Shell Proposed Petrochemicals Complex
Beaver County, Pennsylvania

Source Water Physical and Biological Baseline Characterization Study – Montgomery Pool, Ohio River

August 2016

Prepared for:

Shell Chemical Appalachia LLC

Prepared by:

AECOM

SOURCE WATER PHYSICAL AND BIOLOGICAL BASELINE CHARACTERIZATION STUDY – MONTGOMERY POOL, OHIO RIVER

Prepared for:

Shell Chemical Appalachia LLC

Prepared by:

AECOM

August 2016

Table of Contents

List of Figures

List of Tables

List of Appendices

List of Abbreviations

BVPS	Beaver Valley Power Station
°C	Temperature degrees Celsius
cfs	cubic feet per second
CWA	Clean Water Act
CWIS	Cooling Water Intake Structure
ft.	feet
mg/L	milligrams per liter
MGD	million gallons per day
mORFIn	Modified Ohio River Fish Index
mS/cm	microsiemens per centimeter
NPDES	National Pollutant Discharge Elimination System
ORSANCO	Ohio River Valley Water Sanitation Commission
PADEP	Pennsylvania Department of Environmental Protection
PCB	polychlorinated biphenyls
PFBC	Pennsylvania Fish and Boat Commission
PNDI	Pennsylvania Natural Diversity Inventory
Shell	Shell Chemical Appalachia LLC
SIR	Species Impact Review
T&E	Threatened & Endangered
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WWF	Warm Water Fishes
YOY	Young-of-the-year (fish)

1 Introduction

AECOM developed this source water physical and biological baseline characterization report for the Montgomery Pool on the Ohio River in the vicinity of Shell Chemical Appalachia LLC's (Shell) proposed petrochemicals complex (facility) in Beaver County, Pennsylvania. Shell plans to use the existing (i.e., former Horsehead Corporation) Cooling Water Intake Structure (CWIS) to provide industrial supply water from the Ohio River to the proposed facility. The existing CWIS is designed to provide up to 80 million gallons per day (MGD) of water. With appropriate modifications, Shell plans to use the existing CWIS to provide approximately 20 MGD of water to the proposed facility.

This document was developed following the requirements under the Clean Water Act (CWA) 316(b) Rule for Existing Facilities, and is based upon published literature and available biological and fisheries data. It is the objective of this report to provide the Pennsylvania Department of Environmental Protection (PADEP) with sufficient data to support compliance with 316(b) without the need to collect additional data.

1.1 Purpose

The primary purpose of this report is to identify and characterize the physical properties and biological community of the Ohio River in the vicinity of the CWIS. Operation of the CWIS has the potential to impact aquatic communities due to impingement or entrainment. Impingement is the physical interaction between fishes or other organisms and the intake screens such that escape is not possible. The impinged organisms are carried by the screen to a return sluiceway that deposits impinged organisms back into the source water body. Life stages of fish typically seen in impingement studies range from juvenile to adult. Entrainment is when small organisms that are able to fit through the intake screens are drawn into and through the cooling water system. These organisms may experience high sheer forces, elevated temperature, or chemical stressors before passing out of the system through the discharge of cooling water tower blowdown. Fish eggs and larvae, very small juvenile fish, and larval freshwater mussel (unionids; referred to as glochidia) are susceptible to entrainment. This report identifies aquatic species most susceptible to impingement and entrainment from operation of the CWIS.

1.1.1 Site Location

The proposed facility is located along the left descending bank of the Ohio River immediately west of the town of Monaca, Pennsylvania (**Figure 1**). The site resides on the Montgomery Pool of the Ohio River which is entirely within the state of Pennsylvania. The Beaver River flows into the Montgomery Pool from the north, upstream of the site. Raccoon Creek enters the Montgomery Pool along the left descending bank approximately 2,100 feet downstream of the Shell CWIS (**Figure 2**). The existing CWIS will be inspected, repaired if needed, and modified with new equipment to serve the proposed facility. Section 5, Module 5 of the Part I National Pollutant Discharge Elimination System (NPDES) application provides the mechanical design details.

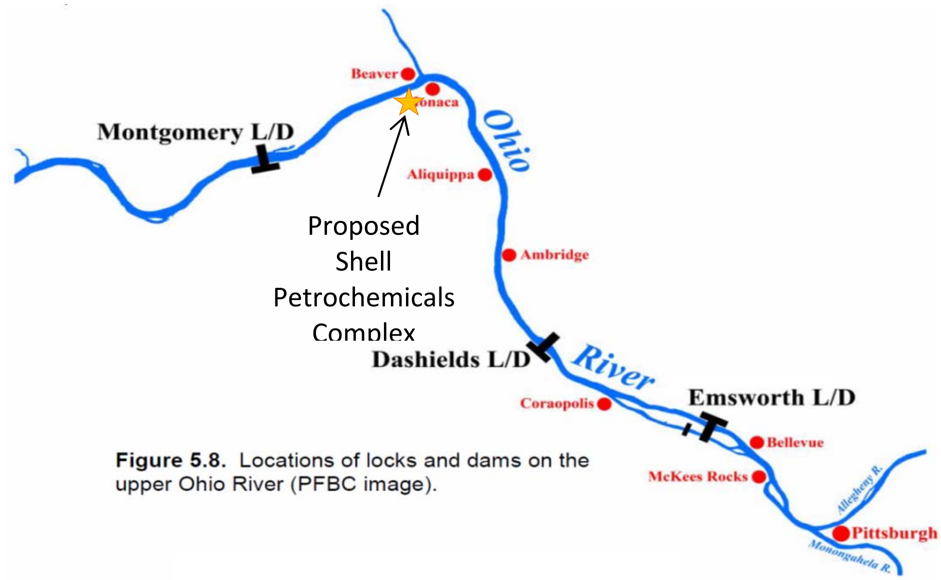


Figure 1: Location of the Proposed Petrochemicals Complex on the Montgomery Pool for the Ohio River in Pennsylvania (Original from PFBC 2010, Figure 5.8)

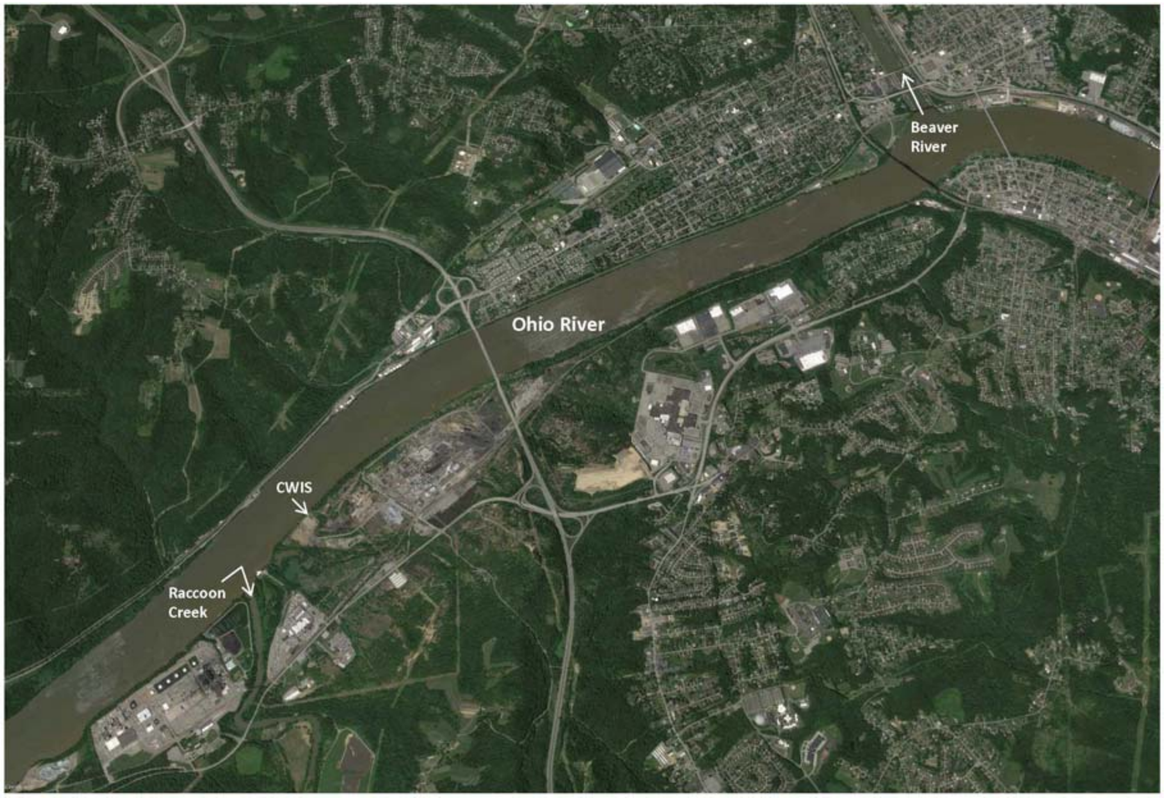


Figure 2: Location of Shell CWIS

1.1.2 Regulatory Requirements

This section summarizes the relevant CWIS definitions promulgated by the United States Environmental Protection Agency (USEPA) under the authority of the CWA section 316(b) to demonstrate that the proposed petrochemical complex will be regulated as an Existing Facility under CWIS regulations. In accordance with the 316(b) rule, this report provides source water physical data (§122.21(r)(2)) and baseline biological characterization data (§122.21(R)(4)).

On May 19, 2014, USEPA released a pre-publication version of a Final Rule with new CWIS regulations for Existing Facilities that included the following definition at 40 CFR Part 125.92(k):

> ***Existing facility*** *means any facility that commenced construction as described in 40 CFR 122.29(b)(4) on or before January 17, 2002 (or July 17, 2006 for an offshore oil and gas extraction facility) and any modification of, or any addition of a unit at such a facility.*[1] *A facility built adjacent to another facility would be a new facility while the original facility would remain as an existing facility for purposes of this subpart. A facility cannot both be an existing facility and a new facility as defined at §125.83.*

On December 18, 2001, USEPA published the Final Phase I Rule with CWIS regulations for New Facilities that included the following definitions at 40 CFR Part 125.83:

> ***Cooling water intake structure*** *means the total physical structure and any associated constructed waterways used to withdraw cooling water from waters of the U.S. The cooling water intake structure extends from the point at which water is withdrawn from the surface water source up to, and including, the intake pumps.*
>
> ***Existing Facility*** *means any facility that is not a* ***New Facility;*** *and*
>
> ***New Facility*** *means any building, structure, facility, or installation that meets the definition of a "new source" or "new discharger" in 40 CFR 122.2 and 122.29(b)(1), (2), and (4) and is a greenfield or standalone facility; commences construction after January 17, 2002; and uses either a newly constructed cooling water intake structure, or an existing cooling water intake structure whose design capacity is increased to accommodate the intake of additional cooling water.*[2] *New facilities include only "greenfield" and "standalone" facilities. A greenfield facility is a facility that is constructed at a site at which no other source is located, or that totally replaces the process or production equipment at an existing facility (see 40 CFR 122.29(b)(1)(i) and (ii)).*[3] *A stand-alone facility is a new, separate facility that is constructed on property where an existing facility is located and whose processes are substantially independent of the existing facility at the same site (see 40 CFR 122.29(b)(1)(iii)).*[4] *New facility does not include new units that are added to a facility for purposes of the same general industrial operation (for example, a new peaking unit at an electrical generating station).*
>
> > *(1) Examples of "new facilities" include, but are not limited to the following scenarios:*

[1] The site meets the definition of an Existing Facility.

[2] The proposed petrochemicals complex will decrease total water intake from approximately 80 MGD to approximately 20 MGD.

[3] The proposed petrochemicals complex will not be a greenfield facility.

[4] The proposed petrochemical complex will not be a stand-alone facility.

(i) A new facility is constructed on a site that has never been used for industrial or commercial activity. It has a new cooling water intake structure for its own use.

(ii) A facility is demolished and another facility is constructed in its place. The newly-constructed facility uses the original facility's cooling water intake structure, but modifies it to increase the design capacity to accommodate the intake of additional cooling water.[5]

(iii) A facility is constructed on the same property as an existing facility, but is a separate and independent industrial operation. The cooling water intake structure used by the original facility is modified by constructing a new intake bay for the use of the newly constructed facility or is otherwise modified to increase the intake capacity for the new facility.

(2) Examples of facilities that would not be considered a "new facility" include, but are not limited to, the following scenarios:

(i) A facility in commercial or industrial operation is modified and either continues to use its original cooling water intake structure or uses a new or modified cooling water intake structure. [6]

(ii) A facility has an existing intake structure. Another facility (a separate and independent industrial operation), is constructed on the same property and connects to the facility's cooling water intake structure behind the intake pumps, and the design capacity of the cooling water intake structure has not been increased.[7] *This facility would not be considered a "new facility" even if routine maintenance or repairs that do not increase the design capacity were performed on the intake structure.*

As described by the above regulatory definitions and examples, the CWIS regulations that apply to an intake structure are not dependent on whether the intake structure is new or existing but whether the proposed facility is new or existing *and if a modification to increase capacity occurs.* Per the above regulatory citations, Shell's proposed petrochemicals facility meets the definition of an Existing Facility.

2 Resources Utilized

A literature and fisheries data search for the Montgomery Pool yielded a variety of published results. The water quality of the Ohio River is considered to be in a state of slow recovery and is being monitored throughout its length. Data were obtained from the Ohio River Valley Water Sanitation Commission (ORSANCO), the Pennsylvania Fish and Boat Commission (PFBC), 316(b) reports from

[5] This example best represents the demolition of the former Horsehead facility and construction of Shell's proposed petrochemical facility. The Shell facility will use Horsehead's original intake structure. Rather than increasing design capacity, the proposed Shell facility will decrease the intake's design capacity from approximately 80 MGD to approximately 20 MGD. As a result, Shell's proposed facility will not be considered a New Facility.

[6] Shell's proposed petrochemicals complex meets the designated criteria and would not be considered a New Facility.

[7] Since the proposed facility will not increase the existing intake's design capacity, the proposed facility will not be considered a New Facility.

nearby facilities, and published studies. The list of available reports and studies were discussed with both PADEP and PFBC staff.

The following subsections provide brief summaries of the pertinent information collected from these resources.

2.1 ORSANCO 2010: 2010 Ohio River Pool Assessments – Montgomery, Racine and John T. Myers.

ORSANCO (2010) presents the results of biological sampling on three Ohio River pools. Data collected are standardized throughout the Ohio River study area and different pools are sampled each year. Data collected include fish abundance from electrofishing surveys, instream habitat characterizations at multiple locations within each pool, and water quality and hydrology measurements at the time of fish surveys. These data are used to assess the biological condition of each pool using a scoring system known as the Modified Ohio River Fish Index (mORFIn). The summarized data presented in this document provide the most recent fish abundance data, substrate characterization data, and overall biological health assessment for the Montgomery Pool. The overall biological condition of the Montgomery Pool in 2010 was “Good” with over forty species of fish collected and only two of fifteen sampled locations receiving a health rating below “Fair”. The Montgomery Pool was found to meet its aquatic life-use designation.

2.2 PFBC 2010: Three Rivers Management Plan, a Strategy for Managing Fisheries Resources of the Allegheny, Monongahela, and Ohio Rivers

PFBC (2010) presents a comprehensive approach to managing fisheries resources in the Allegheny, Monongahela and Ohio Rivers within Pennsylvania. A wide breadth of knowledge about the rivers is summarized including: physiography and land use surrounding the rivers, geology and climate, channel morphology and historical dredging effects, hydrology, water quality, instream habitat characteristics, and fish and other biota assemblages. The document provided much of the background information needed to characterize the biology of the Montgomery Pool and offered insight into historical uses of the Ohio River that affected the biology of the river.

2.3 USACE. 2014: Upper Ohio Navigation Study, Pennsylvania Draft Feasibility Report and Integrated Environmental Impact Statement - Emsworth, Dashields, and Montgomery Locks and Dams

United States Army Corps of Engineers (USACE) 2014 presents a feasibility study to identify the long term plan for maintaining reliable navigation in the Upper Ohio River. Information pertinent to the aquatic biology of the Montgomery Pool is found in Section 3.3.2 of that report and includes: physiography and hydrology of the Upper Ohio River pool, bathymetric information and substrate characterization, water quality, and fish and other biota assemblages. This report also provided results of a larval and juvenile fish study that included sampling in the Montgomery Pool. The results of the study indicated that the Montgomery Pool is a functioning spawning and nursery ground for many species found in the Pool as adults.

2.4 ENSR. 2008: 316(b) Best Professional Judgment for Best Technology Available Report – NOVA Chemicals-AES Beaver Valley Generating Station

ENSR (2008) contains the only record of an impingement study performed on the Montgomery Pool. The Study was conducted in 2006 through 2007 and 46, 24-hour sampling events were conducted. A total of 48,231 fish were collected during the study representing 20 taxa. Greater than 99 percent of the fish collected were gizzard shad and most fish were in the age-0 size class. Greatest impingement rates were observed in July and August.

3 Project Area Summary

The proposed project area is located along the left descending riverbank between Ohio River miles 27.0 to 29.5 in Potter and Center Townships Beaver County, Pennsylvania (immediately west of the town of Monaca). The project area is located entirely within the Montgomery Pool and is approximately two miles upriver from the Montgomery Locks and Dam located at river mile 31.7. The Ohio River is formed from the confluence of the Allegheny and Monongahela Rivers and is the only navigable river in North America with river miles numbered from its origin. The Montgomery Pool is approximately 18.5 miles long and the third Pool on the Ohio River. The Proposed project area is within the last downstream quarter of the pool.

3.1 PA Ohio River setting

The Ohio River begins in the city of Pittsburgh, Pennsylvania with the confluence of the Allegheny and Monongahela Rivers. It is the second largest river system in the United States, based on annual discharge with forty miles located in the state of Pennsylvania. Municipal and industrial wastes deposited into the River throughout the 1800s and early- to mid-1900s resulted in widespread water quality degradation and habitat destruction. Beginning in the 1970’s state and federal efforts focused on increasing water quality in the River and have resulted in increased fish populations and native species reclaiming native ranges (PFBC 2010).

Although the aquatic community in the Pennsylvania portion of the Ohio River has shown positive trends since the 1970’s, it is still negatively impacted by the lock and dam system that inhibits movement of fish and other organisms along the length of the River. These locks and dams have largely eliminated instream riparian habitat throughout the Pennsylvania portion of the Ohio River (PFBC 2010). Additional alterations to instream habitat have resulted from commercial sand and gravel dredging and dredging conducted to facilitate commercial navigation. Finally, the Ohio River is still impacted from persistent contaminants such as polychlorinated biphenyls (PCBs), chlordane and mercury that have prompted the Pennsylvania Department of Environmental Control to publish fish consumption advisories that include Do Not Eat Advisories for catfish and carp in the Ohio River (PFBC 2010).

3.2 Montgomery Pool

The Montgomery Pool is bound upstream by the Dashields Locks and Dam and downstream by the Montgomery Locks and Dam. The pool is gently graded and averages approximately 1,400 ft. wide and 25 ft. deep. Although the terrestrial habitat adjacent to the Pool is predominantly classified as deciduous forest or pasture/crop land, the water body is heavily influenced by the nearby Pittsburgh metropolitan area. High volumes of commercial barge traffic and recreational users are common on all

Ohio River Pools in Pennsylvania. Benthic substrate within the Montgomery Pool is relatively coarse with boulder, cobble and gravel making up approximately 45 percent of the bottom, sand accounting for another 40 percent and only 13 percent of the substrate described as fines (ORSANCO 2010). Habitat along the shoreline has been largely altered with large rocks and boulders to prevent erosion. However, fallen trees provide significant shoreline aquatic habitat for fish. Small amounts of submerged aquatic vegetation have been noted within the Pool (ORSANCO 2010). The Beaver River, entering from the right descending back across from the town of Monaca, Pennsylvania is the only major tributary entering the Montgomery Pool (PFBC 2010). Raccoon Creek (a minor tributary) enters the Montgomery Pool along the left descending bank approximately 2,100 feet downstream of the CWIS (**Figure 2**).

3.3 Depth

Based on multi-beam side-scan sonar surveys in the Pennsylvania portion of the Ohio River, the deepest locations are dredge pits created by commercial sand and gravel dredging (USACE 2014, PFBC 2010). While the dredge pits are present throughout the Dashields, Montgomery, and New Cumberland Pools, deep pits (>60 ft.) are only present in the New Cumberland Pool. Dashields and Montgomery Pools are more evenly graded with typical water depths reaching 22 ft. to 24 ft. (USACE 2014) although greater depths have been observed (40 ft. – 50 ft.) (URS 2014). Within the Montgomery pool, the channel is confined within a relatively narrow, steep-walled valley (PADEP 2010).

3.4 Water Quality

Water quality parameters pH, dissolved oxygen, and specific conductance are monitored at the Montgomery Dam by the United States Geological Survey (USGS) (USGS station 03108490). Specific conductance and pH are monitored year-round and dissolved oxygen is monitored during the warmer months (approximately from April through October). The following discussion uses the most recent "approved" five year data set from the USGS[8].

Specific conductance at the Montgomery Dam generally ranges from 200 microsiemens per centimeter (mS/cm) to 600 mS/cm throughout the year (**Figure 3**). Departures from this range are rare. Monthly average specific conductance ranges from 293 mS/cm to 424 mS/cm with lower values occurring during high flow months and higher values occurring during lower flow months in the summer and fall (**Table** 1). Published water quality standards for specific conductance for the Ohio River have not been identified.

[8] USGS recorded data are initially listed as "provisional" until they have been reviewed and pass through a quality assurance process. After this process they are considered "approved". Data used in this report are from 10/2009 through 10/2014.

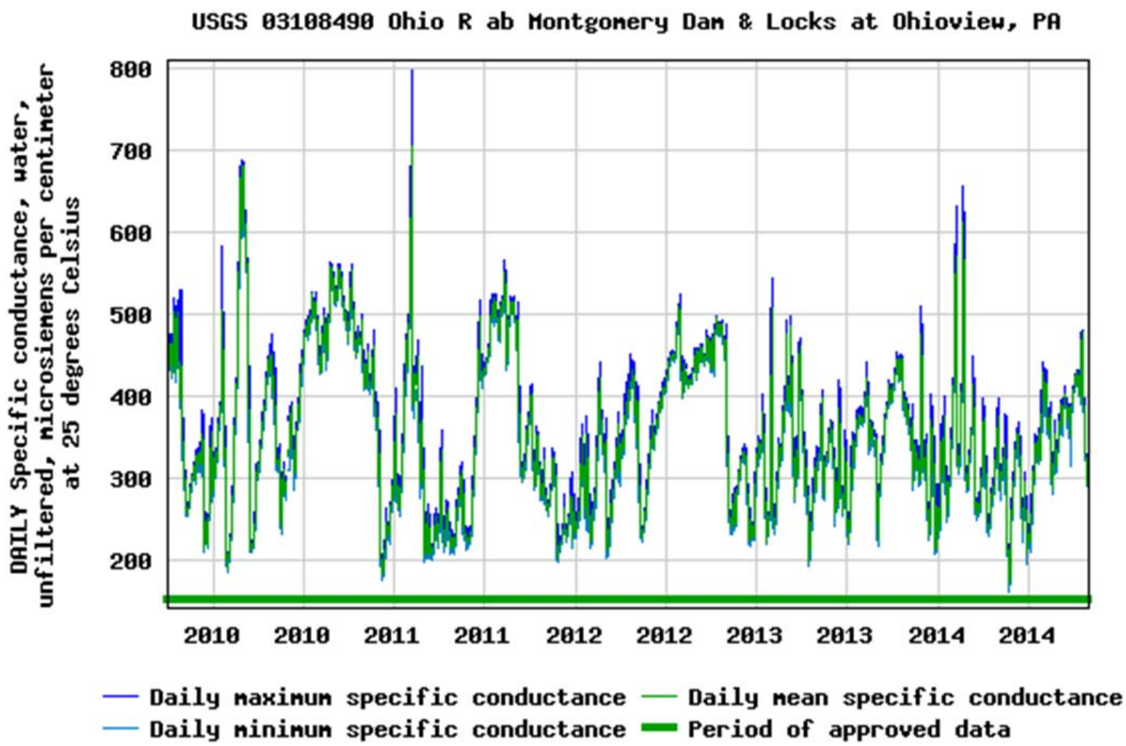


Figure 3: Specific Conductivity at Montgomery Dam and Locks from 10/2009 through 10/2014 (USGS 03108490).

Table 1: Mean Monthly Specific Conductance at Montgomery Locks and Dam from 10/2009 through 10/2014 (USGS 03108490). Value is the mean of monthly average values reported by the USGS.

Month	Mean Monthly Specific Conductance (mS/cm at 25 °C) (10/2009 – 10/2014)
January	316
February	371
March	315
April	321
May	293
June	338
July	410
August	424
September	412
October	419
November	317
December	265

The pH at the Montgomery Dam generally ranges from 7.0 to 8.0 throughout the year (**Figure 4**). Departures from this range are generally in the 8.0 to 9.0 range. Monthly average pH is stable with average values near 7.5 (**Table 2**). ORSANCO's water quality standard for pH is >6.0 and <9.0 (ORSANCO 2014). Based on the most recent five year data set from USGS monitoring station at Montgomery Locks and Dam, pH is within the acceptable range.

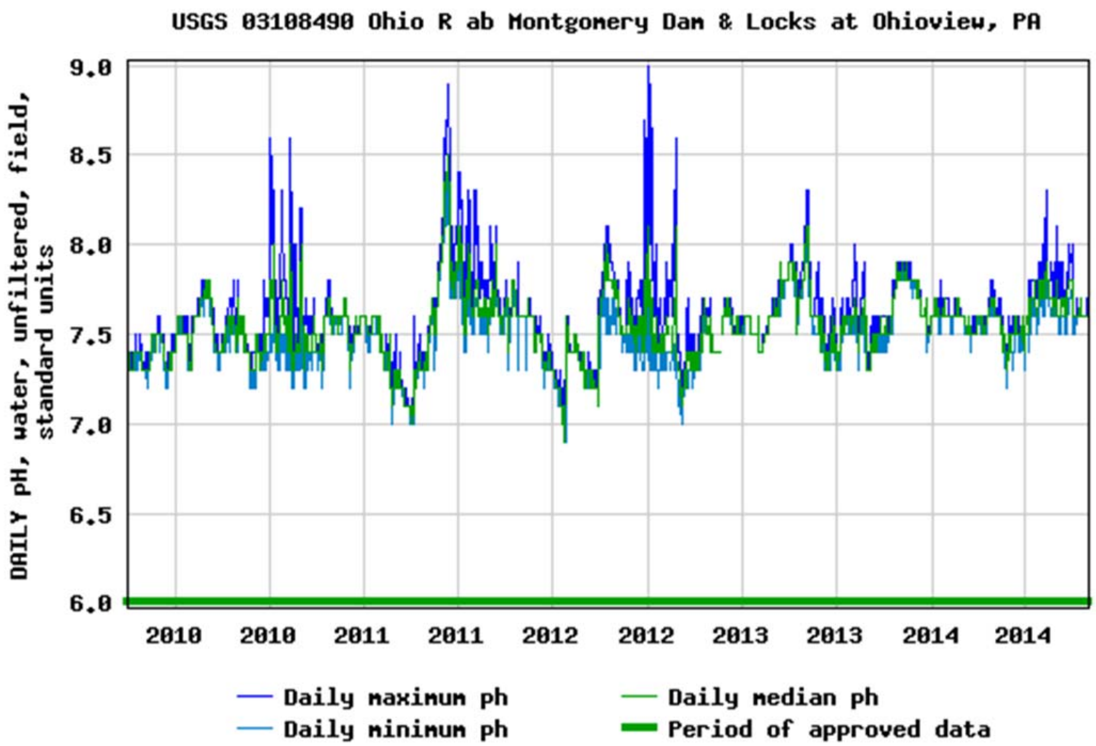


Figure 4: pH at Montgomery Dam and Locks from 10/2009 through 10/2014 (USGS 03108490).

Table 2: Mean Monthly pH at Montgomery Locks and Dam from 10/2009 through 10/2014 (USGS 03108490). Value is the Mean of Monthly Average Values Reported by the USGS.

Month	Mean Monthly pH (Standard Units) (10/2009 – 10/2014)
January	7.49
February	7.50
March	7.45
April	7.59
May	7.58
June	7.60
July	7.61
August	7.59
September	7.52
October	7.54
November	7.57
December	7.49

Dissolved oxygen trends lower in warmer months and higher in cooler months with levels rarely dropping below 6.0 milligrams per liter (mg/L). In 2013 and 2014, dissolved oxygen readings rarely dropped below 8.0 mg/L (**Figure 5**). Minimum average dissolved oxygen is observed during July (7.8 mg/L) (**Table 3**). ORSANCO's water quality standard for dissolved oxygen is > 4.0 mg/L for acute exposure and > 5.0 mg/L for chronic exposure. Dissolved oxygen levels below or near 5.0 mg/L were recorded in 2010 and 2012. However, levels did not fall to 4.0 mg/L and did not remain near 5.0 mg/L for a long period. Dissolved oxygen levels appear to be within ORSANCO's water quality standards at the USGS monitoring station at Montgomery Locks and Dam (ORSANCO 2014).

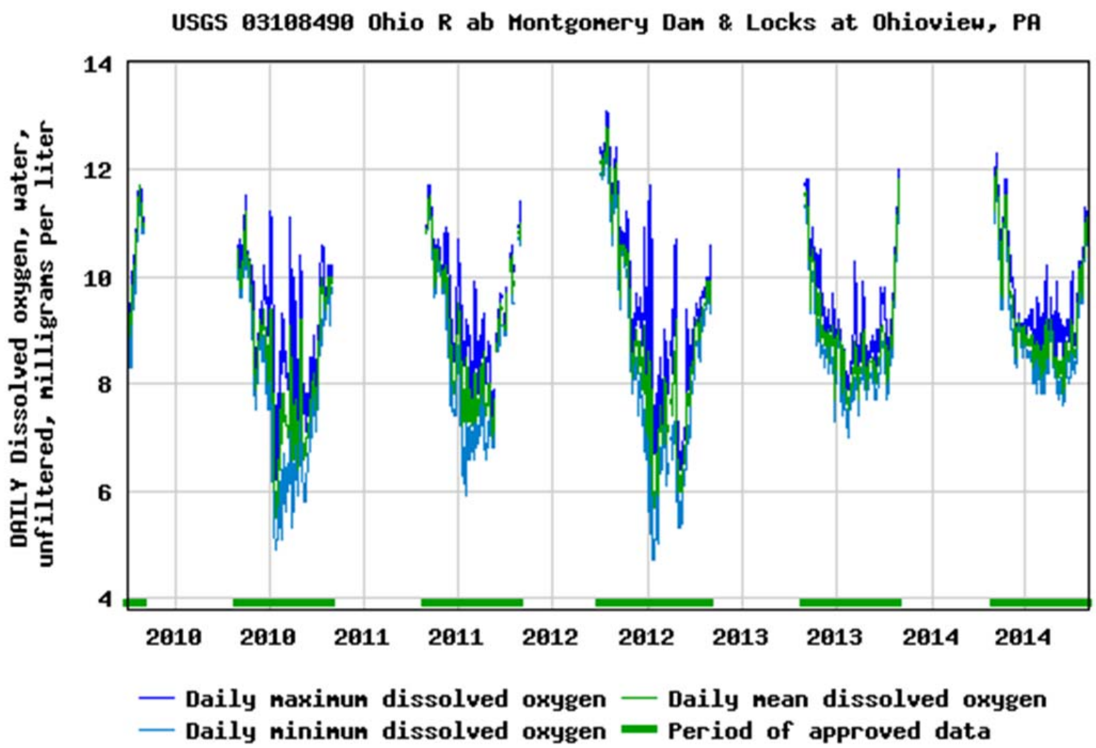


Figure 5: Dissolved Oxygen Measurements at Montgomery Dam and Locks from 10/2009 through 10/2014 (USGS 03108490).

Table 3: Mean Monthly Dissolved Oxygen at Montgomery Locks and Dam from 10/2009 through 10/2014 (USGS 03108490). Value is the Mean of Monthly Average Values Reported by the USGS.

Month	Mean Monthly Dissolved Oxygen (mg/L) (10/2009 – 10/2014)
January	---
February	---
March	---
April	12
May	10.4
June	8.8
July	7.8
August	8
September	8
October	9.8
November	---
December	---

Note: "---" indicates parameter was not measured

3.5 Temperature Regimes

Water temperature follows seasonal trends that are fairly consistent from year to year (**Figure 6**). Maximum water temperature is generally observed during July and August (monthly mean temperature of 26.4°C and 25.7°C for July and August, respectively (

Table 4)). Annual absolute maximum temperatures range from about 30°C to 25°C (USGS 2015). Minimum annual temperatures are generally at or near 0°C and observed in January or February. ORSANCO's water quality criteria for temperature are based on the region of the Ohio River and the Julian date (**Table 5**) (ORSANCO 2013). The most recent analysis of temperature data collected at the USGS Station at Montgomery Locks and Dam indicate that from 2009 through 2013, 0.2% of days exceeded the temperature water quality standard and all exceedances occurred in 2012 (ORSANCO 2014).

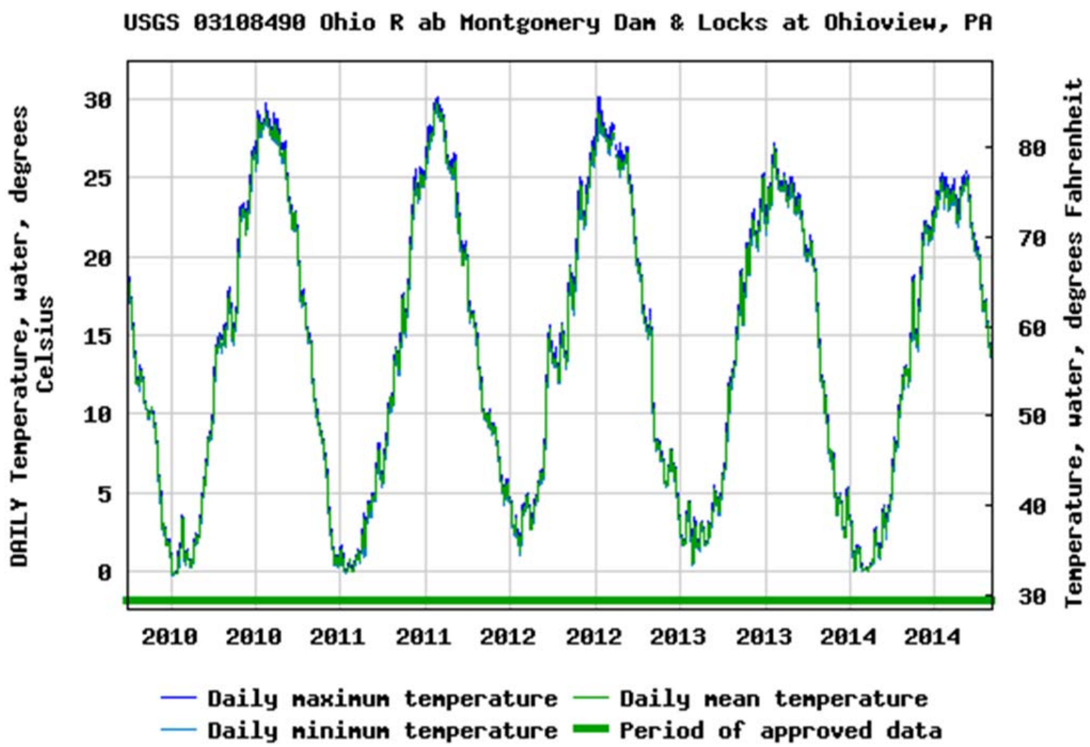


Figure 6: Temperature at Montgomery Dam and Locks from 10/2009 through 10/2014 (USGS 03108490).

Table 4: Mean Monthly Temperature at Montgomery Locks and Dam from 10/2009 through 10/2014 (USGS 03108490). Value is the Mean of Monthly Average Values Reported by the USGS.

Month	Mean Monthly Temperature (°C) (10/2009 – 10/2014)
January	1.4
February	1.9
March	5.6
April	11.5
May	17

Month	Mean Monthly Temperature (°C) (10/2009 – 10/2014)
June	23.2
July	26.4
August	25.7
September	22.7
October	16.1
November	9
December	4.2

Table 5: ORSANCO's water quality criteria for temperature for the Upper, Middle and Lower Ohio River (ORSANCO 2013)

Julian Day	MP 0 to MP 341	MP 341.1 to MP 606.8	MP 606.9 to MP 981
1 - 49	47.1 – 0.086 * Julian Day	47.2 – 0.024 * Julian Day	50.1 – 0.047 * Julian Day
50 - 166	26.6 + 0.328 * Julian Day	34.1 + 0.311 * Julian Day	34.8 + 0.269 * Julian Day
167 - 181	87	87	87
182 - 243	89	89	89
244 - 258	87	87	87
259 - 366	160.8 – 0.300 * Julian Day	176.7 – 0.346 * Julian Day	164.5 – 0.308 * Julian Day

3.6 Flow Regimes

There are no discharge monitoring stations located on the Montgomery Pool. Beaver Valley Power Station (BVPS), just south of Montgomery Locks and Dam, provided an analysis of available flow data that is applicable to the proposed site due to its proximity (approximately 6.5 river miles downstream of the proposed site) and that there are no major tributaries between the two locations. The analysis uses flow data from the closest upstream discharge monitoring station on the Ohio (USGS station 0308600) and a discharge monitoring station on the only major tributary to the Ohio River between the site and the Ohio River discharge monitoring station(USSG Station 03107500 on the Beaver River). The analysis is summarized below (

Table 6) (BVPS 2007).

Based on a 30 year data set, annual mean flow near the site is approximately 39,500 cubic feet per second (cfs). Monthly average flows range from 16,500 cfs in August to 69,900 cfs in March. Flows are generally highest from December through April and lowest in August and September. The 7Q10[9], a descriptor of potential lowest expected flow rate is 5,290 cfs. Table 6 provides flow statistics from this analysis provided by BVPS (2007). For the purpose of developing effluent limits for NPDES permits within the Montgomery Pool, PADEP uses a more conservative 7Q10 of 4,730 cfs as input to their PENTOXSD model per ORSANCO requirements for the Ohio River from Pittsburgh (River Mile 0.0) to the Montgomery Dam (River Mile 31.7).

[9] The 7Q10 is the period of lowest stream flow during a seven-day interval that is expected to occur once every 10 years.

Table 6: Summary of Ohio River Flow Characteristics near Montgomery Locks and Dam (From BVPS (2007) Table 2.2.1)

SUMMARY OF OHIO RIVER FLOW CHARACTERISTICS NEAR MONTGOMERY LOCKS AND DAM[a]													
Monthly Average Flow (cfs)													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Min	11,618	24,113	37,987	30,478	18,638	7,387	7,327	5,730	6,025	5,549	7,194	10,548	27,239
Max	91,624	98,337	116,315	104,796	101,267	81,578	55,868	48,947	42,106	56,360	95,006	96,835	59,884
Mean	50,064	57,196	69,944	59,745	42,635	30,738	21,805	16,526	17,610	21,561	35,536	51,771	39,503
Daily Flow Frequency by Percentile (cfs)													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1%	9,630	9,768	14,800	15,050	9,900	5,574	4,993	4,654	4,735	5,020	4,640	6,500	5,348
10%	16,230	18,580	33,140	24,360	14,850	8,710	7,370	6,408	6,257	7,490	10,910	19,380	8,850
50%	42,290	46,760	64,910	54,200	35,460	22,960	14,520	11,600	11,530	14,970	30,620	46,830	30,330
7-Day Low Flows by Recurrence Interval (cfs)													
					2-yr	5-yr	10-yr	25-yr					
					7,070	5,850	5,290	4,750					

[a] Based on U.S. Geological Survey flow data from gauging stations at Sewickley (0308600, river mile 11.8) on the Ohio River and at Beaver Falls (03107500) on the Beaver River for the period of record 1971 – 2000

Flood events are common in the Pennsylvania section of the Ohio River due to high local topographic relief, confined river channels, highly sloped river valleys, and a high percentage of precipitation resulting in runoff (PFBC 2010). Although flooding has occurred at any time of year, the period between November through April is particularly prone to these events due to frozen or saturated soils in the drainage area (PFBC 2010).

4 Source Water Baseline Biological Characterization

The length of the Ohio River is divided into 19 Pools created by navigation locks and dams. Sampling of the fish community has been conducted on the Ohio River since the 1950's. From 1957 through 2005 rotenone surveys were conducted at lock chambers where all fish were killed and collected for the study. From 1991 through the present, electrofishing surveys were conducted at sampling locations along the length of each Pool. Under either survey type, each Pool was not surveyed every year (i.e., pools may be surveyed once every several years and not annually). The most recent survey of the Montgomery Pool was an electrofishing survey conducted in 2010 by ORSANCO. The bulk of the fisheries data below has been collected from the ORSANCO fish population database (http://www.orsanco.org/fish-population).

The lock and dam structures on the Ohio River are barriers to upstream fish passage, although fish may have a limited opportunity to pass upstream when the locks are operated. These navigation pools are considerably deeper, have lower water velocities, are more lake-like and have less complex instream habitats than that of tributary rivers such as the Allegheny (PFBC 2010). Substrates in the pools have been altered by dredging, both to improve navigation and for commercial dredging of gravel and sand (PFBC 2010). Although the dredged deeper water of the navigation channels provide less complex habitat overall, deep pools with higher water velocity created at the tail waters of the navigation dams provide substantial habitat for walleye and sauger (PFBC 2010).

Shallow water habitat is limited in the Montgomery Pool due to dredging activities (PFBC 2010). However, significant shoreline habitat has been created through placement of manmade structures (rock gabions, pilings, bridge abutments, abandoned barges and large boulder riprap shoreline structures). These structures provide increased habitat complexity which can be utilized by many aquatic species, predator and prey (PFBC 2010). Shallow backwater channels provide warm still water habitat during normal flows with access to the main river channel. The Montgomery Slough is an example of this type of feature and is located just upstream of the Montgomery Locks and Dam. Two tributary waterways feed into the Montgomery Pool near the proposed site: the Beaver River (upstream) and Raccoon Creek (downstream). These streams can provide river dwelling fish additional opportunity for feeding, spawning areas and nursery areas.

The current fish community in the Montgomery Pool is described by the Commonwealth of Pennsylvania (2015) as a warm water fishery (WWF). The Commonwealth of Pennsylvania defines a warm water fishery in general terms as "[waters that serve to provide] maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat." These waters tend to support most fishes except those such as trout or other salmonids that may not be able to survive in the water body due to summertime water temperatures.

4.1 Surveys of Fish Community in the Montgomery Pool

The fish community in the Ohio River Basin was greatly reduced in the first half of the 20th century due to domestic, mining and industrial pollution (USACE 2014). Populations of pollutant-intolerant species were greatly reduced and tolerant species such as gizzard shad, bullhead catfish, freshwater drum, and common carp increased in abundance (USACE 2014). However, due to efforts by state and federal agencies, fish community abundance in Montgomery Pool has been steadily improving since the 1950s and 1960s (**Figure 7** – data from PFBC 2010) (USACE 2014, PFBC 2010). Rotenone studies at the Montgomery Locks have shown that overall species richness has an increasing trend through 2005 (when lock chamber rotenone surveys ceased). Sport and commercially valuable fish species showed the greatest increase in abundance and many native species that were extirpated from portions of the Ohio River have reclaimed historical ranges (USACE 2014).

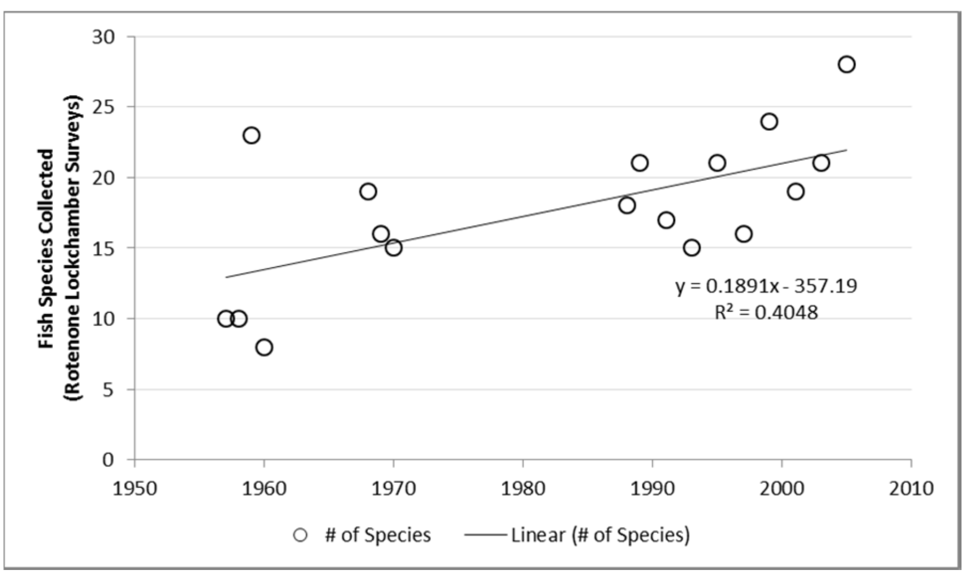


Figure 7: Lock Chamber Rotenone Fisheries Results from Montgomery Locks and Dam 1957 – 2005 with a Line of Best Fit Indicating Greater Fish Species Diversity over Time.

Recent electrofishing surveys of the Montgomery Pool occurred in 2006 and 2010 (ORSANCO 2007 and 2010). While comparisons between the two years may not be straightforward due to river discharge differences between the sampling events, they do provide recent data on the current fish assemblage in the Montgomery Pool. Approximately 40 taxa were collected during both surveys (ORSANCO 2007 and 2010). The most numerous taxa between the surveys were gizzard shad, golden redhorse, silver redhorse, smallmouth buffalo, bluegill, smallmouth bass and sauger. **Table 7** provides total catch by species for the 2006 and 2010 surveys along with a list of species that have been noted in Montgomery Pool in historical sampling (PFBC 2010, ORSANCO 2007 and 2010).

Table 7: Species Observed in Historical Sampling in Montgomery Pool and Number Of Fish Collected by Species During the Most Recent ORSANCO Electrofishing Sampling Events, 2006 and 2010. Data from PFBC 2010, ORSANCO 2007 and 2010.

Family Common Name	Scientific Name	Historical Presence Noted	2006 Electrofishing Survey	2010 Electrofishing Survey
Polyodontidae (Paddlefishes)				
Paddlefish	*Polyodon spathula* [M]	X		
Lepisosteidae (Gars)				
Longnose gar	*Lepisosteus osseus* [M]	X	10	8
Hiodontidae (Mooneyes)				
Goldeye	*Hiodon alosoides* [M]	X		
Mooneye	*Hiodon tergisus* [M]	X	6	7
Anguillidae (Freshwater Eels)				
American eel	*Anguilla rostrata* [M]	X		
Clupeidae (Herrings & Shads)				
Skipjack herring	*Alosa chrysochloris* [M]	X		
Gizzard shad	*Dorosoma cepedianum*	X	266	4,058
Cyprinidae (Minnows)				
Goldfish	*Carassius auratus* [I]	X		
Central stoneroller	*Campostoma anomalum*	X		
Grass carp	*Ctenopharyngodon idella* [I]	X		
Spotfin shiner	*Cyprinella spiloptera*	X	1	35
Common carp	*Cyprinus carpio* [I]	X	44	44
Striped shiner	*Luxilus chrysocephalus*	X		
Silver chub	*Macrhybopsis storeriana*	X	12	32
Golden shiner	*Notemigonus crysoleucas*	X		
Emerald shiner	*Notropis atherinoides*	X	8	171
River shiner	*Notropis blennius* [E]	X		
Bigeye shiner	*Notropis boops*	X		
Silverjaw minnow	*Notropis buccatus*	X		
Spottail shiner	*Notropis hudsonius* [I]	X		9
Silver shiner	*Notropis photogenis*	X		
Rosyface shiner	*Notropis rubellus*	X		
Sand shiner	*Notropis stramineus*	X		
Mimic shiner	*Notropis volucellus*	X	13	
Channel shiner	*Notropis wickliffi*	X		159
Bluntnose minnow	*Pimephales notatus*	X		21
Fathead minnow	*Pimephales promelas*	X		
Blacknose dace	*Rhinichthys atratulus*	X		
Creek chub	*Semotilus atromaculatus*	X		
Catostomidae (Suckers)				
River carpsucker	*Carpiodes carpio*	X	13	28
Quillback	*Carpiodes cyprinus* [M]	X	30	25

Family Common Name	Scientific Name	Historical Presence Noted	2006 Electrofishing Survey	2010 Electrofishing Survey
Highfin carpsucker	*Carpiodes velifer* [M]	X	37	14
White sucker	*Catostomus commersonii* [M]	X		1
Northern hog sucker	*Hypentelium nigricans* [M]	X	3	7
Smallmouth buffalo	*Ictiobus bubalus* [M]	X	217	79
Black buffalo	*Ictiobus niger*	X		3
Bigmouth buffalo	*Ictiobus cyprinellus* [E, M]	X		1
Silver redhorse	*Moxostoma anisurum* [M]	X	157	132
Smallmouth redhorse	*Moxostoma breviceps* [M]	X	110	25
River redhorse	*Moxostoma carinatum*	X	3	8
Black redhorse	*Moxostoma duquesnii* [M]	X		9
Golden redhorse	*Moxostoma erythrurum* [M]	X	227	282
Ictaluridae (Catfishes)				
White catfish	*Ameiurus catus* [I]	X		
Yellow bullhead	*Ameiurus natalis*	X		
Brown bullhead	*Ameiurus nebulosus*	X		
Channel catfish	*Ictalurus punctatus* [M]	X	34	17
Stonecat	*Noturus flavus*	X		
Flathead catfish	*Pylodictis olivaris* [M]	X	11	12
Esocidae (Pikes)				
Northern pike	*Esox lucius* [M]	X		
Tiger muskellunge	*Esox lucius x Esox masquinongy* [I]	X		
Muskellunge	*Esox masquinongy*	X		
Percopsidae (Trout-perches)				
Trout-perch	*Percopsis omiscomaycus*	X		
Atherinopsidae (New World Silversides)				
Brook silverside	*Labidesthes sicculus*	X		1
Fundulidae (Topminnows)				
Banded killifish	*Fundulus diaphanus*	X		
Moronidae (Temperate Basses)				
White perch	*Morone americana* [I, M]	X		
White bass	*Morone chrysops* [M]	X	36	
Hybrid striped bass	*Morone chrysops x Morone saxatilis* [I]	X		
Unidentified Morone sp.	*Morone* sp. [I]			27
Centrarchidae (Sunfishes)				
Rock bass	*Ambloplites rupestris*	X	8	8
Green sunfish	*Lepomis cyanellus*	X	2	
Pumpkinseed	*Lepomis gibbosus*	X	2	2
Warmouth	*Lepomis gulosus* [E]	X		
Bluegill	*Lepomis macrochirus*	X	216	58
Redear sunfish	*Lepomis microlophus* [I]	X	4	
Smallmouth bass	*Micropterus dolomieu* [M]	X	185	210
Spotted bass	*Micropterus punctulatus*	X	15	5
Largemouth bass	*Micropterus salmoides* [M]	X	8	8
White crappie	*Pomoxis annularis*	X		1
Black crappie	*Pomoxis nigromaculatus*	X	6	1
Percidae (Perches)				
Greenside darter	*Etheostoma blennioides*	X	2	1
Rainbow darter	*Etheostoma caeruleum*	X	4	
*Bluebreast darter	*Etheostoma camurum* [T]	X		
Fantail darter	*Etheostoma flabellare*	X	1	
*Spotted darter	*Etheostoma maculatum* [T]	X		
Johnny darter	*Etheostoma nigrum*	X		

Family Common Name	Scientific Name	Historical Presence Noted	2006 Electrofishing Survey	2010 Electrofishing Survey
*Tippecanoe darter	*Etheostoma tippecanoe* [T]	X		
Banded darter	*Etheostoma zonale*	X	1	
Logperch	*Percina caprodes*	X	67	47
Channel darter	*Percina copelandi*	X	1	
Yellow perch	*Perca flavescens*	X	4	
Blackside darter	*Percina maculata*	X		
River darter	*Percina shumardi*	X		
Sauger	*Sander canadensis* [M]	X	243	92
Saugeye	*Sander canadensis x Sander vitreus*	X		
Walleye	*Sander vitreus* [M]	X	11	21
Sciaenidae (drums)				
Freshwater drum	*Aplodinotus grunniens* [M]	X	47	84

Notes:
- **C =** Species is listed as *Candidate* under 58 Pennsylvania Code Chapter 75.
- **E =** Species is listed as *Endangered* under 58 Pennsylvania Code Chapter 75.
- **I =** Introduced species.
- **M =** Species is considered migratory (Wilcox *et al*. 2004).
- **T =** Species is listed as *Threatened* under 58 Pennsylvania Code Chapter 75.
- *** =** Bluebreast, spotted and tippecanoe darters are under consideration for de-listing (44 Pa.B. 7876)[10]

Grouping data by family reveals that gizzard shad, suckers, minnows, sunfishes and perches comprise the majority of the fish assemblage during both the 2006 survey and the 2010 survey (**Figure** 8). ORSANCO (2010) postulated that gizzard shad and minnows (primarily emerald shiner) were more numerous in 2010 due to lower river flows that made sampling for these fish more effective.

[10] Proposed Rulemaking – Pennsylvania Fish and Boat Commission [58 PA. CODE CH. 75] - Fishing; Endangered Species . Saturday, December 20, 2014. URL: http://www.pabulletin.com/secure/data/vol44/44-51/2621.html

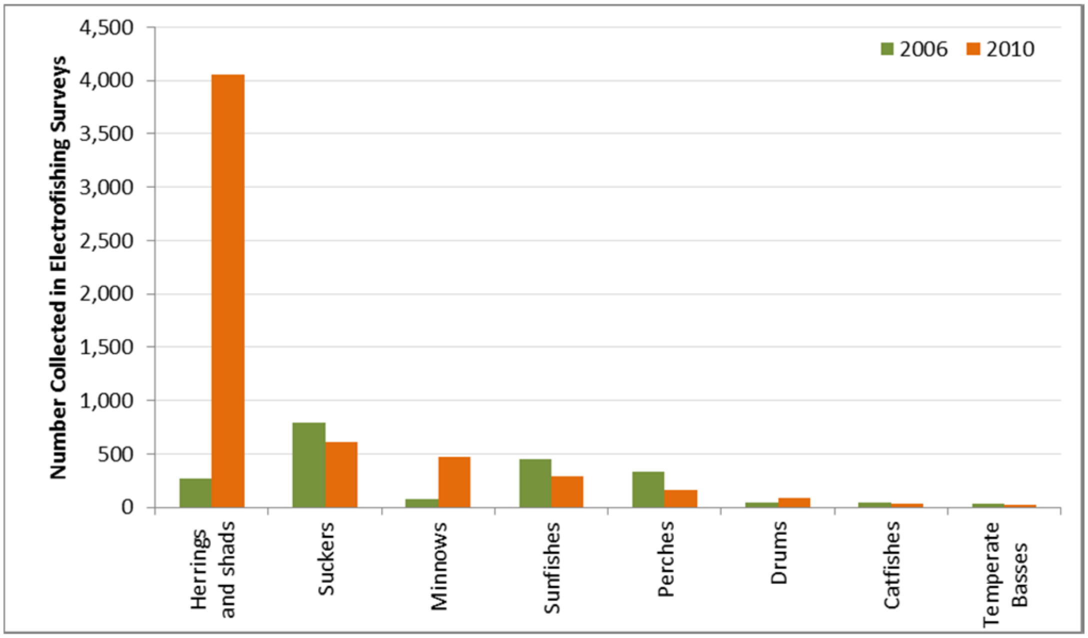


Figure 8: Raw Number of Fish Collected by Family in Electrofishing Samples in 2006 And 2010 in Montgomery Pool, Ohio River. Note, the Herrings and Shads Family Is Represented by a Single Species, Gizzard Shad.

Larval fishes are generally present from March through September in the Upper Ohio River (USACE 2014). Young-of-the-year (YOY) fishes (juveniles) occur concurrently with larval fishes and are present as larval fishes grow. A study of larval and YOY fishes conducted by Pennsylvania State University in 2008 and 2009 yielded 61 species and included several threatened or endangered fishes (Stauffer et. al. 2010 reported in USACE 2014). Tippecanoe darter and bluebreast darter individuals (PA threatened Species) were specifically collected in Montgomery Pool. Fifteen larval sport fish species were also collected indicating that spawning is occurring successfully throughout the upper Ohio River and the three rivers area (USACE 2010).

To augment this published ORSANCO data, the project contacted ORSANCO and obtained the most recent fish and benthic data in the general vicinity of the existing water intake. The existing water intake is located at approximate river Mile 29. **Table 7A** provides a summary of the data for an ORSANCO electrofishing sampling event that occurred July 21 and 23 of 2015. The data was obtained from River Mile 27.6 to 30. **Table 7B** summarizes ORSANCO benthic data that they obtained October 28, 2015 from River Mile 28 to 30.

Table 7A: Species Observed in the Most Recent ORSANCO Electrofishing Sampling Event July 2015. River Mile 27.6 to 30.

Family Common Name	Scientific Name	Left Descending Bank	Right Descending Bank
Lepisosteidae (Gars)			
Longnose gar	*Lepisosteus osseus*	1	
Hiodontidae (Mooneyes)			
Mooneye	*Hiodon tergisus*	3	1
Clupeidae (Herrings & Shads)			
Gizzard shad	*Dorosoma cepedianum*	1	9
Cyprinidae (Minnows)			
Spotfin shiner	*Cyprinella spiloptera*	15	3
Common carp	*Cyprinus carpio* [I]	9	1
Emerald shiner	*Notropis atherinoides*	2	
Channel shiner	*Notropis wickliffi*	2	3
Bluntnose minnow	*Pimephales notatus*	1	5
Catostomidae (Suckers)			
River carpsucker	*Carpiodes carpio*	16	5
Highfin carpsucker	*Carpiodes velifer*	5	
Smallmouth buffalo	*Ictiobus bubalus*	6	2
Black buffalo	*Ictiobus niger*	3	
Silver redhorse	*Moxostoma anisurum*	33	17
Smallmouth redhorse	*Moxostoma breviceps*		2
Black redhorse	*Moxostoma duquesnii*		2
Golden redhorse	*Moxostoma erythrurum*	6	10
Ictaluridae (Catfishes)			
Channel catfish	*Ictalurus punctatus*	12	1
Flathead catfish	*Pylodictis olivaris*	1	
Percopsidae (Trout-perches)			
Trout-perch	*Percopsis omiscomaycus*	17	9
Moronidae (Temperate Basses)			
White bass	*Morone chrysops*	2	
Hybrid striped bass	*Morone chrysops x Morone saxatilis*	1	
Centrarchidae (Sunfishes)			
Rock bass	*Ambloplites rupestris*	1	1
Pumpkinseed	*Lepomis gibbosus*		3
Bluegill	*Lepomis macrochirus*	3	13
Smallmouth bass	*Micropterus dolomieu*	18	15
Spotted bass	*Micropterus punctulatus*	1	
Largemouth bass	*Micropterus salmoides*		4
Black crappie	*Pomoxis nigromaculatus*	2	
Percidae (Perches)			
Rainbow darter	*Etheostoma caeruleum*	1	
Logperch	*Percina caprodes*	2	1
Yellow perch	*Perca flavescens*	8	10
Sauger	*Sander canadensis*	10	8
Saugeye	*Sander canadensis x Sander vitreus*	7	2
Walleye	*Sander vitreus* [M]	15	13
Sciaenidae (drums)			
Freshwater drum	*Aplodinotus grunniens* [M]		3

Table 7B: Benthic Species Observed in the Most Recent ORSANCO Electrofishing Sampling Event October 2015. River Mile 28 to 30

	RMI					RMI		
	27.6	**29.6**	**30**			**27.6**	**29.6**	**30**
Taxa_Name	**Count**				**Taxa_Name**	**Count**		
Ablabesmyia mallochi			2		Laevapex fuscus	24	2	
Arcteonais lomondi		1			Limnesia sp	1		
Argia sp	4	3	5		Limonia sp		2	
Branchiura sowerbyi	5		3		Limnodrilus hoffmeisteri	2		
Caecidotea sp			2		Lirceus sp		3	10
Caenis sp	93	4			Lumbriculidae sp		2	
Chironomus sp	7	23	148		Macromia sp			1
Chrysops sp		1	4		Menetus dilatatus	2		1
Coelotanypus sp	140	13	12		Musculium sp		2	
Coenagrionidae sp	2				Naididae W.O.H.C. sp	93	11	11
Corbicula fluminea	21	6	4		Nanocladius sp			2
Corixidae sp			1		Natarsia sp		1	
Cricotopus (Cricotopus) bicinctus		1	4		Nectopsyche candida	3		
Cryptochironomus sp	22				Oecetis sp	2	4	2
Cyrnellus fraternus	5	20	1		Physa sp	37	4	
Dicrotendipes sp	394	264	107		Pisidiidae sp	1	6	
Dreissena polymorpha	155	260	14		Pisidium sp	2		
Echinogammarus ischnus		6	13		Polypedilum halterale	4	8	3
Enallagma sp		2	1		Polypedilum flavum		4	
Dubiraphia sp	7				Polypedilum illinoense	3	2	2
Gammarus sp	191	430	293		Procladius sp	11	6	
Glossiphoniidae sp			3		Prostoma sp	4		
Glyptotendipes sp	49	42	25		Pseudochironomus sp	7	2	10
Gomphus sp	1				Stenacron sp	8	27	13
Helobdella sp		1			Stenelmis sp		1	
Hemerodromia sp	5		6		Tipula sp		1	
Hydrobiidae sp	74	2	1		Trichocorixa sp		29	
Hydroptila sp	2	2	6		Tribelos sp			2
					Tricorythodes sp		1	
					Turbellaria sp	17	2	20

4.2 2006 – 2007 Impingement Study at NOVA Chemicals/AES Beaver Valley Generating Station

A year-long impingement study was conducted at the NOVA Chemicals/AES Beaver Valley Generating Station cooling water intake structure on the Montgomery Pool in 2006 – 2007. Twenty taxa were collected during 46, 24-hour sampling events. Over 99 percent of the fish collected were gizzard shad and most fish were in the YOY life stage. Impingement rates were greatest in July and August (**Figure 9**).

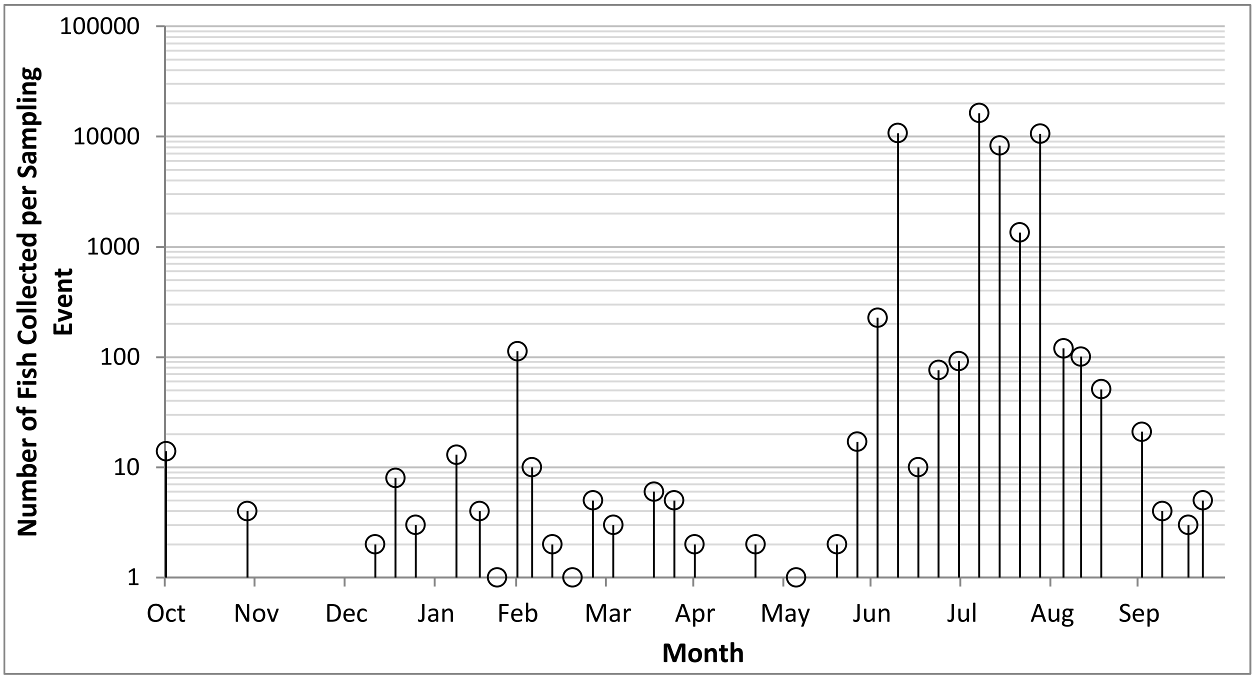


Figure 9: Number of Fish Collected Per Impingement Sampling Event at NOVA Chemical's / AES Beaver Valley Generating Station (2006 - 2007) (ENSR 2008)

Gizzard shad, freshwater drum, white bass, bluegill, and channel catfish were the most frequently collected species (**Table 8**). No taxon besides gizzard shad represented more than 0.5 percent of the total number of fish collected suggesting that impingement of fish from future cooling water intake structures on the Montgomery Pool may be largely dominated by this species. No taxon currently (7/2015) listed as Threatened or Endangered in the State of Pennsylvania was collected during this study.

Table 8: Raw Number of Fish Collected in Impingement Sampling at NOVA Chemical's / AES Beaver Valley Generating Station (2006 - 2007) (ENSR 2008)

Species	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Gizzard shad	-	8	129	8	3	-	9	10,941	36,393	260	37	**47,788**
Freshwater drum	-	1	-	-	2	-	2	35	147	7	3	**197**
White bass	-	-	-	2	3	-	5	173	1	-	-	**184**
Bluegill	-	1	-	1	2	-	-	-	6	1	3	**14**
Channel catfish	-	1	-	-	2	1	-	2	2	3	1	**12**
Sauger	-	1	2	3	-	-	-	-	-	-	1	**7**
White crappie	-	-	-	1	3	-	-	-	2	-	-	**6**
Quillback carpsucker	-	-	-	-	-	1	-	-	2	-	-	**3**

Species	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Common carp	-	-	-	-	-	-	2	-	-	-	-	**2**
Emerald shiner	-	-	-	-	-	-	-	1	1	-	-	**2**
Flathead catfish	-	-	-	1	-	-	-	-	-	-	1	**2**
Striped bass	-	-	-	-	-	-	-	1	-	1	-	**2**
Black crappie	-	-	-	-	-	-	-	-	-	-	1	**1**
Largemouth bass	-	-	-	1	-	-	-	-	-	-	-	**1**
Mimic shiner	-	-	-	-	-	-	1	-	-	-	-	**1**
Rainbow smelt	-	-	-	-	1	-	-	-	-	-	-	**1**
Silver chub	-	-	-	-	-	-	-	-	1	-	-	**1**
Silver redhorse	-	-	-	-	-	-	1	-	-	-	-	**1**
Silver shiner	-	-	-	1	-	-	-	-	-	-	-	**1**
Smallmouth bass	-	1	-	-	-	-	-	-	-	-	-	**1**
Monthly Total	**-**	**13**	**131**	**18**	**16**	**2**	**20**	**11,153**	**36,555**	**272**	**47**	**48,227**

4.3 Unionid (Mussel) Community in the Montgomery Pool

According to data provided by PFBC, there are 14 unionid species known to occur in the Montgomery Pool (**Table 9**) (PFBC, 2013). These data are a compilation of survey data and species encounters from a variety of survey efforts from 2001 to 2012. Of the 14 species known to occur in the Montgomery Pool, seven are listed as riverine species indicative of lotic (flowing water) systems with stable habitat. Fragile papershell (*Leptodea fragilis*), mapleleaf (*Quadrula. quadrula*), and pink heelsplitter (*Potamilus alatus*) are considered habitat generalists and are not indicative of riverine species.

Table 9: Recent Live and Fresh Dead Unionid Species Observed in the Pennsylvania Pools of the Ohio River

Species	Common Name	Emsworth	Dashields	Montgomery	New Cumberland
Actinonaias ligamentina	Mucket	-	-	X	X
Alasmidonta marginata	Elktoe	-	-	X	-
Amblema plicata	Three-ridge	-	-	X	-
Anodonta suborbiculata	Flat floater	-	-	-	X
Elliptio dilatata	Spike	-	-	X	X[2]
Lampsilis siliquoidea	Fatmucket	X	-	-	X
Lasmigona complanata	White heelsplitter	-	-	X	X
Lasmigona costata	Fluted-shell	-	X	X	X
Leptodea fragilis	Fragile papershell	-	X[1]	X	X
Ligumia recta	Black Sandshell	-	-	X	X
Obliquaria reflexa	Threehorn wartyback	-	X	X	X
Potamilus alatus	Pink heelsplitter	X[1]	X	X	X
Pyganodon grandis	Giant floater	-	-	X	X
Quadrula quadrula	Mapleleaf	-	X	X	X
Truncilla donaciformis	Fawnsfoot	-	X	X	X
Truncilla truncata	Deertoe	-	-	-	X
Utterbackia imbecillis	Paper pondshell	-	-	X	X
Total		**2**	**6**	**14**	**15**

[1] Denotes fresh dead record
[2] Denotes species recently re-introduced

In 2013, URS (now AECOM) performed a study designed to assess the existing mussel community between river miles 27.0 and 29.5 near the proposed cooling water intake structure (URS 2014). Ten species of mussels were observed during the study. No State or Federally listed threatened or endangered mussel species were identified through the Pennsylvania Natural Diversity Inventory (PNDI), or Species Impact Review (SIR) reviews. In addition, no State or Federally listed threatened or endangered mussel species were found during the field study. Excerpts from this report are contained in **Appendix A**.

4.3.1 Threatened & Endangered (T&E) Species Identified or Potentially to Reside in Montgomery Pool

One bigmouth buffalo was collected in electrofishing samples in 2010 (ORSANCO 2010) and tippecanoe darter and bluebreast darter larvae were collected from the Montgomery Pool in 2008-2009. Bigmouth buffalo are listed as endangered in Pennsylvania while tippecanoe darter and bluebreast darter are listed as threatened[11].

Two other endangered fish species (river shiner and warmouth) and one other threatened species (spotted darter)[11] have been documented in the Montgomery Pool in historical sampling (PFBC 2010). No other Pennsylvania listed threatened, endangered or candidate species have been identified in the Montgomery Pool.

Historically, 53 species of unionids have been recorded within the upper Ohio River drainage basin within Pennsylvania (**Table 10**; Taylor, 1989; PFBC, 2013). There are ten federally endangered species listed within the Ohio River drainage basin in Pennsylvania. The PFBC lists seven state endangered species (some overlap with federal listings) and one state threatened species within the Ohio River drainage basin in Pennsylvania; two of the seven species listed are federally endangered species that had historical occurrences in the Ohio River in Beaver County (USFWS, 2013). None of these species has recent observations in the main stem Pennsylvania portion of the Ohio River. The most recent recording of a state and/or federally listed threatened or endangered unionid species in the Montgomery Pool of the Ohio River was noted by Arnold E. Ortmann, circa 1919.

Table 10: Unionid Records for the Upper Ohio River in Pennsylvania

Species	Common Name	Federal Status[1]	PA Status[1,2]	Montgomery Pool[1,2]	Ohio River[1,3]
Subfamily Ambleminae					
Amblema plicata	Threeridge	-	-	O	R
Cyclonaias tuberculata	Purple Wartyback	-	-	-	R
Elliptio crassidens	Elephantear	-	-	-	R
Elliptio dilatata	Spike	-	-	O	R
Fusconaia flava	Wabash Pigtoe	-	-	-	R
Fusconaia subrotunda	Longsolid	-	-	-	R
Plethobasus cooperianus	Orangefoot Pimpleback	E	-	-	H
Plethobasus cyphyus	Sheepnose	E	-	-	R
Pleurobema clava	Clubshell	E	E	-	H
Pleurobema cordatum	Ohio Pigtoe	-	-	-	R
Pleurobema plenum	Rough Pigtoe	E	-	-	O
Pleurobema rubrum	Pyramid Pigtoe	-	-	-	H
Pleurobema sintoxia	Round Pigtoe	-	-	-	H
Quadrula cylindrica cylindrica	Rabbitsfoot	PT	E	-	H
Quadrula metanevra	Monkeyface	-	-	-	R

[11] Bluebreast, spotted and tippecanoe darters are under consideration for de-listing (44 Pa.B. 7876).

Species	Common Name	Federal Status[1]	PA Status[1,2]	Montgomery Pool[1,2]	Ohio River[1,3]
Quadrula pustulosa	Pimpleback	-	-	-	R
Quadrula quadrula	Mapleleaf	-	-	O	R
Quadrula verrucosa	Pistolgrip	-	E	-	H
Subfamily Anodontinae					
Alasmidonta marginata	Elktoe	-	-	O	O
Pyganodon grandis	Giant Floater	-	-	O	R
Utterbackia imbecillis	Paper Pondshell	-	-	O	R
Anodonta suborbiculata	Flat Floater	-	-	-	O
Anodontoides ferussacianus	Cylindrical Papershell	-	-	-	H
Lasmigona complanata	White Heelsplitter	-	-	O	R
Lasmigona compressa	Creek Heelsplitter	-	-	-	R
Lasmigona costata	Flutedshell	-	-	O	H
Simpsonaias ambigua	Salamander Mussel	-	E	-	O
Strophitus undulatus	Creeper	-	-	-	R
Subfamily Lampsilinae					
Actinonaias ligamentina	Mucket	-	-	O	R
Cyprogenia stegaria	Fanshell		-	-	H
Ellipsaria lineolata	Butterfly	-	-	-	R
Epioblasma torulosa rangiana	Northern riffleshell	E	E	-	H
Epioblasma triquetra	Snuffbox	E	E	-	H
Lampsilis abrupta	Pink Mucket	E	-	-	R
Lampsilis cardium	Plain Pocketbook	-	-	-	O
Lampsilis fasciola	Wavyrayed Lampmussel	-	-	-	H
Lampsilis ovata	Pocketbook	-	-	-	H
Lampsilis siliquoidea	Fatmucket	-	-	-	R
Leptodea fragilis	Fragile Papershell	-	-	O	R
Ligumia recta	Black Sandshell	-	-	O	R
Obliquaria reflexa	Threehorn Wartyback	-	-	O	R
Obovaria olivaria	Hickorynut	-	-	-	H
Obovaria retusa	Ring Pink	-	-	-	H
Obovaria subrotunda	Round Hickorynut	-	-	-	R
Potamilus alatus	Pink Heelsplitter	-	-	O	R
Potamilus ohiensis	Pink Papershell	-	-	-	R
Ptychobranchus fasciolaris	Kidneyshell	-	-	-	H
Toxolasma parvus	Lilliput	-	-	-	R
Truncilla donaciformis	Fawnsfoot	-	-	O	R
Truncilla truncata	Deertoe	-	-	-	H
Villosa fabalis	Rayed Bean	E	E	-	O
Villosa iris	Rainbow	-	-	-	R
	Total Records	**9**	**7**	**14**	**53**

[1]E = endangered; T = threatened; PT = Proposed Threatened; O = live record; H = pre 1920; R = recent

[2] PAFBC (unpublished data, 2013)

[3]Taylor (1989) records of mussels in the Upper Ohio River miles zero to 300

4.3.2 Reproduction (Spawning and Recruitment) and Seasonality

Most fish species in the Ohio River drainage spawn in the spring and summer (Ross et al 1982, Auer 1983, Becker 1982). Recruitment of larvae occurs from late spring into early fall. Certain species such as shiner and minnows may mature within their first year. Based on the life histories compiled for potentially susceptible fish species in Section 4.2, May through June is typically the period of greatest spawning activity in the Upper Ohio River. A larval and YOY fish study performed in the upper Ohio River in 2008 and 2009 during the months of March through September yielded 61 species (USACE 2014, Stauffer 2010). Only seven of these species were represented solely by adults suggesting that successful spawning of the majority of collected fish species was occurring throughout the surveyed area (USACE 2014).

Freshwater unionids require a fish host to complete their life cycle. Many species of unionids have separate sexes for adult males and females. However, some species are hermaphroditic and may self-fertilize. Once fertilized, the female adults release tiny glochidia (parasitic larva) into the water column. The parasitic larva requires a specific host (typically fish) to attach to and continue development. The larva attach to gills and/or fins of the host fish where they become blood parasites for a period before transforming into juvenile unionids. The juveniles then release from the host fish and fall into the substrate where they grow into adults. The intermediate fish host is integral to the dispersal and survival of unionids in the systems in which they live. The Pink Heelsplitter and the Fragile Papershell are thought to use the Freshwater Drum as an intermediate host while the Mapleleaf is thought to use the Flathead Catfish and the Channel Catfish as its host. According to the Three Rivers Management Plan, both the Flathead Catfish and Freshwater Drum are common fish species observed in the Montgomery Pool (PFBC, 2010).

4.4 Species Susceptible to Impingement or Entrainment at the Site

For Existing Facilities, fragile species are defined in 40 CFR 125.92(m):

> *Fragile species* means those species of fish and shellfish that are least likely to survive any form of impingement. For purposes of this subpart, *fragile species* are defined as those with an impingement survival rate of less than 30 percent, including but not limited to alewife, American shad, Atlantic herring, Atlantic long-finned squid, Atlantic menhaden, bay anchovy, blueback herring, bluefish, butterfish, gizzard shad, grey snapper, hickory shad, menhaden, rainbow smelt, round herring, and silver anchovy.

Susceptibility to impingement or entrainment is dependent on a number of biotic and abiotic factors, as shown in Table 11. Potential exists for state threatened and endangered fish species observed in the Montgomery Pool to be impinged or entrained. However, it is highly unlikely based on the observed habitat at the location of the existing structure. Additionally, over 99% of the species collected at the nearby Nova Chemical facility were gizzard shad (a fragile but non-listed fish species). The tippecanoe and bluebreast darters were recently proposed for delisting by the PFBC in July 2010.

Table 11: Factors Effecting Susceptibility to Impingement or Entrainment

Category	Factor Type	Factors	Source
Impingement	Abiotic Factors	Water temperature, dissolved oxygen, turbidity, cooling water intake design, and intake velocities.	Baker (2007)
	Biotic Factors	Swimming ability, body shape, size, diel and seasonal movements, and health of the organism.	Baker (2007)
Entrainment	Abiotic Factors	Intake location, water volume used for cooling, velocity at intake, and screen mesh size.	Graham et al. (2008)
	Biotic Factors	Organism size, swimming ability, swimming behavior (pelagic or benthic), diurnal behavior, and spawning habitat.	Graham et al. (2008)

Water quality abiotic factors listed in Table 11 are documented and discussed in Section 3.4. Discussion of species that are most susceptible to impingement or entrainment at the proposed site is focused on documented abundance in the Montgomery Pool and known life history characteristics of those species.

The following taxa and groups are considered to be susceptible to potential impingement or entrainment at the CWIS based on available fish community data, recreational importance, and an understanding of life history of the fishes in the Montgomery Pool, (**Table 12**):

Table 12: Potentially Susceptible Fish Species to Impingement and Entrainment in the Montgomery Pool.

Taxa	Reasoning
Smallmouth bass	Smallmouth bass are one of the most sought after species in the Upper Ohio River/Three Rivers area and the fishery has supported national bass fishing tournaments (PFBC 2010). One of the most abundant recreationally targeted fish in both the 2006 and 2010 ORSANCO electrofishing surveys. Susceptible based on abundance and the presence of persistent populations within the Pool.
Sauger	Sauger is one of the most sought after species in the Upper Ohio River/Three Rivers area and, along with walleye, have developed into a popular fishery (PFBC 2010). In Montgomery Pool, Sauger was more abundant than walleye in surveys conducted by the PFBC from 1990 through 2008 (PFBC 2010). Susceptible based on abundance and the presence of persistent populations within the Pool.
Freshwater drum	A recreational fishery exists for freshwater drum in Montgomery Pool (PFBC 2010). Freshwater drum eggs and larvae are highly susceptible to entrainment due to their buoyant, free floating nature.
Bluegill	Bluegill is the most abundant panfish collected in electrofishing sampling of the Montgomery Pool in 2006 and 2010. Although sunfish are nest builders, the larvae are motile and are susceptible to entrainment. Juvenile and adult bluegill are regularly observed in impingement samples in many freshwater settings.
Gizzard shad	Gizzard shad were the most numerous fish in the 2010 electrofishing sampling of Montgomery Pool and were the most numerous fish collecting in impingement sampling by many power generating facilities on the Ohio River (EPRI 2009). This species can be abundant and be impinged in large numbers, especially during the late fall and winter months when they can experience mortality due to cold water temperature (EPRI 2009).
Cyprinidae spp. (shiners and minnows)	Shiner and minnow spp. were abundant in the 2010 electrofishing sampling of Montgomery Pool. Two species, emerald shiner and channel shiner comprised the bulk of the Cyprinidae spp. collected. This group of fish is an important part of the food web for recreationally important species including black bass species, walleye, sauger, and pike/muskellunge. Susceptible based on abundance and the presence of persistent populations within the Pool. Species within this group are generally susceptible to impingement or entrainment throughout their lives due to their small size.
Redhorse sp. (*Moxostoma* spp.)	Redhorse sucker species were the second most numerically dominant group in the 2006 and 2010 electrofishing surveys of Montgomery Pool. Golden redhorse and silver redhorse were consistently abundant between surveys. Although relatively few of these fish are collected in impingement sampling surveys on the Ohio River (EPRI 2009), they are included due to their abundance in the aquatic community surveys. Susceptible based on abundance and the presence of persistent populations within the Pool.

Taxa	Reasoning
White Bass	Although absent or not abundant during the ORSANCO electrofishing surveys conducted in 2006 and 2010, white bass were the third most abundant species in impingement sampling during the NOVA Chemicals / AES Beaver Valley Generating Station investigation in 2006-2007. This species was primarily collected during July and averaged about four inches in length (YOY life stage). Susceptible based on observed impingement at a nearby cooling water intake.

4.5 Life Histories of Important Taxa

Life history details for taxa or group of taxa potentially susceptible to impingement or entrainment at the proposed site have been gathered from peer reviewed articles, regional and state agency documents, and books containing life history and identification keys. General behavior and preferred habitat details are provided in the text and spawning and early life history details are provided in the tables for each taxa or grouping. See Sections 4.5.5 (Gizzard shad) and 4.5.6 (Cyprinidae spp.) for a discussion of fragile species in the Montgomery Pool.

4.5.1 Smallmouth bass (Edwards et al. 1983)

Smallmouth bass of all life stages exhibit a negative phototaxis and tend to seek some cover away from the light, utilizing submerged debris, vegetation, boulders, etc. Smallmouth bass tend to reside near the edge of the stream's current during the day. Their movement also tends to be restricted to a single pool during a season. Juveniles reside in shallow water, moving into deeper water as adults. Spawning and early life stage information is given in **Table 13**.

Table 13: Smallmouth Bass Life History Data - Spawning and Early Life Stages

Species	Spawning Period	Spawning Temperature	Larval Recruitment	Life History Notes
Smallmouth bass	Mid May – June	55-75°F	June - July	Eggs- Demersal and adhesive eggs laid in a nest, protected by the male. Hatch in 2.25-9.5 days. Larvae – Remain in nest for 6-15 days, remain in school above the nest protected by the male for as long as 28 days. High mortality rate after leaving the nest due to predation.

From Becker (1983).

4.5.2 Sauger

Sauger in large rivers are found in backwaters and mouths of slow moving tributaries (Smith 1979). In the Montgomery Pool, they have been noted to be present in the plunge pool created by the Dashields Dam (PFBC 2010). Juvenile sauger prey upon small invertebrates while adults are generally piscivorous (Schell et. al. 2004, Smith 1979). Spawning occurs around April and occurs over gravel or cobble substrate. Females can generally deposit between 5,000 and 40,000 eggs (Auer 1982, Smith 1979). Spawning occurs at night (Becker 1982). Eggs are demersal and adhesive and hatching may take three weeks (Smith 1979). Sauger have been found spawning in habitat immediately downstream of Ohio River navigational dams (Vallazza et. al. 1984 as referenced in Schell et. al. 2004). Spawning and early life stage information is given in **Table 14**.

Table 14: Sauger Life History Data - Spawning and Early Life Stages

Species	Spawning Period	Spawning Temperature	Larval Recruitment	Life History Notes
Sauger	April – Early May	39-54°F	May - June	Eggs – Eggs harden in water are demersal and adhesive prior to hardening – semi-buoyant and non-adhesive after hardening. Eggs are round and 1.0 mm to 1.5 mm in length. YOY – juvenile fish in the Ohio River attain a length of at least 8 inched within the first year.

From Becker (1983), Auer (1982) and Schell et. al. (2004).

4.5.3 Freshwater drum

Freshwater drum are primarily a benthic fish. Younger fish (under 20 millimeters) feed in the water column on zooplankton, while adults may occasionally feed on YOY fish in the water column (Ross et al. 2001). Freshwater drum demonstrate 24-hour cyclical in their movements (Rypel and Mitchell 2007). During the day, drum reside in deeper waters, while at night, their densities increase along shorelines (Rypel and Mitchell 2007). Juvenile (age 0 – age 1) drum have the highest presence on the shoreline at night, possibly as a method of predation avoidance (Rypel and Mitchell 2007). Freshwater drum also have shown feeding behavior in the water column during the day, but primarily benthic activity at night (Rypel and Mitchell 2007). It is also possible that freshwater drum shoreline density increases at night due to macroinvertebrate drift also increasing at night. They spawn in the water column, and have planktonic larvae and eggs (Ross et al. 2001). Freshwater drum spawn in the main channel in large rivers such as the Ohio River, generally far from the shore (Wallus and Simon 2006). Eggs are buoyant to semi-buoyant and drift with the current (Wallus and Simon 2006). Spawning and early life stage information is given in **Table 15**.

Table 15: Freshwater Drum Life History Data - Spawning and Early Life Stages

Species	Spawning Period	Spawning Temperature	Larval Recruitment	Life History Notes
Freshwater drum [b]	June – August	64-77°F	June - September	Eggs – May be buoyant to semi-buoyant. Deposited in open waters. Hatch between 22 and 36 hours. Most abundant in early summer. Vertical distribution in the water column appears to be uniform in the day, but denser towards the bottom at night. Larvae – Buoyant or semi-buoyant, mostly relying on current transportation. Horizontal swimming and feeding behavior begins after 6 days post hatching. Yolk sac larvae abundant near surface during daylight, however, post-yolk sac drum more abundant near surface at night. Young of year spend most time on bottom.

From Becker (1983) and Wallus and Simon (2006).

4.5.4 Bluegill

Bluegill of all life stages are opportunistic feeders, feeding on zooplankton and aquatic insects throughout the water column. Bluegill will move into deeper waters during the summer to seek cooler water, as well as during the winter to seek warmer water (Stuber et al. 1982). Young bluegill and other sunfish display behavior where they tend to reside in shallow waters or shoreline during the day, retreating to deeper water at night to avoid predation (Rypel and Mitchell 2007). Spawning and early life stage information is given in **Table 16**.

Table 16: Bluegill Life History Data - Spawning and Early Life Stages

Species	Spawning Period	Spawning Temperature	Larval Recruitment	Life History Notes
Bluegill	Late May – Early August; Peak in June	67-80°F	June - September	Eggs – Demersal and adhesive eggs laid in a nest, protected by the male. Bluegill nests are in colonies of 40-50 nests. Hatch in 32.5-71 hours. Larvae – Free swimming 3 days after hatching. Larvae per nest up to 67,000 reported.

From Becker (1983) and Auer (1982).

4.5.5 Gizzard shad

Gizzard shad is considered an open water species, usually residing at or near the surface year round (Miller 1960). Juveniles tend to congregate in shallow water near shore in mid-summer (Miller 1960). Populations tend to peak from late summer to early fall due to the inclusion of YOY (Miller 1960). YOY shad exhibit shoaling behavior, but begin to disperse in the fall (Miller 1960). Shoaling behavior tends to cease after the shad reach 1 year old (Miller 1960). King et al. (2010) describes gizzard shad as an open water, pelagic species demonstrating a negative rheotaxic response to flow and sensitivity to low temperatures and drastic changes in water temperatures. Gizzard shad have also been found to congregate near warm water discharges from industrial facilities during cooler water periods (King et al. 2010). Yu and Peters (2003) documented higher numbers of gizzard shad collected in nighttime electrofishing samples indicating that that gizzard shad may reside higher in the water column at night. Gizzard shad spawning activity also only occurs during nighttime (Miller 1960). Spawning and early life stage information is given in

Table 17.

Table 17: Gizzard Shad Life History Data - Spawning and Early Life Stages

Species	Spawning Period	Spawning Temperature	Larval Recruitment	Life History Notes
Gizzard shad	Late April - August	50-70°F	Late April - August	Eggs - Demersal, adhesive, hatch in 36-95 hours. Larvae – Exhibit upward swimming and downward settling behavior, poor swimming ability for several weeks after hatching.

From Becker (1983).

4.5.6 Cyprinidae spp. (Shiners and minnows)

Fishes of the Family Cyprinidae are the largest and most widely distributed family in North America. Certain members of the family can reach considerable sizes and may support commercial fisheries in certain regions. However, the majority of the species in the family are relatively small in size, but extremely diverse. They can make up a large portion of this mid-water biomass in many streams. These smaller Cyprinids are important forage for predatory fish and some can be used as indicators of water quality (Smith 1979). Two species, emerald shiner and channel shiner, were the most abundant Cyprinidae spp. collected in electrofishing sampling of the Montgomery Pool in 2010 when river flows were low and conditions were conducive for collections of smaller fish (ORSANCO 2010). Spawning and early life stage information for these species is given in **Table 18**.

The emerald shiner has been noted to be the most abundant fish in large North American River systems (Smith 1979). This small fish (up to 3.5 in) aggregates into large schools in mid- or surface-waters. Its food consists of small aquatic or terrestrial insects, small crustaceans and algae (Smith 1979). Spawning occurs in the summer, but may commence as early as late May (Becker 1983). Eggs (about 900 to 5,400 per female) are broadcast spawned over sand or gravel substrate free of detritus (Auer 1982). Emerald shiner likely mature within the first year of life (Smith 1979).

The channel shiner has relatively recently been distinguished from the mimic shiner. Both fish occur sympatrically and have overlapping physical characteristics. Hrabik (1996) provides a good summary of what is known about the channel shiner. The channel shiner is generally restricted to large rivers and the lower portions of larger streams. It is often found along the shoreline over mud sand and gravel substrates. Little more is documented for the channel shiner since it had been identified as mimic shiner for so long.

Table 18: Shiner sp. Life History Data - Spawning and Early Life Stages

Species	Spawning Period	Spawning Temperature	Larval Recruitment	Life History Notes
Emerald shiner	Late May – Early August	68.2 – 73.8°F, triggered at 72°F	June-August	Eggs – Large (3.0 to 3.3 mm diameter; Demersal, non-adhesive. Larvae – Remain near bottom for 72-96 hours, then become planktonic within the upper 2 m of water, drifting with currents. Fry gather into large schools.
Channel Shiner*	May - July	No Data	June - September	Eggs – Demersal and adhesive until after water hardening. About 1.0 mm in diameter. Three day incubation period. Larvae – Growth is rapid and fish can reach sexual maturity within the year.

From Becker (1983) and Auer (1982).

* Data from mimic shiner a similar species occurring sympatrically with channel shiner.

4.5.7 Redhorse sp. (Moxostoma sp.)

Redhorse are a group of sucker-mouthed fishes in the family Moxostoma. Sucker play an important ecological role in the early stages of the freshwater food web. They feed mostly on aquatic insects, mollusks and crustaceans collected from the substrate. They may make up most of the fish biomass in many streams and they can be a valuable forage fish for larger predatory sport fish (Becker 1983). Spawning and early life stage information for these species is given in **Table 19**.

Golden redhorse are a benthic species, feeding primarily in shallow areas with slow current. Feeding increases throughout the day, significantly increasing after sunset, and peaks an hour before midnight. Golden redhorse tend to retain high site fidelity for most of the year, but have been recorded to travel distances of 13 to 55 km. Movements tend to be minimal during low water periods of mid-summer. Fish will occupy shallow shoals during spawning events in late spring. Spawning activity occurs only during daytime hours (Ross et. al. 1982).

Silver redhorse are very similar in appearance to the golden redhorse and share some of the same life history traits. The Silver redhorse prefers slower currents and fine substrates as can be found in long deep pools in medium to large rivers (Ross et. al 1982 and Smith 1979). Spawning occurs in the spring over gravel in shallow riffles or deep runs (Ross et al. 1982).

Table 19: Redhorse sp. Life History Data - Spawning and Early Life Stages

Species	Spawning Period	Spawning Temperature	Larval Recruitment	Life History Notes
Golden redhorse	May	60-72°F	Late May - June	Eggs – Laid in shallow runs/ripples over gravel. Young of year are 25-45 mm by early august (southern Wisconsin).
Silver Redhorse	April - May	Not specified	May - June	Eggs – Demersal and adhesive, about 3.4 mm in diameter. Yellow in color. Hatching occurs in 5 to 6 days. Larvae – Most growth is observed in July, August and early September. Demersal.

[a] From Becker (1983).

4.5.8 White Bass

White bass are a temperate bass species that can be found throughout the Mississippi River drainage. They prefer open waters of reservoirs or medium to large rivers with slow to moderate currents (Becker 1983). White bass are targeted by recreational fishermen and are governed as panfish in Pennsylvania (PFBC 2005). White bass are prolific and considerable changes in abundance can be observed from year to year (PFBC 2005). Young feed on zooplankton, but transition to a mainly piscivorous diet as they grow (Becker 1983).

Table 20: White Bass. Life History Data - Spawning and Early Life Stages

Species	Spawning Period	Spawning Temperature	Larval Recruitment	Life History Notes
White Bass	April-June	55-79°F	May-June	Eggs – demersal eggs are scattered at or near the surface preferably over firm sand or gravel bottoms. Eggs are 0.7 – 1.2 mm in diameter. Larvae – Larvae less than 4 days old swim vertically throughout the water column, but maintained horizontal position on day 4. Larvae feed on zooplankton.

[a] From Becker (1983).

5 Summary and Conclusions

This assessment summarizes what is currently known concerning the physical and biological aspects of the Montgomery Pool. The aquatic community has been thoroughly studied by ORSANCO since the 1950's. The most recent assessment of the Montgomery Pool is that it meets its aquatic life-use designation. Further information about the early life history of fish residing in the Montgomery Pool is provided by USACE (2014) and Stauffer et al. (2010). The physical characteristics of the Montgomery Pool are dominated by manmade modifications (e.g., Lacks and Dams and dredging) that are on-going and well documented.

The aquatic community of Montgomery Pool was severely degraded in the first half of the 20th century, but has rebounded slowly to its present condition. Native species, once extirpated, have regained their historical ranges and ORSANCO has scored the overall biological condition of the Pool in 2010 as "Good". Despite the heavy modification of the River's hydrology, 85 species of fish have been documented from the Montgomery Pool since the 1950's.

The effects of power facility cooling water withdrawals on the Ohio River have been studied (Perry et al. 2002) and based on analysis of losses of fish at multiple facilities along the length of the Ohio River the authors concluded that in most cases, entrainment and impingement losses have little to no effect on fish populations. Continued annual monitoring of the aquatic community at a power station near the proposed petrochemicals complex (Beaver Valley Power Station on the New Cumberland Pool) as detailed in FirstEnergy Nuclear Operating Company (2014) has documented that no adverse environmental impacts have been evident resulting from station operation. In addition, a year-long impingement study performed within 1.5 miles of the proposed petrochemicals site in 2006-2007 showed that the vast majority of fish impinged (>99 percent) were gizzard shad (an extremely prolific forage fish species). Less than 1 percent of the fish collected were of direct value to recreational fishermen (ENSR 2008).

Data presented herein from the various studies on the Upper Ohio River provide sufficient data to estimate which species may be impacted by impingement or entrainment due to the site CWIS. Additional biological surveys or hydrological studies are not necessary to describe the physical and biological aspects of the source waterbody.

6 References

Auer, N.A. (ed.) 1982. Identification of larval fishes of the Great Lakes Basin with emphasis on the Lake Michigan drainage. Spec. Publ. 82-3, Great Lakes Fish. Comm., Ann Arbor, MI, 744 pp.

Baker, J.L. 2007. Health of Fish Impinged On Cooling-Water Intake Screens. Auburn University. Auburn, AL. May, 2007.

Becker, G.C. 1983. Fishes of Wisconsin. The University of Wisconsin Press. Madison, WI.

Beaver Valley Power Station (BVPS). 2007. Units 1 and 2 License Renewal Application. Appendix E – Environmental Report. 312 pp.

Commonwealth of Pennsylvania. 2015. Chapter 93. Water Quality Standards – Designated Uses and Water Quality Criteria, §93.9w. Drainage List W. - Ohio River Basin in Pennsylvania. URL: http://www.pacode.com/secure/data/025/chapter93/s93.9w.html

Edwards, E. A., G. Gebhart, and O. E. Maughan. 1983. Habitat Suitability Information: Smallmouth Bass. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.36. 47pp.

Electric Power Research Institute (EPRI). 2009. Ohio River Ecological Research Program: Impingement Mortality Characterization Study at 15 Power Stations. EPRI, Palo Alto, CA, American Electric Power Company, Columbus, OH, American Municipal Power, Columbus, OH, Allegheny Energy Supply Company, Greensburg, PA, Buckeye Power, Inc., Columbus, OH, Dayton Power & Light, Dayton, OH, Duke Energy, Plainfield, IN, E.ON U.S. (Louisville Gas & Electric), Louisville, KY, E.ON U.S. (Western Kentucky Energy Corporation), Henderson, KY, Ohio Valley Electric Corporation/Indiana- Kentucky Electric Corporation, Piketon, OH, Owensboro Municipal Utilities, Owensboro KY, Tennessee Valley Authority, Chattanooga, TN: 2009. 1018540.

ENSR. 2008. 316(b) Best Professional Judgment for Best Technology Available Report – NOVA Chemicals-AES Beaver Valley Generating Station. Prepared for: NOVA Chemicals, Inc. AES Beaver Valley Cogeneration, Inc. 227 pp.

FirstEnergy Nuclear Operating Company. 2014. Beaver Valley Power Station, 2014 Annual Environmental Operating Report. Non Radiological – Units No. 1 and 2. 500 pp.

Graham, L.F., Dorin, M., Lin, P. 2008. Understanding Entrainment at Coastal Power Plants: Informing a Program To Study Impacts and Their Reduction. Prepared for California Energy Commission. CEC-500-2007-120. March, 2008.

Hrabik, R. 1996. Taxonomic and distributional status of *Notropis volucellus* and *Notropis wickliffi* in the Mississippi River drainage: A literature review. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1996. LTRMP 96-S001. 15 pp.

King, R.G, Seegert, G, Vondruska, J, Perry, E.S, and Dixon, D.A. 2010. Factors Influencing Impingement at 15 Ohio River Power Plants. North American Journal of Fisheries Management. 30:1149-1175, 2010.

Miller, R.R. 1960. Systematic and Biology of the Gizzard shad (Dorosoma cepedianum) and Related Fishes. Fishery Bulletin 173. Fish and Wildlife Service. Volume 60. 1960.

Normandeau Associates Inc. and URS Corporation (Normandeau and URS). 2008. Detailed Characterization of the Aquatic Resources and Impingement Mortality at the Peach Bottom

Atomic Power Station for Peach Bottom Atomic Power Station. Prepared for Exelon. October, 2008.

Ohio River Valley Water Sanitation Commission (ORSANCO). 2010. 2010 Ohio River Pool Assessments – Montgomery, Racine and John T. Myers. ORSANCO Biological Programs. 19 pp.

Ohio River Valley Water Sanitation Commission (ORSANCO). 2013. Pollution Control Standards for Discharges to the Ohio River, 2013 Revision. 66 pp.

Ohio River Valley Water Sanitation Commission (ORSANCO). 2014. Assessment of Ohio River Water Quality Conditions. June, 2014. 75 pp.

Ortmann 1919. A Monograph of the Naiades of Pennsylvania, Part 3: Systematic Account of the Genera and Species. Memoirs of the Carnegie Museum. 8(1): 1-385 (with 21 plates).

Pennsylvania Fish and Boat Commission (PFBC). 2005. White Bass Management and Fishing in Pennsylvania. URL: http://www.fishandboat.com/pafish/bass_white/00whbass_overview.htm.

Pennsylvania Fish and Boat Commission (PFBC). 2010. Three Rivers Management Plan, A Strategy for Managing Fisheries Resources of the Allegheny, Monongahela, and Ohio Rivers. Bureau of Fisheries Management Division Area 8. 172 pp.

Pennsylvania Fish and Boat Commission (PFBC). 2013. Unpublished Data. Mussel Species of the Montgomery Pool of the Ohio River. 2013.

Perry, E., G. Seegert, J. Vondruska, T. Lohner, and R. Lewis. 2002. Modeling Possible Cooling-Water Intake System Impacts on Ohio River Fish Populations. The Scientific World Journal. 2002;2(S1):58–80.

Ross, S.T, Brenneman, W.M, Slack, W.T, O'Connell, M.T, and Peterson, T.L. 2001. The Inland Fishes of Mississippi. University Press of Mississippi. 2001.

Rypel, A.L, and Mitchell, J.B. 2007. Summer Nocturnal Patterns in Freshwater Drum (Aplodinotus grunniens). American Midland Naturalist. Vol. 157, No. 1 (Jan., 2007), pp. 230-234

Schell, S. A., R. S. Hale, S. M. Xenakis, C. J. O'Bara, D. T. Henley, T. C. Stefanavage, and L. D. Frankland. Ohio River Percid Investigation: Ohio River Fisheries Management Team, Technical Committee Final Report No. 2004.1, Ohio Department of Natural Resources, Division of Wildlife, Columbus, OH.

Smith, P.W. 1979. The Fishes of Illinois. Urbana, IL: University of Illinois Press, 314 pp.

Stauffer, J.R. Jr., R Taylor, R Cleaver Yoder, B Lorson, K M. Taylor, and B Fost. 2010. Larval and Young of Year Fish Survey of the Upper Ohio River System, PA. 396 pp.

Taylor, R.W. 1989. Changes in freshwater mussel populations of the Ohio River: 1,000 BP to recent times. *Ohio Journal of Science* 89(5):188-191.

URS. 2014. Shell Proposed Petrochemicals Complex Freshwater Mussel (Unionidae) Survey Report, Ohio River Mile 27.0 – 29.5 Beaver County, Pennsylvania. Prepared for Shell Chemical Appalachia, LLC. February 2014.

USACE. 2014. Upper Ohio Navigation Study, Pennsylvania Draft Feasibility Report and Integrated Environmental Impact Statement - Emsworth, Dashields, and Montgomery Locks and Dams. US Army Corps of Engineers, Pittsburgh District. 378 pp.

Vallazza, J. M., J. W. Deller, W. E. Lynch and D. L. Johnson. 1994. Seasonal behavior, movements, and habitat preferences of hybrid striped bass and sauger in the Ohio River. Final Report for the Ohio Department of Natural Resources, Division of Wildlife, Fish Management in Ohio, Federal Aid in Sport Fish Restoration Project F-69-P.

Wilcox, D.B., E.L. Stefanik, D.E. Kelner, M.A. Cornish, D.J. Johnson, I.J. Hodgins, S.J. Zigler, and B.L. Johnson. 2004. Improving fish passage through navigation dams on the upper Mississippi River system. Environmental Report 54. Upper Mississippi River – Illinois Waterway System Navigation Study. Interim Report. U.S. Army Corps of Engineers.

Yu, S.L Peters, E.J. 2003. Diel and seasonal abundance of fishes in the Platte River, Nebraska, USA. Fisheries Science. 2003, 69:154-160.

Appendix A

Excerpt from AECOM 2013 Freshwater Mussel Survey Report

Excerpts include the following:

- Figure 1 – Project Survey area
- Figure 3d – Transects near intake
- Tables 7 through 11 that summarize mussel survey results

General Survey Area

Ohio River Mile

Permitted Nova Maintenance Dredge Area

Potential Area of Direct Impact (Original Proposed)

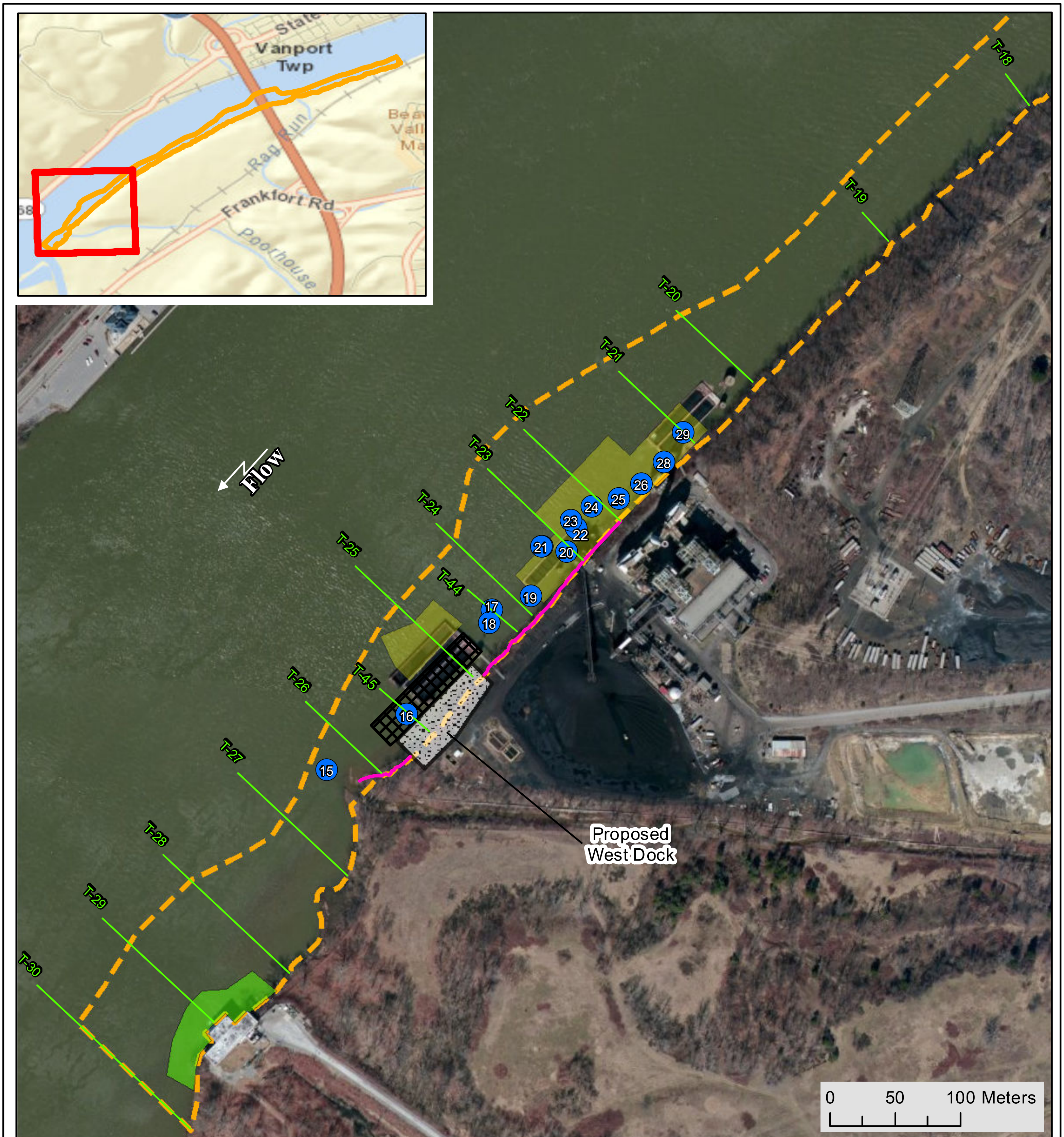
N

Basemap: ESRI Data Resource Center
http://www.arcgis.com

Shell Chemicals Appalachia LLC
Horsehead Corporation
Ohio River Miles 27.0 - 29.5, Beaver Co., PA

Figure 1 - Project Survey Area

URS



General Survey Area
Potential Area of Direct Impact (Original Proposed)
Permitted Nova Maintenance Dredge Area
Qualitative Locations
SurveyTransects
Proposed Dock Locations
Proposed Dredge Area

Note: T-29 omitted: intake could not be locked out; area dredged annually

Note: Nova Dredge Area is a permitted disturbance are for maintenance dredging.

Basemap: ESRI Data Resource Center
http://www.arcgis.com

N

Shell Chemicals Appalachia LLC
Horsehead Corporation
Ohio River Miles 27.0 - 29.5, Beaver Co., PA

Figure 3d - Transect and qualitative search locations (downstream portion of study area)

URS

Table 7. Summary of unionids observed in qualitative and transect searches in the project area, Ohio River, 2013

	Qualitative				Transect					
	L	FD	WD	SF	L	FD	WD	SF	Total Live	Rel. Ab. (%)
Anodonta suborbiculata	-	-	-	-	1	-	-	-	1	0.5
Lampsilis siliquoidea	1	-	-	-	1	-	-	-	2	1.1
Lasmigona complanata	2	-	-	-	3	-	-	-	5	2.6
Leptodea fragilis	-	-	1	-	-	-	-	-	0	-
Ligumia recta	1	-	-	-	4	-	-	-	5	2.6
Obliquaria reflexa	18	-	-	-	2	-	-	-	20	10.5
Potamilus alatus	65	2	6	1	32	-	12	1	97	51.1
Pyganodon grandis	-	-	-	-	1	-	-	-	1	0.5
Quadrula quadrula	45	-	2	-	14	-	2	-	59	31.1
Truncilla donaciformis	-	-	-	-	-	-	1	-	0	-
Total	132	2	9	1	58	0	12	1	190	
Effort (min)	589				1491					
CPUE[1] (no./hour)	13.4				2.3				-	
Surface Density [2]	-				0.2				-	
Species Richness Total	7				9				10	
Species Richness Live	6				8				8	

L = live, FD = fresh dead, WD = weathered dead, SF = sub-fossil

[1] CPUE = number live per work person hour (no. live * time/60)

[2] Surface Density is estimated as number live per $10m^2$ area, 255-$10m^2$; no excavations were performed; thus, density and population estimates cannot be calculated.

Table 8. Summary of number live unionids, depth, and average substrate characteristics of transect samples shore to riverward in the project area, Ohio River, 2013.

			Avg. Depth (ft)		Average Substrate Composition (%)								
Distance from Bank (m)	No. Live	No. Samples	Start	End	BO	CB	GR	SD	ST	CL	LWD	VEG	OTR
0	n/a	41	2.2	4.5	3.2	15.7	7.3	8.9	49.6	8.3	4.3	2.4	0.2
1 - 10	12	41	4.0	8.9	4.6	15.2	8.5	5.4	48.1	11.0	4.1	2.7	0.2
11 - 20	17	41	8.6	15.2	2.8	14.9	8.5	2.9	53.1	12.3	4.3	0.0	1.2
21 - 30	3	41	15.1	20.5	4.4	14.9	11.1	4.8	44.6	15.0	3.0	0.0	2.2
31 - 40	7	38	20.1	22.8	2.8	14.3	9.9	11.4	38.8	17.0	2.4	0.0	3.4
41 - 50	5	35	21.7	24.0	2.9	21.0	15.4	8.7	35.0	13.9	1.4	0.0	1.7
51 - 60	2	19	24.4	26.2	5.8	28.8	17.8	13.1	27.7	4.2	2.6	0.0	0.0
61 - 70	1	12	23.1	26.8	9.2	30.0	14.6	13.8	28.8	0.0	3.8	0.0	0.0
71 - 80	6	12	23.8	27.4	12.7	19.2	11.5	18.5	38.1	0.0	0.0	0.0	0.0
81 - 90	3	8	25.4	25.8	16.3	17.5	15.0	28.1	21.9	0.0	0.0	0.0	1.3
91 - 100	2	8	25.8	26.1	11.3	15.0	18.1	26.3	26.3	0.0	0.0	0.0	3.1
Total	58				4.8	17.5	11.1	9.2	42.0	10.5	3.0	0.7	1.3

m = meters; BO = boulder; CB = cobble; GR = gravel; SD = sand; ST = silt; CL = clay; LWD = large woody debris; VEG =vegetation; OTR = Other (shell material, concrete, or detritus/particulate organic matter)

Table 9. Unionid distribution along transects throughout the project area, Ohio River, 2013.

	GSA				PADI															SPA											NDA		Mall Lot 2										
Dist. from Bank (m)	T1	T2	T3	T27	T4	T8	T9	T10	T21	T22	T23	T24	T25	T40	T41	T42	T43	T44	T45	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T26	T28	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	Total	Cum. %
0 - 10	1	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	1	12	20.7
11 - 20	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	3	0	0	0	0	2	17	50.0
21 - 30	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	55.2
31 - 40	0	0	0	-	0	1	2	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	7	67.2
41 - 50	0	0	0	-	0	0	1	0	-	0	0	0	0	2	1	0	0	0	0	0	1	0	0	0	-	0	-	0	0	-	0	0	0	0	0	0	0	0	-	0	0	5	75.9
51 - 60	-	-	0	-	0	0	0	0	-	0	0	0	0	0	0	0	2	-	-	0	0	-	0	-	-	-	-	-	0	-	0	0	-	-	-	-	-	-	-	-	-	2	79.3
61 - 70	-	-	-	-	0	0	-	0	-	0	0	-	-	1	0	0	0	-	-	0	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	1	81.0
71 - 80	-	-	-	-	0	0	-	0	-	1	0	-	-	2	0	0	1	-	-	0	-	-	-	-	-	-	-	-	-	-	2	0	-	-	-	-	-	-	-	-	-	6	91.4
81 - 90	-	-	-	-	-	-	-	-	-	1	0	-	-	0	1	0	0	-	-	1	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	3	96.6
91 - 100	-	-	-	-	-	-	-	-	-	0	0	-	-	2	0	0	0	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	2	100.0
Total	1	0	0	0	0	4	3	1	0	3	1	0	0	10	4	0	3	0	2	3	2	0	0	0	0	0	0	0	1	0	2	0	0	0	9	3	0	0	0	3	3	58	
Time	27	44	48	24	59	53	43	39	34	49	46	37	18	71	52	64	61	22	14	71	24	27	22	19	15	28	24	38	31	12	45	50	29	28	40	24	32	35	24	36	32	1491	
CPUE[1] (no./hour)	**2.2**	0.0	0.0	0.0	0.0	**4.5**	**4.2**	**1.5**	0.0	**3.7**	**1.3**	0.0	0.0	**8.5**	**4.6**	0.0	**3.0**	0.0	**8.6**	**2.5**	**5.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.9**	0.0	**2.7**	0.0	0.0	0.0	**13.5**	**7.5**	0.0	0.0	0.0	**5.0**	**5.6**	**2.33**	
Area (m^2)	50	50	60	30	80	80	60	80	40	100	100	60	60	100	100	100	100	50	50	100	60	50	60	50	30	50	40	50	60	40	80	100	50	50	50	50	50	50	30	50	50	2550	
Surface Density[2]	**0.20**	0.00	0.00	0.00	0.00	**0.50**	**0.50**	**0.13**	0.00	**0.30**	**0.10**	0.00	0.00	**1.00**	**0.40**	0.00	**0.30**	0.00	**0.40**	**0.30**	**0.33**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.17**	0.00	**0.25**	0.00	0.00	0.00	**1.80**	**0.60**	0.00	0.00	0.00	**0.60**	**0.60**	**0.23**	

GSA = General Survey Area, PADI = Potential Area of Direct Impact, NDA = Nova Dredge Area, SPA = Shoreline Protection Area, Mall Lot =

[1] CPUE = number live per work person hour ((no. live / time)*60)

[2] Surface Density is estimated as number live per $10m^2$ area; no excavations were performed; thus, density and population estimates cannot be calculated.

Table 10. Summary of CPUE per qualitative sample and overall in each of the sites within the project area, Ohio River, 2013.

Site	Sample ID	No. Live	Time	CPUE/Sample[1]
PADI	Q16	1	10	6.0
	Q17	1	10	6.0
	Q18	3	10	18.0
	Q19	1	10	6.0
	Q20	1	10	6.0
	Q21	3	10	18.0
	Q22	3	10	18.0
	Q23	4	11	21.8
	Q24	3	11	16.4
	Q25	2	12	10.0
	Q26	2	10	12.0
	Q27	0	10	0.0
	Q28	3	10	18.0
	Q29	2	10	12.0
	Q30	2	10	12.0
	Q31	2	10	12.0
	Q32	0	10	0.0
	Q33	4	11	21.8
	Q34	2	10	12.0
	Q35	5	10	30.0
	Q36	6	10	36.0
	Q37	4	10	24.0
	Q38	2	10	12.0
	Q39	0	10	0.0
	Q40	0	10	0.0
	Q41	0	10	0.0
	Q42	0	11	0.0
	Q43	0	11	0.0
Sub-Total - Average CPUE		*56*	*287*	*11.7*
PADI-AT	Q11	2	10	12.0
	Q12	0	10	0.0
	Q13	0	10	0.0
	Q14	2	10	12.0
Sub-Total - Average CPUE		*4*	*40*	*6.0*
SPA	Q4	2	11	10.9
	Q5	0	10	0.0
	Q6	0	10	0.0
	Q7	0	12	0.0
	Q8	0	13	0.0
Sub-Total - Average CPUE		*2*	*56*	*2.1*
GST	Q1	0	10	0.0
	Q15	0	10	0.0
	Q2	0	14	0.0
	Q3	0	10	0.0
Sub-Total - Average CPUE		*0*	*44*	*0.0*
MALL LOT 2	Q44	1	10	6.0
	Q45	0	10	0.0
	Q46	7	10	42.0
	Q47	3	10	18.0
	Q48	9	10	54.0

Table 10. Summary of CPUE per qualitative sample and overall in each of the sites within the project area, Ohio River, 2013.

Site	Sample ID	No. Live	Time	CPUE/Sample[1]
MALL LOT 2 cont'd	Q49	12	11	65.5
	Q50	5	11	27.3
	Q51	2	10	12.0
	Q52	1	10	6.0
	Q53	4	10	24.0
	Q54	7	10	42.0
	Q55	4	10	24.0
	Q56	6	10	36.0
	Q9	0	10	0.0
	Q10	9	10	54.0
	Q8-Dup	0	10	0.0
Sub-Total - Average CPUE		70	162	*25.9*
Overall Total - Average CPUE	58	132	589	13.4

GST = General Survey Area, PADI - AT = Potential Area of Direct Impact qualitative searches in lieu of transects due to river depth and sampling constraints; PADI = Potential Area of Direct Impact, NDA = Nova Dredge Area, SPA = Shoreline Protection Area; Mall Lot = river mile 27.0 - 27.8

[1] CPUE = number live per work person hour ((no. live / time)*60)

Table 11. Unionid community characteristics in the project area, Ohio River, 2013.

Species/Metric	No. Live	Rel. Ab. (%)	FD	WD	SF	No. Measured	Age (ea) Min.	Age (ea) Max.	Length (mm) Min.	Length (mm) Max.	Zebra Mussel[5] Count	Zebra Mussel[5] #	Zebra Mussel[5] % Cov.
Anodonta suborbiculata	1	0.5	0	0	0	1	7	7	107.5	107.5			
Lampsilis siliquoidea	2	1.1	0	0	0	1	25	25	126	126			
*Lasmigona complanata**	5	2.6	0	0	0	3	5	12	76.5	155.8			
Leptodea fragilis	0	0.0	0	1	0		0	0					
Ligumia recta	5	2.6	0	0	0	4	6	8	98.2	123.4			
*Obliquaria reflexa**	20	10.5	0	0	0	3	5	16	35.7	41.5	1	1	0.1
*Potamilus alatus**	97	51.1	2	18	2	46	4	21	70	183.7	34	42	30.0
Pyganodon grandis	1	0.5	0	0	0	1	0	0	110.3	110.3			
Quadrula quadrula	59	31.1	0	4	0	20	6	17	48.7	93.2	16	9	10.0
Truncilla donaciformis	0	0.0	0	1	0		0	0					
Total	190		2	24	2	79					51		
CPUE (no./hour)[1]	13.4												
Surface Density[2]	0.2												
Species Richness Total	10												
Species Richness Live	8												
Rarefaction Species Richness													
slope (±95% Conf. Int.)	3.3 (0.13)												
10 individuals	3												
50 individuals	6												
100 individuals	7												
300 individuals	8												
500 individuals	9												
1000 individuals	10												
Estimated Mortality (%)[3]	1.0												
Estimated Recruitment (%)[4]	4.7												
No. Young (≤5ea)	9												

ea = external annuli count, FD = fresh dead, WD = weathered dead, SF = sub-fossil

* young individuals(≤5ea) of this species were collected

[1] CPUE = number live per work person hour ((no. live /time)*60); qualitative samples only (132 unionids collected over 589 minutes)

[2] Surface Density is estimated as number live per m^2 area (2,550m^2; no excavations were performed; thus, actual density and population estimates cannot be calculated).

[3] Estimated mortality = No. FD/(total number live + FD) *100

[4] Estimated recruiment = No. ≤5ea/(total number live) *100

[5] Count = number of live unionids with zebra mussels attached, # = the average number of of zebra mussels observed attached, % coverage = the average percent of unionid shell covered