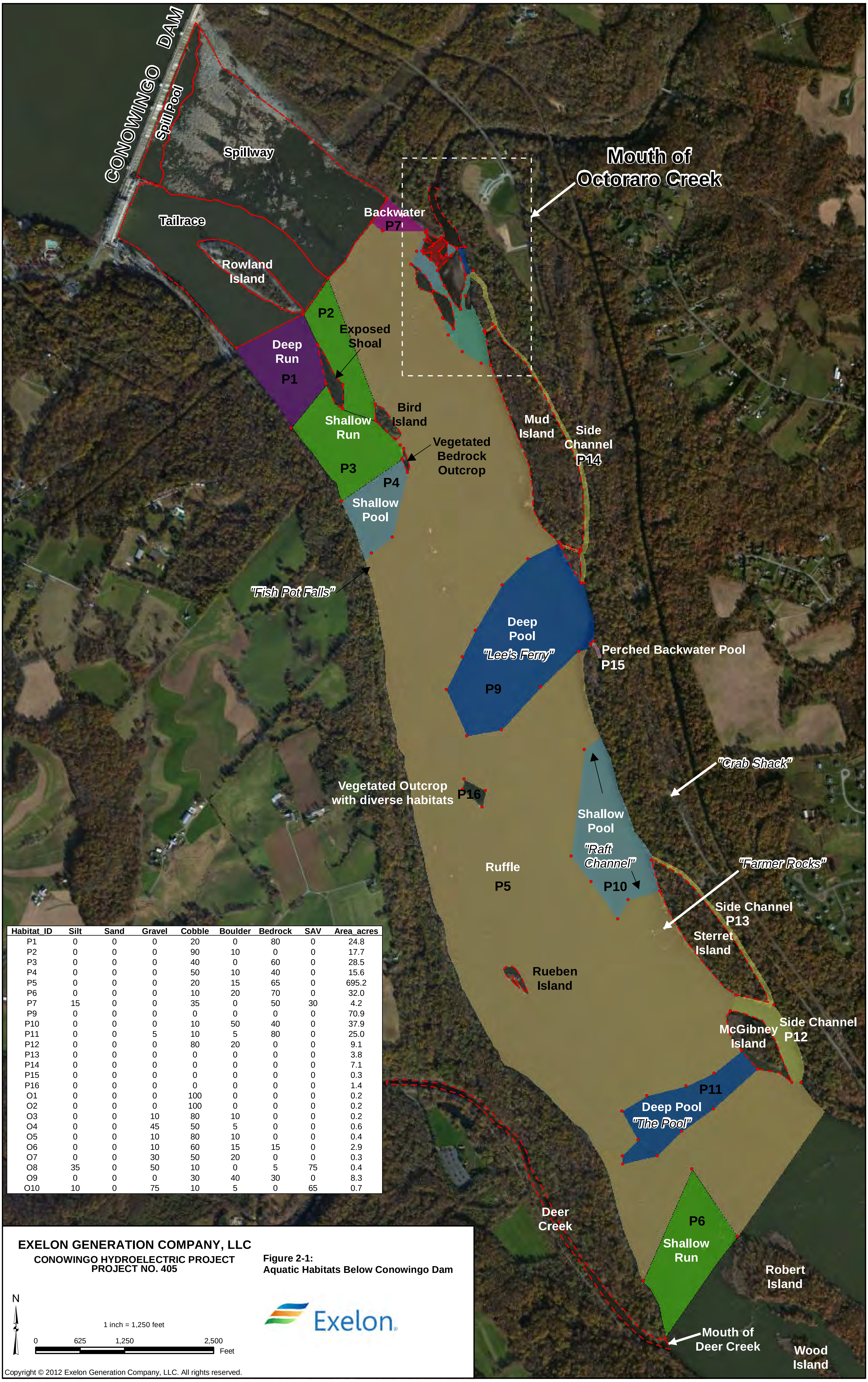
[4] Darters includes: greenside darter *Etheostoma blennioides*; banded darter *E. zonale*; tessellated darter *E. olmstedi*.

TABLE 4.3.2-1: FISHES OBSERVED DURING FOUR FALL STRANDING STUDIES WITHIN AND JUST DOWNSTREAM OF THE SPILLWAY REACH BELOW CONOWINGO DAM.

	27-Oct		3-Nov		10-Nov		17-Nov		Fall Total				Dead Fish Observed	
Species	East	West	East	West	East	West	East	West	East	West	All	Percent	No.	Percent
Gizzard shad	2	12	1	29	6	64	1	6	10	111	121	6.8	41	33.9
Carp				3		2	1		1	5	6	0.3	3	50.0
Minnows	137	1		265			16		153	266	419	23.6	1	0.2
Quillback		1							0	1	1	0.1		
Shorthead redhorse		1					1		1	1	2	0.1	1	50.0
Catfishes		1	3	3	1	2	2	1	6	7	13	0.7	12	92.3
Banded killifish	297	15	100	226	66	30	50		513	271	784	44.1	6	0.8
Smallmouth bass			1						1	0	1	0.1	1	100.0
Largemouth bass	56		4		4		2		66	0	66	3.7	1	1.5
Sunfish (*Lepomis*)	165		20		25		35		245	0	245	13.8		
Walleye		2	1			1		1	1	4	5	0.3	4	80.0
Darters				106					0	106	106	6.0		
Unidentified	10								10	0	10	0.6		
Totals	**667**	**33**	**130**	**632**	**102**	**99**	**108**	**8**	**1,007**	**772**	**1,779**	**100**	**70**	**3.9**

*Observed, no estimate made.

Table Notes: Individual survey totals represent live and dead individuals. The percentages of dead fish are species specific, except for total.



Habitat_ID	Silt	Sand	Gravel	Cobble	Boulder	Bedrock	SAV	Area_acres
P1	0	0	0	20	0	80	0	24.8
P2	0	0	0	90	10	0	0	17.7
P3	0	0	0	40	0	60	0	28.5
P4	0	0	0	50	10	40	0	15.6
P5	0	0	0	20	15	65	0	695.2
P6	0	0	0	10	20	70	0	32.0
P7	15	0	0	35	0	50	30	4.2
P9	0	0	0	0	0	0	0	70.9
P10	0	0	0	10	50	40	0	37.9
P11	0	0	5	10	5	80	0	25.0
P12	0	0	0	80	20	0	0	9.1
P13	0	0	0	0	0	0	0	3.8
P14	0	0	0	0	0	0	0	7.1
P15	0	0	0	0	0	0	0	0.3
P16	0	0	0	0	0	0	0	1.4
O1	0	0	0	100	0	0	0	0.2
O2	0	0	0	100	0	0	0	0.2
O3	0	0	10	80	10	0	0	0.2
O4	0	0	45	50	5	0	0	0.6
O5	0	0	10	80	10	0	0	0.4
O6	0	0	10	60	15	15	0	2.9
O7	0	0	30	50	20	0	0	0.3
O8	35	0	50	10	0	5	75	0.4
O9	0	0	0	30	40	30	0	8.3
O10	10	0	75	10	5	0	65	0.7

EXELON GENERATION COMPANY, LLC

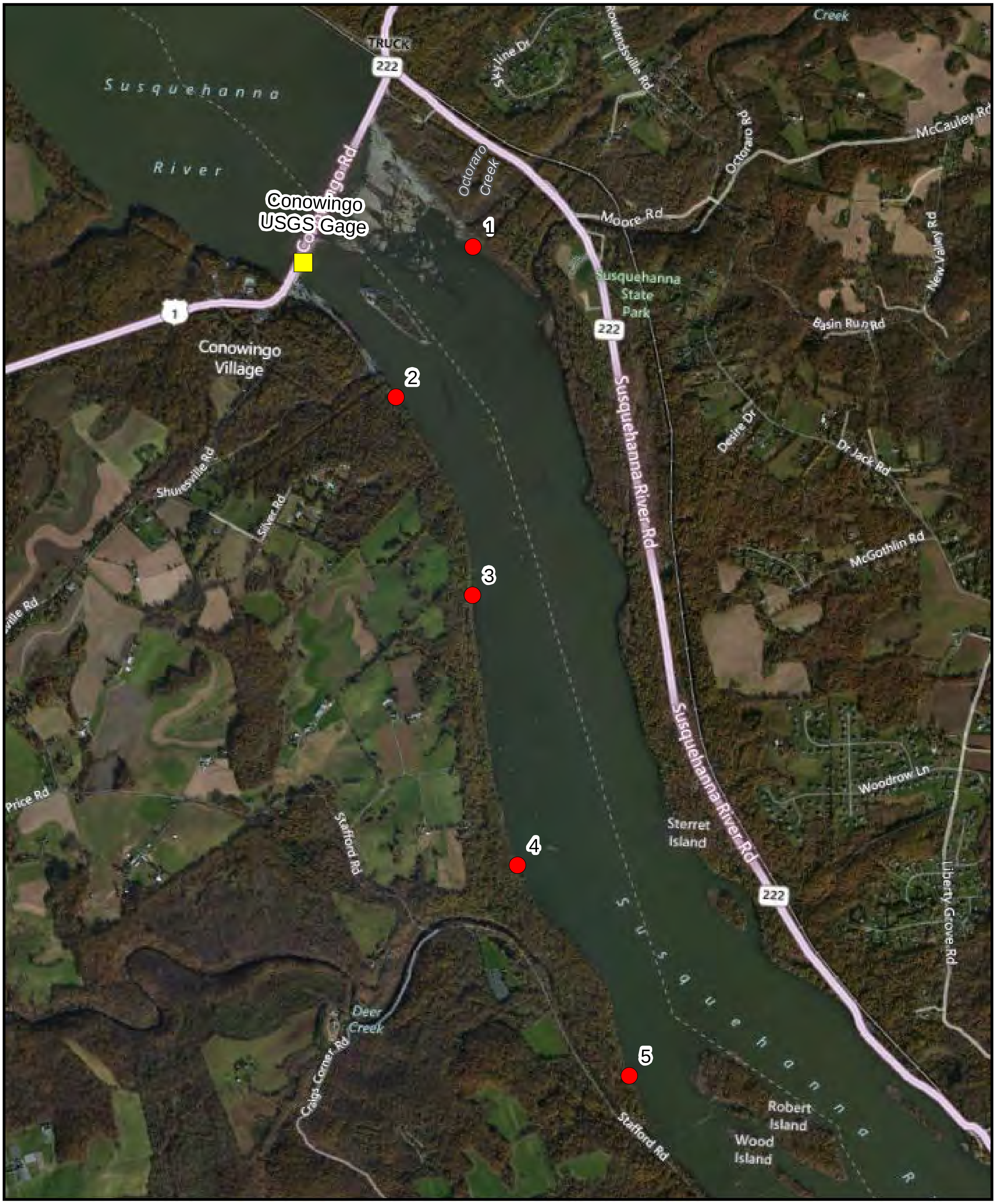
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure 2-1:
Aquatic Habitats Below Conowingo Dam

Path: X:\GISMaps\project_maps\rsp\conowingo\3_08_downstream_flow_and_fish_stranding\fig__2-1_habitat_below_dam.mxd

FIGURE 2-2: LOW-RELIEF SPILLWAY REACH HABITAT.

FIGURE 2-3: HIGH-RELIEF SPILLWAY REACH HABITAT.



EXELON GENERATION COMPANY, LLC

RSP STUDY 3.8
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.5 miles

0 0.25 0.5 1 Miles

N

Figure 3-1
Figure Title: Locations of USGS Gage and water level recorders below Conowingo Dam.

Path: X:\GISMaps\project_maps\rsp\conowingo\3_08_downstream_flow_and_fish_stranding\figure_3_1_water_level_recorder_location.mxd

FIGURE 4.1.1-1: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 1. ARROW INDICATES APPROXIMATE SURVEY START TIME.

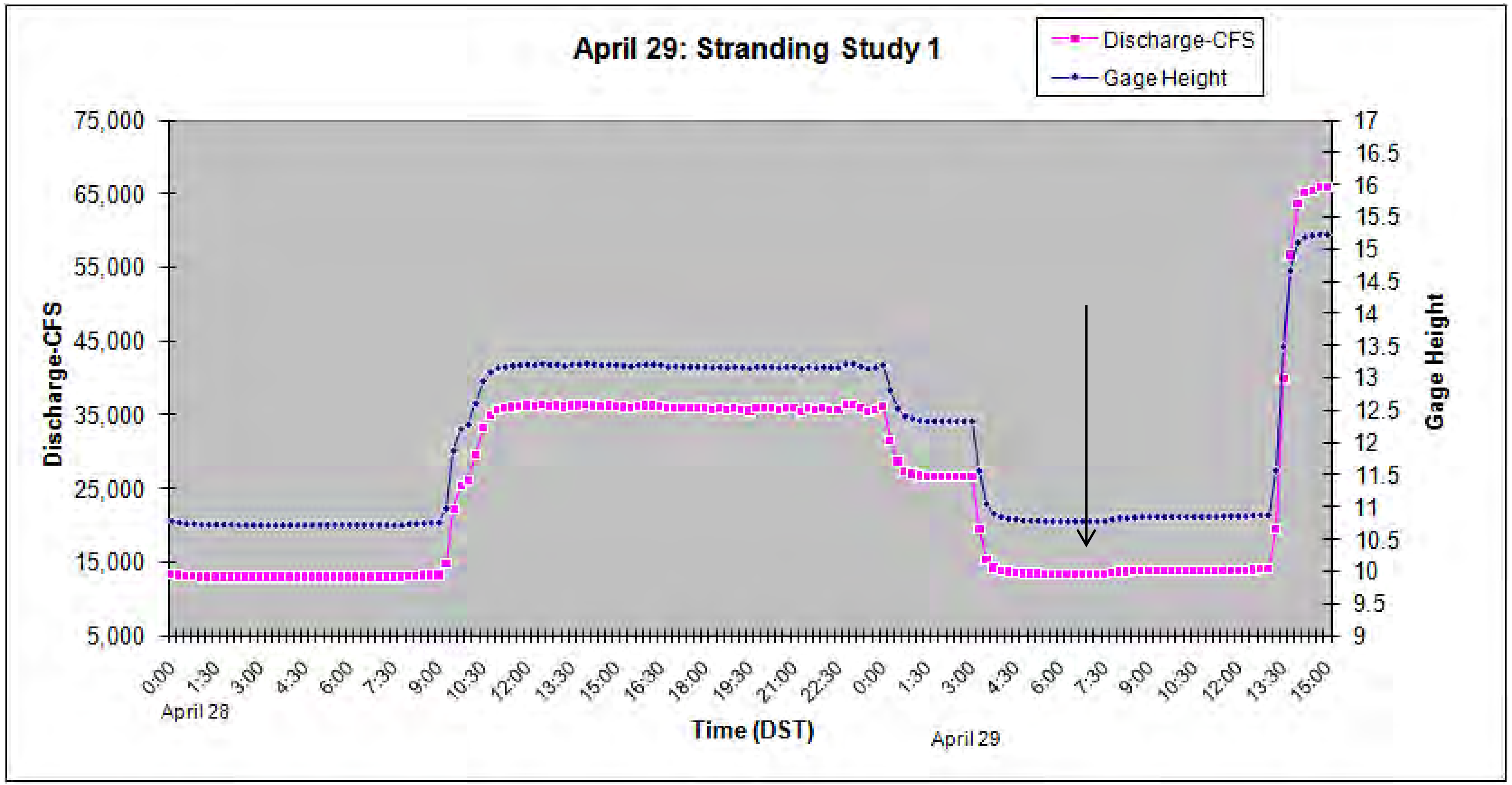


FIGURE 4.1.1-2: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 2. ARROW INDICATES APPROXIMATE SURVEY START TIME.

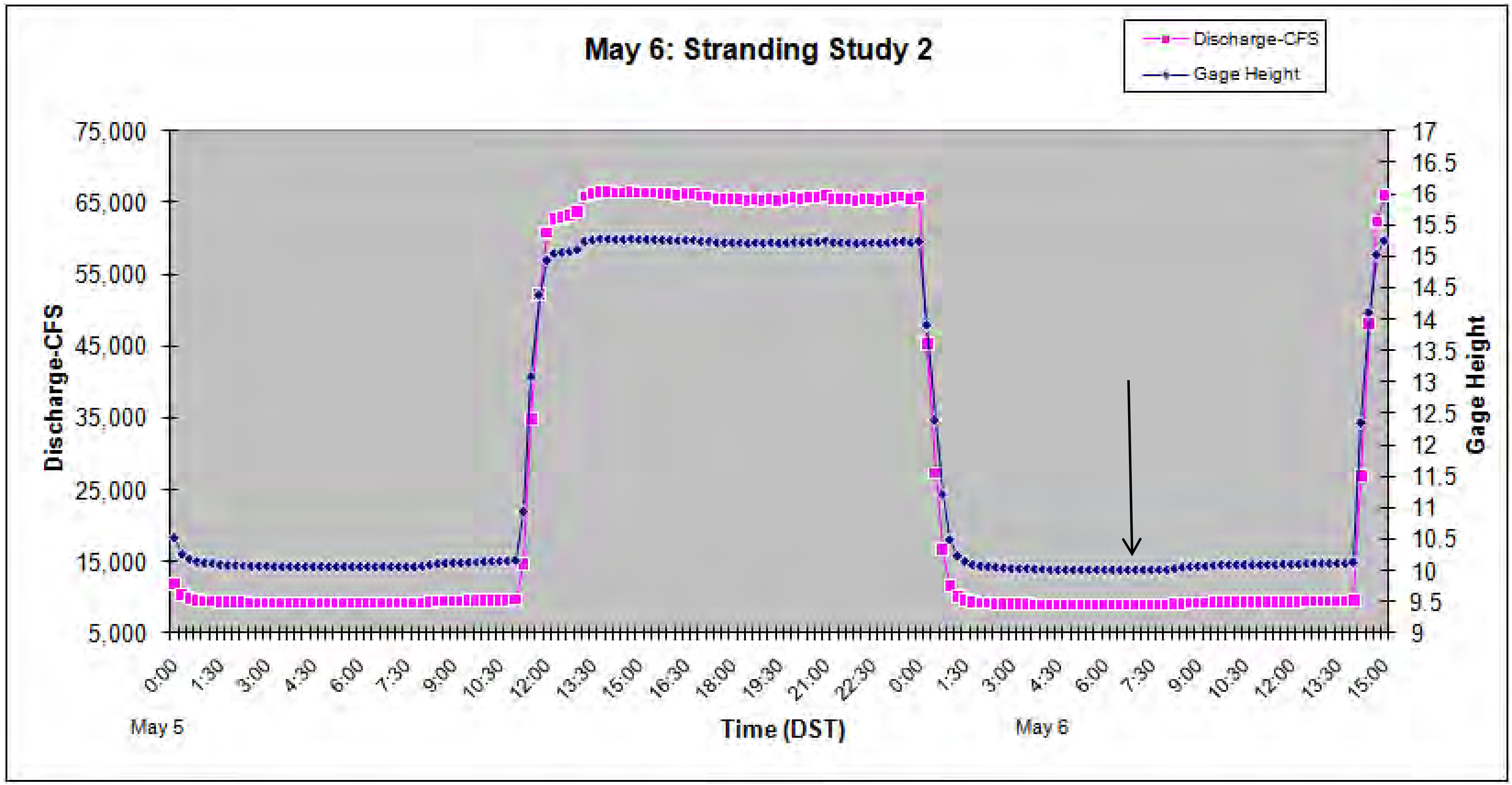


FIGURE 4.1.1-3: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 3. ARROW INDICATES APPROXIMATE SURVEY START TIME.

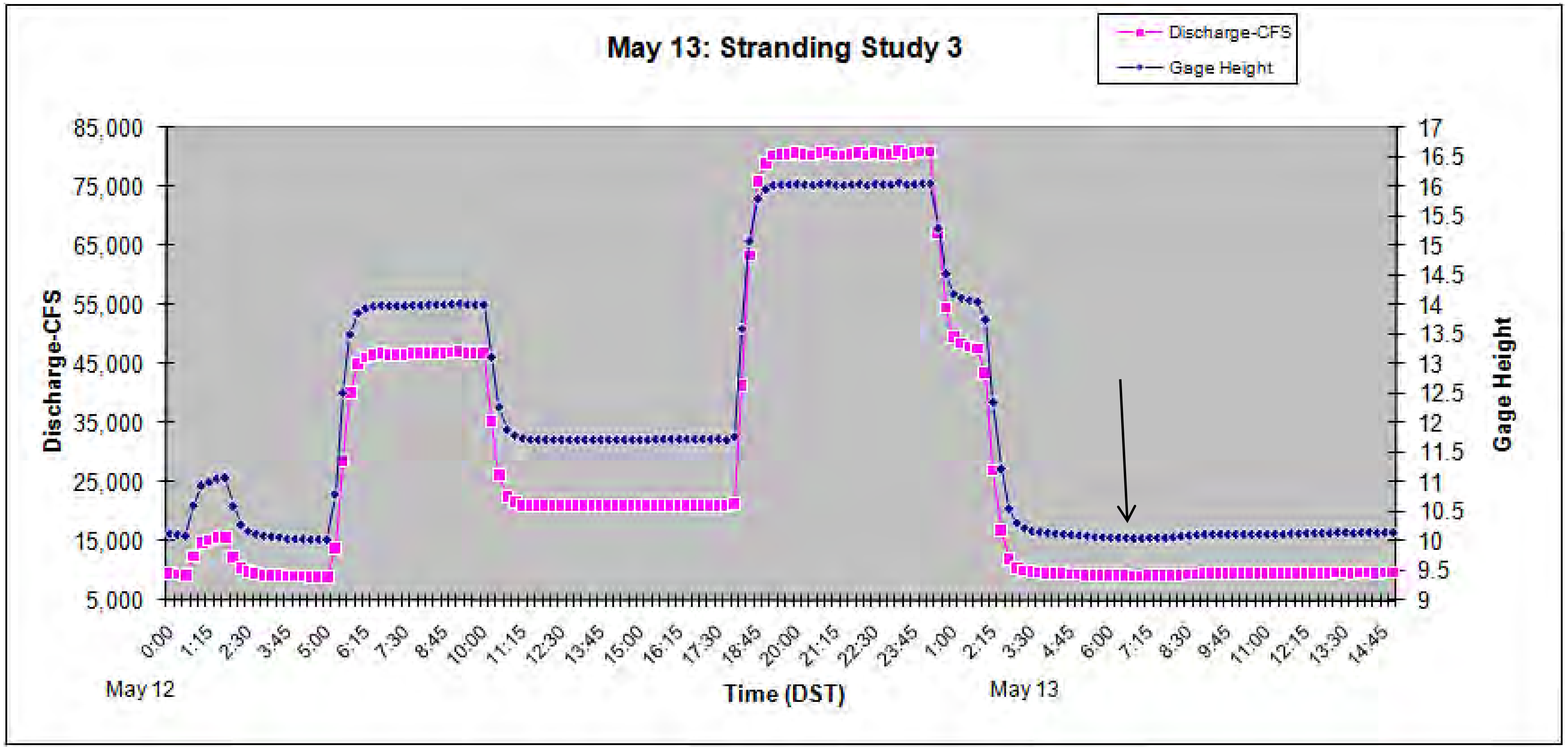


FIGURE 4.1.1-4: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 4. ARROW INDICATES APPROXIMATE SURVEY START TIME.

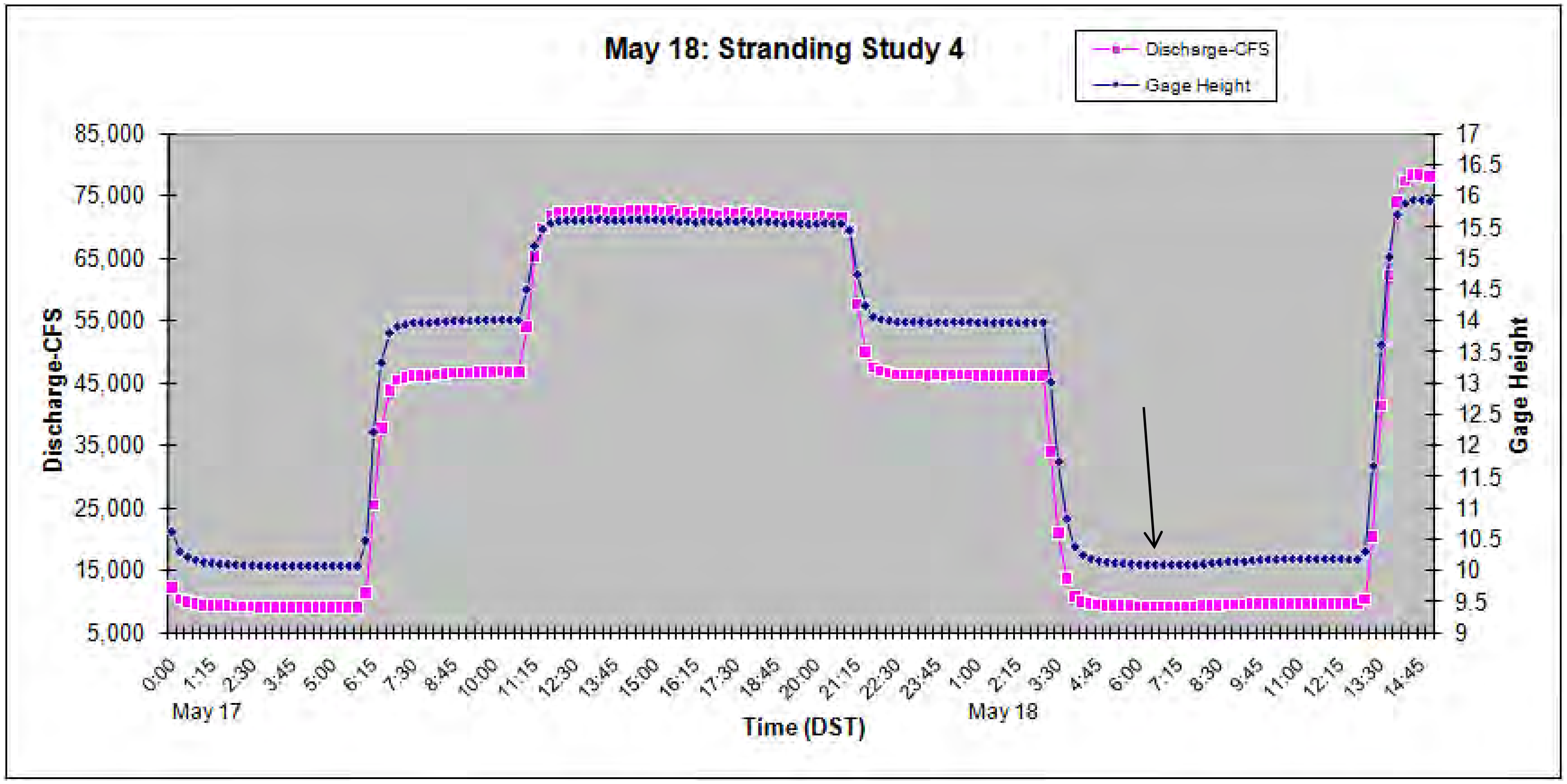
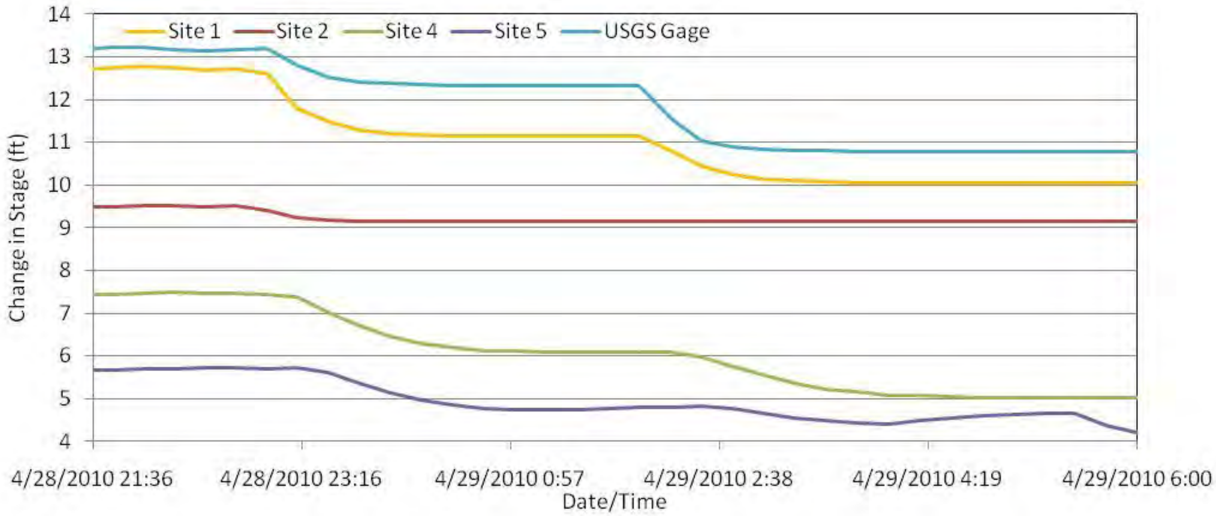
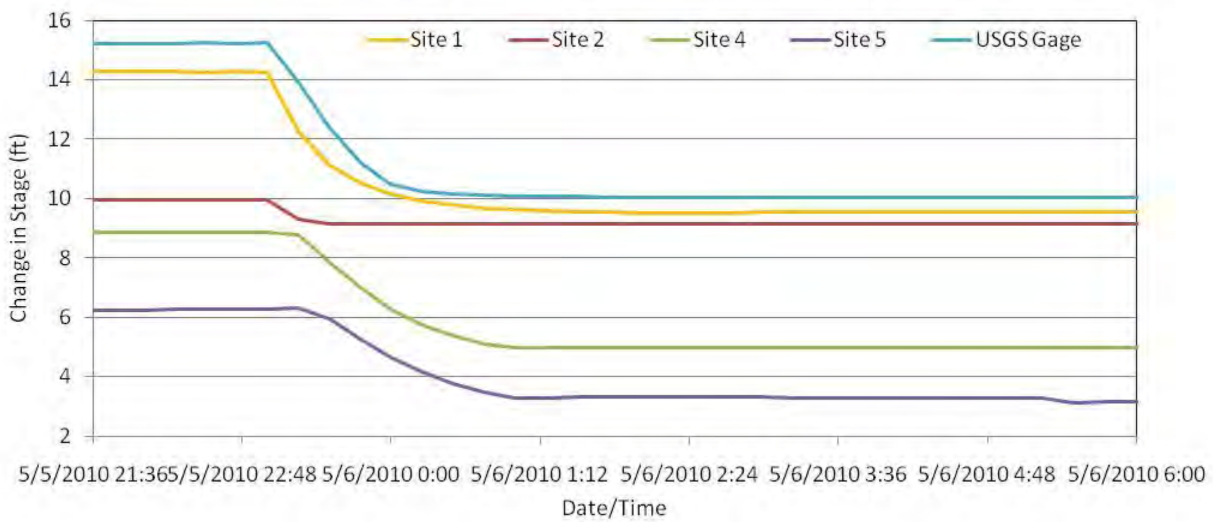
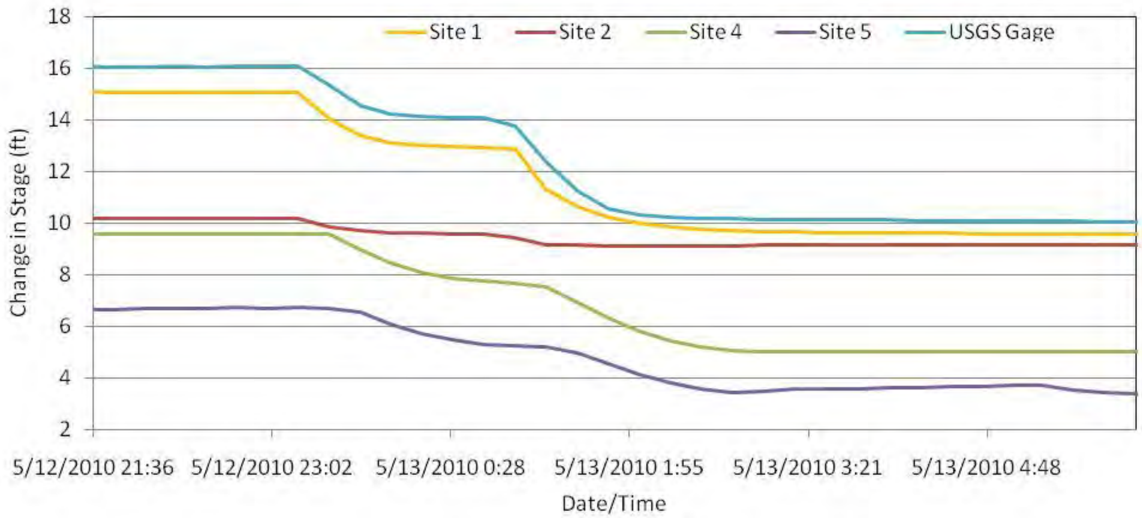


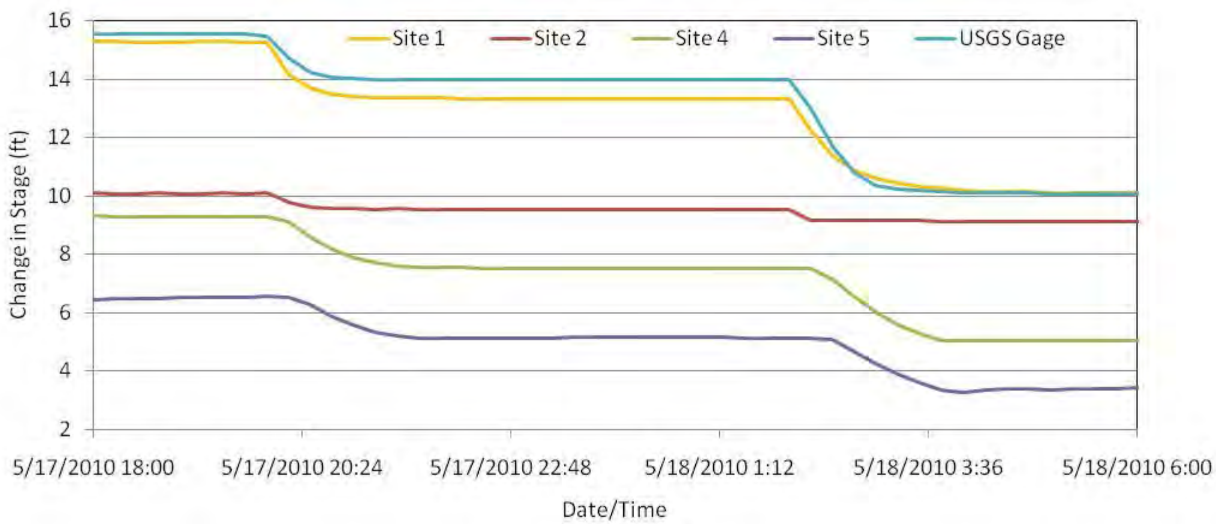
FIGURE 4.1.1-5: COMPARISON OF WATER LEVEL (STAGE) CHANGES AFTER DOWN-RAMPING AT FIVE LOCATIONS BELOW CONOWINGO DAM FOR SPRING STRANDING STUDIES.







18
16
14
12
10
8
6
4
2
Site 1
Site 2
Site 4
Site 5
USGS Gage
Change in Stage (ft)
5/12/2010 21:36
5/12/2010 23:02
5/13/2010 0:28
5/13/2010 1:55
5/13/2010 3:21
5/13/2010 4:48
Date/Time



16
14
12
10
8
6
4
2
Site 1
Site 2
Site 4
Site 5
USGS Gage
Change in Stage (ft)
5/17/2010 18:00
5/17/2010 20:24
5/17/2010 22:48
5/18/2010 1:12
5/18/2010 3:36
5/18/2010 6:00
Date/Time

Exelon

N

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 500 feet
0 250 500 1,000 Feet

Figure 4.1.2-1:
Spillway Reach Locations Where 25-74 and ≥ 75 Fish were Found During Spring Stranding Studies

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.08\Fig 4.1.2-1_Number_Studies_1to4.mxd

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PROJECT NO. 405

N

1 inch = 500 feet

0 250 500 1,000 Feet

Figure 4.1.2-2:
Spillway Reach Locations Where Selected Fish Species were Found During Spring Stranding Studies

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.08\Fig 4.1.2-2_Species_Spring_Studies.mxd

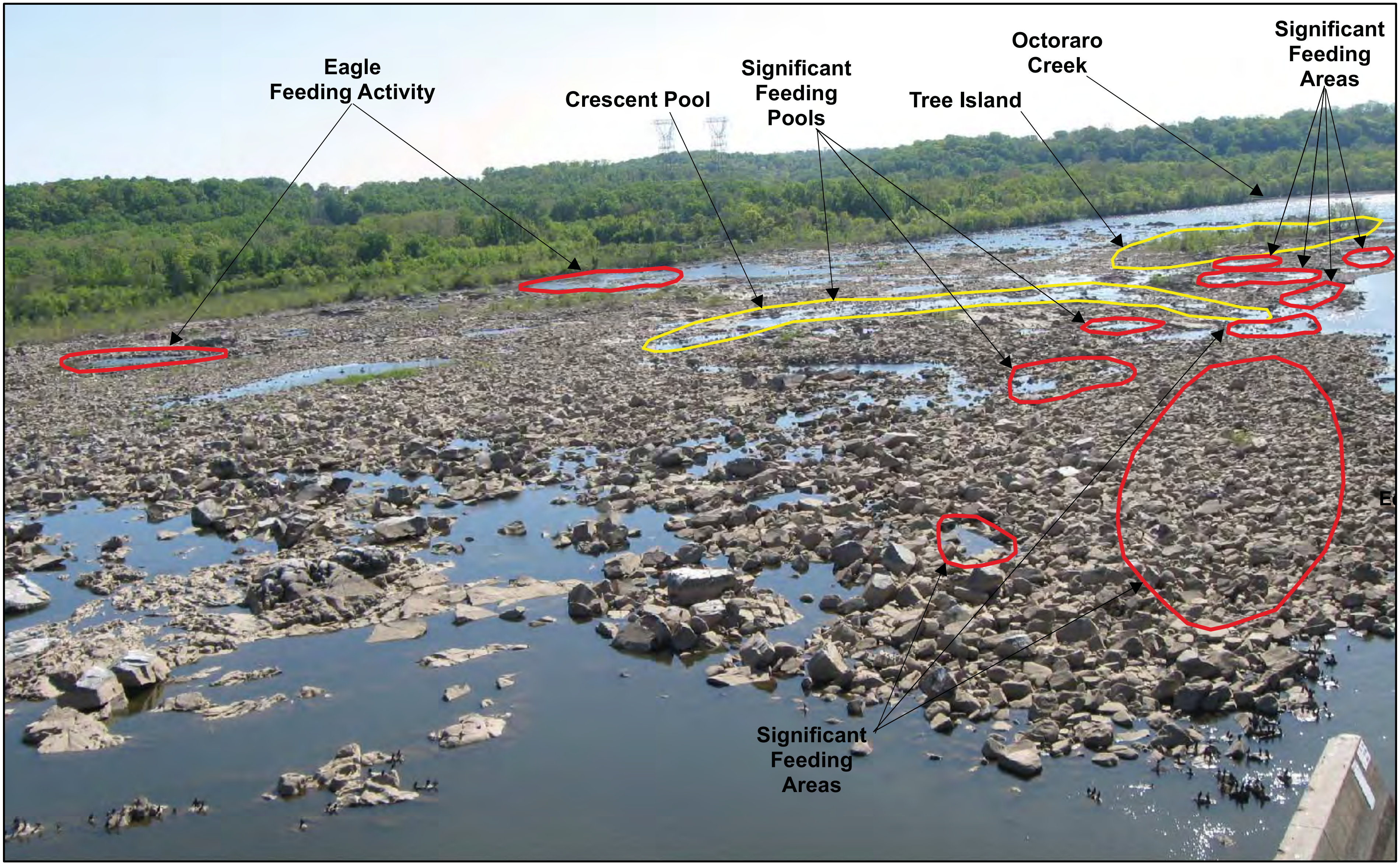


Figure 4.1.3-1

View of Conowingo Dam spillway reach from east fish lift, showing landmarks and areas of significant bird feeding activity.

FIGURE 4.2.1-1: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 5. ARROW INDICATES APPROXIMATE SURVEY START TIME.

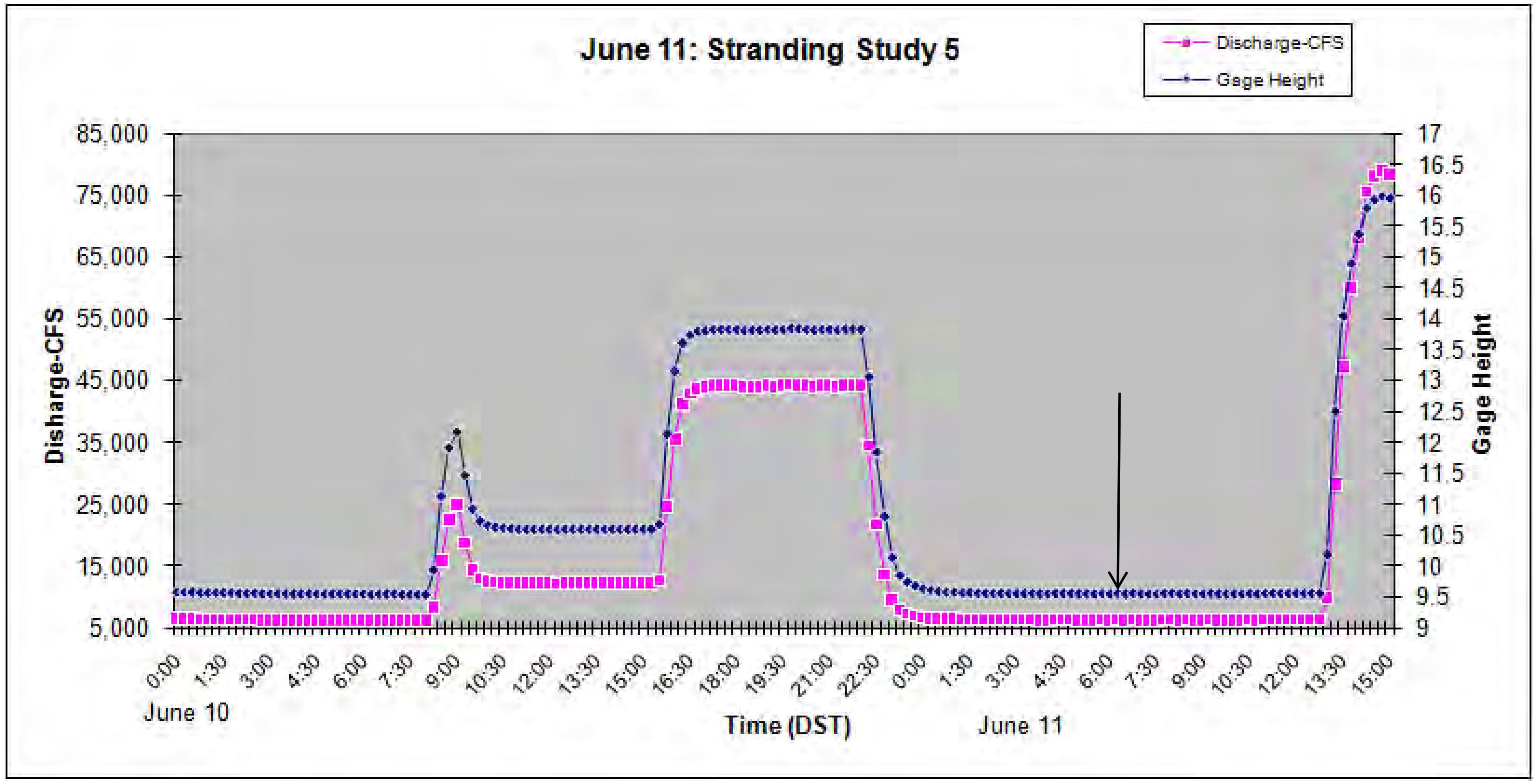


FIGURE 4.2.1-2: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 6. ARROW INDICATES APPROXIMATE SURVEY START TIME.

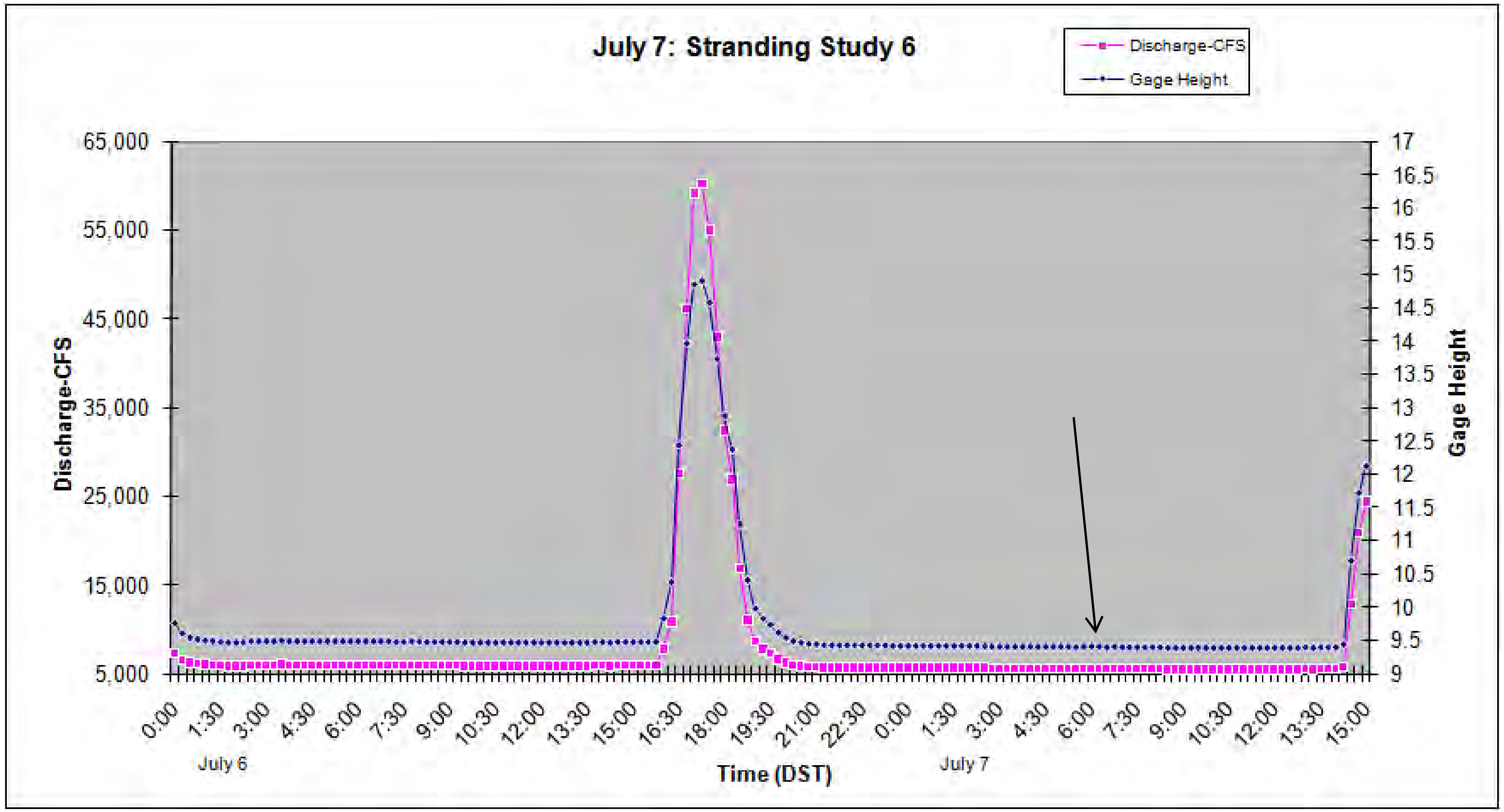


FIGURE 4.2.1-3: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 7. ARROW INDICATES APPROXIMATE SURVEY START TIME.

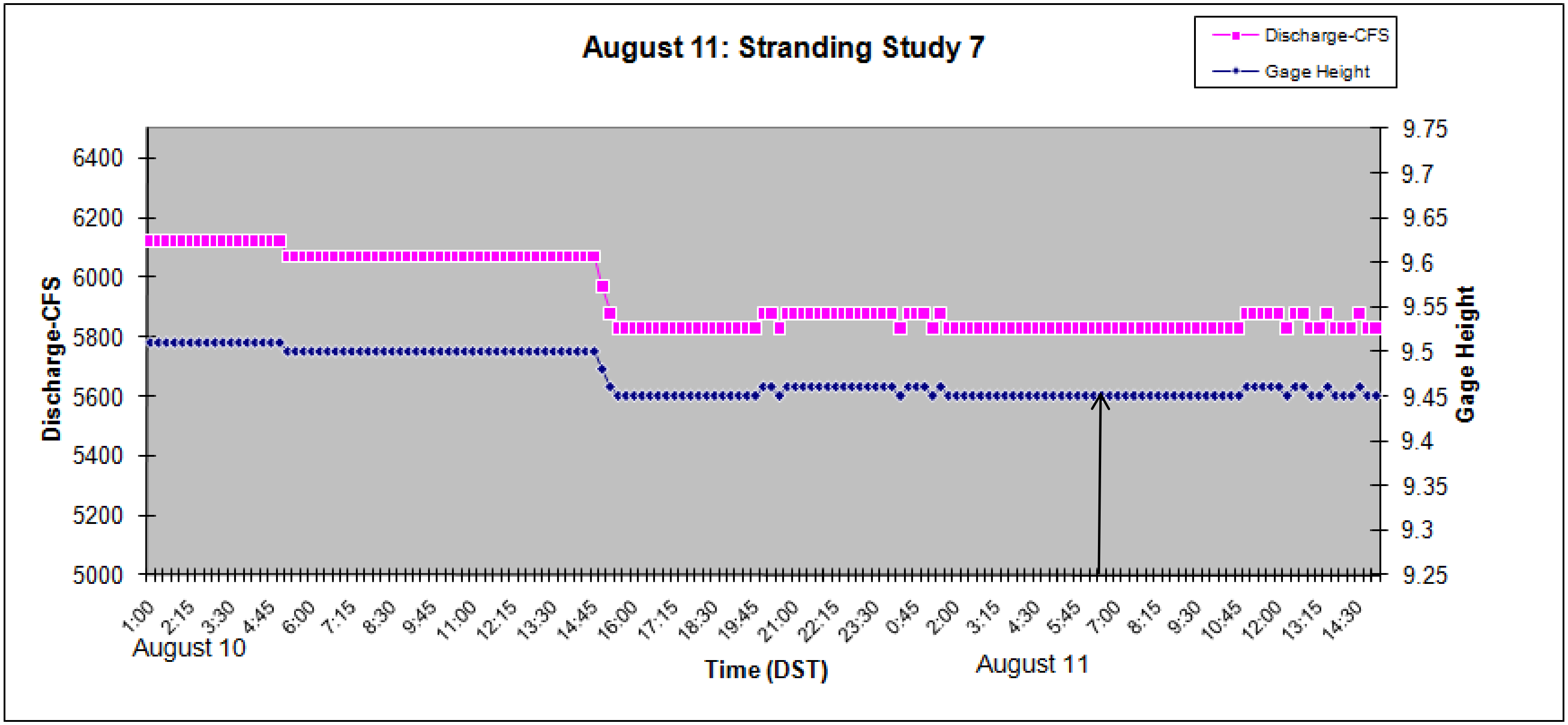


FIGURE 4.2.1-4: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 8. ARROW INDICATES APPROXIMATE SURVEY START TIME.

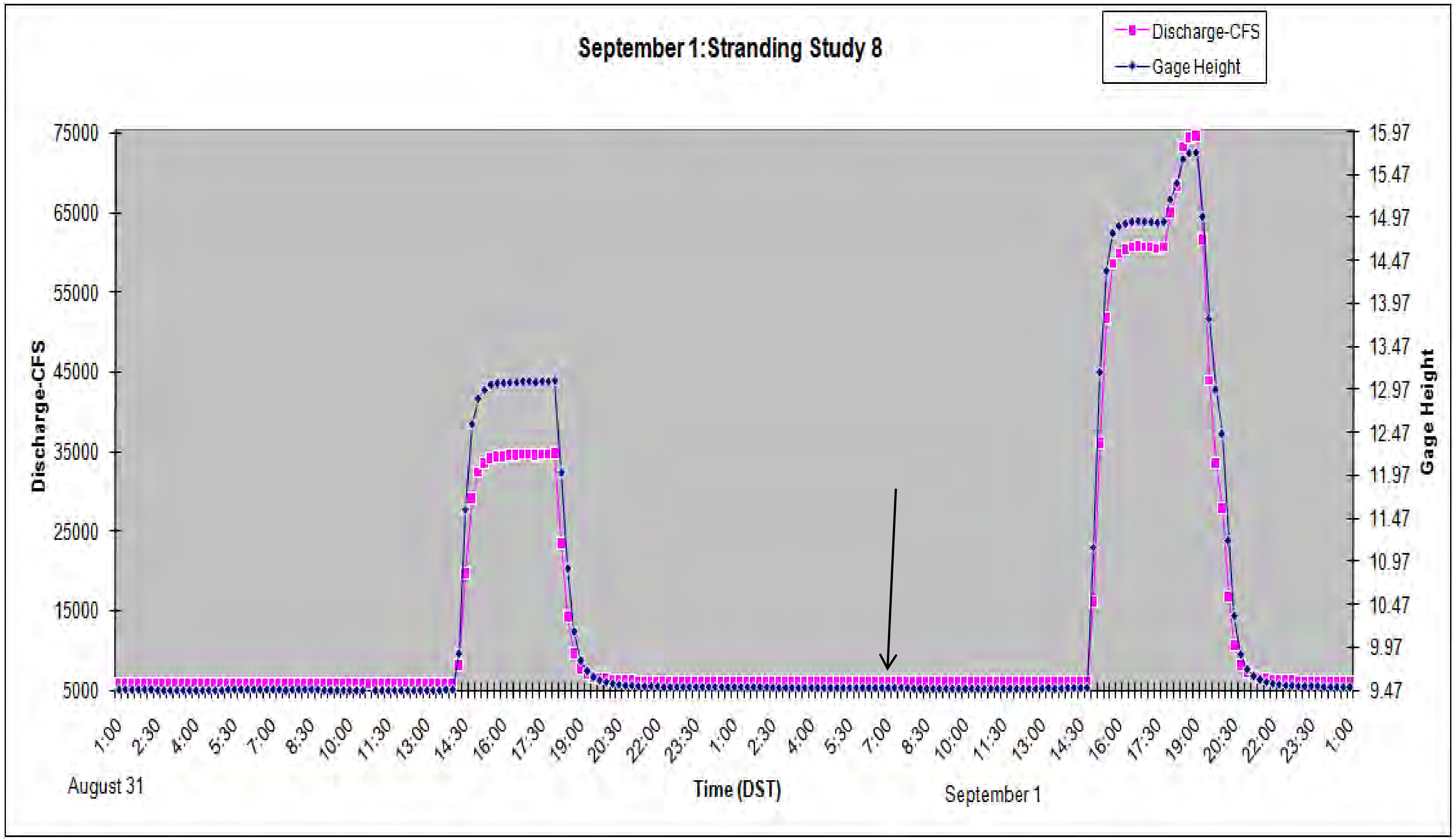
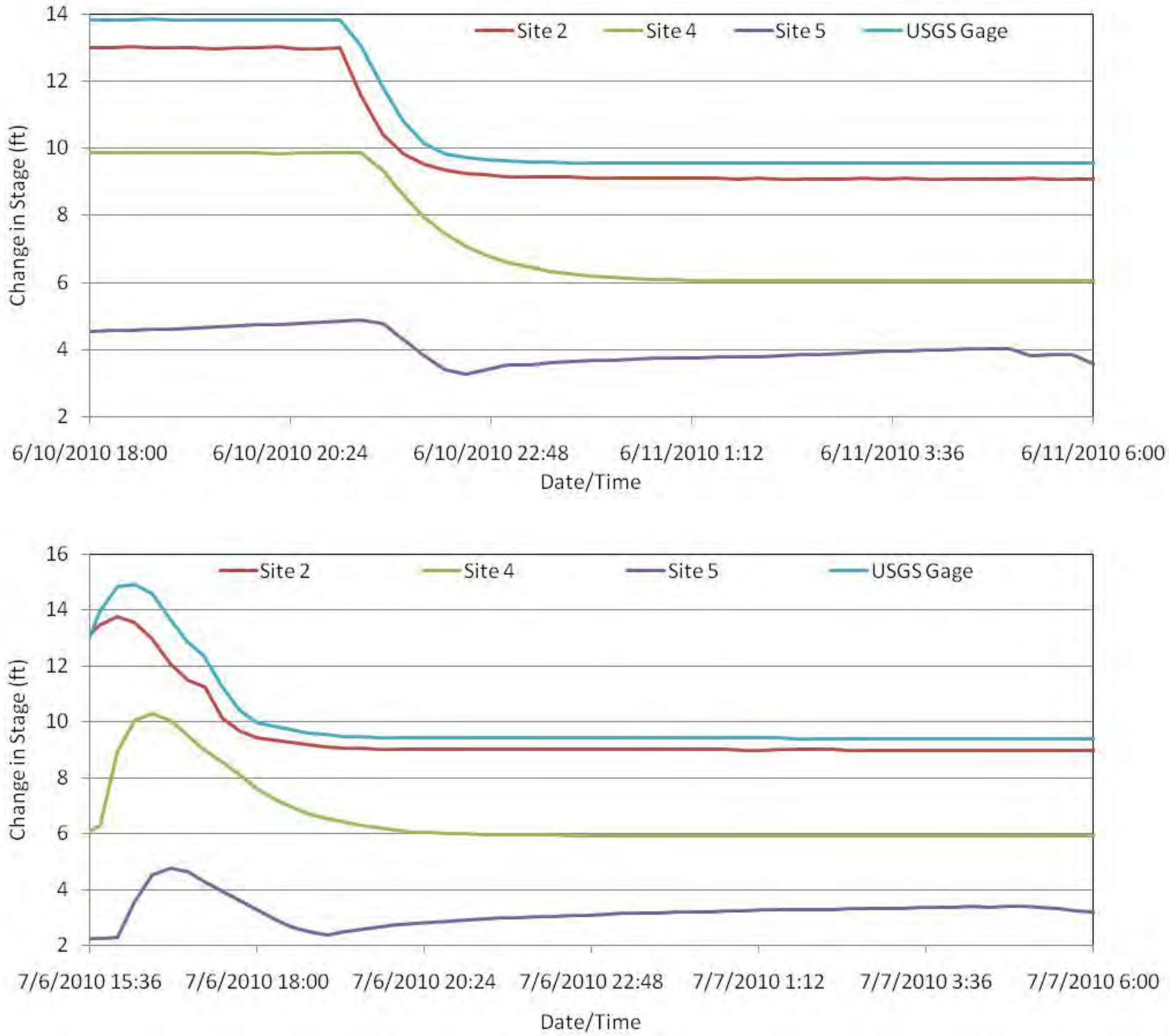
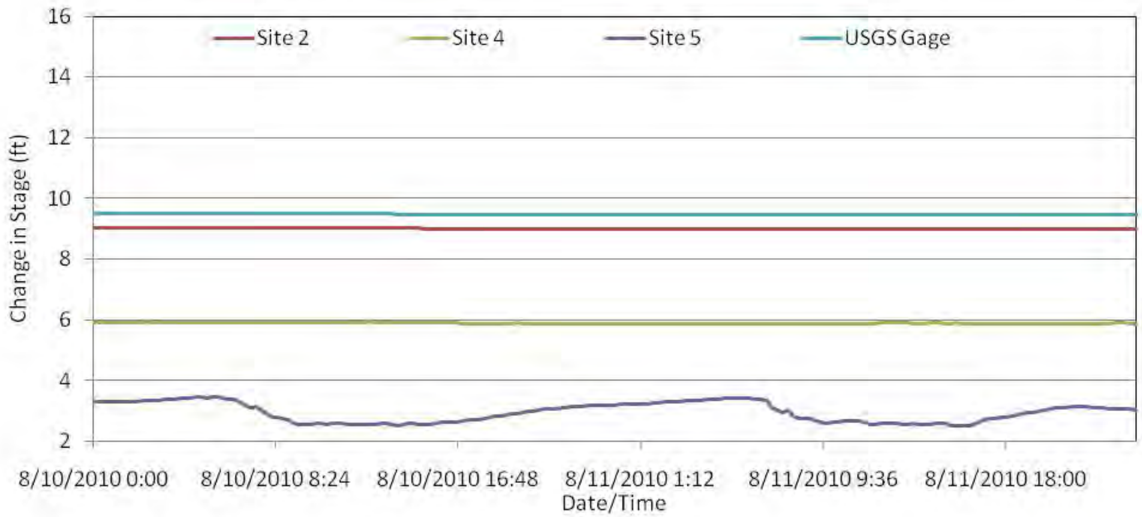
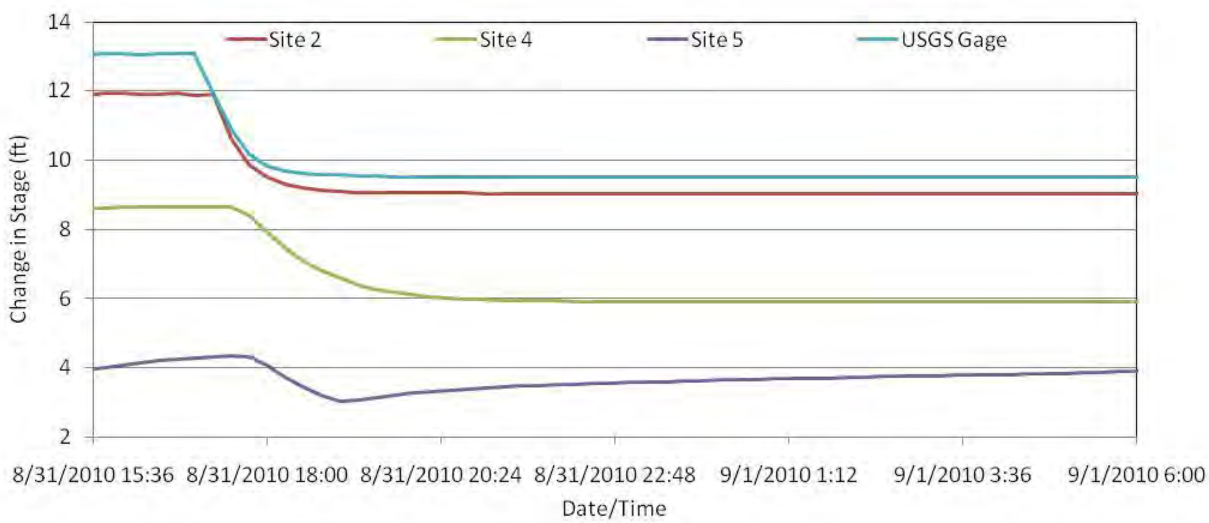


FIGURE 4.2.1-5: COMPARISON OF WATER LEVEL (STAGE) CHANGES AFTER DOWN-RAMPING AT FOUR LOCATIONS BELOW CONOWINGO DAM FOR SUMMER STRANDING STUDIES.




Site 2
Site 4
Site 5
USGS Gage
Change in Stage (ft)
16
14
12
10
8
6
4
2
8/10/2010 0:00
8/10/2010 8:24
8/10/2010 16:48
8/11/2010 1:12
8/11/2010 9:36
8/11/2010 18:00
Date/Time


Site 2
Site 4
Site 5
USGS Gage
Change in Stage (ft)
14
12
10
8
6
4
2
8/31/2010 15:36
8/31/2010 18:00
8/31/2010 20:24
8/31/2010 22:48
9/1/2010 1:12
9/1/2010 3:36
9/1/2010 6:00
Date/Time

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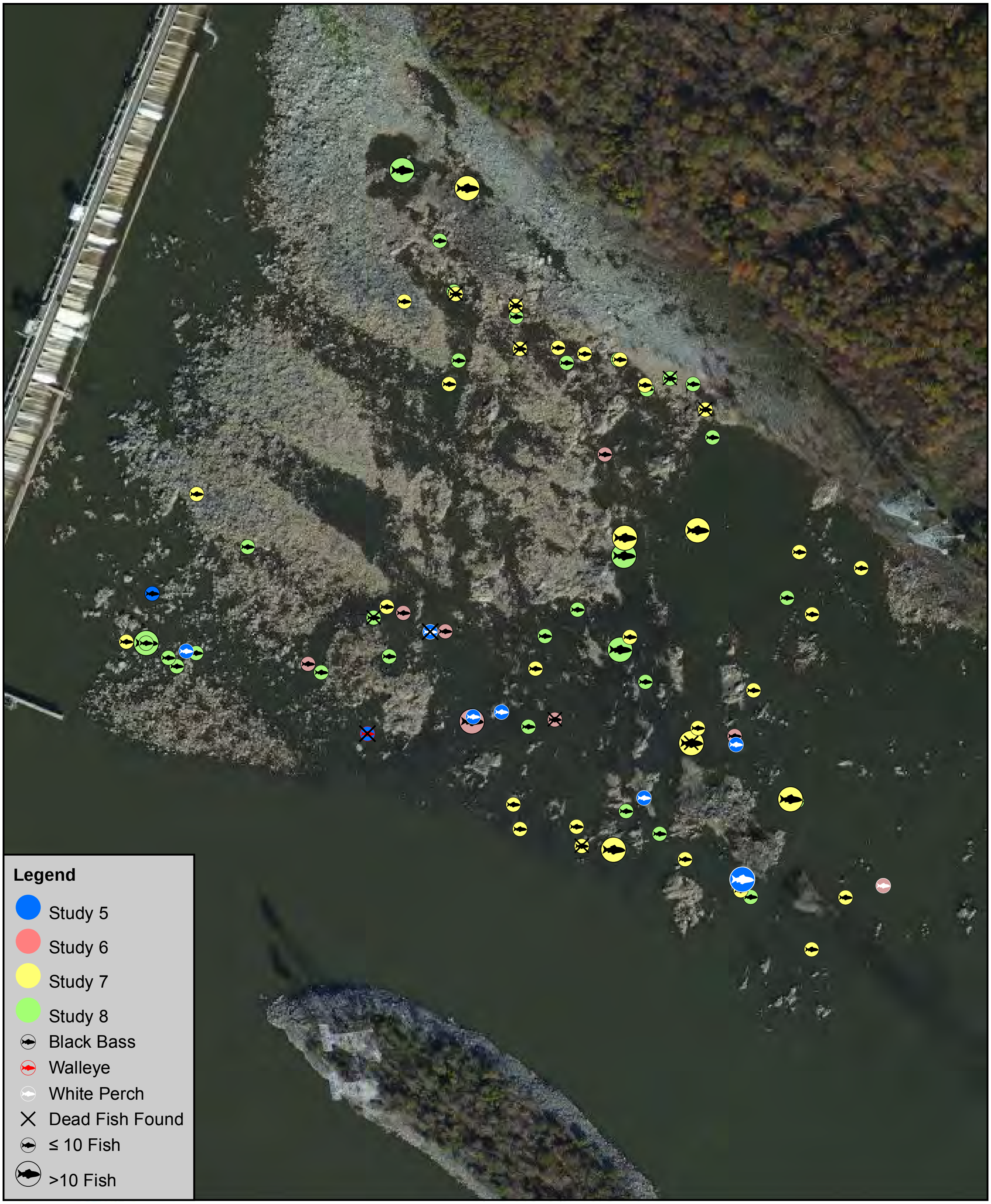
N

1 inch = 500 feet

0 250 500 1,000 Feet

Figure 4.2.2-1:
Spillway Reach Locations Where >100 Fish were Found During Summer Stranding Studies



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PROJECT NO. 405

Exelon

N

1 inch = 400 feet

0 200 400 800 Feet

Figure 4.2.2-2:
Spillway Reach Locations Where Selected Fish Species were Found During Summer Stranding Studies

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.08\Fig 4.2.2-2_Species_Summer_Studies.mxd

FIGURE 4.3.1-1: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 9. ARROW INDICATES APPROXIMATE SURVEY START TIME.

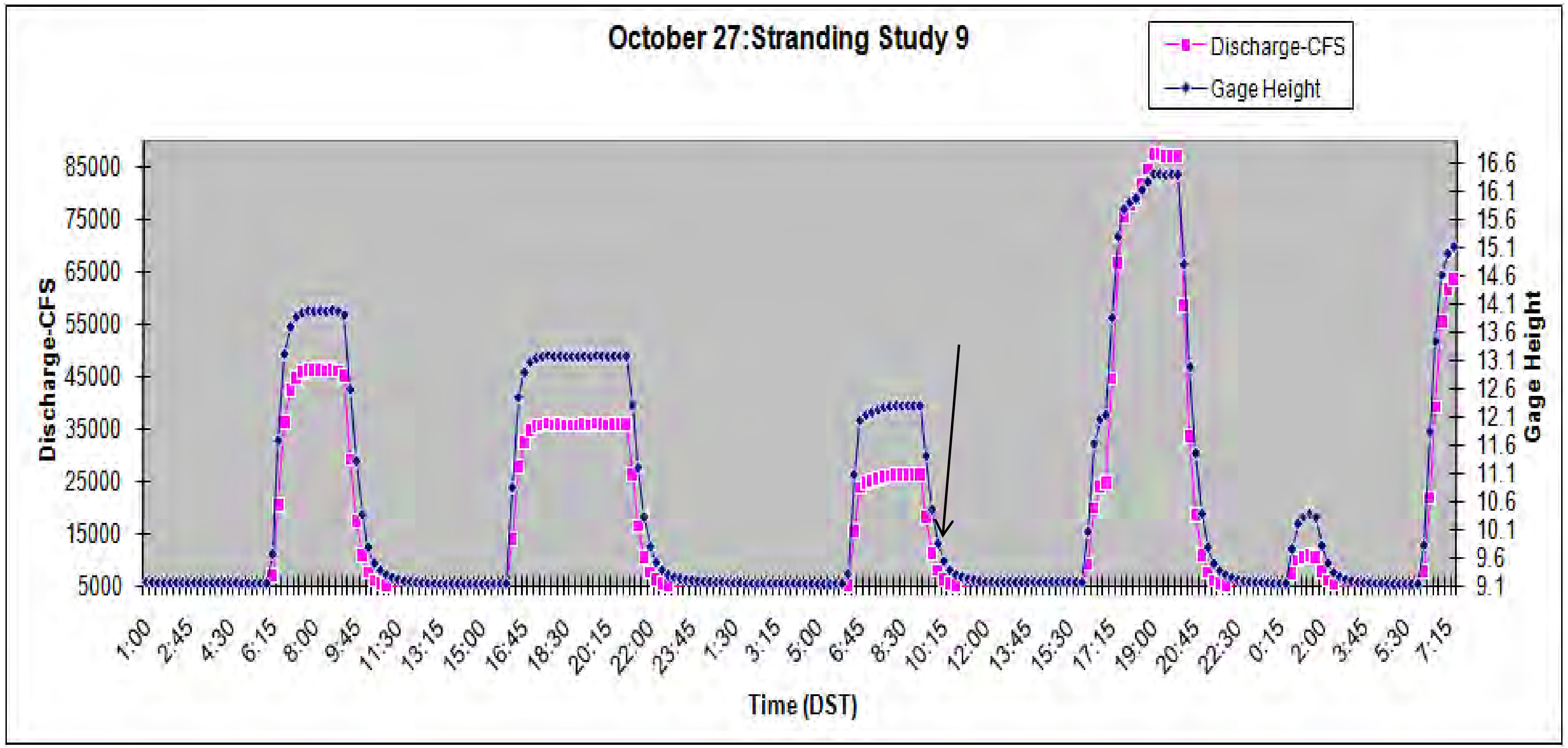


FIGURE 4.3.1-2: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 10. ARROW INDICATES APPROXIMATE SURVEY START TIME.

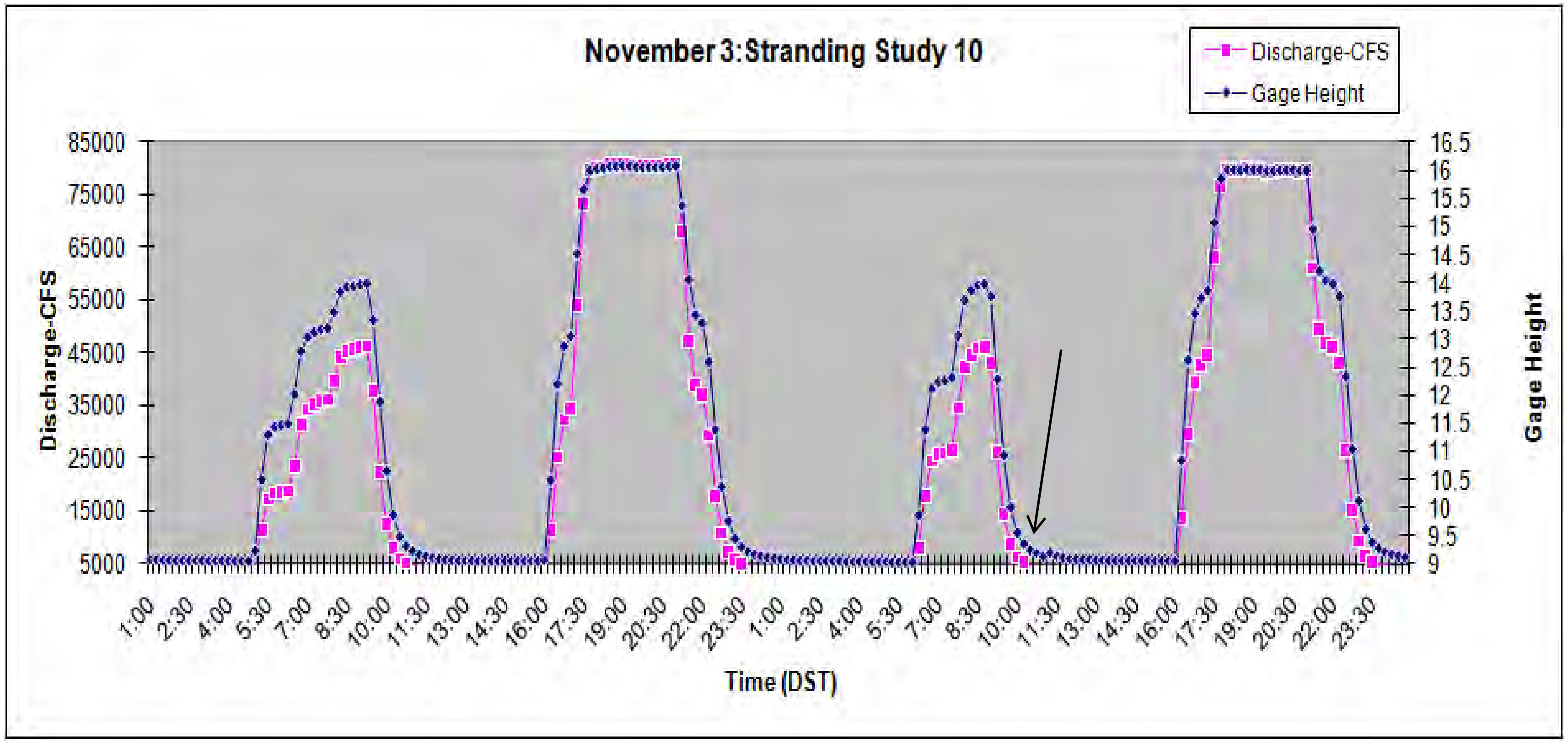


FIGURE 4.3.1-3: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 11. ARROW INDICATES APPROXIMATE SURVEY START TIME.

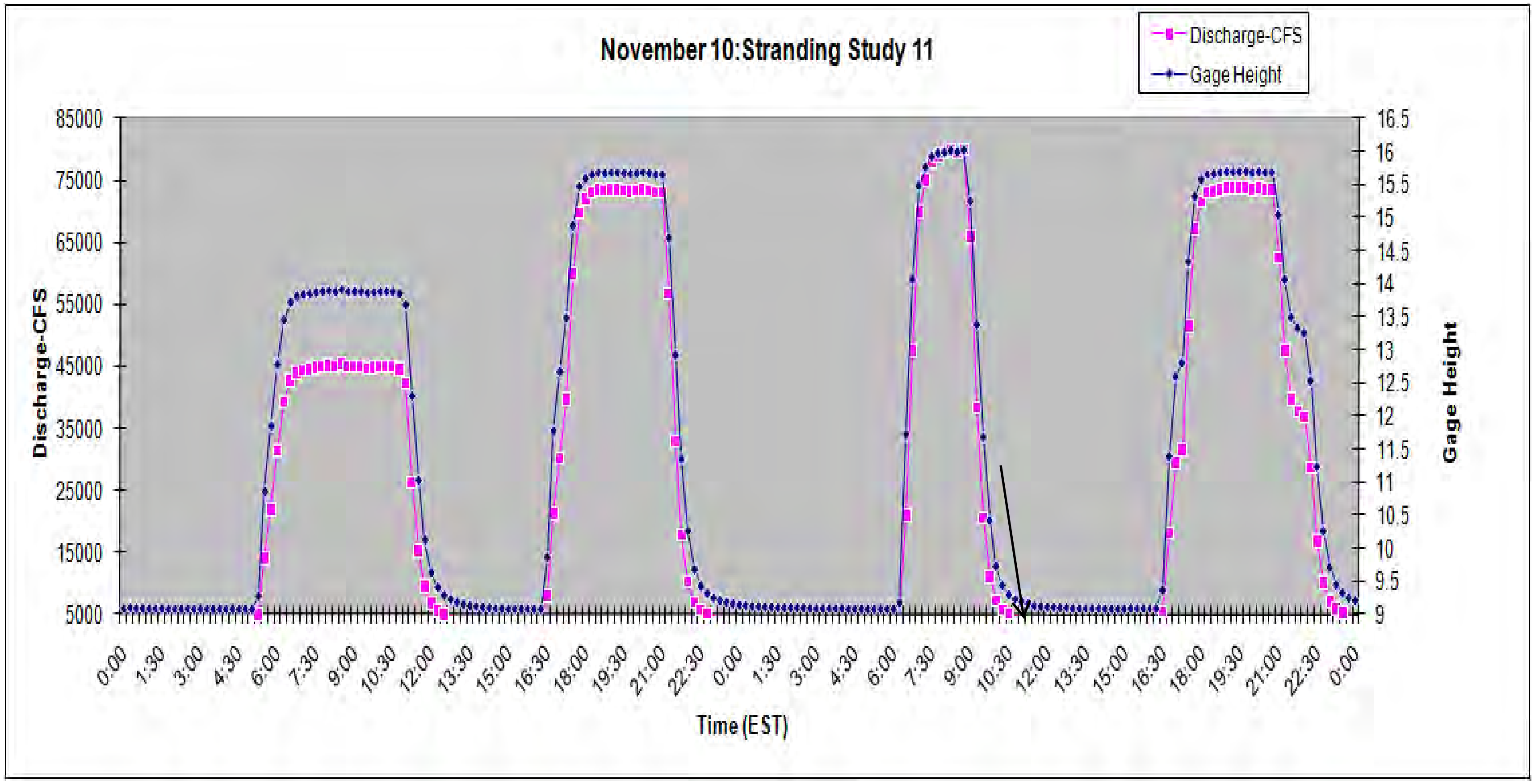


FIGURE 4.3.1-4: TAILRACE STAGE AND HYDRO STATION DISCHARGE BELOW CONOWINGO DAM, STRANDING STUDY NO. 12. ARROW INDICATES APPROXIMATE SURVEY START TIME.

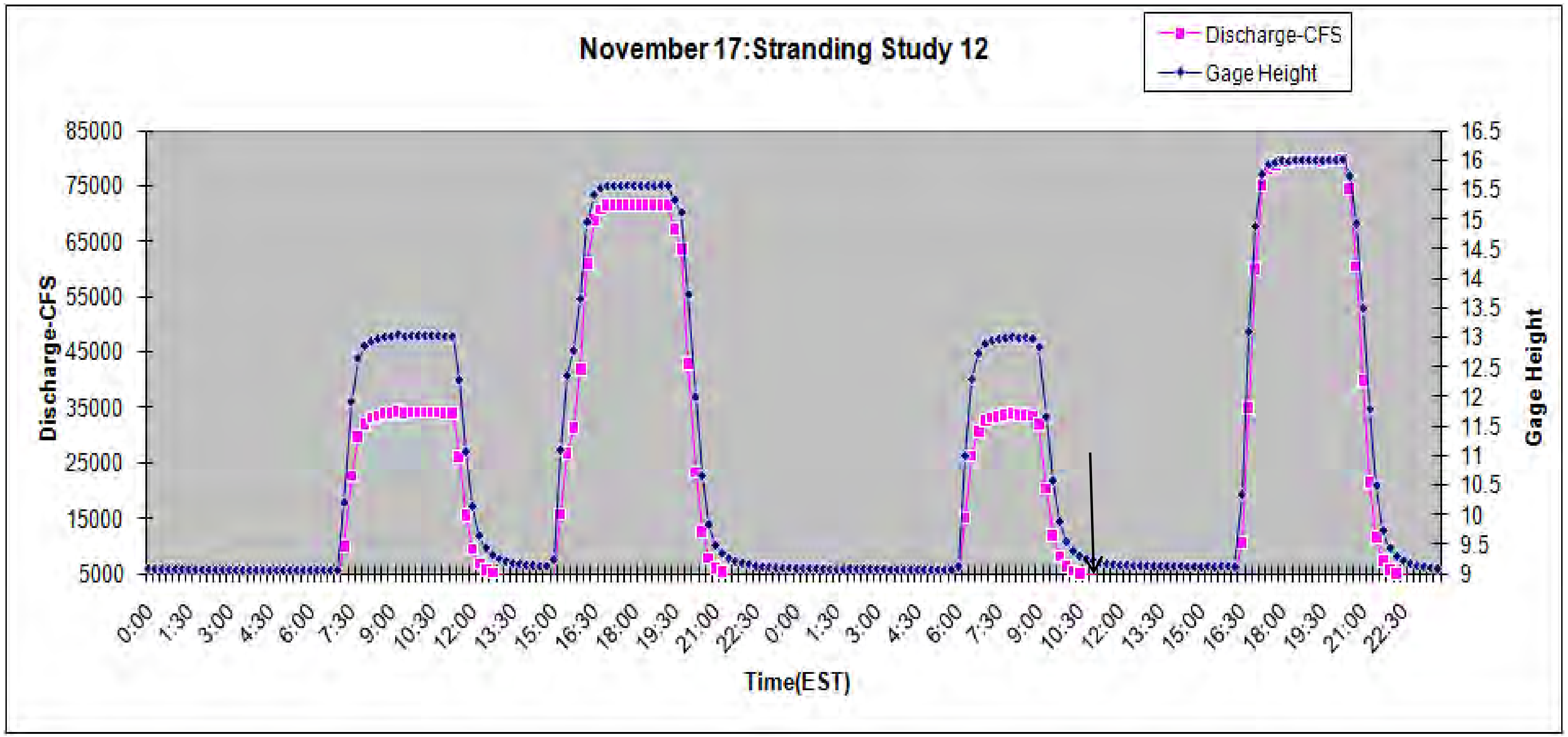
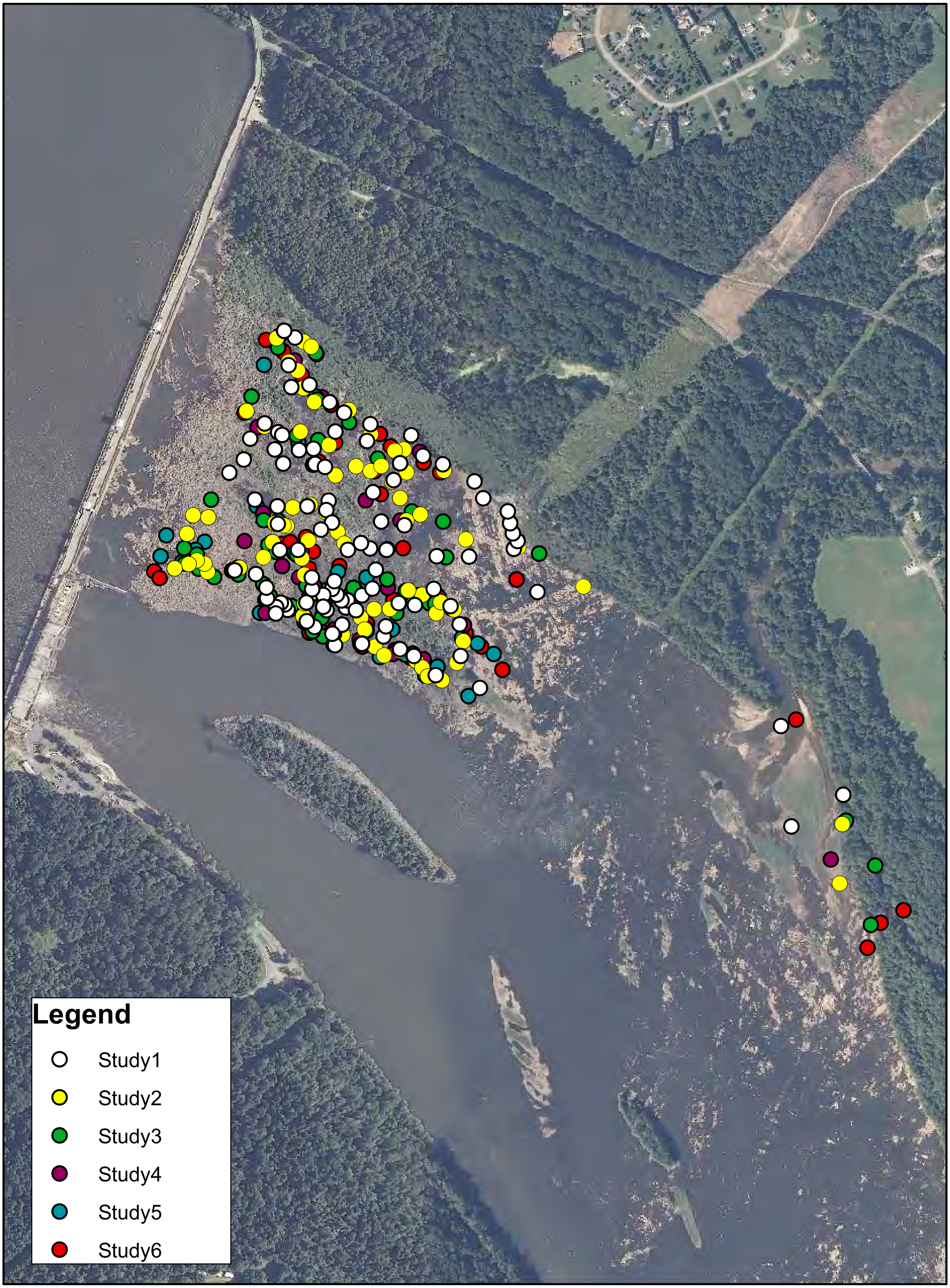
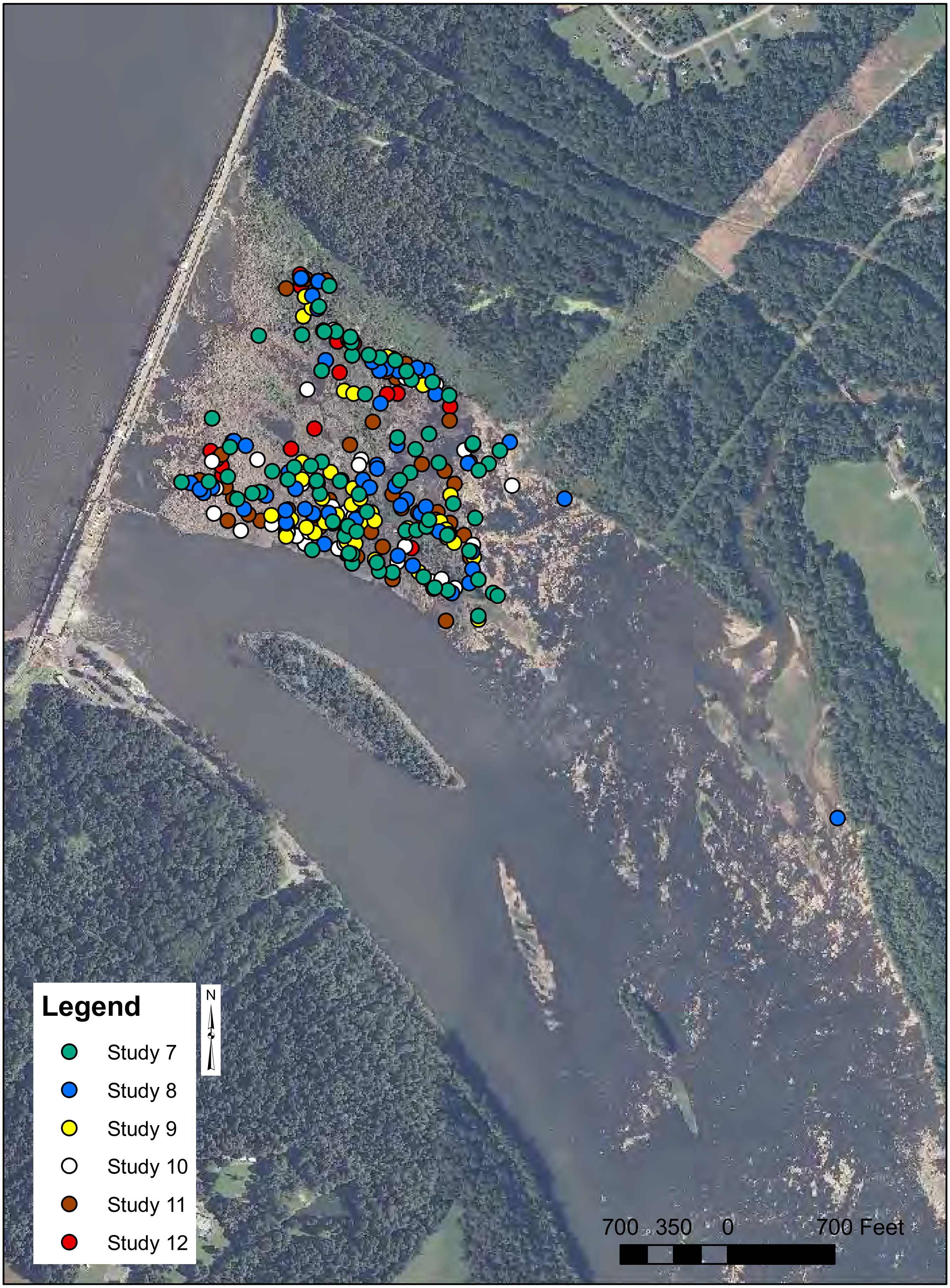


FIGURE 4.3.2-1: WALLEYE WITH APPARENT TALON WOUNDS, STUDY 11.

FIGURE 4.4-1: AERIAL PHOTO SHOWING ISOLATED/PERCHED POOLS IN THE CONOWINGO SPILLWAY DURING A MINIMUM FLOW RELEASE. CONOWINGO DAM OUTFLOW IN FIGURE IS APPROXIMATELY 3,800 CFS.

APPENDIX A: SPATIAL COVERAGE OF STRANDING SURVEYS


Legend
Study1
Study2
Study3
Study4
Study5
Study6


Legend
Study 7
Study 8
Study 9
Study 10
Study 11
Study 12
N
700 350 0 700 Feet