MUDDY RUN PUMPED STORAGE PROJECT EVALUATION OF TEMPORARY EEL COLLECTION FACILITY IN OCTORARO CREEK, (YEAR 2)

FERC PROJECT NO. 2355

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EXECUTIVE SUMMARY

Exelon Generation Company, LLC (Exelon) received a license from the Federal Energy Regulatory Commission (FERC) on December 22, 2015 for the Muddy Run Pumped Storage Project (Muddy Run Project). An American Eel Passage Plan (Eel Plan) was developed by Exelon and included as a condition of the Pennsylvania 401 Water Quality Certification (DEP File No. EA 36-033; dated 10 December 2014) for the Muddy Run Project, and is a condition of the new FERC license for the Muddy Run Project.

In 2015, Exelon designed, installed, and operated the temporary eel trapping facility at the CWA site, making 2016 the second year of the three-year evaluation. Eels collected in Octoraro Creek were transported to and held at the U.S. Fish and Wildlife Service (USFWS) eel passage facility at Conowingo Dam and subsequently transported and released at designated points in the Susquehanna River watershed. The temporary facility has the potential to become a permanent trapping facility dependent upon the success of this three-year evaluation.

The purpose of this three year study is to determine if Octoraro Creek is a viable source of juvenile eels for stocking and to evaluate the effectiveness of the temporary eel ramp.

Specifically, the objectives of the 2016 field investigation were to:

- Reinstall a temporary eel collection facility on Octoraro Creek immediately downstream of CWA's Pine Grove Low-Head Dam;
- Operate, maintain, and monitor the temporary eel collection facility (daily or as needed basis) from May 1 through September 15, 2016;
- Collect catch and length data (by substrate type), water quality, stream flow, and moon phase data during the entire sampling period;
- Stock at designated sites or deliver eels collected by the temporary ramps to the USFWS eel collection/holding facility at Conowingo Dam;
- Transport eels from the USFWS holding facility at Conowingo Dam to designated points in the Susquehanna River watershed;
- Conduct weekly quality control (QC) checks and cleaning of the eel collection facility to maintain proper attraction water flow;
- Document any modifications made to the facility during the course of the season to improve functionality and eel attraction capability.

The facility was installed and placed in service on May 1, 2016. The facility operated a total of 137 days from May 1 to September 15, with monitoring checks occurring on 95 days.

A total of 21,094 juvenile eels was collected; 13,353 from the Enkamat substrate and 7,741 from the Milieu substrate. Nearly one-third (6,343 of 21,094, 30.0%) of the captured eels were collected between June 2 – June 7, with nearly half (9,213 of 21,094, 43.7%) of the captured eels caught within a six day period (July 31 – August 5), after a small increase in stream flow.

Flow in the Octoraro Creek and juvenile eel catch appeared to be directly related in 2016. During periods of time when flows increased, the number of juvenile eels collected within a day or so also increased. These two peaks in abundance also occurred near the new moon.

A total of 20,618 live juvenile eels collected at the facility were transported within 48 hours of capture. Over half (10,707 of 20,618 eels, 51.9%) of the eels were transported directly to the designated stocking sites. Of the 10,706 juvenile eels transported directly from Octoraro Creek, 10,606 were released at Muddy Creek Forks (Site A) with the remaining eels stocked in Octoraro Lake or Conewago Creek (Site B). The other 9,911 eels were transported to the USFWS Conowingo Dam holding facility. A total of 11,894 juvenile eels were transported from the Conowingo holding facility. Muddy Creek Forks (Site A) received 11,398 juvenile eels, while 118 were stocked in Octoraro Lake, and 376 juvenile eels were placed into Conewago Creek (Site B).

Of the 21,094 juvenile eels that were captured at this facility, 476 eels were dead in the collection box (97.7% survival). A total of 32 juvenile eels died during transport. Twenty-eight eels (0.28% mortality) died while being transported to the USFWS Conowingo holding facility. Only one eel died during a direct transport from the Octoraro facility to Muddy Creek Fork (Site A). Mortality during transport efforts from the USFWS Conowingo holding facility was 0.03% (3/11,894). Overall mortality during the transport and stocking efforts was 0.10% (32/32,512).

Cleaning and calibration of the trapping facility was performed weekly. Scrubbing of the barrel that held the pump and the spray bars occurred prior to any calibration. The pump, manifold and garden hoses were also cleaned or changed as needed during the season.

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LIST OF ABBREVIATIONS

Agencies/Groups

CWA	Chester Water Authority
EPAG	Eel Passage Advisory Group
EXELON	Exelon Generation Company, LLC
FERC	Federal Energy Regulatory Commission
PADEP	Pennsylvania Department of Environmental Protection
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service

Units of Measure

C	Celsius
cfs	cubic feet per second
DO	dissolved oxygen
hr	hour
km	kilometer
m	meter
mg/L	milligrams per liter
mm	millimeter
QC	quality control

Miscellaneous

YSI 550A	YSI Incorporated (water quality measuring device)

1 INTRODUCTION

Exelon Generation Company, LLC (Exelon) received a license from the Federal Energy Regulatory Commission (FERC) on December 22, 2015 for the Muddy Run Pumped Storage Project (Muddy Run Project). An American Eel Passage Plan (Eel Plan) was developed by Exelon and included as a condition of the Pennsylvania 401 Water Quality Certification (DEP File No. EA 36-033; dated 10 December 2014) for the Muddy Run Project, and is a condition of the new FERC license for the Muddy Run Project.

The Eel Plan required Exelon to investigate the feasibility of installing and operating a juvenile eel trapping facility on Octoraro Creek. The evaluation was conducted at a location identified on Octoraro Creek immediately downstream of the Chester Water Authority (CWA) Pine Grove Low-Head Dam. This site was approved by the Pennsylvania Department of Environmental Protection (PADEP) and other members of the Eel Passage Advisory Group (EPAG)[1].

In 2015, Exelon designed, installed, and operated the temporary eel trapping facility at CWA small hydroelectric site on Octoraro Creek, making 2016 the second year of a three-year evaluation. Eels collected in Octoraro Creek were transported directly to stocking sites or the U.S. Fish and Wildlife Service (USFWS) eel passage facility at Conowingo Dam and subsequently transported and released at designated locations in the Susquehanna River watershed. This temporary facility has the potential to become a permanent trapping facility dependent upon the success of this three-year evaluation.

The purpose of this three-year study is to evaluate the effectiveness of the temporary eel ramp(s) and to determine if Octoraro Creek is a viable source of juvenile eels for stocking areas of the Susquehanna River between and upstream of the four lower river hydroelectric stations.

Specifically, the objectives of the 2016 field investigation were to:

- Reinstall a temporary eel collection facility on Octoraro Creek immediately downstream of CWA's Pine Grove Low-Head Dam;
- Operate, maintain, and monitor the temporary eel collection facility (daily or as needed basis) from May 1 through September 15, 2016;
- Collect catch and length data (by substrate type), water quality, stream flow, and moon phase data during the sampling period;
- Stock at designated sites or deliver eels collected by the temporary ramps to the USFWS eel collection/holding facility at Conowingo Dam;
- Transport eels from the USFWS holding facility at Conowingo Dam to designated points in the Susquehanna River watershed;

[1] EPAG members include the United States Fish and Wildlife Service, Pennsylvania Fish and Boat Commission, Pennsylvania Department of Environmental Protection, Maryland Department of Natural Resources, Susquehanna River Basin Commission, and Exelon.

- Conduct weekly quality control (QC) checks and cleaning of the eel collection facility to maintain proper attraction water flow;
- Document any modifications made to the facility during the course of the season to improve functionality and eel attraction capability.

2 BACKGROUND

Areas of lower Octoraro Creek up to and including the area near CWA's Pine Grove Low-Head Dam were surveyed over a 13 week period from June 16 through September 10, 2014, using fyke nets, red-light headlamps, and fine mesh dip nets (Figure 2.0-1 and Normandeau 2014). Based on the information gathered during the 2014 survey eels were consistently found in the north corner of the spillway adjacent to the Dam, while eels did not seem to be as abundant at the downstream sites during the same period. The report recommended that a site near the Dam be considered for future juvenile eel trapping (Normandeau 2014). Exelon and EPAG discussed the possibility of utilizing this north corner of the spillway site for the temporary eel collection facility in 2015. However, due to concerns by the CWA relating to existing structures at the site, an alternative site along the south shore of the Dam was selected and approved by the CWA and EPAG. The alternative site is located immediately downstream of the art building (Figure 2.0-2). The 2016 temporary trapping facility was set-up identical to the 2015 trapping facility including the same ramp configuration, holding tanks, and pump and hose set-up (Normandeau and Gomez and Sullivan 2015).

Recent trapping efforts by the USFWS (Minkkinen and Park 2014 and personal communication with USFWS, Christopher Reily, October 27, 2016) on the west shore of the Susquehanna River below Conowingo Dam have shown that the bulk of the juvenile eel migration occurs from May into September with most eels collected in June and July (Figure 2.0-3).

3 METHODS

3.1 Design, Construction, and Installation of Facility

The 2016 temporary trapping facility was identical to the 2015 trapping facility (Appendix Table A). The juvenile eel ramps are constructed of two aluminum cable trays. One cable tray contains landscape fabric climbing substrate (Enkamat 7010) attached to the tray bottom, similar to that used by USFWS for the Conowingo Dam eel passage facility (Figure 3.1-1). This substrate consists of a dense three-dimensional mesh of fused filaments which provides a climbing surface for the juvenile eels. The other cable tray contains Milieu small substrate, which has staggered vertical tubes that the eels push against as they climb the substrate (Figure 3.1-1). Milieu small substrate (25 mm diameter pipes) was chosen instead of Akwadrain, as it has proven very effective for similar size eels at other sites (Roanoke-Gaston Hydropower Project, 2011). Each ramp consists of approximately 7 m x 305 millimeter (mm) wide cable trays positioned at a 30° angle, plus a continuous length of tray that was bent and shaped at a 90° angle over a 25 mm radius at the top of the ramp to convey juvenile eels into separate holding tanks, one for each substrate type. The base of each ramp was underwater under all conditions and the base allowed for a smooth transition from the existing riverbed adjacent to a quiescent pool located in the creek. Ramps were held in place by three T-shaped solid metal braces, evenly spread across the length of the ramp, and driven into the ground beneath the ramps (Figure 3.1-2). On either side of these braces a hole was drilled into the flat bar and a piece of threaded rod bent to fasten the ramps to these braces using wing nuts. Ramps were covered from the top down to near the tail water median flow height to protect juvenile eels when ascending (Figure 3.1-3).

Water flow to each ramp was supplied via a 38 mm water line from a ½ horsepower submersible pump (Gorman Rupp Model 2XH5) (rated at approx. 250 liters/minute) installed in a 114 liter (L) barrel submerged about 1.2 meters below the water surface in the forebay above CWA's Pine Grove Low-Head Dam. The barrel contained about 50 holes, (38 mm diameter), that were covered with one mm mesh screen to prevent any material from entering the pump, hose lines, and manifold that could cause clogging. The barrel was secured by cable to a railing. The original trash rack for the old pump house (Art Building) was used to keep the barrel away from the shoreline. The depth of the water at this trash rack is approximately three meters. The underground 38 mm water line was encased in 101 mm PVC to protect the line from being crushed under the driveway. The 38 mm water line was attached to a manifold with seven garden spigots that supplied water to the spray bars and additional attraction flow lines (Figure 3.1-4). Water was continuously discharged down the ramp and into the collection tanks via a spray bar, keeping the substrate moist and creating a flow to attract juvenile eels (Figure 3.1-5). Climbing ramp flow was augmented by additional attraction flow from the overflow of the collection tanks via a gravity feed garden hose. Two additional attraction flow hoses were attached to the cover near the entrance of the ramp at the water's edge. One of these hoses was turned upward to create a splashing effect while the other original hose created a laminar attraction flow (Figure 3.1-3).

The facility contained two collection tanks, one for each of the two ramp substrate types. Each collection tank was 292 mm wide with a length of 432 mm. The depth of the water in the collection tank for the Enkamat substrate was about 330 mm, approximately 41.65 L (Figure 3.1-6). The depth of the water in the collection tank for the Milieu substrate was about 305 mm, approximately 38.44 L. The collection tanks were filled by allowing some of the spray bar flow to enter the collection tanks, thus providing a constant flow of freshwater to each tank. Each collection tank contained a drain comprised of a 51 mm PVC pipe

with holes drilled through it and wrapped in one mm mesh to prevent juvenile eel escapement (Figure 3.1-5). Each collection tank drain line was directed to the highest point possible (gravity feed) of the ramp, thus providing eel scent from the eels in the collection tank to the ramp. The bend of each ramp was custom fitted into the collection tank and ended about 50 mm above the high water mark in the tank. Each collection tank was custom fitted with a lid that was held down by a C-clamp. When necessary, an aerator was added to each tank to supply additional aeration.

3.2 Data Collection

Sample data including eel counts and lengths were recorded, verified, tabulated, and entered into an electronic format for each ramp. Water quality and environmental conditions were recorded, verified, tabulated, and entered into an electronic format during each sampling event.

Eel count data included actual counts or volumetric estimates (if necessary). Volumetric estimates were performed by placing 100 juvenile eels in a container and marking the actual height of the eels on the container. After removing the 100 eels from the marked container, additional eels were placed up to the known height of the container, tallied, and repeated until the number of remaining eels was insufficient to reach the mark on the container. The remaining eels were individually counted and added to the volumetric estimate to estimate the total number of eels collected for the day.

Length measurements were taken, with a maximum of 25 individuals per substrate (when available) per sampling event. Eels were measured to the nearest millimeter (mm) after being anesthetized (Figure 3.2-1).

Water quality data (temperature and dissolved oxygen) was taken per sampling event with a YSI 550A water quality meter that was calibrated prior to each sampling event. A Hobo Water Temp Pro monitor was also installed inside the water supply manifold that recorded hourly water temperature. The Hobo monitor was downloaded at season end.

Environmental data including stream flow, moon phase, and weather condition were also recorded.

3.3 Juvenile Eel Transport

Juvenile eels that were captured from the Octoraro Creek facility were transported directly to designated stocking sites or to the USFWS eel collection/holding facility at Conowingo Dam where they were held before transport and release at designated locations in the Susquehanna River watershed. Stocking sites that eels were directly transported to included Octoraro Lake, Muddy Creek Forks (Site A), and Conewago Creek (Site B).

When less than 50 eels were collected during a sampling event they were transported in 19 liter buckets with lids that contained the maximum amount of water to prevent sloshing. When counts of juvenile eels were greater than 50 individuals, a small enclosed transport tank (250 L) that was filled completely to prevent sloshing, was used with supplemental oxygen to maintain dissolved oxygen levels in the tank.

4 RESULTS

The Exelon juvenile eel trapping facility on Octoraro Creek was installed and put into service May 1, with continued operation through September 15, 2016. The facility operated 137 days with monitoring checks occurring on 95 days. Daily checks were initially scheduled, but due to low numbers of individuals (<100 juvenile eels per collection tank/per day) during portions of the sampling season, every other day checks were instituted with the concurrence of the EPAG. The every other day checks occurred from May 11-27, June 18-22, June 28-July 2, July 3-31, and August 12 through season end (September 15). The greatest number of juvenile eels were collected during the two-day sample period of July 29-31 (2,437 eels and comprised 11.6% of the season total). A total of 21,094 juvenile eels were collected during the 2016 season (Table 4.0-1).

4.1 4.1 Juvenile Eel Collection and Length Distribution by Substrate Type

Enkamat

Of the 21,094 juvenile eels collected, 63.3% (13,353 eels) were caught in the ramp containing Enkamat substrate (Table 4.1-1). The average length of juvenile eels from this substrate was 125.9 mm, with a median size of 125 mm. The length of juvenile eels ranged from 99 – 176 mm. Only one juvenile eel measured less than 100 mm and only one measured greater than 175 mm (Table 4.1-2). The highest one-day total of 1,040 juvenile eels occurred on June 6 (Table 4.0-1). During the sample period of July 29-31 (two-day collection), this substrate collected 1,427 individuals. Volumetric estimates were taken from the Enkamat substrate on June 3, 5, and 6 as well as from July 31 to August 5. Twenty-three (nearly 25%) of the monitoring checks recorded juvenile eel numbers greater than 100 individuals during the season for the Enkamat substrate.

Milieu

A total of 7,741 (36.7% of 21,094) juvenile eels were collected in the ramp with the Milieu substrate (Table 4.0-1). The smallest eel caught was 107 mm; the largest was 202 mm (Table 4.1-1). The average length of eels caught by this substrate was 138.1 mm, with a median size of 136 mm. No juvenile eels using this substrate measured less than 100 mm, but 17 juvenile eels measured greater than 175 mm (Table 4.1-2). The highest one-day collection of juvenile eels occurred on August 2 with 825 individuals (Table 4.0-1). During the two-day sample period of July 29-31, this substrate collected 1,010 juvenile eels. Volumetric estimates were taken on June 5 and 6 and between July 31 and August 5.

4.2 Juvenile Eel Collection by Week

The majority (73.7%) of the juvenile eels were caught during the sample periods of June 2-6 and July 31-August 5. A total of 9,283 juvenile eels were collected in the Enkamat substrate during these two periods, accounting for 69.5% of the season total for that substrate type. A total of 6,273 juvenile eels were collected from the Milieu substrate during the same two periods accounting for 81.0% of the total eels collected during the season for that substrate type.

The 14th week (July 31 – August 6) of sampling collected the greatest percentage (45.2%, 9,540 individuals) of eels in one week (Table 4.2-1, Figure 4.2-1 and Figure 4.2-2). Weeks five and six ranked third and second, respectively, in numbers of eels caught. Weeks four and eight collected over 500 eels per week. Six of the weeks collected less than 30 eels per week, which included the first two weeks and the last three weeks of operation. Weekly catch data are also provided in Appendix Table B.

4.3 Peak Periods of Eel Collections

During the season, there were some obvious peak periods, each occurring over a six day period. The first peak occurred between June 2 and 7, accounting for 6,343 of 21,094 (30.1%) juvenile eels collected at the facility (Table 4.0-1). The second peak (July 31-August 5), yielded 9,213 of the 21,094 (43.7%) juvenile eels.

4.4 Juvenile Eel Catch in Relation to Environmental Factors

See Appendix Table B for weekly averages of juvenile eel capture, river flow, lunar fraction, water temperature, and DO.

River Flow

River flow and juvenile eel catch appeared to be directly related during the 2016 season. When flows increased, the number of juvenile eels collected within a day or so also increased. The United State Geological Survey (USGS) 01578475 Octoraro Creek near Richardsmere, MD gage is located approximately 21 km downstream of CWA's Pine Grove Low-Head Dam. The highest daily average creek flow value per the USGS gage station occurred on May 7, 2016 (512 cubic feet per second, cfs, Table 4.4-1). A slightly higher flow event occurred during the end of May and the beginning of June just prior to the first peak eel collection period. Week one had the highest average weekly flows but only ranked seventeenth in number of eels captured. Daily average creek flows during Week 14 reached over 200 cfs after the creek had been below 110 cfs for the prior four weeks which could be the reason for the highest eel catch week. Weeks four through six closely correspond with some of the higher average weekly creek flows and weekly eel catches (Figure 4.4-1). The two lowest daily average creek flow weeks (Weeks 19 and 20) correspond with the two lowest eel collection weeks. A slight increase of creek flow occurred during the Week 17 which corresponds to increases in juvenile eel collection for this time period. The higher catch numbers during Week 14 of the study and the reduction of flow throughout the study may be a function of other variables (e.g., migration timing).

River Flow and Lunar Cycle

Creek flow and increases in juvenile eel catch appeared to be correlated during the 2016 season. When flows increased, the number of juvenile eels collected within a few days also increased (Figure 4.4-1). This flow/increase in juvenile catch relationship was most notable during Weeks 5 and 6, and Week 14. These two peaks in abundance also occurred near the new moon (Table 4.4-2 and Figure 4.4-2). Both increases in flow and the lower illuminance associated with a new moon have been reported to be associated with increases in eel catch at eel traps (Welsh *et al*. 2015, and Schmidt *et al*. 2009).

Water Temperature

Water temperature and eel catch did not appear to be related this season. When temperatures were below 19.0°C, Weeks 1 through 3 corresponded with some of the lowest eel catches of the season (Table 4.4-3). Over the course of the study, the average weekly water temperature ranged from a high of 27.7°C during Week 13 to a low of 14.5°C during Week 1. (Table 4.4-3 and Figure 4.4-3). The HOBO Water Temp Pro monitor data was used for the daily average temperature.

Dissolved Oxygen

Dissolved oxygen and eel collection numbers did not appear to be related this season. The high eel catches during Week 14 coincide with the weekly lowest average dissolved oxygen readings. Detailed dissolved oxygen readings are presented in Table 4.4-4 and weekly averages are displayed in Figure 4.4-4. Dissolved oxygen was usually taken in the morning when possible DO sag might occur.

4.5 Juvenile Eel Transport and Mortality

See Table 4.5-1 and Table 4.5-2 for detailed information of transport, stocking, and mortality data.

Transport

Juvenile eels collected at the Octoraro Creek facility were transported within 48 hours of capture. The eels were transported in either 19 liter buckets with lids and aeration that contained the maximum amount of water to prevent sloshing or when counts of juvenile eels were greater than 50 individuals per bucket, a small transport tank (250 L) was used with supplemental oxygen to maintain desired dissolved oxygen levels in the tank. All live juvenile eels were observed to be free of fungus and injury.

Total elapsed time from collection/holding to each stocking location varied between trips. Transport time from Octoraro Creek to the USFWS Conowingo facility was about 30 minutes. For eels that were stocked in Octoraro Lake, the transports were usually completed within 10 minutes. When eels were directly transported from the Octoraro Creek ramp to Muddy Creek Forks, (Site A), each trip varied between one and two hours based on the number of eels available for release (Table 4.5-2). Eel transports originating from the holding tanks at the USFWS facility at Conowingo Dam and stocked at Muddy Creek Forks (Site A) were accomplished within one hour. Eel transports from the USFWS holding facility to Conewago Creek (Site B), were completed in approximately two hours (± 20 minutes).

Over half (10,707 of 20,618 eels, 51.9%) of the eels were transported directly to the stocking sites. As seen in Table 4.5-1, of the 10,707 juvenile eels that were released directly at the designated stocking sites, 10,606 eels were stocked at Muddy Creek Forks (Site A, Figure 4.5-1) while the rest were stocked in Octoraro Lake (98 eels) or Conewago Creek (Site B, 2 eels, Figure 4.5-2). The remaining eels (9,911) were transported to the USFWS Conowingo Dam holding facility for later transport to upstream locations (Figure 4.5-1). The eels were transported in 19 L buckets or in a small transport tank that was available for use starting on May13.

Juvenile eels that were transported from the USFWS Conowingo holding facility were stocked weekly at designated stocking sites. A total of 11,894 juvenile eels were transported from this facility. Of the 11,400 eels that were transported to Muddy Creek Forks (Site A), 11,398 eels were stocked. An additional 118 juvenile eels were stocked in the Octoraro Lake and the remaining 376 juvenile eels were transported and stocked in Conewago Creek (site B).

Mortality

Of the 21,094 juvenile eels that were captured at this facility, 476 eels were dead in the collection tank (97.7% survival). All mortality came from a single collection tank (Enkamat) on a single occasion (August 3). Along with the 476 dead eels, an additional 507 live eels (over 50%) were also in this tank. The other collection tank (Milieu) had no mortality with 807 eels collected from this tank, and both tanks had been sampled less than 24 hours prior. The number of eels observed in the Enkamat collection tank on August 3

was not the highest observed this year. The temperature was 24.1 °C with a dissolved oxygen reading 2.1 mg/L in both collection tanks.

A total of 32 juvenile eels died during transport. Twenty-eight eels (0.28% mortality, 28 of 9,911 eels) died while being transported to the USFWS Conowingo holding facility. Only one eel died (0.01%, 1 of 10,607 eels) during a direct transport from the Octoraro facility to Muddy Creek Fork (Site A). Mortality during transport efforts from the USFWS Conowingo holding facility was 0.03% (3 of 11,894 eels). Overall mortality during the transport and stocking efforts was 0.10% (32 of 32,512 eels). Detailed data on eel transport to designated stocking sites is located on Table 4.5-1.

4.6 Quality Control Activities

Cleaning and calibration activities were conducted at least weekly during the season. Scrubbing of the barrel housing the pump, along with the spray bars was performed prior to performing any calibrations. Garden hoses and the manifold were cleaned as needed during the season.

Calibration of the ramp flow was executed each week after cleaning, using a graduated bucket. Three different locations of each ramp were checked for calibration purposes - the spray bar, the collection tank drain, and the additional attraction flows at the entrance of each ramp. The attraction flow at the top of the ramp (top attraction flow) was calculated by subtracting the spray bar amount from the drain of the collection tank. Details and calibration records are listed in Table 4.6-1.

The amount of algae growth within the hoses and spray bar increased throughout the season. In an effort to increase the flow of attraction water to the ramps, the pump was exchanged three times for the same horsepower and model submersible pump on June 20, July 26, and August 10, 2016. The inside of the barrel was cleaned of Caddisfly casings and muck during these times. The attraction flow hoses were replaced or snaked clean on three days when the pump was replaced. On three other occurrences, (June 6, July 13, and August 24), the hoses were replaced or cleaned without exchanging the pump.

4.7 Other Species Caught

Three additional species were caught in addition to American Eel. Thirteen River Crayfish (Cambaridae family) were netted from the collection tank of the Enkamat substrate on ten occasions during the season. Sixteen River Crayfish were netted from the collection tank of the Milieu substrate on fifteen occasions during the season. A Snapping Turtle (*Chelydra serpentina*, roughly 225 mm diameter shell length) was removed from the Milieu substrate tank on June 15, 2016, during this check no juvenile eels were found in this collection tank. A Northern Water Snake (*Nerodia sipedon*) was also removed from the Milieu substrate collection tank on July 19, 2016.

5 CONCLUSIONS AND DISCUSSION

The purpose of this three-year evaluation study is to evaluate the effectiveness of the temporary eel ramp(s) and to determine if Octoraro Creek is a viable source of juvenile eels for stocking. The USFWS facility has one Enkamat ramp compared to the Octoraro Creek facility which contains one Enkamat and one Milieu ramp. During the time when both ramps operated simultaneously (May 13 – Sept 9), Conowingo's facility captured 2,684 eels compared to the Octoraro Creek facility that captured 21,058 juvenile eels during the 2016 season (Figure 4.2-2). Only 36 eels were captured at the Exelon collection facility at CWA's Pine Grove Low-Head Dam in the thirteen day prior to the USFWS Conowingo eel collection facility starting operation. With both ramps operating simultaneously, the Octoraro Creek facility captured roughly eight times the number of eels collected by the USFWS Conowingo facility. During this time, the size range of the juvenile eels caught at the USFWS Conowingo facility was 82-186 mm with an average length of 118.4 mm (personal communication with USFWS, Christopher Reily, October 27, 2016). The size of the juvenile eels caught in the ramp with the Enkamat substrate at the Octoraro Creek facility was similar with a size range of 99-176 mm and an average length of 125.9 mm. Juvenile eels that were captured using the Milieu substrate were larger (average size 138.1 mm), but this substrate did not capture any eels under 107 mm. Overall, the ramps at the Octoraro Creek facility collected a wider size range of eels.

The attraction flow to the ramps during the season was less than the design specifications for the system. The design specifications of the ramps were to have a total attraction flow of 210-230 L/min, and the actual total attraction flows were between 53.2 and 97.8 L/min (Average 81.3 L/min). The hardiness of this species and its ability to adjust to parameters outside of those developed was evidenced by the numbers captured here. Future testing and adjustments to increase water flow to design specifications, as well as the location of the attraction flow discharge will be investigated.

The scaffolding, collection tanks, and hoses are not shaded at this time. Collections tanks were cleaned, hoses inspected, and spray bars checked during each sample to insure flow. Due to the algae build up inside the hoses, a routine (weekly) clean-out of the hoses and manifolds helped maintain a more consistent attraction flow.

Additional water temperature and DO readings were taken periodically in the forebay at the pump level and at the base of the ramp in the tailwater. The data indicated that the water above the dam was not stratified and these readings were similar to those observed in the collection tanks (Table 5.0-1). Unlike year one, a one day mortality was observed this season. On August 3, 2016, mortality was observed in the Enkamat collection tank, but not all individuals in this tank were morbid, and the Milieu collection tank that is circulated with the same river water showed no mortality. A DO level of 2.1 mg/L was observed in both collection tanks. Prior catches contained more individuals in the collection tanks than the day mentioned above. Aeration was added until numbers decreased and the dissolved oxygen levels increased. Most of the temperature and DO readings were taken early in the morning, possibly correlating to a DO sag that is usually observed in the early morning hours. During the middle of August the DO values in the collection tanks were nearly double the DO values at the pump with some eels being collected with no additional aeration added to the tanks (Table 5.0-1). On September 6, 8, and 10 the DO values were higher in the collection tanks then in the forebay at the pump level but during these monitoring checks no juvenile eels were present.

The highest daily average stream flow value per the USGS gage station occurred on May 7, 2016 (512 cubic feet per second, cfs) compared to the highest daily average stream flow value of 1,490 cfs in 2015 (Table 4.4-1 and Normandeau and Gomez and Sullivan 2015). Unlike the 2015 season, the CWA operated their small hydro during the 2016 season. They operated this facility on approximately 23 of the 95 monitoring check days this year when creek flows were high enough. With the creek flow below normal on some monitoring check days, water was flowing only through the minimum flow notch adjacent to the art building and not through the hydro on the other side of the river (Appendix Table A). No differences in eel catches were noted when either of the above situations were occurring.

During the 2016 Octoraro Creek eel season, Octoraro Creek had a lower than normal river flow. Shortly after an episode of increased flow (from 60 cfs to over 400 cfs) in the creek (July 29-August 2), a pulse of eels was evident in the collection tanks at CWA's Pine Grove Low-Head Dam eel facility, resulting in the highest six day (9,213 eels collected between July 31 – August 5) total observed during the entire season. Figure 5.0-1 shows comparison of 2015 and 2016 weekly catch and average creek flow data. This event co-occurred with a new moon phase. No high flow events occurred on the Susquehanna River during the 2016 eel season.

6 References

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7 TABLES AND FIGURES

Table 4.0-1: Daily Number of Juvenile Eels Caught by Substrate Type, Octoraro Creek, 2016

Date	Enkamat	Milieu	Total
5/2/2016	1	0	1
5/3/2016	4	0	4
5/4/2016	3	0	3
5/5/2016*	1	0	1
5/6/2016*	2	0	2
5/7/2016	12	0	12
5/8/2016	0	0	0
5/9/2016*	3	0	3
5/11/2016*	5	0	5
5/13/2016*	5	0	5
5/15/2016*	15	0	15
5/17/2016	4	0	4
5/19/2016	7	0	7
5/21/2016*	28	4	32
5/23/2016*	27	2	29
5/25/2016*	94	6	100
5/26/2016	137	9	146
5/27/2016	97	15	112
5/28/2016	175	23	198
5/29/2016*	59	47	106
5/30/2016	201	54	255
5/31/2016	375	184	559
6/1/2016	192	125	317
6/2/2016	288	237	525
6/3/2016*	*650*	279	929
6/4/2016	989	444	1433
6/5/2016	*852*	*391*	1243
6/6/2016*	*1040*	*562*	1602
6/7/2016*	466	145	611
6/8/2016*	321	105	426
6/9/2016	143	12	155
6/10/2016	142	9	151
6/11/2016	49	6	55
6/12/2016	58	12	70
6/13/2016*	84	19	103
6/14/2016	65	12	77
6/15/2016	34	0	34
6/16/2016*	20	10	30

Date	Enkamat	Milieu	Total
6/17/2016	72	24	96
6/18/2016	15	6	21
6/20/2016	68	18	86
6/22/2016	103	23	126
6/23/2016	26	7	33
6/24/2016	34	34	68
6/25/2016	166	37	203
6/26/2016	97	20	117
6/27/2016	31	15	46
6/28/2016	20	5	25
6/30/2016	59	30	89
7/2/2016	29	17	46
7/3/2016	14	4	18
7/5/2016	16	2	18
7/7/2016	77	14	91
7/9/2016	31	25	56
7/11/2016	41	12	53
7/13/2016	25	8	33
7/15/2016	6	5	11
7/17/2016	41	21	62
7/19/2016	12	1	13
7/21/2016	4	4	8
7/23/2016	2	5	7
7/25/2016	15	3	18
7/27/2016	5	5	10
7/29/2016	45	48	93
7/31/2016	***1427***	***1010***	**2437**
8/1/2016	*671*	328	999
8/2/2016	*500*	*825*	1325
8/3/2016	*983*	*807*	1790
8/4/2016	*832*	*716*	1548
8/5/2016	*585*	*529*	1114
8/6/2016	231	96	327
8/7/2016	39	70	109
8/8/2016*	47	36	83
8/9/2016*	37	24	61
8/10/2016*	22	29	51
8/11/2016*	61	16	77
8/12/2016*	60	2	62

Date	Enkamat	Milieu	Total
8/14/2016*	2	3	5
8/16/2016	8	2	10
8/18/2016	5	1	6
8/20/2016	5	2	7
8/22/2016*	75	94	169
8/23/2016	25	13	38
8/25/2016	22	17	39
8/27/2016	0	1	1
8/29/2016	2	3	5
8/31/2016	2	0	2
9/2/2016	8	10	18
9/4/2016	1	1	2
9/6/2016	0	0	0
9/8/2016	0	0	0
9/10/2016	0	0	0
9/12/2016	0	1	1
9/14/2016	0	0	0
9/15/2016	1	0	1
	13,353	**7,741**	**21,094**

*Days the hydroelectric facility was operating
Bolded numbers are peak days
The peak periods are shown in boxes
Number in *italics* were volumetrically estimated

Table 4.1-1: Number of Juvenile Eel Captured and Length Measurements

Substrate	Enkamat	Milieu	Total
Number eels collected	13,353	7,741	21,094
% per substrate	63.3%	36.7%	
Range on lengths (mm)	99 - 176	107 - 202	
Average length (mm)	125.9	138.1	
Number measured	1,619	1,129	2,748

Table 4.1-2: Juvenile Eel Length Frequency, 2016

TL (mm)	Enkamat	Milieu	Total
90-94	0	0	0
95-99	1	0	1
100-104	14	0	14
105-109	62	2	64
110-114	143	16	159
115-119	263	42	305
120-124	289	91	380
125-129	281	140	421
130-134	223	205	428
135-139	157	162	319
140-144	99	160	259
145-149	52	108	160
150-154	18	72	90
155-159	10	51	61
160-164	4	38	42
165-169	2	17	19
170-174	0	9	9
175-179	1	9	10
180-184	0	4	4
185-189	0	1	1
190-194	0	1	1
195-199	0	0	0
200-204	0	1	1
205-209	0	0	0
Total measured	**1,619**	**1,129**	**2,748**

Table 4.2-1: Weekly Juvenile Eel Collection By Week And Ranks

	Wk 1	**Wk 2**	**Wk 3**	**Wk 4**	**Wk 5**	**Wk 6**	**Wk 7**	**Wk 8**	**Wk 9**	**Wk 10**
Enkamat	23	13	54	530	2754	3013	348	397	236	138
Milieu	0	0	4	55	1370	1230	83	119	87	45
Total	23	13	58	585	4124	4243	431	516	323	183
Rank	17	18	14	4	3	2	7	5	8	10
# Sampling Days	6	4	4	5	7	7	7	5	5	4
	Wk 11	**Wk 12**	**Wk 13**	**Wk 14**	**Wk 15**	**Wk 16**	**Wk 17**	**Wk 18**	**Wk 19**	**Wk 20**
Enkamat	72	59	65	5229	266	20	122	12	1	1
Milieu	25	31	56	4311	177	8	125	13	1	1
Total	97	90	121	9540	443	28	247	25	2	2
Rank	12	13	11	1	6	15	19	16	19	20
# Sampling Days	3	4	3	7	6	4	4	3	4	3

Top 3 ranked weeks are shown in boxes.

Wk 1: May 1 - May 7
Wk 2: May 8 - May 14
Wk 3: May 15 - May 21
Wk 4: May 22 - May 28
Wk 5: May 29 - June 4
Wk 6: June 5 - June 11
Wk 7: June 12 - June 18
Wk 8: June 19 - June 25
Wk 9: June 26 - July 2
Wk 10: July 3 - July 9
Wk 11: July 10 - July 16
Wk 12: July 17 - July 23
Wk 13: July 24 - July 30
Wk 14: July 31 - August 6
Wk 15: August 7 - August 13
Wk 16: August 14 - August 20
Wk 17: August 21 - August 27
Wk 18: August 28 - September 3
Wk 19: September 4 - September 10
Wk 20: September 11 - September 15

Table 4.4-1: USGS 01578475 - Octoraro Creek at Richardmere, MD Gage Flows (cfs)

Day	May	June	July	August	September
1	172	136	119	292	65
2	169	125	113	408	99
3	214	197	91	198	85
4	227	231	90	133	71
5	196	194	119	99	65
6	312	251	113	86	62
7	**512**	219	100	81	59
8	352	175	89	87	55
9	242	145	81	107	54
10	181	77	80	99	52
11	184	92	82	102	50
12	175	106	76	110	49
13	175	105	71	101	46
14	174	100	80	100	45
15	169	99	75	90	43
16	155	123	68	47	
17	136	167	91	47	
18	115	143	78	51	
19	135	122	79	45	
20	153	110	83	51	
21	158	102	68	105	
22	184	99	59	88	
23	182	94	58	52	
24	192	111	70	50	
25	167	148	82	49	
26	132	120	86	48	
27	96	105	66	47	
28	118	105	57	46	
29	128	112	196	45	
30	147	106	186	45	
31	147		368	45	

Bolded value represent the highest daily average river flow

Table 4.4-2: Fraction of Moon Illumination, 2016 Est *(1.0 Equals Full Moon)*

Day	May	June	July	August	September
1	0.39	0.21	0.14	0.03	0.00
2	0.28	0.12	0.07	0.01	0.01
3	0.18	0.06	0.02	0.00	0.03
4	0.10	0.01	0.00	0.02	0.08
5	0.04	0.00	0.01	0.06	0.14
6	0.01	0.02	0.04	0.12	0.21
7	0.00	0.06	0.09	0.19	0.29
8	0.03	0.12	0.16	0.27	0.38
9	0.09	0.20	0.24	0.36	0.47
10	0.16	0.29	0.33	0.45	0.57
11	0.25	0.39	0.42	0.54	0.67
12	0.35	0.49	0.52	0.64	0.76
13	0.45	0.58	0.61	0.73	0.84
14	0.55	0.68	0.70	0.81	0.91
15	0.65	0.76	0.78	0.88	0.97
16	0.74	0.84	0.86	0.94	
17	0.81	0.90	0.92	0.98	
18	0.88	0.95	0.97	1.00	
19	0.94	0.98	0.99	0.99	
20	0.97	1.00	1.00	0.96	
21	0.99	0.99	0.98	0.90	
22	1.00	0.97	0.94	0.82	
23	0.98	0.92	0.88	0.72	
24	0.95	0.85	0.80	0.61	
25	0.89	0.77	0.70	0.49	
26	0.82	0.67	0.59	0.38	
27	0.74	0.56	0.47	0.28	
28	0.64	0.45	0.36	0.18	
29	0.53	0.34	0.25	0.11	
30	0.42	0.23	0.16	0.05	
31	0.31		0.09	0.01	

Table 4.4-3:Water Temperature (Daily Average, °C) HOBO Water Temp Pro

Day	May	June	July	August	September
1	14.0	25.4	24.5	26.2	24.2
2	14.4	23.9	24.4	25.3	24.1
3	14.9	23.1	24.0	24.1	23.3
4	14.8	24.1	23.2	23.5	23.0
5	14.5	23.1	24.6	25.4	22.7
6	14.2	24.1	26.9	26.1	23.1
7	14.0	24.3	27.4	26.7	24.3
8	14.8	22.8	27.0	26.2	26.0
9	14.5	20.9	26.6	26.2	27.2
10	14.6	20.8	25.7	27.0	27.2
11	14.6	23.0	25.9	26.7	26.1
12	15.1	24.9	26.3	26.9	22.3
13	14.9	22.6	25.1	27.4	22.2
14	16.1	22.8	26.5	27.5	23.6
15	15.4	22.2	27.1	27.1	23.0
16	15.0	21.6	27.1	25.9	
17	14.8	22.7	28.1	27.0	
18	14.9	23.0	26.9	26.6	
19	16.3	23.4	26.7	26.8	
20	17.1	25.8	27.4	26.3	
21	16.9	24.3	27.5	24.8	
22	16.1	24.1	27.2	24.1	
23	17.0	23.9	26.6	22.9	
24	18.7	24.3	27.4	22.1	
25	19.6	24.3	29.1	24.5	
26	20.2	24.8	27.8	26.1	
27	21.5	23.9	28.6	25.8	
28	22.1	24.3	27.2	25.6	
29	22.6	24.8	27.8	25.9	
30	23.7	25.1	26.1	25.4	
31	24.8		27.5	25.1	

Table 4.4-4: Dissolved Oxygen (mg/L) Reading Taken in Collection Tank

Day	May	June	July	August	September
1		5.4		2.2	
2	9.4	5.5	4.6	3.5	4.7
3	9.2	4.5	5.6	2.1	
4	9.6	2.5		3.3	4.2
5	10.2	3.1	6.2	3.7	
6	10.5	5.1		3.7	4.1
7	9.8	5.1	7.1	3.9	
8	10.4	6.3		4.2	4.2
9	10.8	5.5	4.7	4.2	
10		6.2		3.3	3.5
11	8.9	6.6	5.7	3.9	
12		7.7		3.7	3.5
13	10	8.2	N/A		
14		6.9		3.5	4.2
15	9.2	5.4	5.4		3.8
16		6.9		3.5	
17	9.6	6.7	5.2		
18		6.4		4.0	
19	8.7		5.5		
20		7.1		3.8	
21	9.0		5.1		
22		6.5		3.8	
23	8.7	6.8	4.0	3.5	
24		6.3			
25	7.5	4.9	4.2	4.0	
26	7.6	5.3			
27	N/A	7.5	4.3	3.7	
28	7.4	5.7			
29	6.9		5.7	4.7	
30	6.7	4.7			
31	5.7		2.6	3.7	

N/A - Problems with the meter

Table 4.5-1: Eel Transport/Stocking Data, 2016.

Location of stocking	Number Transported	Died in transport	Died in Holding	Number Stocked	Mortality (%)
Octoraro Creek Collection tanks	**21,094**		**476**		**2.26%**
Transported to USFWS Conowingo holding facility	9,911	28		9,883	0.28%
Octoraro to Octoraro Lake *	98	-		98	0.00%
Conowingo to Octoraro Lake	118	1		117	0.85%
Total stocked in Octoraro Lake	**216**	**1**		**215**	
Octoraro to Muddy Creek Forks (Site A) **	10,607	1		10,606	0.01%
Conowingo to Muddy Creek Forks (Site A)	11,400	2		11,398	0.02%
Total stocking in Muddy Creek Forks (Site A)	**22,007**	**3**		**22,004**	
Octoraro to Conewago Creek (Site B) ***	2	-		2	0.00%
Conowingo to Conewago Creek (Site B)	376	-		376	0.00%
Total stocked in Conewago Creek (Site B)	**378**	**-**		**378**	
TOTAL	# 32,512	32		22,597	0.10%
USFWS Conowingo Collection tanks	2,684				
USFWS removed for study	16				

* Transported Directly to Octoraro Lake from Octoraro Creek (May 2-13, prior to USFWS starting) (August 12)

** Transported Directly to Muddy Creek Forks (Site A) from Octoraro Creek (June 6-10, June 12, and July 31 -August 9)

*** Transported Directly to Conewago Creek (Site B) from Octoraro Creek (September 15, after USFWS shutdown Conowingo holding facility)

Some eels were counted twice if they were transport to and from the USFWS Conowingo holding facility

Table 4.5-2: Detailed Individual Eel Transport Data, 2016

Transport to Muddy Creek Forks (Site A)												
	Number	Holding Facility			Loaded for Transport			Prior to Unloading			Stocking Site	
Date	of Eels	Time	Temp	DO	Time	Temp	DO	Time	Temp	DO	Temp	DO
5/21	59	1032	17.5	10.6	1044	16.7	10.3	1126	14.7	8.6	14.4	10.3
5/26	275	1225	20.8	8.4	1235	21.4	7.0	1320	23.7	5.6	21.1	9.6
6/2	2,095	1355	25.3	7.8	1415	26.1	12.0	1505	26.3	15.0	22.3	9.1
6/6	2,188	806	26.9	6.2	852	26.2	12.7	930	26.1	2.7	23.1	10.3
6/6	1,602	1505	25.6	5.1	1605	25.7	10.8	1815	26.0	24.4	23.4	8.6
6/7	1,858	1420	27.6	6.5	1415	24.0	4.6	1525	25.2	9.7	23.3	7.7
6/8	425	1016	22.4	6.3	1105	22.0	7.0	1205	19.7	3.0	18.5	7.5
6/9	155	820	19.6	5.5	930	19.7	5.7	1020	19.8	7.2	15.3	9.8
6/10	151	900	25.3	6.7	905	23.8	7.1	1015	23.9	7.0	15.6	9.9
6/12	70	815	22.9	5.9	830	22.8	6.2	945	24.7	7.4	20.5	8.8
6/19	531	946	24.6	7.4	1006	25.0	12.7	1052	25.0	27.1	19.3	9.4
6/24	662	1020	27.0	6.8	1047	26.3	11.5	1141	26.4	17.9	21.3	8.9
6/30	627	846	27.7	7.6	921	27.0	18.1	1007	27.0	27.4	19.2	8.0
7/8	484	1000	29.3	7.6	1040	30.0	24.5	1140	29.8	15.5	23.4	8.6
7/14	885	940	29.7	7.1	1015	29.8	16.5	1130	29.6	25.5	24.3	8.0
7/18	298	1230	30.9	7.2	1245	31.0	12.6	1345	31.2	22.1	25.3	9.4
7/22	176	1000	30.6	6.5	1008	30.5	5.4	1100	30.4	5.3	22.0	8.6
7/25	45	1005	31.2	7.8	1015	31.0	12.4	1250	31.4	16.8	25.6	8.3
7/29	94	757	27.5	5.7	1010	26.6	6.1	1053	26.6	5.8	21.9	7.8
7/31	2,437	830	27.2	2.6	900	26.7	10.5	1032	26.7	11.6	21.5	7.0
8/1	998	930	27.2	2.2	1005	27.6	3.3	1113	27.6	12.6	23.3	7.0
8/2	1,325	930	26.8	3.5	1025	26.8	3.0	1125	26.8	12.5	22.7	8.0
8/3	1,314	1045	25.9	2.1	1115	25.8	11.3	1230	25.8	13.6	22.1	9.0
8/4	1,548	955	26.3	3.3	1105	25.5	10.3	1253	25.6	12.3	22.8	8.2
8/5	1,122	1230	30.2	5.7	1300	25.6	3.6	1400	25.7	12.5	21.9	8.7

Transport to Muddy Creek Forks (Site A)												
	Number	**Holding Facility**			**Loaded for Transport**			**Prior to Unloading**			**Stocking Site**	
Date	**of Eels**	**Time**	**Temp**	**DO**	**Time**	**Temp**	**DO**	**Time**	**Temp**	**DO**	**Temp**	**DO**
8/6	327	800	25.4	3.5	830	25.4	13.7	930	25.4	13.0	21.5	7.0
8/7	109	715	25.3	3.9	810	25.3	4.0	900	23.3	6.7	20.2	7.9
8/8	83	945	25.7	3.4	1000	25.7	3.3	1100	25.7	2.4	21.1	9.4
8/9	61	1000	25.8	4.2	1020	25.6	5.8	1115	25.6	5.8	21.1	6.1
Total	**22,004**											
Transport to Conewago Creek (Site B)												
	Number	**Holding Facility**			**Loaded for Transport**			**Prior to Unloading**			**Stocking site**	
Date	**of Eels**	**Time**	**Temp**	**DO**	**Time**	**Temp**	**DO**	**Time**	**Temp**	**DO**	**Temp**	**DO**
8/19	36	845	31.7	5.5	930	31.3	6.4	1120	30.4	7.2	24.3	6.9
8/26	275	942	30.2	5.0	1000	30.5	3.7	1140	21.5	5.8	24.7	5.8
9/2	57	1006	29.8	4.9	1030	29.2	4.6	1237	28.5	4.5	20.9	6.0
9/9	8	945	29.0	6.8	1000	29.3	6.0	1135	26.9	7.1	24.5	5.9
9/15	2	832	23.7	3.8	942	22.2	8.6	1150	23.0	8.9	20.5	6.3
Total	**378**											

Table 4.6-1: Calibration of Flows (Liters Per Minute) in The Eel Collection Facility, 2016

	DATE										
	4/28	**5/7**	**5/15**	**5/21**	**5/26**	**6/2**	**6/6 ***	**6/13**	**6/20 ****	**6/27**	**7/2**
Enkamat Ramp											
Spray bar	17.6	22.2	16.4	20.4	16.6	15.2	20.4	20.0	14.8	15.8	16.6
Collection tank drain	4.6	7.4	3.6	2.0	3.4	3.6	3.8	4.0	2.6	2.2	4.4
Top Attraction flow	13.0	14.8	12.8	18.4	13.2	11.6	16.6	16.0	12.2	13.6	12.2
Bottom Attraction flow	28.8	27.4	28.8	25.2	26.8	24.4	21.6	24.0	30.2	28.2	22.6
Total Attraction Flow	**46.4**	**49.6**	**45.2**	**45.6**	**43.4**	**39.6**	**42.0**	**44.0**	**45.0**	**44.0**	**39.2**
Milieu Ramp											
Spray bar	18.6	23.8	17.4	16.8	18.6	16.0	20.8	20.6	16.2	16.0	18.0
Collection tank drain	4.0	4.4	4.4	3.0	4.0	3.4	4.2	4.0	2.8	3.4	2.6
Top Attraction flow	14.6	19.4	13.0	13.8	14.6	12.6	16.6	16.6	13.4	12.6	15.4
Bottom Attraction flow	23.2	18.0	27.4	26.8	27.6	24.8	27.0	24.0	36.6	28.0	28.8
Total Attraction Flow	**41.8**	**41.8**	**44.8**	**43.6**	**46.2**	**40.8**	**47.8**	**44.6**	**52.8**	**44.0**	**46.8**
Overall Attraction Flows	88.2	91.4	90.0	89.2	89.6	80.4	89.8	88.6	97.8	88.0	86.0

* 6/6 - hoses were changed to attempt to increase flow

** 6/20 - Pump and/or hoses were changed/cleaned to attempt to increase flow

(continued)

Table 4.6-1: (Continued)

	DATE										
	7/7	**7/13 ****	**7/19**	**7/26 ****	**8/4**	**8/10 ****	**8/16**	**8/24 ***	**8/31**	**9/6 ***	**9/14**
Enkamat Ramp											
Spray bar	18.0	15.8	16.4	16.6	13.6	15.6	12.8	12.0	12.0	12.8	11.8
Collection tank drain	3.6	2.6	3.8	3.6	7.8	2.0	3.6	2.8	3.0	2.4	2.6
Top Attraction flow	14.4	13.2	12.6	13.0	5.8	13.6	9.2	9.2	9.0	10.4	9.2
Bottom Attraction flow	18.8	30.0	22.0	20.2	13.0	23.8	23.0	26.8	20.4	20.0	18.0
Total Attraction Flow	**36.8**	**45.8**	**38.4**	**36.8**	**26.6**	**39.4**	**35.8**	**38.8**	**32.4**	**32.8**	**29.8**
Milieu Ramp											
Spray bar	18.6	16.0	16.6	16.4	12.8	14.4	12.4	12.4	12.2	12.6	11.8
Collection tank drain	3.2	3.6	3.4	3.4	3.8	1.8	2.8	3.6	2.8	2.0	2.4
Top Attraction flow	15.4	12.4	13.2	13.0	9.0	12.6	9.6	8.8	9.4	10.6	9.4
Bottom Attraction flow	27.4	32.8	25.2	27.0	13.8	24.4	20.8	27.6	19.8	20.0	21.0
Total Attraction Flow	**46.0**	**48.8**	**41.8**	**43.4**	**26.6**	**38.8**	**33.2**	**40.0**	**32.0**	**32.6**	**32.8**
Overall Attraction Flows	**82.8**	**94.6**	**80.2**	**80.2**	**53.2**	**78.2**	**69.0**	**78.8**	**64.4**	**65.4**	**62.6**

* 7/26, 8/24, 9/6 - Cleaned hoses to attempt to increase flow

** 7/13, 7/26, 8/10, - Pump and/or hoses were changed/cleaned to attempt to increase flow

Table 5.0-1: Additional Temperature and Dissolved Oxygen Readings Taken

	DATE												
	5/26	**6/4**	**6/12**	**7/17**	**7/28**	**8/3**	**8/4**	**8/5**	**8/6**	**8/7**	**8/8**	**8/10**	**8/11**
Enkamat													
Collection Tank													
Temperature (°C)	22.8	23.9	22.9	25.9	24.8	25.7	26.3	25.6	25.4	25.3	25.7	25	25
Dissolved Oxygen	2.7	2.5	5.9	5.1	4.1	2.1	3.3	3.7	3.7	3.9	4.2	3.3	3.9
Milieu													
Collection Tank													
Temperature (°C)	23.1	23.8	22.7	25.8	24.8	25.7	26.3	25.6	25.4	25.4	25.7	24.9	25
Dissolved Oxygen	7.6	3.8	6.4	5.2	4.1	2.1	2.7	3	3.2	3.9	3.8	3.5	3.7
Tailrace at surface													
Temperature (°C)		23.7	22.6	25.9	24.8								
Dissolved Oxygen		7.8	7.7	7.2	3.7								
Forebay at pump level													
Temperature (°C)								25.5	25.3	25.7	25.7	24.7	24.8
Dissolved Oxygen								4.4	4.6	3.4	3.8	1.4	2.2

(continued)

Table 5.0-1: (Continued)

	DATE												
	8/16	**8/18**	**8/20**	**8/23**	**8/25**	**8/31**	**9/2**	**9/4**	**9/6**	**9/8**	**9/12**	**9/14**	**9/15**
Enkamat													
Collection Tank													
Temperature (°C)	25.8	25.7	25.6	24	24	25.3	24.9	23.9	23.5	24.7	23.5	24.4	23.7
Dissolved Oxygen	3	3.9	4	3.5	4	3.7	4.7	4.2	4.2	4.2	3.5	4.2	3.8
Milieu													
Collection Tank													
Temperature (°C)	25.8	25.6	25.5	23.3	24	25.2	24.9	24	23.7	24.7	23.4	24.4	23.7
Dissolved Oxygen	4	4.2	3.4	4	3.9	3.8	4.7	4.1	4	4.2	3.6	6	3.8
Tailrace at surface													
Temperature (°C)					24	25.3	25	24.1		24.5	23.6		
Dissolved Oxygen					4.2	5.7	6.6	6.7		5.3	6.3		
Forebay at pump level													
Temperature (°C)	25.8	25.7	25.2	24.1	24		25.2	24.2	23.8	24.4	23.4	24.1	23.7
Dissolved Oxygen	1.9	2.5	2.5	2	2.4		4.8	3.7	2.8	3.4	2.1	4	2.5

EXELON GENERATION COMPANY, LLC

MUDDY RUN PUMPED STORAGE PROJECT
PROJECT NO. 2355

N

0 0.5 1 2
Miles

Figure 2.0-1:
Lower Octoraro Creek From Pine Grove Dam to the Mouth at the Susquehanna River, Octoraro Creek (Stone Masonry Dam As Known As Pine Grove Low-Head Dam)

Path: X:\GISMaps\project_maps\2016_Octoraro_Creek_Report\Figure_2_0_1.mxd

Figure 2.0-2: Location of the Juvenile Eel Collection Facility on South Shore (Left Bank) Of Octoraro Creek Downstream of Art Building

Figure 2.0-3: USFWS Weekly Catch of Juvenile American Eel at Conowingo, 2008-2016

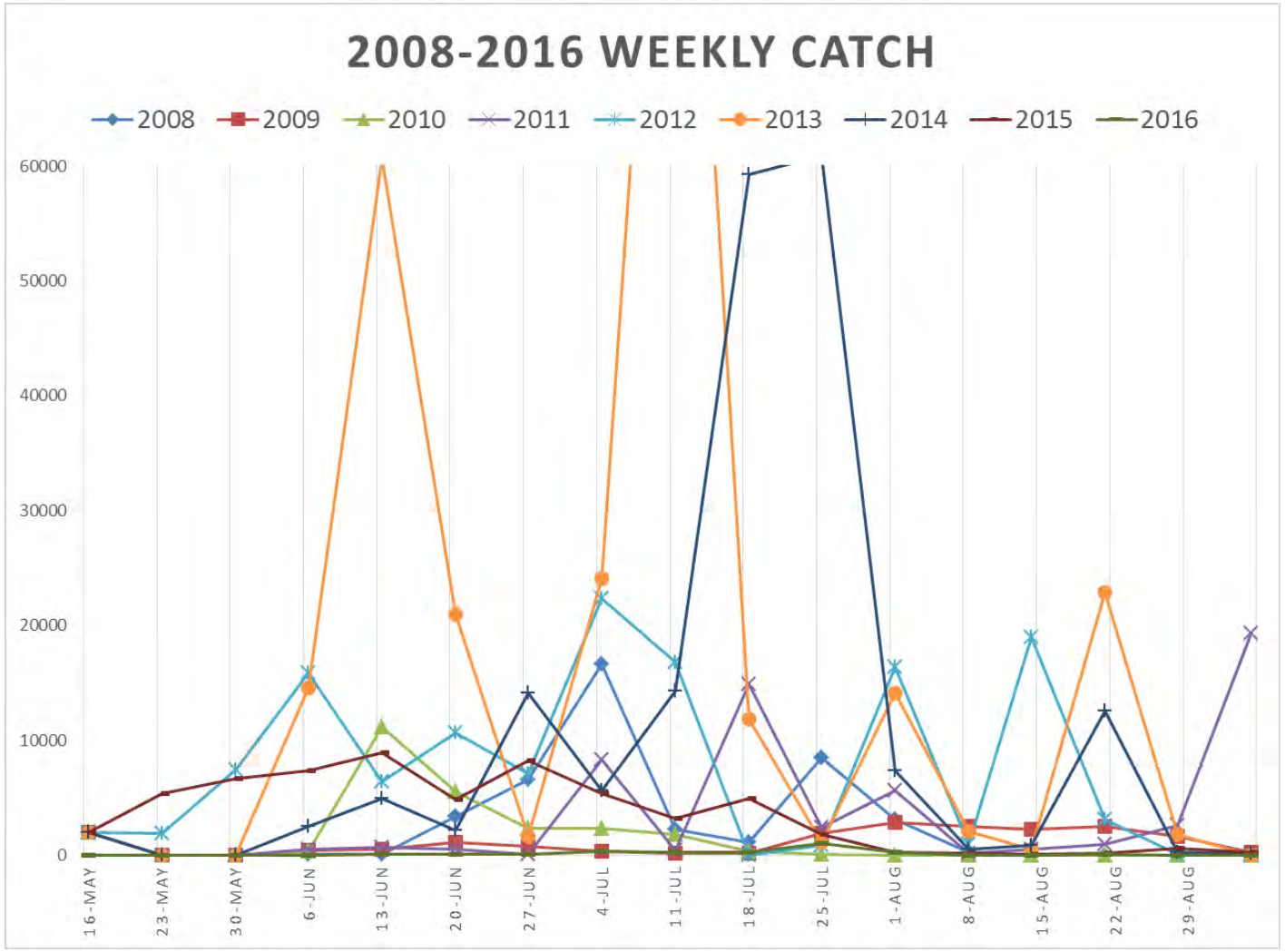


Figure 3.1-1: Photo of Enkamat and Milieu Substrate Installed in Ramps, Octoraro Creek

Figure 3.1-2: T-Bar Support for Ramp Support, Octoraro Creek

Figure 3.1-3: Additional Attraction Flow Hose Added to Entrance, Octoraro Creek, 2016

Figure 3.1-4: Manifold for Garden Hose Supply Lines for Attraction Flows, Octoraro Creek, 2016

Figure 3.1-5: Overview Photo of Spray Bar, and Screened Drain in Collection Tank, Octoraro Creek

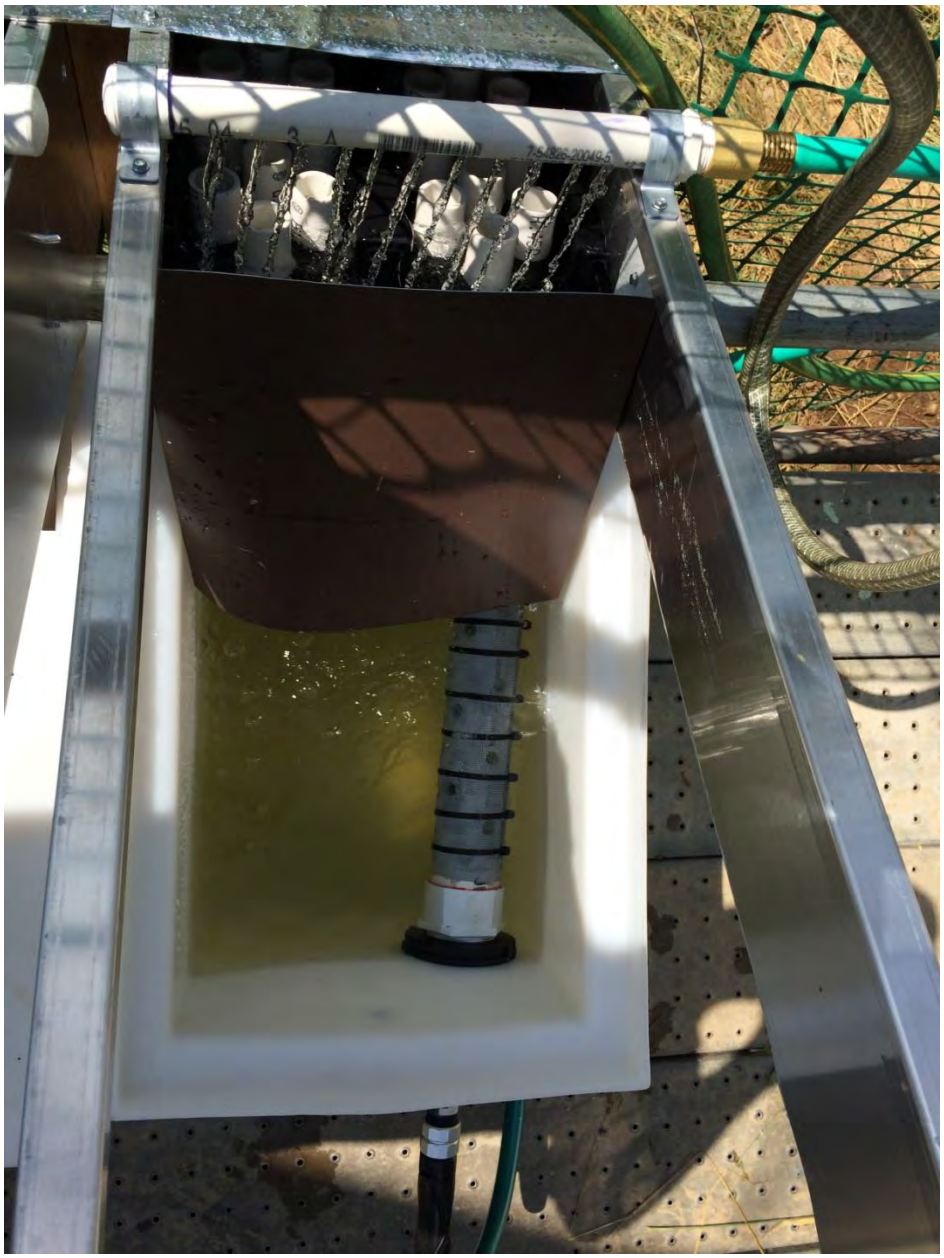


Figure 3.1-6: Individual Collection Tanks for Each Substrate, Octoraro Creek

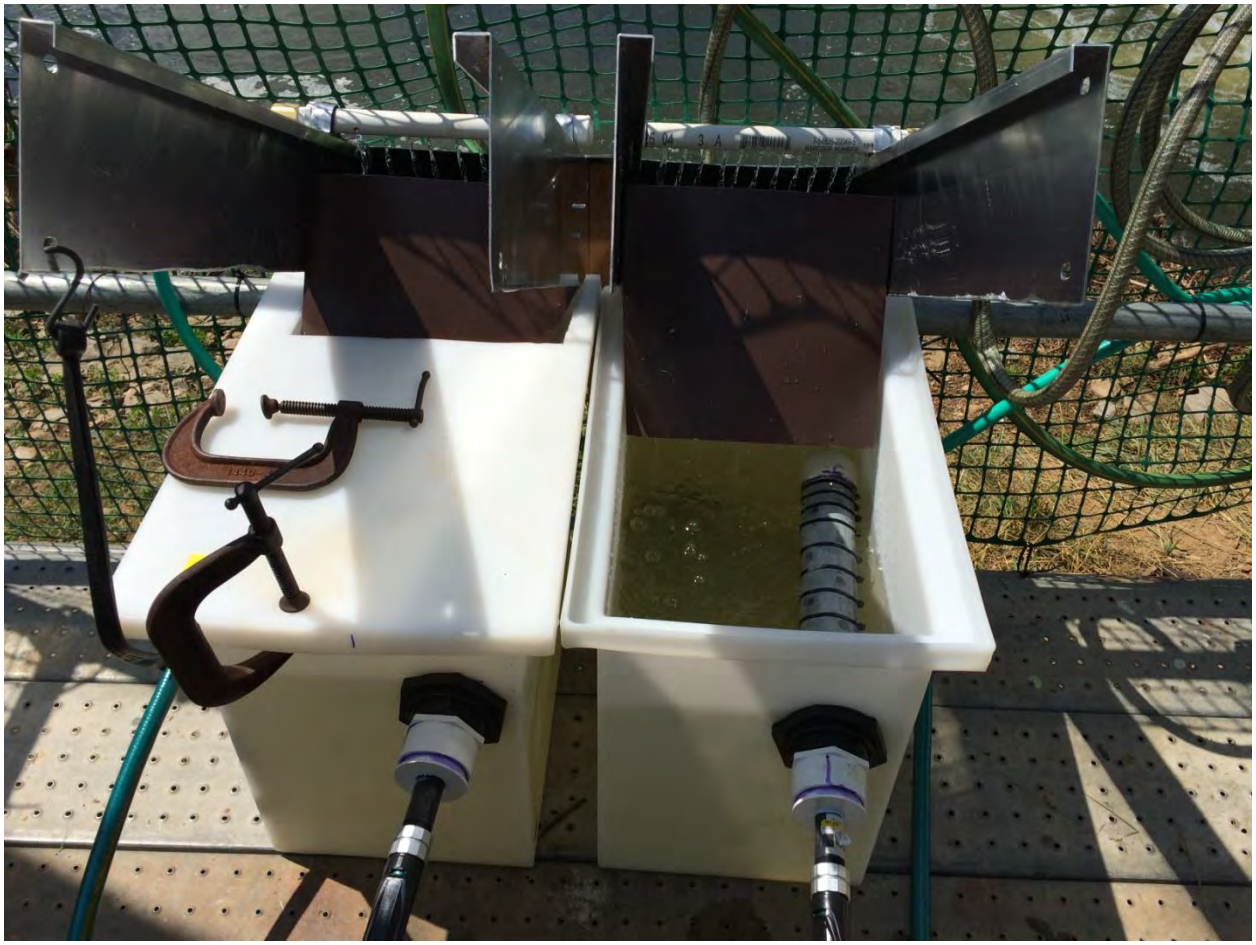


Figure 3.2-1: Measuring Juvenile Eels to Nearest Millimeter While Sedated, Octoraro Creek

Figure 4.2-1: Percent Eel Catch Per Week, Octoraro Creek, 2016

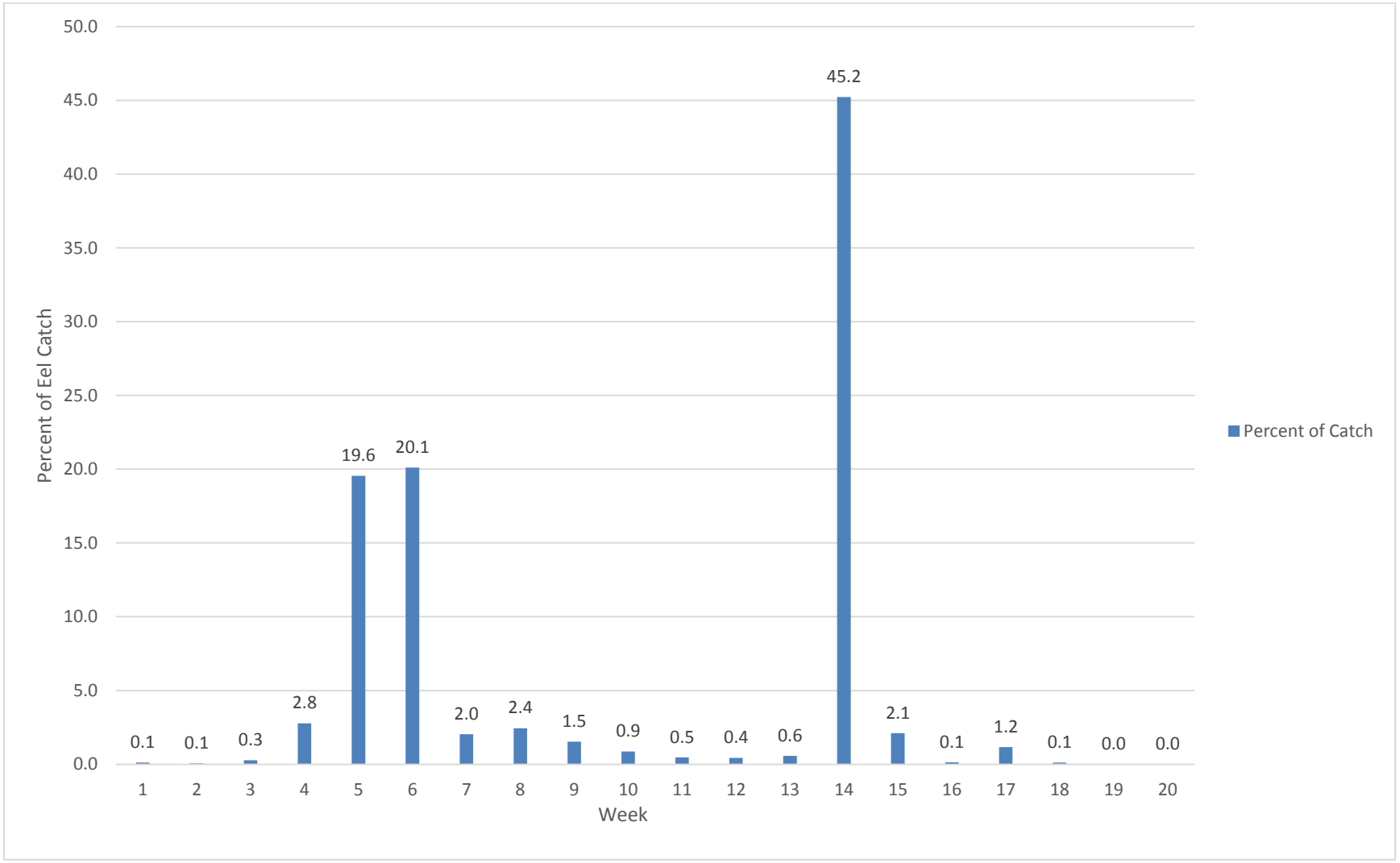


Figure 4.2-2: Comparison of Weekly Juvenile Eel Collection of the Conowingo and Octoraro Eel Ramps, 2016

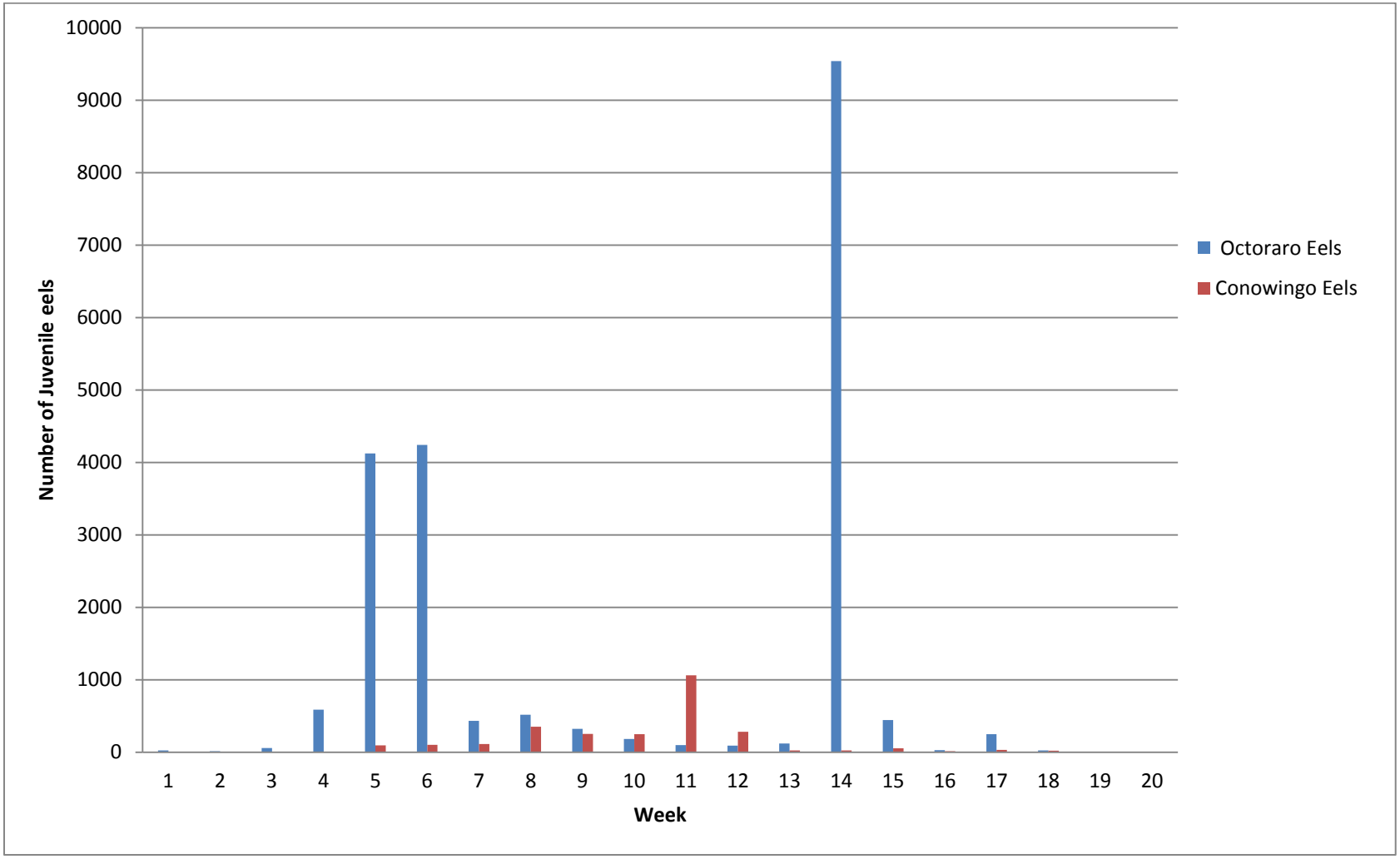


Figure 4.4-1: Weekly Eel Catch to Weekly Average Creek Flow, Octoraro Creek, 2016

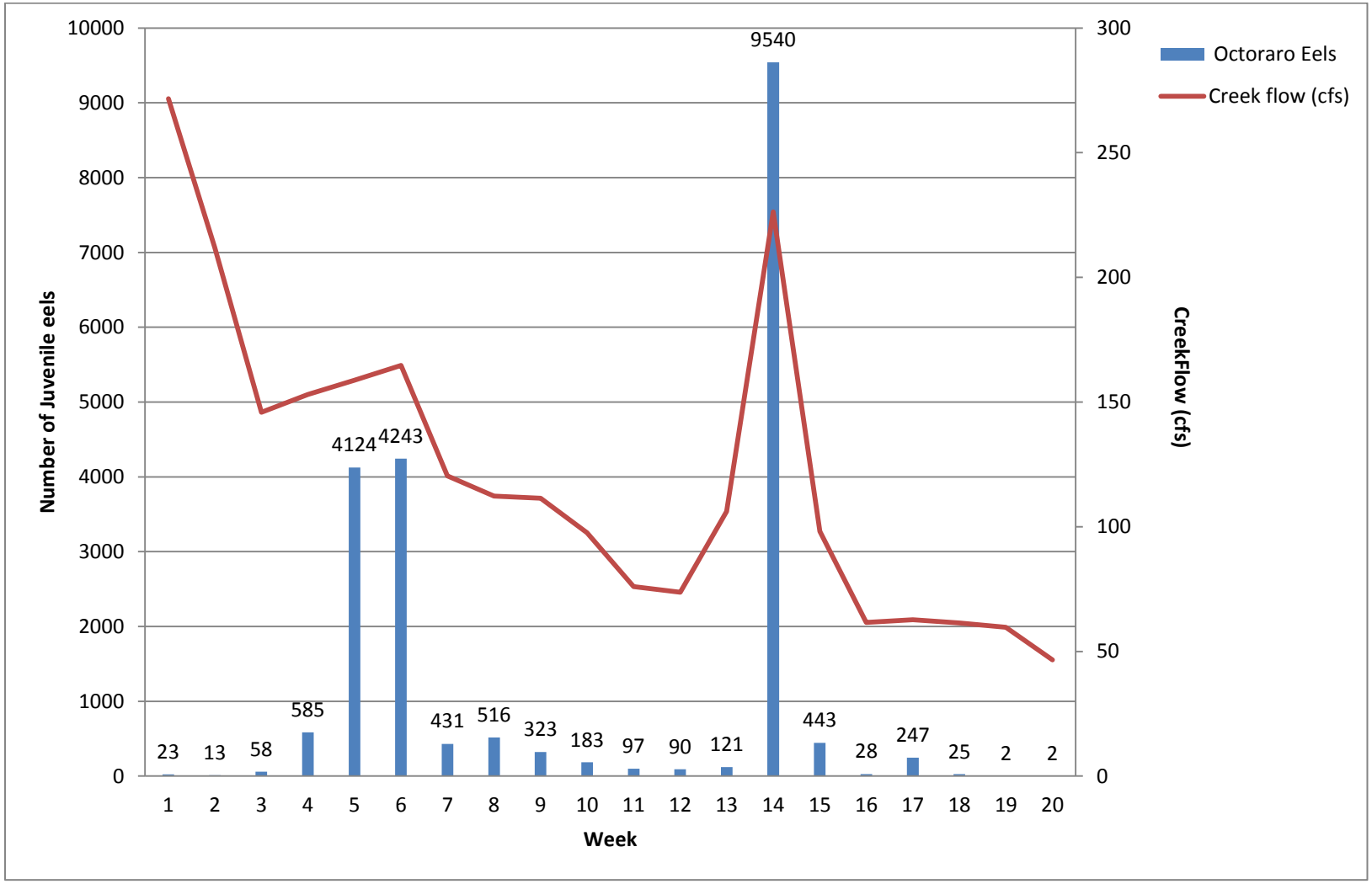


Figure 4.4-2: Weekly Eel Catch to Weekly Average Lunar Fraction, Octoraro Creek, 2016 *(1.0 Equals Full Moon)*

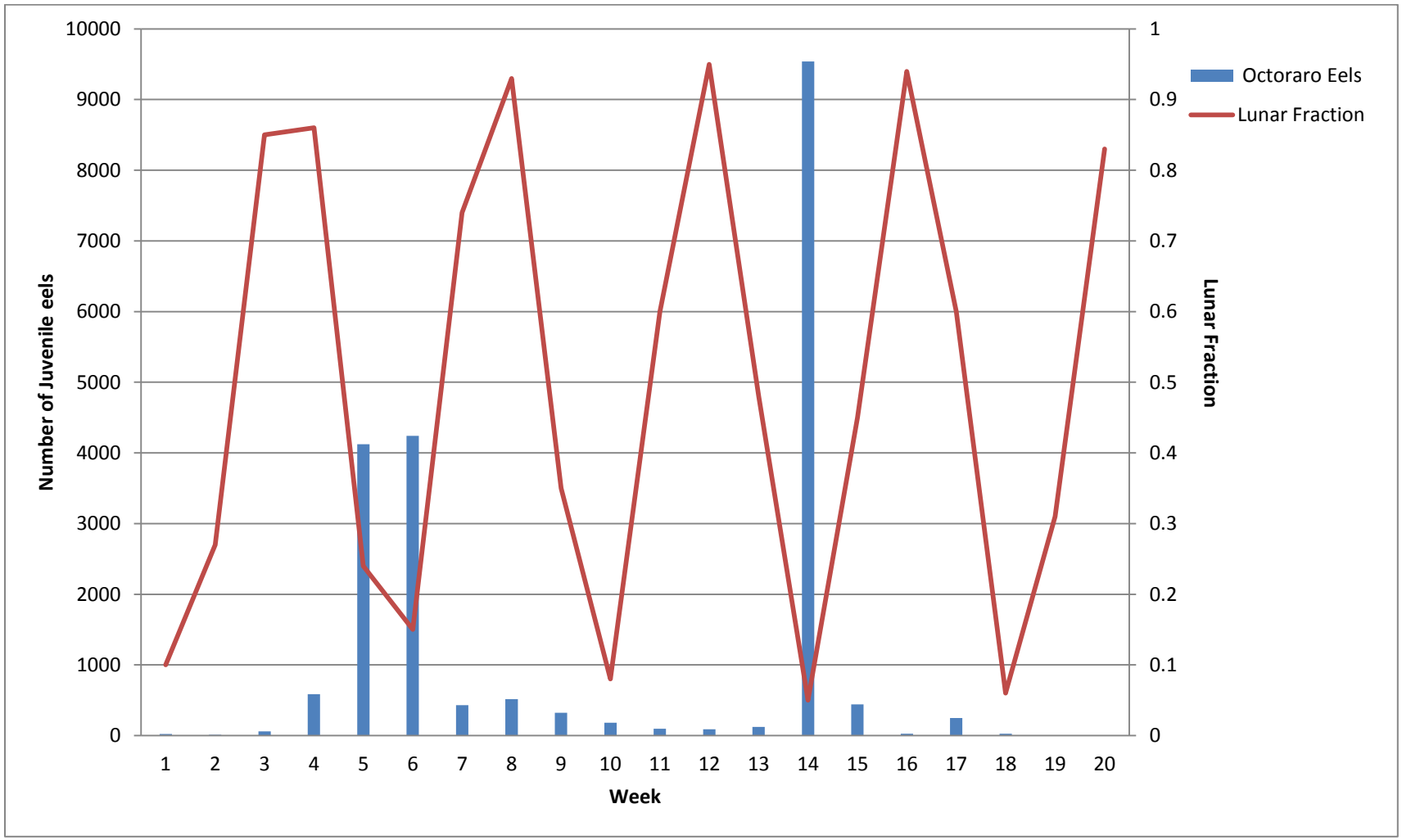


Figure 4.4-3: Weekly Eel Catch to Weekly Average Water Temperature, Octoraro Creek, 2016

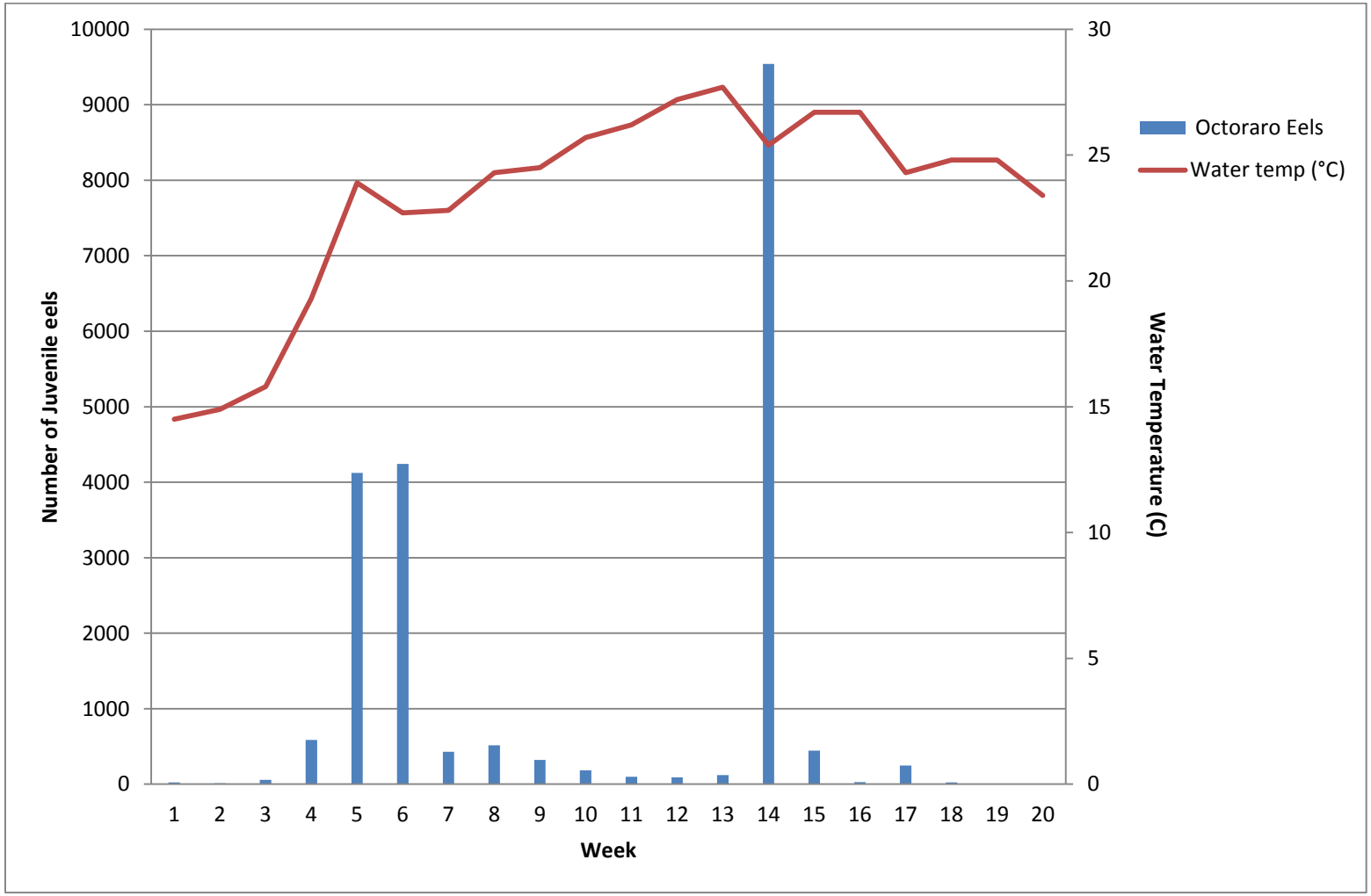


Figure 4.4-4: Weekly Eel Catch to Weekly Average Dissolved Oxygen, Octoraro Creek Eel Facility Collection Tanks, 2016

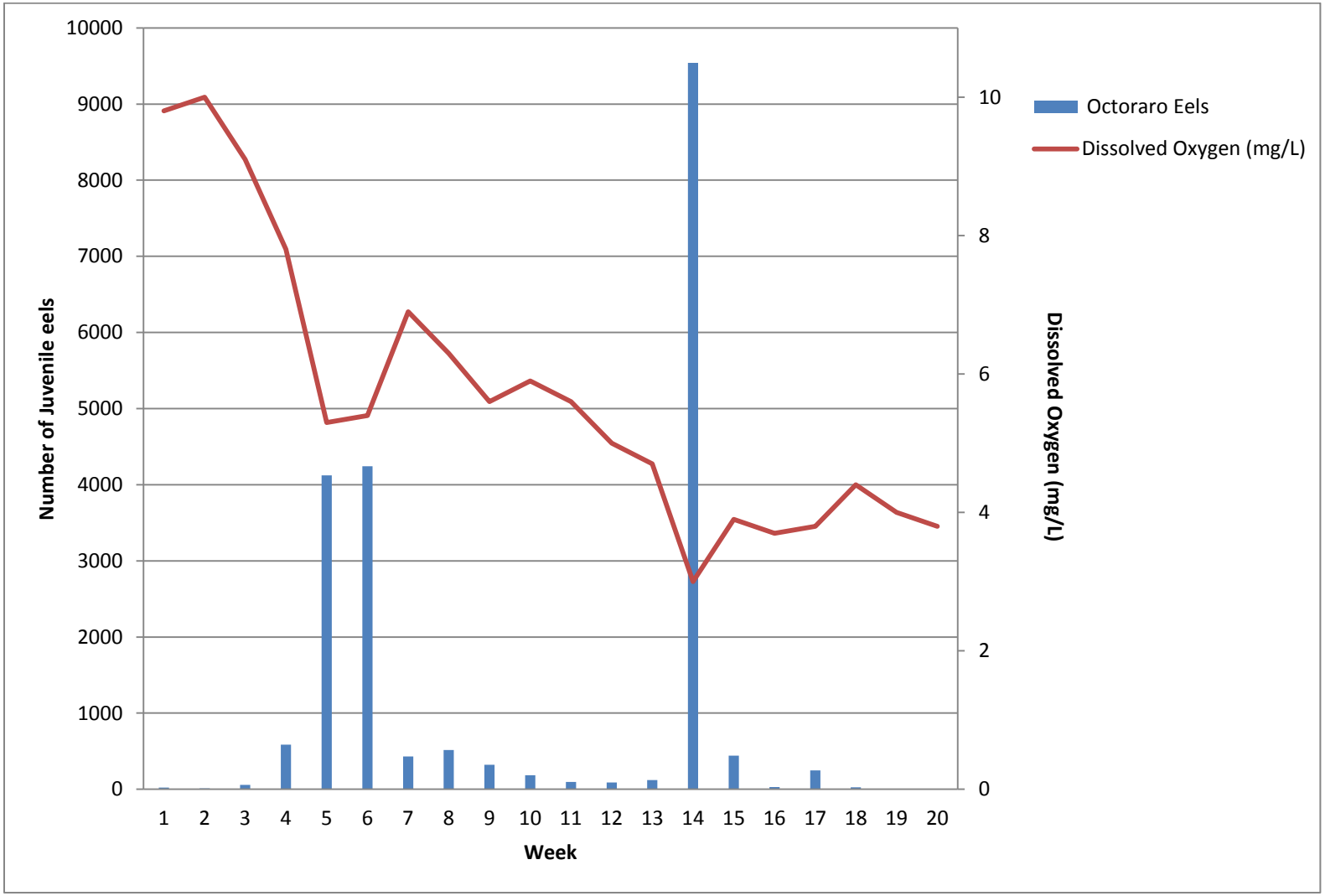
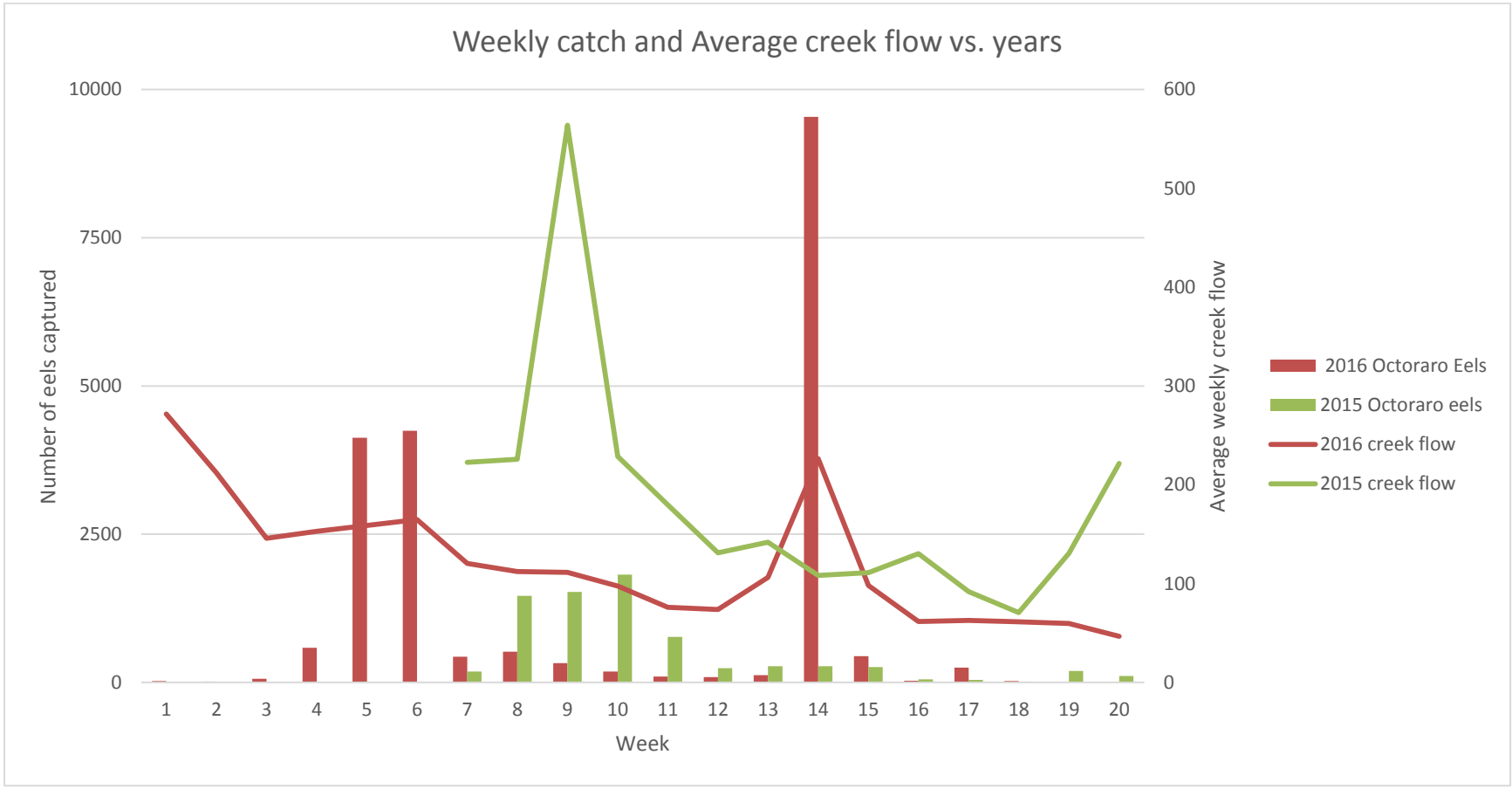


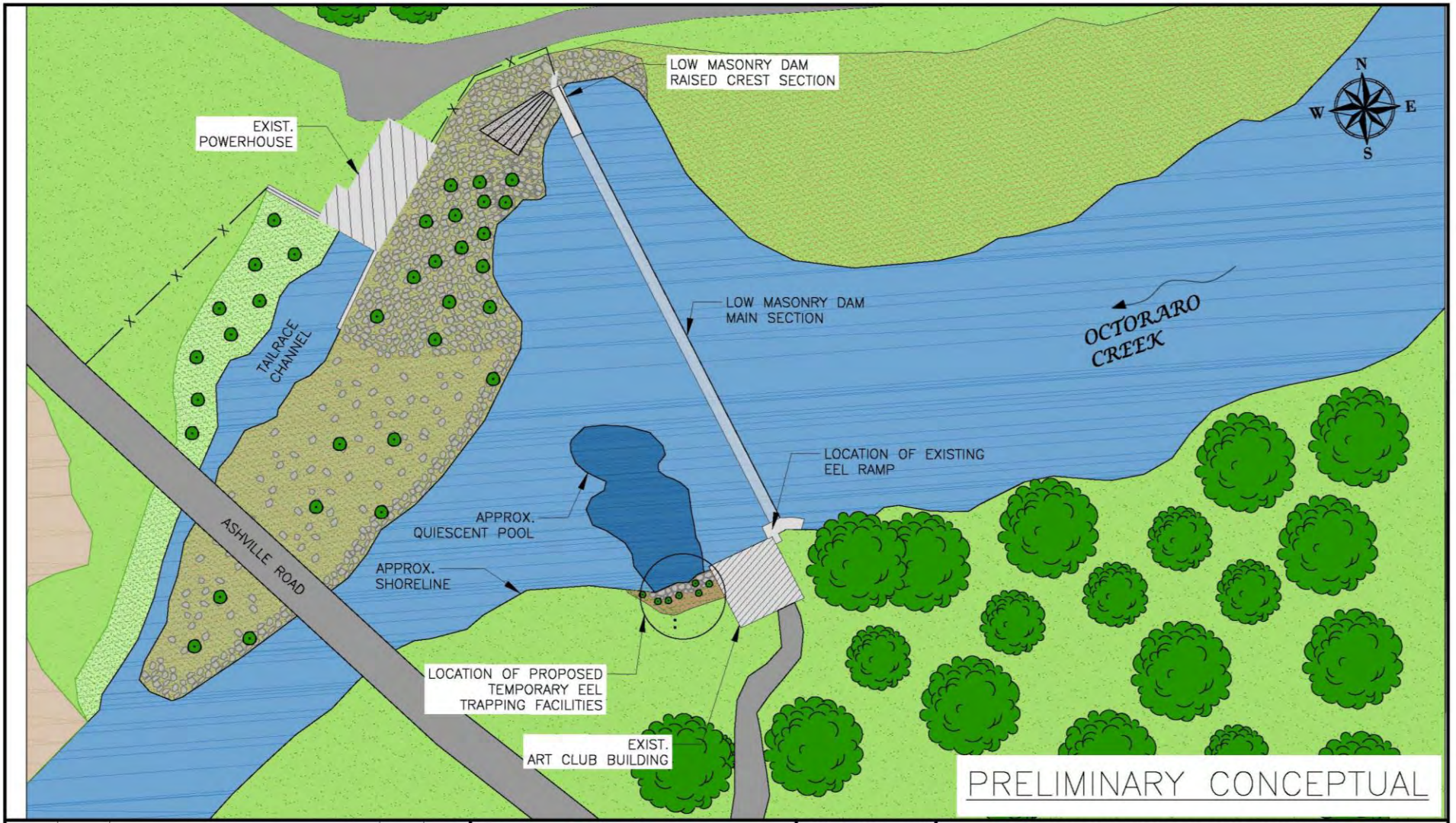
Figure 4.5-1: Muddy Creek Forks (Site A) Stocking Location, 2016

Figure 4.5-2: Conewago Creek (Site B) Stocking Location, 2016

Figure 5.0-1: Weekly Eel Catch to Weekly Average Creek Flow, Octoraro Creek, 2015 and 2016



Appendix Table A:
Conceptual Design of Trapping Facility on South Shore of Octoraro Creek, 2015



NO.	DATE	DESCRIPTION	BY	APP
0	3/3/15	CONCEPTUAL OCTORARO CREEK EEL FACILITIES	CRS	-

FOR: Exelon. EXELON GENERATION COMPANY, LLC

BY: GOMEZ AND SULLIVAN ENGINEERS
Williamsville, NY • Utica, NY • Albany, NY • Henniker, NH
www.gomezandsullivan.com

DESIGNED BY:	CRS
DRAWN BY:	CRS
CHECKED BY:	-
APPROVED BY:	-
PROJECT NO.:	1385
DATE:	3/3/2015

OCTORARO CREEK AMERICAN EEL
TEMPORARY UPSTREAM TRAPPING FACILITY - LEFT BANK

SITE PLAN - EXISTING CONDITIONS

SCALE: 1" = 40'-0" DRAWING NO.: 1

PHOTO 1: VIEW OF ART BUILDING AND "QUIESCENT POOL" FROM RIGHT BANK

NO.	DATE	DESCRIPTION	BY	APP
0	3/3/15	CONCEPTUAL OCTORARO CREEK EEL FACILITIES	CRS	-

FOR: Exelon. EXELON GENERATION COMPANY, LLC

BY: GOMEZ AND SULLIVAN ENGINEERS
Williamsville, NY • Utica, NY • Albany, NY • Henniker, NH
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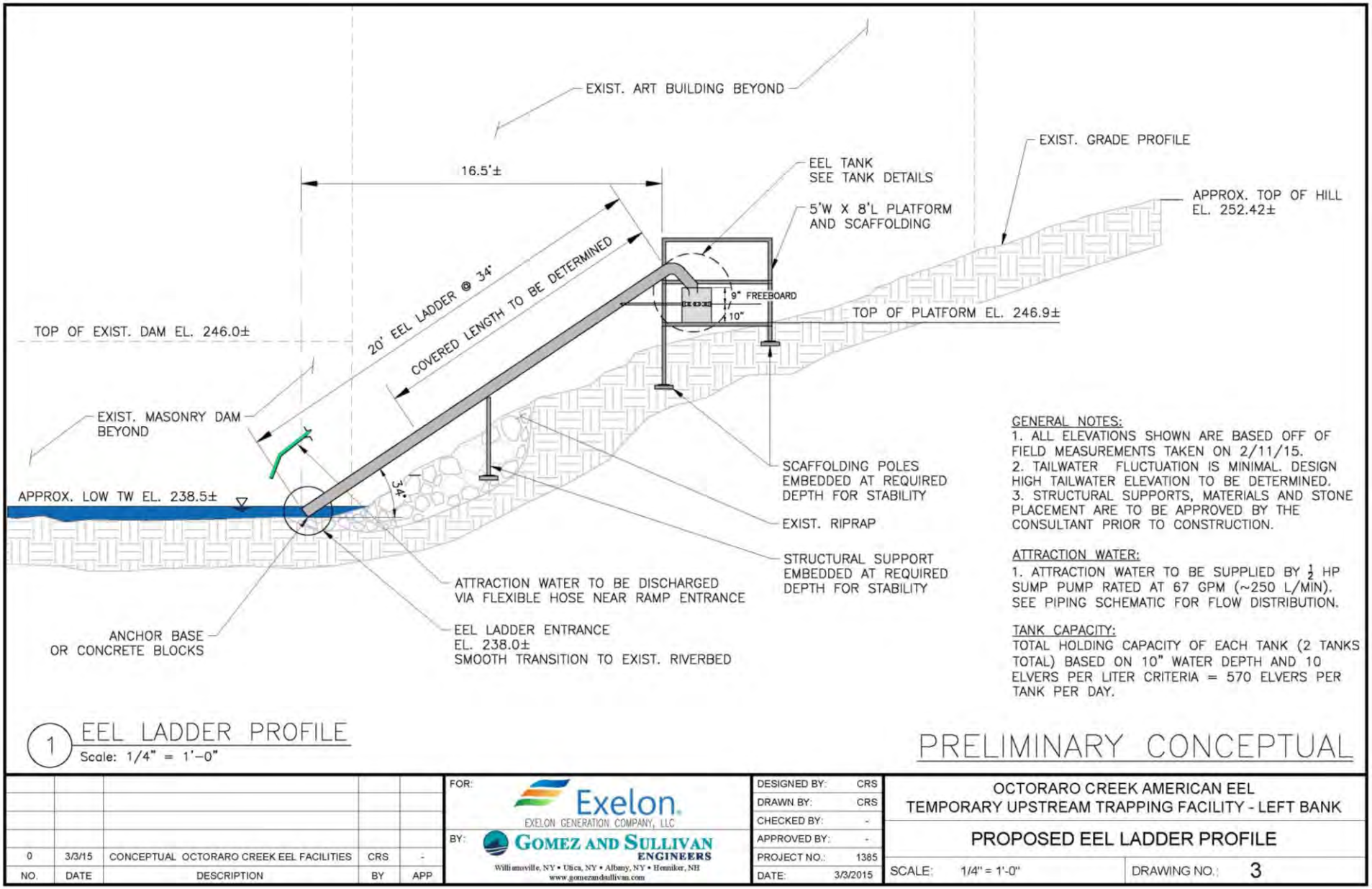
DESIGNED BY:	CRS
DRAWN BY:	CRS
CHECKED BY:	-
APPROVED BY:	-
PROJECT NO.:	1385
DATE:	3/3/2015

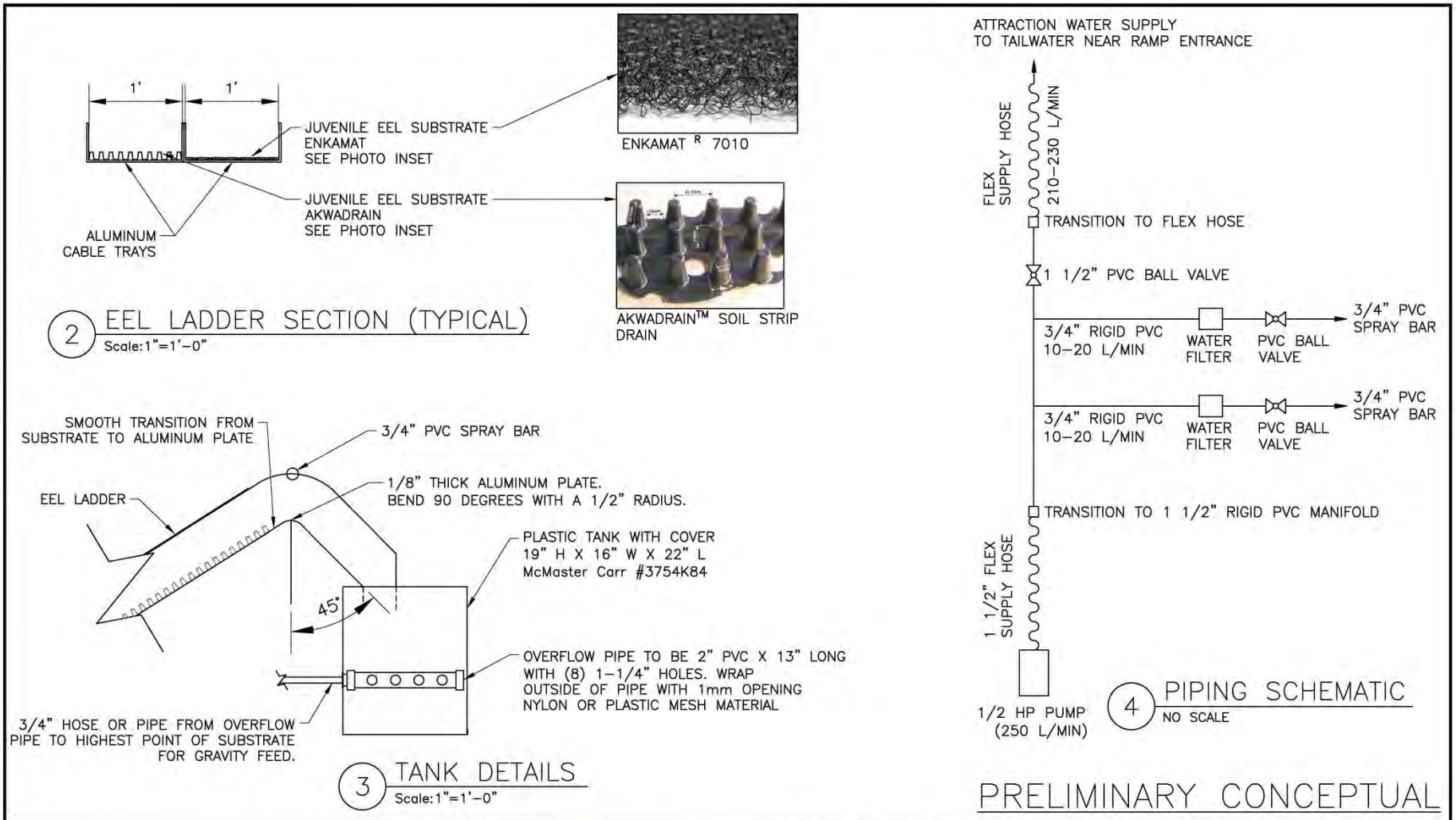
OCTORARO CREEK AMERICAN EEL
TEMPORARY UPSTREAM TRAPPING FACILITY - LEFT BANK

PLAN: 34° EEL LADDER ALONG DAM

SCALE: 1" = 10'-0" DRAWING NO.: 2

Muddy Run Pumped Storage Project
FERC Project Number 2355





NO.	DATE	DESCRIPTION	BY	APP
0	3/3/15	CONCEPTUAL OCTORARO CREEK EEL FACILITIES	CRS	-

FOR: Exelon. EXELON GENERATION COMPANY, LLC
BY: GOMEZ AND SULLIVAN ENGINEERS
Williamsville, NY • Utica, NY • Albany, NY • Henniker, NH
www.gomezandsullivan.com

DESIGNED BY:	CRS
DRAWN BY:	CRS
CHECKED BY:	-
APPROVED BY:	-
PROJECT NO.:	1385
DATE:	3/3/2015

OCTORARO CREEK AMERICAN EEL
TEMPORARY UPSTREAM TRAPPING FACILITY - LEFT BANK

TYPICAL EEL LADDER SECTION AND DETAILS

SCALE: 1" = 1'-0" | DRAWING NO.: 4

Appendix Table B:
Weekly Biological Data and Environmental Conditions for Octoraro Creek, 2016

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Octoraro Eels	23	13	58	585	4124	4243	431	516	323	183	97	90	121	9540	443	28	247	25	2	2
Creek flow (cfs)	271.7	211.9	145.9	153	158.7	164.7	120.4	112.3	111.4	97.6	76	73.7	106.1	226.3	98.1	61.6	62.7	61.4	59.7	46.6
Lunar Fraction	0.1	0.27	0.85	0.86	0.24	0.15	0.74	0.93	0.35	0.08	0.6	0.95	0.48	0.05	0.45	0.94	0.6	0.06	0.31	0.83
Water temp (°C)	14.5	14.9	15.8	19.3	23.9	22.7	22.8	24.3	24.5	25.7	26.2	27.2	27.7	25.4	26.7	26.7	24.3	24.8	24.8	23.4
Dissolved Oxygen (mg/L)	9.8	10	9.1	7.8	5.3	5.4	6.9	6.3	5.6	5.9	5.6	5	4.7	3	3.9	3.7	3.8	4.4	4	3.8
Percent of Catch	0.1	0.1	0.3	2.8	19.6	20.1	2.0	2.4	1.5	0.9	0.5	0.4	0.6	45.2	2.1	0.1	1.2	0.1	0.0	0.0
Conowingo Eels				5	95	100	113	353	252	247	1061	280	26	25	53	14	31	20	6	3

Week 1: May 1 - May 7
Week 2: May 8 - May 14
Week 3: May 15 - May 21
Week 4: May 22 - May 28
Week 5: May 29 - June 4
Week 6: June 5 - June 11
Week 7: June 12 - June 18
Week 8: June 19 - June 25
Week 9: June 26 - July 2
Week 10: July 3 - July 9
Week 11: July 10 - July 16
Week 12: July 17 - July 23
Week 13: July 24 - July 30
Week 14: July 31 - August 6
Week 15: August 7 - August 13
Week 16: August 14 - August 20
Week 17: August 21 - August 27
Week 18: August 28 - September 3
Week 19: September 4 - September 10
Week 20: September 11 - September 15