LOWER SUSQUEHANNA RIVER

INTEGRATED SEDIMENT AND NUTRIENT MONITORING PROGRAM

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°C	Degrees Celsius
^{7}Be	Beryllium isotope
ADCP	Acoustic Doppler Current Profiler
ADH	Adaptive Hydraulics Model
Alpine	Alpine Ocean Seismic Survey, Inc.
Ar	Argon
BMP	Best Management Practice
Bulk ρ	Bulk density
C	Carbon
CBL	Chesapeake Biological Laboratory
CEII	Critical Energy Infrastructure Information
cfs	cubic feet per second
CH_4	Methane
CHN	Carbon Hydrogen Nitrogen
cm	centimeter
CO_2	Carbon Dioxide
Conowingo	Conowingo Hydroelectric Project
CTD	Conductivity, Temperature, and Depth
DIC	Dissolved inorganic carbon
DO	Dissolved oxygen
DHMH	Maryland Department of Health and Mental Hygiene
ETM	Estuarine Turbidity Maximum
Exelon	Exelon Generation
Fe	Iron
FeS	Iron sulfide
FeS_2	Iron disulfide
FERC	Federal Energy Regulatory Commission
ft.	feet
h	Hour
$HgCl_2$	Mercury chloride
KY	Kentucky
L	Liter
LISST	Laser In- Situ Scattering Transmissometer
LSRWA	Lower Susquehanna River Watershed Assessment
m	Meter
MD	Maryland
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
MGS	Maryland Geological Survey
mi^2	Square mile
mL	milliliters
mm	millimeter
N	Nitrogen
N_2	Nitrogen gas
NH_4^+	Ammonium
NO_2	Nitrogen dioxide
NO_3	Nitrate
H_2S	Hydrogen sulfide

HCl	Hydrochloric acid
Horn Point	UMCES Horn Point Laboratory
NL	Nutrient load
NWS	National Weather Service
O_2	Oxygen gas
P	Phosphorus
PA	Pennsylvania
PADEP	Pennsylvania Department of Environmental Protection
PI	Principal Investigator (UMCES)
PICS	Particle Imaging Camera System
POC	Particulate organic carbon
POM	Particulate organic matter
PON	Particulate organic nitrogen
POP	Particulate organic phosphorus
PPE	Personal Protective Equipment
PSD	Particle size distribution
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
ROMS	Regional Ocean Modeling System
ROMS-CSTM	ROMS Community Sediment Transport Modeling
S	Sulfur
SFM	Sediment flux modeling
SO_4	Sulfate
SRP	Soluble reactive phosphorus
SSC	Suspended sediment concentration
SSL	Suspended sediment load
SV_GRAB	Single vertical grab sample
SV_ISO	Single vertical isokinetic sample
TCD	Thermal conductivity detector
TMDL	Total Maximum Daily Load
the Bay	Chesapeake Bay
the Commission	Federal Energy Regulatory Commission
the Corps	United States Army Corps of Engineers
the Plan	Lower Susquehanna River Sediment and Nutrient Monitoring Plan
the Pond	Conowingo Pond
the Program	Lower Susquehanna River Sediment and Nutrient Monitoring Program
the Project	Conowingo Hydroelectric Project
the State	State of Maryland
µL	Microliter
µm	Micron
UMCES	University of Maryland Center for Environmental Science
USGS	United States Geological Survey
WI_GRAB	Width-integrated grab sample
WI_ISO	Width-integrated isokinetic sample
WQSTM	Water Quality/Sediment Transport Model

1 INTRODUCTION

On November 20, 2013 the Maryland Department of Natural Resources (MDNR) transmitted to Exelon a study proposal developed by the University of Maryland Center for Environmental Science (UMCES) identifying data collection and analysis to supplement the findings of the Lower Susquehanna River Watershed Assessment (LSRWA).[1] UMCES hypothesized that this study may provide useful information about the Bay and its tributaries to assist in its restoration, a goal Exelon's companies in the watershed have long supported. As such, Exelon has agreed to provide financial support for this study and to lead development of an integrated study effort.

Following preliminary meetings, a workshop was held on April 8th and 9th 2014 to collaboratively develop an integrated sediment and nutrient monitoring program. Attendees at the workshop included: Exelon, MDNR, Maryland Department of the Environment (MDE), the United States Geological Survey (USGS), UMCES, the United States Environmental Protection Agency (EPA) Chesapeake Bay Program, and the US Army Corps of Engineers (the Corps)(collectively, the Parties). Meeting minutes from the workshop can be found in Appendix A.[2]

As discussed at the workshops, this document details the comprehensive, integrated program which is representative of the pertinent elements of the various sediment and nutrient monitoring plans developed by the Parties. The goals of this Integrated Sediment & Nutrient Monitoring Program (the Program) are to quantify the amount of suspended sediment concentration (SSC), associated nutrients, suspended sediment load (SSL), and nutrient load (NL) present in the major entry points to the Lower Susquehanna River Reservoir System and the upper Chesapeake Bay (the Bay). While the entire Lower Reservoir System will be investigated, special emphasis will be given to sediment and nutrient loads into and out of Conowingo Pond (the Pond) during high flow events.

As such, the primary goals of the Program as outlined in this plan (the Plan) are to:

1. Determine the impact, if any, of storm events between 100,000 and 400,000 cfs on sediment and associated nutrients entering the Lower Susquehanna River from upstream sources (including Conowingo Pond), and

2. Determine the potential resulting impacts of storm events, if any, on Bay water quality from sediment and nutrients entering the Conowingo Pond from upstream sources, scouring from sediment behind Conowingo Dam and passing through the Dam.

In order to achieve these goals, specific Program objectives will include:

1. Determine SSC and SSL of major entry points to the Lower Susquehanna River Reservoir System, including Conowingo Pond, during a storm event;

2. Quantify the amount of sediment passing Conowingo Dam during a storm event;

3. Determine the percentage of total SSL passing Conowingo Dam during storm events

[1] The LSRWA was a 3 year, joint study conducted by various agencies and stakeholders which examined the impact of sediment deposited to the Chesapeake Bay from the Lower Susquehanna River Reservoir System. The LSRWA primarily focused on sediment transport during storm events when flows equaled or exceeded 400,000 cfs and the potential impacts of sediment to the water quality of the Bay. The draft LSRWA was released on November 13, 2014.

[2] A second workshop was held with the Parties on August 20, 2014 at the USGS Offices in Baltimore, MD. Meeting minutes for this workshop can also be found in Appendix A.

4. Determine the nutrient concentrations, associated with SSC and SSL, of major entry points to Conowingo Pond during a storm event;

5. Determine the bioavailability and reactivity of sediment and associated nutrients passing Conowingo Dam during a storm event; and

6. Develop a better understanding of the fate and effects of particles in the upper Bay.

While preliminary field efforts are already underway, it is anticipated that this Program will be fully implemented in fall 2014/spring 2015. The Program is proposed to be a 2 year field study depending on the number of storm events which occur annually. Field data collection will occur during the 2014, 2015 and potentially early 2016 field seasons while model integration will occur throughout 2016. At the conclusion of all field efforts, the results of this Program will be used to update the suite of Chesapeake Bay Watershed and Water Quality models for use in the 2017 Chesapeake Bay TMDL Midpoint Assessment.

2 GENERAL APPROACH

Recent studies have shown that the three reservoirs of the Lower Susquehanna River (Lake Clarke, Lake Aldred, and Conowingo Pond) have reached dynamic equilibrium. In order to gain a better understanding of the downstream impacts this may have on Bay water quality in-depth suspended and bottom sediment and nutrient data collection and various nutrient analyses, experiments, and modeling are proposed at predetermined locations from Marietta, PA to the upper Chesapeake Bay. Specific components of this Program will include:

- Collecting water samples at Marietta, PA, Holtwood, and Conowingo Dam to determine SSC, Particle Size Distribution (PSD), and nutrients;
- Collecting water samples at major Conowingo Pond tributaries as well as Deer and Octoraro Creeks to determine SSC, PSD, and nutrients;
- Collecting or obtaining flow data at the sampling locations listed above to calculate SSL and NL of all major entry points to the Pond and Bay;
- Installation of continuous turbidity monitors at Marietta, PA, Holtwood, and downstream of Conowingo Dam;
- Conducting pre- and post-storm bathymetry surveys of Conowingo Pond;
- Collecting sediment cores at predetermined locations throughout Conowingo Pond to determine dry bulk density (bulk ρ) values and for use in various biogeochemical analyses and experiments;
- Characterization of Conowingo Pond sediment deposits through various biogeochemical analyses and modeling;
- Suspended particle characterization of particles entering and leaving Conowingo Pond; and
- Conducting various estuarine physics and biogeochemical experiments and modeling to better understand the fate and effects of particles on Bay dissolved oxygen and better inform analysis of water clarity and chlorophyll in the upper Bay.

All field data collection, experiments, and analyses are scheduled to occur during the 2014, 2015 and potentially early 2016 field seasons. The results of these efforts will be used to update the suite of Chesapeake Bay Watershed and Water Quality models in 2016. The updated suite of models will then be used as part of the 2017 TMDL Midpoint Assessment (Section 7).

SSC, nutrients, SSL, and NL will be calculated based on a number of methods including in-stream measurements, collection of water samples, utilization of bulk ρ values derived from sediment cores, pre- and post-storm bathymetry surveys, and continuous turbidity monitoring.

Discrete water samples will be collected at predetermined intervals across the mainstem of the Susquehanna River at Marietta, PA (Rt. 462/Columbia Bridge), Holtwood Dam (Forebay skimmer wall) and the Norman Wood Bridge, and Conowingo Dam (headworks [spillway side] and catwalks [tailrace side]). Figure 3-1 and 3-2 depict the locations of each sampling site while Table 3-1 provides additional information about each site. Water samples will be submitted to a laboratory(s) and analyzed for SSC, PSD, and nutrients.

Discrete SSC and nutrient data collected at Holtwood/Norman Wood Bridge combined with flow data provided by the Holtwood Station will be used to calculate Conowingo Pond SSL and NL inflow (i.e., Lake Aldred outflow). Discrete SSC, PSD, and nutrient data collected at Conowingo Dam combined with flow data provided by the Conowingo Station and/or the USGS gage will be used to calculate Conowingo Pond SSL and NL outflow.

Discrete water samples will also be collected at major Pond tributaries and at Deer and Octoraro Creeks - which are currently and historically sampled by MDNR and USGS respectively. Water samples will be submitted to a laboratory and analyzed for SSC, PSD, and nutrients. Discrete SSC and nutrient data combined with flow data collected or obtained at each tributary location will be used to calculate tributary SSL and NL inflow to the Pond and upper Bay. For the purpose of this study, tributary sampling locations will include:

- Muddy Creek;
- Broad Creek;
- Fishing Creek;
- Peters Creek;
- Conowingo Creek;
- Octoraro Creek; and
- Deer Creek

Figure 3-2 depicts the location of each sampling site while Table 3-1 provides additional information about each site. Flow data at the Muddy, Octoraro, and Deer Creek sites will be obtained from the USGS gages located on each creek. Due to the fact that USGS gages are not present on Broad, Fishing, Peters, or Conowingo Creeks, channel geometry, velocity, and water level measurements will be collected at each site to develop site specific Stage-Discharge rating curves for each sampling location.

In addition to SSC, all water samples collected as part of this program will be submitted to a laboratory(s) and analyzed for total nitrogen, total dissolved nitrogen, particulate nitrogen, nitrate, nitrite, nitrate plus nitrite, total phosphorus, total dissolved phosphorus, orthophosphate, particulate phosphorus, total particulate carbon, and total organic carbon. Turbidity and PSD will be analyzed as needed. Enough sampling material will be collected to conduct reactivity experiments as discussed in Section 3.

Pre- and post-storm bathymetry surveys of Conowingo Pond will be conducted to identify areas of deposition and scour and to determine the volume of sediment scoured during a given storm/scour event. For the purpose of this Plan, and due to accuracy limitations of the bathymetry equipment, post-storm mobilization will occur following any event when flows equal or exceed 300,000 cfs. In the event that a storm equaling or exceeding this threshold does not occur in a given year, annual baseline surveys will occur in the late spring/early summer of the following year for the duration of this study.

Sediment cores will be collected at predetermined locations throughout the Pond to support both sediment and nutrient monitoring efforts. Bulk ρ (dry mass per unit wet volume) data derived from the cores will be utilized to convert the volume of scoured sediment (wet volume, derived from bathymetry surveys) to a dry mass (load). The mass derived from this calculation, combined with the inflow from major Pond tributaries and the outflow from Conowingo Pond, will be used to back-calculate Conowingo Pond inflow from Holtwood (i.e. Lake Aldred outflow).[3] Volume-to-mass conversions will also be used to determine the contribution of scour (percent) to the outflow of the Pond.

At the conclusion of all SSC and nutrient field data collection efforts a Conowingo Pond storm budget will be developed to estimate the contribution of sediment and nutrients scoured from the Pond during a storm event to Bay water quality.

In addition to suspended sediment monitoring, extensive nutrient data collection, analyses, experiments, and modeling will be conducted to determine the nutrient composition of the sediment, where the sediment is transported to in the Bay, and the effects this may have on Bay water quality. Various nutrient analyses and experiments will occur in three distinct geographic regions of the study area including: 1) Conowingo Pond; 2) suspended particles entering or exiting the Pond; and 3) below Conowingo Dam. Sediment cores will be collected at predetermined locations throughout the Pond for various biogeochemical analyses including: grain size, bulk ρ, pore water chemistry, solid phase chemistry, and diagenetic rate processes (bioavailability) on surface deposits. Sediment nutrient flux and sediment oxygen demand will also be determined for these cores.

Suspended particles entering and exiting Conowingo Pond will be characterized using water samples collected at each sampling location. Chemical characterization of particles entering and leaving the Pond (forms of Phosphorus (P), measurement of Nitrogen (N)/P production from particulates and diagenesis experiments), and settling rates of particulates will be characterized. Additional samples from tributaries will also be characterized for diagenesis rates.

Various estuarine physics and biogeochemical experiments and modeling will also occur below Conowingo Dam to better understand the fate and effects of particles in the upper Bay. Results of the experimental biogeochemistry component will involve adding Conowingo Pond particulates to cores collected at 4 sites in the upper Bay and examining the release (the bioavailability of P and N) under realistic summer temperature and oxygen conditions. This will involve multiple incubations of >20 cores (including controls), with net fluxes measured as well as changes in pore water P, N, Fe and S species. These data will be input into the SFM stand-alone model platform. The field event program will follow the fate of particulates as Conowingo Pond flooding impacts the Bay on 2 occasions. Physical parameters, suspended particulate concentrations, and water column dissolved and particulate species will be measured. Particulate nutrients and sediment-water exchange before and after settlement of Conowingo Pond particulates will also be measured. These measurements will be used to calibrate ROMS sediment transport modeling of the upper Bay in order to better understand the fate and effects of particles in the upper Bay.

[3] Conowingo Pond inflow will also be calculated from SSC and nutrient data collected at Holtwood and the Norman Wood Bridge. The back calculation method provides a second option for determining inflow that will be particularly useful following high flow events or when sampling from the Norman Wood Bridge is not safe or practical. It will also serve as a check of inflow based on data collected from Holtwood and Norman Wood Bridge. Due to accuracy limitations of the bathymetry equipment, calculating Pond inflow from data collected at Holtwood and the Norman Wood Bridge will be the primary method used for flow events between 100,000 – 400,000 cfs.

3 FIELD DATA COLLECTION AND ANALYSES

The Integrated Sediment and Nutrient Monitoring Program will be comprised of three main tasks. These tasks will include:

- Task 1.0 – Suspended Sediment Monitoring;
- Task 2.0 – Nutrient Monitoring, Experiments, and Modeling; and
- Task 3.0 – Sediment Core Collection and Analyses

Although these tasks are broken down by individual component, it is anticipated that there will be significant overlap between tasks as data collected during one task may be complementary to another (i.e., core data will be used for both suspended sediment monitoring as well as nutrient monitoring). These tasks are described in greater detail below.

TASK 1.0 – SUSPENDED SEDIMENT MONITORING

Field efforts associated with suspended sediment monitoring will include collection of: discrete water samples, flow, velocity, water level, channel geometry, and pre- and post-storm bathymetry surveys. Specific sub-tasks discussed in this section include:

- Task 1A – Mainstem Susquehanna River Sampling;
- Task 1B – Maryland Non-Tidal Network Tributary Sampling;
- Task 1C – Conowingo Pond Tributary Sampling; and
- Task 1D – Conowingo Pond Bathymetry Surveys

Task 1A – Mainstem Susquehanna River Sampling

The USGS (PA and MD) will collect discrete water samples at the following locations:

- Marietta, PA (Rt. 462/Columbia Bridge);
- Holtwood Dam (Forebay skimmer wall) and the Norman Wood Bridge; and
- Conowingo Dam (Tailrace catwalks)

In addition to USGS sampling locations, Exelon will be responsible for collecting water samples along the spillway at Conowingo Dam. Figures 3-1 and 3-2 denote the locations of the sampling sites while Table 3-1 contains additional information for each location.

Water samples will be collected during 6 storm events over the range of the hydrograph with the goal of capturing the rising limb, peak, and falling limb of each event as closely as possible. For the purpose of this study a storm event will be defined as any event when Susquehanna River flows are between 100,000 and 400,000 cfs. Sampling will be triggered based on the National Weather Service (NWS) projected peak flow as predicted at the Marietta gage on the Susquehanna River. It is anticipated that the 6 sampling events will span the 2014 and 2015 field seasons with sampling beginning in the fall of 2014.[4]

Water samples will be collected at the three sites during the same event at the same general position on the hydrograph to allow for comparisons of the data entering the reservoirs, output from the upper two reservoirs (Lake Clarke and Lake Aldred), and output from Conowingo Pond into the upper Chesapeake Bay. Ideally when conducting a mass balance it would be useful to know the concentration of the same slug of water as it moves through the system, however, the practical logistics of sampling for suspended

[4] In the event that 6 sampling events which span the range of this study (100,000-400,000 cfs) do not occur during the 2014 and 2015 field seasons, Exelon reserves the right to continue sampling when such flow events occur.

sediment prohibit this. Continuous turbidity data collected at each location will be used to gain a better understanding of the travel time of water and sediment through the reservoir system. Furthermore, continuous measurements of turbidity will be used to establish comparability between samples collected at the three sites relative to sediment concentrations over the course of the event.

USGS mainstem sampling will occur once per day for the duration of the storm event at each site. A daily sampling frequency, combined with the continuous turbidity dataset at each site, will be adequate for capturing the range of the hydrograph (rise, peak, and fall). If desired, and agreed upon by the Parties, sampling may be conducted twice per day during the peak of the storm. Following the first few storm events the field collected data will be evaluated to determine if the sampling frequency should be adjusted. Water samples will be collected using a range of collection methods from width-integrated isokinetic samples to single vertical grab samples. All data collection will follow USGS protocols as outlined in the National Field Manual. Specific collection methods will vary depending on the site location and sampling conditions.

Sampling at Marietta will consist of collecting width-integrated isokinetic (WI_ISO) and single vertical isokinetic (SV_ISO) samples from the Rt. 462/Columbia Bridge. SV_ISO samples will be collected daily for the duration of the storm event in order to capture the rise, peak, and fall of the hydrograph. WI_ISO samples will be collected at least once per storm event for cross reference. The WI_ISO samples will be collected concurrently with the SV_ISO samples. The Marietta site offers suitable platforms for high-quality sample collection. Flow data for the Marietta site will be obtained from the Susquehanna River USGS Gage located at Marietta (Gage no. 01576000).

Holtwood sampling will consist of collecting width-integrated grab (WI_GRAB) samples or single vertical grab (SV_GRAB) samples from the forebay skimmer wall at Holtwood Dam. Samples will be collected daily for the duration of the storm event to capture the rise, peak, and fall of the hydrograph. Given that it is unclear how well mixed and representative the water at this location may be, WI_ISO samples will also be collected from the Norman Wood Bridge during two storm events.[5] WI_ISO sampling at the Norman Wood Bridge will occur during the first 2-3 storm events. Data collected at this location will be compared to the data collected at the Holtwood forebay to determine the representativeness of the Holtwood data. If it is found that the Holtwood data is not representative of the river cross-section, sampling protocols will be reexamined and updated accordingly. Due to the logistical challenges of sampling at this location, the data collected from this site will have greater and undetermined uncertainty. Flow data for the Holtwood and Norman Wood Bridge locations will be provided to the USGS by the Holtwood Station.

Sampling at Conowingo Dam will consist of both tailrace and spillway sampling. The USGS will collect WI_GRAB samples from the tailrace catwalks (upper and lower) at Conowingo Dam once per day for the duration of the storm event Exelon will collect WI_GRAB samples concurrently with USGS tailrace sampling from the open gates along the headworks of the Dam (spillway side) at a minimum of once per day. Flow data at Conowingo Dam will be obtained from Conowingo Station and/or the USGS gage located at the Station.

In order to determine if the water going over the spillway is well mixed or stratified, Exelon will install one sampling well to the abutment between crest gates 15 and 16 on the upstream face of the Dam. These

[5] The Norman Wood Bridge is approximately 175 ft. above the water surface and approximately 3,500 ft. long. This bridge has moderate traffic volume though in cases of closures to other thoroughfares the volume can be high. Sampling from this bridge would require lane closures for the duration of the sample collection. Lane closures would require coordination with the local police force or highway patrol. Additionally, during high flow conditions a substantial amount of large debris is flushed downstream which cause a hazard to both those sampling on the bridge and the sampling equipment. Most of the debris (if not all) will be flowing down the center to right bank as it passes over the spillway.

crest gates will be opened for every spill event over the course of the study. To ensure field personnel safety while sampling, additional railings and fall protection will be installed at crest gates 15 and 16. Design drawings for the sampling well can be found in Appendix B.

Once installed, depth-integrated samples will be collected over a number of spill events using a Kemmerer sampler. Samples will be taken at multiple depths throughout the water column to ensure an accurate profile is captured. "Plunge" or surface grab samples will also be collected using a weighted bottle sampler at the same gates in order to compare the data collected by the different methods. If samples can be safely collected using existing railing infrastructure and fall protection, additional water samples will be collected at all open gates during a spill event.

Based on the results of the sampling well data a determination will be made as to whether the water is well mixed or stratified. If the water is found to be well mixed, all future sampling will be conducted via the "plunge" sample method using railings/fall protection or platforms. If the water is found to be stratified, additional infrastructure may be installed at predetermined locations across the headworks to allow for depth-integrated sampling.

Although it was originally proposed that up to nine additional sampling wells would be installed across the face of the Dam, cost estimates for fabrication and installation of these wells make this approach impractical. More economical alternatives are currently being evaluated in the event that the water is found to be stratified and depth-integrated sampling is required.

Water samples collected at each individual gate will be submitted to a laboratory for gate-by-gate analysis. In addition, samples collected along the headworks will be churn split and a composite sample(s) will be submitted to the laboratory for analysis. Conowingo Dam spillway sampling, filtering, and analysis protocols can be found in Exelon's Sediment and Nutrient Monitoring Quality Assurance Project Plan (QAPP) (Appendix C).

All mainstem Susquehanna River water samples (Marietta, Holtwood, and Conowingo) will be submitted to a laboratory for analysis of SSC, PSD, and nutrients.[6] Samples collected by the USGS for nutrient analysis will be shipped overnight on ice and analyzed at the USGS National Water-Quality Laboratory in Denver, CO. All USGS samples will be filtered in the field or at USGS offices prior to shipping. USGS water samples collected for analysis of SSC and PSD will be analyzed at the USGS Sediment Laboratory in Louisville, KY.

Water samples collected by Exelon along the headworks will be packed on ice and sent via courier to the Chesapeake Biological Laboratory (CBL) in Solomons, MD. Upon receipt of the water samples, CBL will be responsible for all filtering and nutrient analyses and analysis of SSC. Samples will also be submitted to the UMCES Horn Point Lab where PSD analysis will be conducted. Split samples will be provided upon request to MDNR and the USGS to ensure lab comparability.[7] Both Exelon and the USGS will collect enough water such that samples can also be provided to UMCES for their independent analysis which will be conducted as part of the nutrient analysis and experiments discussed in Task 2B.

SSC and nutrient values obtained from the laboratories combined with flow data collected or obtained at each site will then be used to calculate the mainstem NL and SSL entering and exiting Conowingo Pond.

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[6] Nutrient analysis will include: total nitrogen, total dissolved nitrogen, particulate nitrogen, nitrate, nitrite, nitrate plus nitrite, total phosphorus, total dissolved phosphorus, orthophosphate, particulate phosphorus, total particulate carbon, and total organic carbon.

[7] Exelon will continue to work with MDNR and the USGS to determine if it is logistically feasible to use the USGS Sediment Laboratory for analysis of SSC and PSD at select Exelon sampling locations. If it is found that the USGS Sediment Laboratory can be reasonably used for Exelon collected samples, water samples will be provided to the USGS lab for analysis of SSC and PSD instead of CBL and Horn Point. If it is found that this arrangement is not logistically feasible, Exelon will use CBL and Horn Point as described throughout this document.

Mainstem Turbidity Monitoring

Continuous turbidity monitors (EXO2 multiparameter turbidity sonde) will be installed at each mainstem sampling location. Continuous turbidity measurements, collected via the EXO2 sonde, will be used to establish a site specific surrogate relationship between turbidity and SSC. By developing this surrogate relationship, the continuous measurements collected at each site will be used to characterize the range of SSC over time when water samples are not collected. Continuous measurements will also be used to establish comparability between samples collected at the three sites relative to sediment concentrations over the course of the event.

The installation of the turbidity sonde would include a single accessible measuring point chosen to be representative of time variations in turbidity and, if possible, be reflective of the mean river cross section. Turbidity values will be recorded every 15 minutes.

Task 1B – Maryland Non-Tidal Monitoring Network Tributary Sampling

MDNR and the USGS (PA) will collect discrete water samples at the following Maryland Non-tidal Network sampling locations:

- Muddy Creek - Paper Mill Rd. Bridge (USGS);
- Octoraro Creek - New Bridge Rd. Bridge (USGS); and
- Deer Creek - Stafford Rd. Bridge (MDNR)

Figure 3-2 denotes the location of the sampling sites while Table 3-1 contains additional information for each location. Sampling requirements associated with the Non-tidal Monitoring Network sampling program include monthly baseline sampling events (12) and recommended 2 storm sampling events per quarter (8) for a total of 20 sampling events annually. Storm event sampling will be triggered based on the NWS projected peak flow as predicted at the Marietta gage on the Susquehanna River, weather forecasts (rainfall), and monitoring of USGS gages located on each tributary. For the objectives of this study, tributary sampling events will correspond with a mainstem Susquehanna River high flow event (100,000-400,000 cfs).

Water samples will be collected at least once during the storm event as close to the peak of the hydrograph as possible.[8] If the event occurs over multiple days a sample can be collected on separate days. Due to the historical SSC and nutrient dataset collected at Deer and Octoraro Creeks as part of the Non-tidal Monitoring Network it is believed that enough data currently exists to allow for the development of sediment and nutrient rating curves. As such sampling once per storm event (as close to the peak as possible) is adequate for these locations.

Given that Muddy Creek does not have the same amount of historical data available as Deer and Octoraro Creeks supplemental data will be collected to develop storm and site specific sediment and nutrient rating curves. Exelon will deploy an ISCO automatic sampler at Muddy Creek programed to collect water samples at predetermined intervals over the range of the hydrograph for the duration of the storm event to complement and supplement the WI_ISO collected once per event. This data will be used to develop a better understanding of sediment and nutrient loads over the course of the storm event at this specific location. Water samples collected via the ISCO sampler will be churn split, with composite samples submitted to a laboratory for analysis of SSC, PSD, and nutrients. After the first several storm events the

[8] It is anticipated that the tributaries will rise and fall during a storm event far quicker than the mainstem Susquehanna River will. As such, tributary sampling may occur days before the mainstem peaks. If sampling crews wait for the mainstem to peak before sampling at the tributary locations, the tributary rising limb and peak will be missed.

data collected via the ISCO sampler will be reviewed and sampling protocols or frequencies will be adjusted as necessary.

All water samples, other than the ISCO samples at Muddy Creek, will be collected using the WI_ISO sampling method in accordance with Non-tidal Monitoring Network sampling and filtering protocols as defined in the program QAPP (Appendix C). All filtering associated with nutrient analysis will be conducted in the field prior to submittal of samples to the laboratory. Flow data for each event will be obtained from the USGS gages located on each tributary.

All Non-tidal Monitoring Network samples (Muddy, Octoraro, and Deer Creeks) will be submitted to a laboratory for analysis of SSC, PSD, and nutrients.[9] Samples collected for nutrient analysis will be submitted to the MD Department of Health and Mental Hygiene (DHMH) laboratory located in Baltimore, MD. Samples collected for analysis of SSC and PSD will be shipped to the USGS Sediment Laboratory in Louisville, KY. Both MDNR and the USGS will collect enough water such that samples can also be provided to UMCES for their independent analysis which will be conducted as part of the nutrient analysis and experiments discussed in Task 2B.

SSC and nutrients values obtained from the laboratories combined with flow data obtained at each site will then be used to calculate tributary NL and SSL entering Conowingo Pond (Muddy Creek) or the Susquehanna River (Octoraro and Deer Creeks).

Task 1C – Conowingo Pond Tributary Sampling

Exelon will collect discrete water samples at the following locations:

- Broad Creek - Robinson Mill Rd. Bridge and/or Boy Scout Dam;
- Fishing Creek - Harmony Ridge Rd. Bridge;
- Peters Creek - Peach Bottom Rd. Bridge; and
- Conowingo Creek - Mason Dixon Rd. Bridge

Figures 3-2 denotes the location of the sampling sites while Table 3-1 contains additional information for each location.

Tributary sampling locations were selected based on a number of criteria including:

- Drainage Area – selected Pond tributaries, combined with Muddy Creek, represent the 5 largest tributary drainage areas entering the Pond (Table 3-2). Drainage areas for the selected tributaries range from 138 mi^2 (Muddy Creek) to 10 mi^2 (Peters Creek). No other tributary has a drainage area greater than 5 mi^2.

- Existing Chesapeake Bay Model – Conowingo Pond Sub-basins – the 3 sub-basins found in the vicinity of Conowingo Pond include: Broad Creek (SL0_2721_2720), Muddy Creek (SL2_2750_2720), and all tributaries on the East side of the Pond (including Fishing, Peters, and Conowingo Creeks)(SL9_2720_0001). As such, the significant tributaries which are located in these sub-basins are well represented by the tributary sampling locations proposed in this Plan.

- Land-use - prominent deltaic features have been observed at the mouths of Fishing and Peters Creeks. The morphology and grain size of these deposits suggest a substantial sediment supply

[9] Nutrient analysis will include: total nitrogen, total dissolved nitrogen, particulate nitrogen, nitrate, nitrite, nitrate plus nitrite, total phosphorus, total dissolved phosphorus, orthophosphate, particulate phosphorus, total particulate carbon, and total organic carbon.

directly from these tributaries during storm events most likely from overland runoff due to upstream and surrounding land uses as well as bank and bed erosion.

While other tributaries do enter Conowingo Pond, those locations were not selected as they are not believed to be significant contributors of sediment and nutrients to the Pond and therefore are not relevant to the selection criteria previously described.

Water samples will be collected during 6 storm events. For the purpose of this study a storm event will be defined as a tributary high flow event that corresponds with a mainstem Susquehanna River high flow event (100,000-400,000 cfs). Water samples will be collected during the storm event over the range of the hydrograph with the goal of capturing the rising limb, peak, and falling limb of the event as closely as possible.[10] Storm event sampling will be triggered based on the NWS projected peak flow as predicted at the Marietta gage on the Susquehanna River, weather forecasts (rainfall), and monitoring of USGS gages located on tributaries of similar sizes (i.e. Muddy, Octoraro, and Deer Creeks). Once the tributaries return to base flow conditions, daily water samples will be collected until the mainstem Susquehanna River is no longer spilling at Conowingo Dam. If after the first few storm events it is found that the tributaries are not major contributors of sediment and nutrients to the Pond during baseflow conditions sampling will be stopped once the hydrograph has returned to normal water levels (as opposed to once Conowingo Dam stops spilling).

Water samples will be collected at each site using the WI_ISO sampling method in accordance with Exelon Sediment and Nutrient monitoring protocols as defined in the Program QAPP (Appendix C). Due to the fact that historical sediment and nutrient data does not exist at these sampling locations, ISCO automatic samplers will be deployed at Fishing and Conowingo Creeks for the first two storm events to bolster the existing dataset, complement the WI_ISO samples, and develop storm and site specific sediment and nutrient rating curves. ISCO water samples will be collected at predetermined intervals. Samples collected during each sampling interval will be composited and churn split for submittal to a laboratory for analysis of SSC, PSD, and nutrients. If after the first few storm events it is found that the WI_ISO samples adequately represent tributary sediment and nutrient loads, then ISCO sampling will be discontinued; however, if it is found that the WI_ISO do not adequately represent tributary sediment and nutrient loads, then ISCO sampling will be continued and expanded to Peters and Broad Creek. Furthermore, if after the first few rounds of sampling it is found that some or all of the tributaries are not significant contributors of SSC and nutrients to the Pond, all tributary sampling (ISCO and WI_ISO) at those locations may be discontinued.

All Pond tributary water samples collected by Exelon will be packed on ice and submitted via courier to CBL for analysis of SSC and nutrients.[11] CBL will be responsible for all filtering prior to nutrient analysis. Horn Point Laboratory will be responsible for analysis of PSD.[12] In addition, enough water will be collected such that samples can be provided to UMCES Horn Point Laboratory for the nutrient analysis and experiments discussed in Task 2B; UMCES will interact with Exelon to ensure sufficient sample masses. Split samples from select sampling events will be provided upon request to the DHMH and/or USGS laboratories as a means of data comparison and quality assurance.

Due to the fact that USGS gages are not present on the selected Pond tributaries, supplemental field data will be collected to develop site specific Stage-Discharge rating curves for each tributary sampling

[10] It is anticipated that the tributaries will rise and fall during a storm event far quicker than the mainstem Susquehanna River will. As such, tributary sampling will need to occur as the mainstem begins to rise or prior to its peak.

[11] Nutrient analysis will include: total nitrogen, total dissolved nitrogen, particulate nitrogen, nitrate, nitrite, nitrate plus nitrite, total phosphorus, total dissolved phosphorus, orthophosphate, particulate phosphorus, total particulate carbon, and total organic carbon.

[12] See Footnote 7 on page 8

location. Velocity and depth measurements will be collected at each location during separate storm events that do not correspond with a SSC and nutrient sampling event. All measurements will be collected following standard USGS stream gaging protocols as defined in Exelon's QAPP (Appendix C).

All velocity and depth measurements will be taken from a bridge using standard flow metering equipment.[13] In addition, continuous water level data will be monitored at each location using *In-situ* Aqua or LevelTROLL water level loggers, or equivalent water level loggers, for the duration of the study. Staff gages will be installed on each Pond tributary near the existing water level logger as a means of validating the continuous water level data. The combination of velocity, channel geometry, and water level data will be used to develop a Stage-Discharge rating curve for each tributary.

SSC, nutrients, and flow data obtained for each site will then be used to calculate tributary NL and SSL entering Conowingo Pond. The combination of NL and SSL from Pond tributaries (including Muddy Creek), Holtwood, and Conowingo Dam will be used to develop a storm mass balance of the Pond. From this mass balance a determination can be made as to the contribution of Pond scour to the Bay.

Broad Creek

Broad Creek was identified as an important tributary due to its size (second largest drainage area of the Pond tributaries) and that it is its own sub-basin in the Chesapeake Bay model. Due to the limited number of bridges found in this area there are only three potential sampling locations: 1) Robinson Mill Rd. Bridge; 2) Boy Scout Dam Bridge; or 3) the Rt. 623 / Flintville Rd. Bridge. For various reasons none of the three potential locations are ideal for sample collection. Figure 3-3 depicts each of these locations.

The Robinson Mill Rd. Bridge is located 1.4 miles upstream of the Boy Scout Dam which creates the Lake Straus impoundment. While flow data could be collected at this site using standard flow metering protocols, SSC and nutrient data collection would not be practical as it would not take into consideration the effects of the Lake Straus impoundment (net scour and/or deposition). As such, water samples collected upstream of the dam would not be representative of SSC and nutrients discharged to Conowingo Pond during storm events.

Due to its proximity to the dam, isokinetic sampling from the Boy Scout Dam Bridge is not possible. The collection of width-integrated surface grab samples, while challenging, appears to be possible based on the results of a dry run conducted during base flow conditions. Due to the configuration of the Bridge over the Dam, flow metering would not be possible from this location.

The Rt. 623 / Flintville Rd. Bridge is located 0.75 miles upstream of the mouth of Broad Creek. The Creek in this area is heavily influenced by backwater from Conowingo Pond thus making collection of representative flow, SSC, and nutrient data highly unlikely. While USGS methods exist for collecting flow data in such an environment, establishing and maintaining such a gage can be challenging and very costly. In addition, although it has been observed that during high flow events Broad Creek's flow counteracts the Pond backwater effect, this has not been examined in depth. Although it may be possible to collect isokinetic samples from the Rt. 623 Bridge during high flow events, it is unclear how representative these samples would be of SSC and nutrients which originate from Broad Creek. It is believed that even if the Broad Creek flow counteracts the Pond backwater effect, the resulting water samples will still be a combination of Broad Creek and Conowingo Pond SSC and nutrients.

Given this, Exelon proposes the following for sampling at Broad Creek:

[13] If flows and field conditions are deemed safe, velocity and depth measurements will be taken by wading across the stream at the transect. It is anticipated that wading will only be possible during low flow conditions and not during sampling events.

- Establish a stage-discharge rating curve at the Robinson Mill Rd. Bridge following the same protocols established at Fishing, Peters, and Conowingo Creeks. Once established, prorate the flow to the creek's mouth by drainage area ratio.

- Conduct initial WI_ISO sampling at the Robinson Mill Rd. Bridge to gain a better understanding of the amount of suspended sediment and nutrients in Broad Creek and as a means of comparison to WI_GRAB samples collected at the Boy Scout Dam Bridge.

- Conduct WI_GRAB sampling during 6 storm events from the Boy Scout Dam Bridge for analysis of SSC, PSD, and nutrients. Sampling will be conducted over the range of the hydrograph with the goal of capturing the rising limb, peak, and falling limb as closely as possible.

- If after the first few storm events it is found that sampling from the Boy Scout Dam Bridge is not possible, use another Pond tributary with similar drainage area, characteristics, and land-use as a surrogate for SSC and nutrients. The surrogate SSC and nutrients would then be combined with Broad Creek flow to determine Broad Creek SSL and NL.

Although preliminary discussions explored the possibility of conducting Broad Creek sampling at a Non-tidal Network level, due to the logistical challenges and uncertainty of sampling at this location Exelon is proposing to conduct sampling during 6 storm events only.

Laboratory QA/QC

MDNR will conduct QA/QC on laboratory nutrient and sediment data analyzed by CBL and Horn Point Laboratory for the Conowingo Pond tributaries as they have the software programs in place to review for outliers, merge field and lab results, and process data in a format that is acceptable and compatible for the Chesapeake 2017 Mid-point Assessment.[14] CBL is contracted by MDNR to analyze all MD Chesapeake Bay Mainstem and Tributary water quality monitoring stations. Monitoring data will be submitted to Exelon, their consultants, and the EPA Chesapeake Bay Program as soon as it has been processed. Exelon and their consultants will receive the original data from the labs as well as the processed, QA/QC'd, and formatted results for all sampling locations.

Exelon reserves the right to conduct its own QA/QC of all laboratory data. If discrepancies between the MDNR and Exelon QA/QC'd datasets are found the parties will work with one another to resolve the discrepancy(s) as needed.

Task 1D – Conowingo Pond Bathymetry Surveys

Pre- and post-storm Conowingo Pond bathymetry surveys will be conducted to identify areas of deposition and scour and to determine the volume of sediment scoured during a given storm/scour event. For the purpose of this Plan, and due to accuracy limitations of the bathymetry equipment, post-storm mobilization will occur following any event when flows equal or exceed 300,000 cfs. In the event that a storm equaling or exceeding this threshold does not occur in a given year, annual baseline surveys will occur in the late spring/early summer for the duration of this study. An initial pre-storm baseline survey was conducted in October 2011. Additional baseline surveys were conducted in June 2013 and 2014.

To further complement the existing bathymetry data, and to help inform the selection of core locations as discussed in Task 3.0, the Maryland Geological Survey (MGS) conducted bathymetry, side scan sonar, and seismic profile surveys of Conowingo Pond the week of October 6, 2014.

[14] See Footnote 7 on page 8

Table 3-1: Proposed Suspended Sediment and Nutrient Sampling Locations

Location		Site Description	Lat/Long	No. Total Sampling Events 2014-2015	Responsible Party	Proposed Sampling						Notes
						Discrete Water Samples *(SSC, PSD, & Nutrients)*	ISCO Water Samples	Flow	Turbidity	Cross-Section Velocity & Depth	Continuous Water Level Monitors & Staff Gages	
UPSTREAM OF CONOWINGO POND	**Marietta, PA**	Rt. 462/Columbia Bridge	40° 01' 42.82" N 76° 31' 04.88" W	6	USGS (PA)	WI_ISO, SV_ISO		X	X		X^	Continuous turbidity operational for entire study period. SV_ISO sampling daily for the duration of the storm event. WI_ISO sampling once per storm concurrently with SV_ISO for cross reference. SV_ISO samples will be collected over the range of the hydrograph.
	Holtwood Dam	Forebay skimmer wall	39° 49' 42.38" N 76° 19' 59.56" W	6	USGS (PA)	WI_GRAB, SV_GRAB		X	X			Continuous turbidity operational for entire study period. WI_GRAB or SV_GRAB will be collected from Forebay skimmer daily for the duration of the storm event.
	Norman Wood Bridge	Predetermined intervals across Bridge	39° 48' 57.04" N 76° 19' 29.91" W	2	USGS (PA)	WI_ISO		X				WI_ISO sampling during two storm events (2 of the first 3). Depending on the results of the first 2 sampling events when compared to the Holtwood forebay samples additional sampling may occur.
CONOWINGO POND	**Muddy Creek**	Rt. 2024 / Paper Mill Rd. Bridge	39° 46' 22.85" N 76° 18' 57.57" W	32*	USGS (PA)	WI_ISO	X	X			X^	WI_ISO sampling will occur once per storm event as close to the peak as possible. ISCO water samples will be collected over the range of the hydrograph during the first several storm events to develop storm and site specific SSC and nutrient curves. Depending on initial ISCO results, ISCO sampling may be continued for all 6 storm events.
	Broad Creek	Robinson Mill Rd. Bridge Boy Scout Dam	39° 40' 47.77" N 76° 16' 50.86" W 39° 41' 21.91" N 76° 15' 47.70" W	6	Exelon	WI_GRAB		X		X	X	Standard flow metering protocols will be followed to determine flow at the Robinson Mill Rd. Bridge. Flow values will then be prorated to account for the Boy Scout Dam. WI_GRAB samples will be collected from the Boy Scout Dam bridge to cover the range of the hydrograph during a storm event. In the event that sampling from the bridge is not practical, another tributary (with similar characteristics and land-use) will be used as a surrogate to determine Broad Creek SSC and nutrients. Depending on the results of the initial ISCO sampling at Fishing and Conowingo Creeks, ISCO sampling may be implemented downstream of the Boy Scout Dam in the future.
	Fishing Creek	Harmony Ridge Rd. Bridge	39° 47' 39.73" N 76° 15' 33.84" W	6	Exelon	WI_ISO	X	X		X	X	WI_ISO sampling to cover the range of the hydrograph during a storm event. Cross-section velocity, depth, and water level data to develop a site specific Stage-Discharge rating curve for flow calculations. ISCO water samples will be collected over the range of the hydrograph during the first several storm events to develop storm and site specific SSC and nutrient curves. Depending on initial ISCO results, ISCO sampling may be continued for all 6 storm events.
	Peters Creek	Rt. 444 / Peach Bottom Rd. Bridge	39° 45' 40.89" N 76° 13' 38.42" W	6	Exelon	WI_ISO		X		X	X	WI_ISO sampling to cover the range of the hydrograph during a storm event. Cross-section velocity, depth, and water level data to develop a site specific Stage-Discharge rating curve for flow calculations. Depending on the results of the initial ISCO sampling at Fishing and Conowingo Creeks, ISCO sampling may be implemented at this site in the future.

Location		Site Description	Lat/Long	No. Total Sampling Events 2014-2015	Responsible Party	Proposed Sampling						Notes
						Discrete Water Samples *(SSC, PSD, & Nutrients)*	ISCO Water Samples	Flow	Turbidity	Cross-Section Velocity & Depth	Continuous Water Level Monitors & Staff Gages	
	Conowingo Creek	Mason Dixon Rd. Bridge	39° 43’ 50.74” N 76° 10’ 41.94” W	6	Exelon	WI_ISO	X	X		X	X	WI_ISO sampling to cover the range of the hydrograph during a storm event. Cross-section velocity, depth, and water level data to develop a site specific Stage-Discharge rating curve for flow calculations. ISCO water samples will be collected over the range of the hydrograph during the first several storm events to develop storm and site specific SSC and nutrient curves. Depending on initial ISCO results, ISCO sampling may be continued for all 6 storm events.
	Conowingo Dam	Headworks *(Spillway Side)* Catwalks *(Tailrace)*	39° 39’ 40.62” N 76° 10’ 22.57” W	6	USGS (MD) *(Tailrace)* Exelon *(Headworks)*	WI_GRAB, SV_GRAB		X	X		X^	Continuous turbidity operational for entire study period. WI_GRAB or SV_GRAB collected from tailrace catwalks and spillway headworks. Tailrace sampling will occur daily over the course of the storm, headwork sampling will occur over the range of the hydrograph. In the event of a storm occurring of such magnitude that personnel would not be allowed to sample on the headworks, an ISCO sampler would be mobilized at the sampling well for collection of water samples to be analyzed for SSC, PSD, and nutrients.
DOWNSTREAM OF CONOWINGO POND	**Octoraro Creek**	New Bridge Rd.	39° 42’ 24.58” N 76° 06’ 54.27” W	32*	USGS (PA) SRBC	WI_ISO		X			X^	WI_ISO sampling will occur once per storm event as close to the peak as possible.
	Deer Creek	Stafford Rd. Bridge	39° 37’ 22.89” N 76° 09’ 50.90” W	32*	MDNR	WI_ISO		X			X^	WI_ISO sampling will occur once per storm event as close to the peak as possible. If the storm event were to occur over multiple days a sample could be collected on separate days.

** Denotes Maryland Non-tidal Network Monitoring Station – Annual sampling requirements include monthly baseline sampling events plus 1 storm event per quarter (16 sampling events/year)*

^Denotes USGS Gage present at or near sampling location

Table 3-2: Conowingo Pond Tributary Drainage Areas[15]

TRIBUTARY NAME	TOTAL DRAINAGE AREA (mi^2)	DRAINAGE AREA AT SAMPLING LOCATION (mi^2)
Muddy Creek*	138.36	132.77
Broad Creek*	40.2	25.1 *(Robinson Mill Rd.)* 30.3 *(Boy Scout Dam)*
Conowingo Creek*	38.9	32.5
Fishing Creek*	14.22	14.06
Peters Creek*	10.22	10.04
Peddler Run	5.31	N/A
Michaels Run	4.13	N/A
Unnamed Tributary *(behind Peach Bottom Station)*	3.75	N/A
Unnamed Tributary *(entering Hopkins Cove)*	2.31	N/A
Unnamed Tributary *(northern tip of Mt. Johnson Island)*	1.8	N/A

* *Denotes proposed monitoring site*

[15] The tributaries contained in this table represent the 10 largest tributaries which discharge to Conowingo Pond. While other Pond tributaries do exist they were not included in this table or considered for detailed study due to their size (~1.0 mi^2 or less).

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PROJECT NO. 405

1 inch = 1.3 miles

0 0.5 1 2 Miles

Figure 3-1
Sampling Locations -
Marietta, PA to Holtwood

Path: X:\GISData\Sediment Monitoring Plan - 12.04.2013\Integrated Sediment Monitoring Program\Figure 3-1 Sampling Locations Marietta to Holtwood - 11 x 17.mxd

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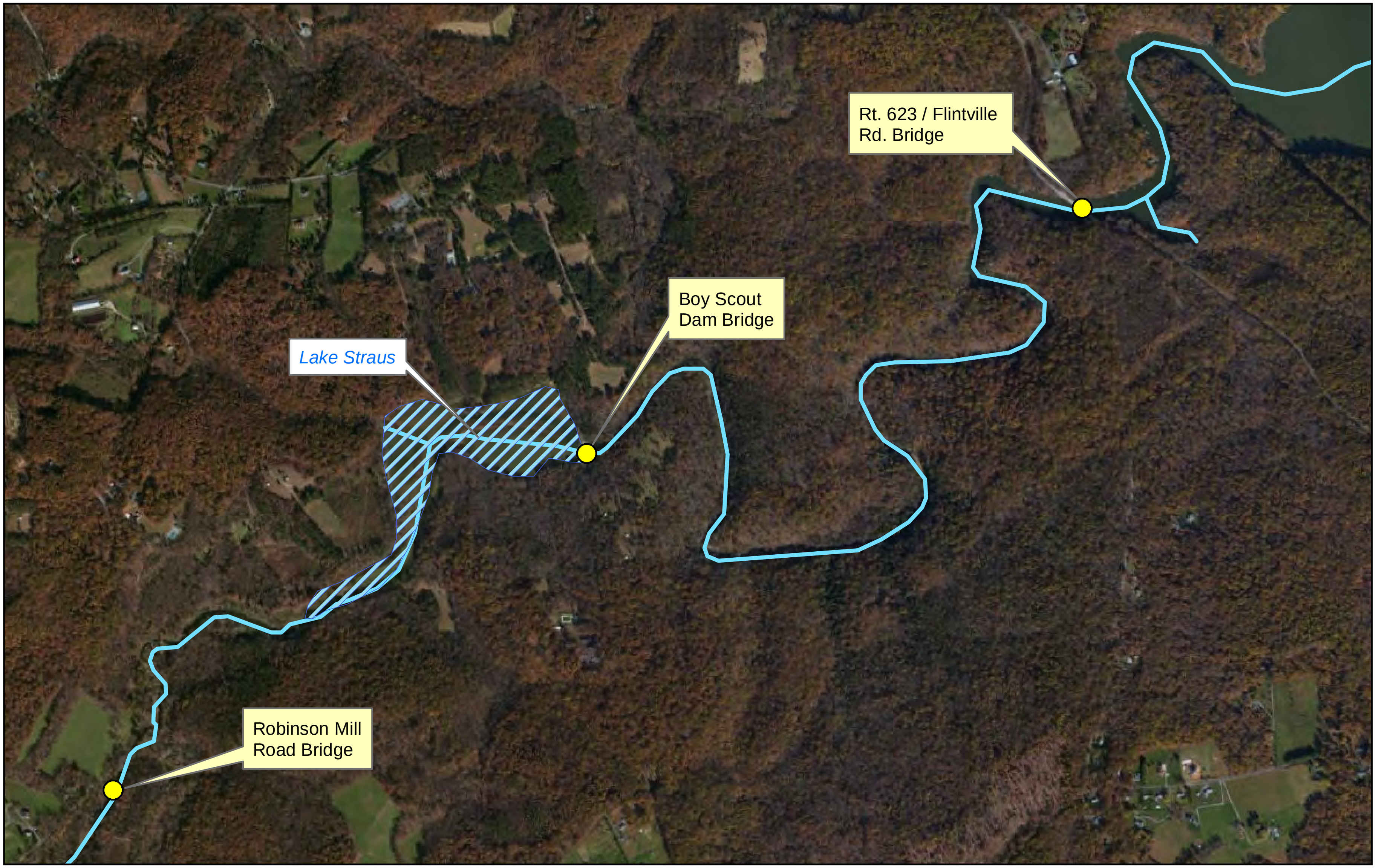
PROJECT NO. 405

1 inch = 1.3 miles
0 0.5 1 2 Miles

Figure 3-2
Sampling Locations -
Holtwood to Deer Creek

Path: X:\GISData\Sediment Monitoring Plan - 12.04.2013\Integrated Sediment Monitoring Program\Figure 3-2 Conowingo Pond Sampling Locations - 11 x 17.mxd



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1 inch = 1,500 feet

0 375 750 1,500 2,250 3,000 Feet

N

Figure 3-3
Broad Creek -
Potential Sampling Locations

TASK 2.0 – NUTRIENT MONITORING, EXPERIMENTS, AND MODELING

UMCES will be responsible for conducting various nutrient related analyses, experiments, and modeling to determine the nutrient composition of sediment entering and exiting Conowingo Pond, where the sediment is transported to in the Bay, and the effects this may have on Bay water quality. The nutrient component of the Program will be divided into three geographical areas of study including: 1) Conowingo Pond; 2) Suspended particulates at Pond entry (Holtwood and tributaries) and exit locations (Conowingo Dam); and 3) Studies below Conowingo Dam. In addition, this component of the Program will consist of three main tasks:

- Task 2A – Characterization of Conowingo Pond Sediment Deposits – Short and Long Core Chemistry and Data Analysis including SFM Modeling;
- Task 2B – Suspended Particle Characterization; and
- Task 2C – Estuarine Physics/Modeling/Biogeochemistry

Task 2A will involve short-core sediment-water exchange measurements at 13 sites on 2 different dates, encompassing the range of spatial and temporal variability. In addition, 3 more samplings of 8 sites are planned for pre/post scour measurements. Each date a subset of cores from each site will be characterized for pore water chemistry, solid phase chemistry, and diagenetic rate processes (bioavailability) on surface deposits (C, N, P remineralization). Up to 13 long cores will be collected for grain size, dry bulk density, pore water and solid phase chemistry, and diagenetic rate processes.

Chemical characterization of particles entering and leaving Conowingo Pond will be conducted as part of Task 2B. Characterizations will include: forms of P, measurements of N/P production from particulates/diagenesis experiments, and settling rates of particulates.

Task 2C includes both an experimental biogeochemistry component and a field event/modeling component. The experimental biogeochemistry component involves adding Conowingo Pond particulates to cores collected at 4 sites in the upper Chesapeake Bay and examining the release (the bioavailability of P and N) under realistic summer temperature and oxygen conditions. This will involve multiple incubations of >20 cores (including controls), with net fluxes measured as well as changes in pore water P, N, Fe and S species. These data will be input into the SFM stand-alone model platform. The field event program will follow the fate of particulates as Conowingo Pond flooding impacts the Bay on 2 occasions. Physical parameters, suspended particulate concentrations, and water column dissolved and particulate species will be measured. Particulate nutrients and sediment-water exchange before and after settlement of Conowingo Pond particulates will also be measured. These measurements will be used to calibrate ROMS sediment transport modeling of the upper Bay in order to better understand the fate and effects of particles in the upper Bay.

Detailed descriptions of each task are included below.

Task 2A – Characterization of Conowingo Pond Sediment Deposits

There are two main field components to the work in Conowingo Pond. Long cores will be used to characterize physical, biogeochemical, and geochronological characteristics of the deeper sediment deposits and short cores will characterize surface deposits and the net exchange of nutrients and gases across the sediment-water interface. The long-core sediment collection will need specialized expertise in vibracoring that neither UMCES nor MGS possesses. Exelon will be responsible for obtaining a contractor to collect the long cores in cooperation with UMCES and MDNR. Collection of the short cores will require an undistributed sediment-water interface. Given that UMCES has had success in the past with collecting short cores via a light box core method in Chesapeake Bay and a number of reservoirs, they will be responsible for the collection of all short cores.

Sediment-Water Exchange

At water depths >2-3 m, box cores will be used for sediment-water exchange, pore water chemistry, and diagenesis experiments. In coarser shallow sediments, UMCES may utilize pole coring devices that will allow sampling short core collection in these more difficult environments. These boxes are subcored with 2.5 inch id core liners to a sediment depth of ~15 cm, with ~15 cm of overlying water. It is anticipated that a total of 58 station occupations will be done over time, with 13 sites done in fall or spring (depending on timing of funding), 13 in late summer, and 8 sites used for 3 more event-related sampling events (i.e. before scour, after scour, 6-8 weeks after scour). Sampling sites will be determined by consultation with Exelon and USGS personnel with the goal of collecting deep cores ~3-4 m long.

UMCES sediment-water techniques have been employed successfully in a number of Chesapeake Bay environments (Kana et al. 2006, Wazniak et al. 2009, Cornwell and Owens 2011, Gao et al. 2012). UMCES core incubations have compared well to larger, in situ core incubations (Cornwell et al. 2008), and in recent years UMCES has carried out experiments in San Francisco Bay (Cornwell et al. 2014), coastal Maine, Puget Sound, the Delaware River and Delaware Bay wetlands (Owens and Cornwell 2010). The key to getting good results starts with collecting cores with an intact interface and not stressing the core with too much physical disturbance or stress from altered oxygen or temperature during transport. UMCES incubation procedures are outlined in Table 3-3, and consist of time course incubations of sediment with sampling of the overlying water. Solute fluxes have been measured in the Chesapeake Bay for many years (Callender 1982, Boynton and Kemp 1985). UMCES' main contribution to this work has been the addition of high precision gas analyses using gas ratios (Kana et al. 1994). By using changes in the N_2:Ar and O_2:Ar ratio, changes in both gases can be examined with a precision of 0.02%. At the end of incubations, all cores are photographed.

In approximately half of the cores, UMCES will examine detailed near-surface pore water concentrations. Sampling depths from the flux cores will generally be 0-0.5, 0.5-1, 1-2, 2-3, 4-6 and 8-10 cm. Analytes will include soluble reactive P, ammonium, nitrate, sulfate, chloride, iron and hydrogen sulfide. UMCES will use oxygen microelectrodes (Revsbech et al. 1980) to measure the penetration of oxygen into the sediment; depth intervals are 0.1 mm, controlled by an automated Unisense measurement system (http://www.unisense.com/). The solids from these pore water cores will be used for chemical analyses of the forms of P, C, N, S and Fe (Table 3-4). On all flux cores, surficial C, N, total P and chlorophyll a will be measured (top 0.5 cm). The top 2 cm of a core from all of the flux sites will be characterized using slurry incubations ("diagenesis"). Slurry depth sections will also be characterized for grain size and for coal carbon following Johnson and Bustin (2006). Coal will be estimated as the total C via CHN analysis after HCl hydrolysis and peroxide oxidation.

Long Core Characterization – Physical Parameters, Chemistry

One of the two vibracores from each site will be subsampled for sediment to be used for pore water chemistry and solid phase chemistry (Table 3-4), as well as for diagenesis experiments (see next section). Subsampling will be a challenge due to the fact that UMCES would like to have a minimum oxidation of sediment for biogeochemical parameters. At the Horn Point Laboratory, cores will be split lengthwise and samples rapidly placed in a N_2-filled glove bag and placed into centrifuge tubes. UMCES anticipates sampling depths of 0.25, 0.5 and 1 m in the upper core and 2-3 more depths deeper in the cores. Under N_2, UMCES will transfer this sediment into centrifuge tubes for pore water analysis and into serum bottles for diagenesis experiments. The solid phase will be analyzed for the UMCES suite of nutrient elements. UMCES will measure both grain size and coal-carbon analyses. Table 3-5 outlines the whole program.

Diagenesis Experiments – A Measure of Nitrogen and Phosphorus Bioavailability

Perhaps the most important measurement in this program is the bioavailability of Susquehanna River and Conowingo Pond organic matter. It is the decomposition of organic matter that produces inorganic forms of C, N and P. In the aquatic realm, both organic matter quantity and quality are generally thought of. In general, there is a gradient of reactivity of organic matter in estuaries, with terrestrially derived matter often being much more prone to decomposition than the more labile organic matter produced by algae (Bianchi 2007). There is also a large difference in the reactivity of organic matter as it ages, with much lower rates over time (Middelburg 1989, Zimmerman and Canuel 2002). While ratios of C and N can be an indicator of the lability of organic matter, more often stable isotopes of carbon are used to differentiate organic matter derived from terrestrial versus marine sources (Cornwell and Sampou 1995, Bianchi 2007). The use of C is also problematic because of the presence of unreactive coal from historic mining inputs'; as part of this Program UMCES will assess coal content in long core samples to see if normalizing rates to non-coal, non-carbonate C helps relate the data to organic C concentrations.

The bioavailability of particulate P has been the subject of hundreds of publications (Pacini and Gachter 1999, Uusitalo et al. 2000, Ellison and Brett 2006, Deborde et al. 2007, Andrieux-Loyer et al. 2008, Hartzell et al. 2010) and is of relevance in streams, rivers, lakes, reservoirs and estuaries. Most approaches involve chemical extractions that identify a number of different forms of inorganic P in the solid phase (Williams et al. 1971, Liebezeit 1991, Ruttenberg 1992), often including forms bound to iron oxides, carbonates, and aluminum oxides, or as organic P. In the Chesapeake Bay, this approach has been applied to suspended sediments along the bay axis (Conley et al. 1995), the Potomac River (Cornwell 2007), to bottom sediments in the mid/lower Bay (Nelson 1967), and several tributaries (Hartzell 2009, Hartzell et al. 2010, Hartzell and Jordan 2012). Alternatively, distributions of inorganic P relative to iron oxides and iron sulfides have been made in a correlative way (Bryner 2000, O'Keefe 2007). Other than chemical extractions, split-chamber determinations of algal-available P have been made with algal cultures exposed to suspended sediments (DePinto et al. 1981). UMCES P bioavailability will be related to total inorganic P in suspended particulates, P release during sediment diagenesis experiments, and through direct experimentation of material added to cores.

Approaches to the measurement of the reactivity of organic matter and its constituent elements (C, N, and P) generally involve a long-term incubation of sediment. The best Chesapeake Bay data set for organic matter reactivity is from the southern Chesapeake Bay (Burdige 1991), a data set used for model calibration for the early versions of the current Bay model. There are a number of approaches to making these measurements:

- Sediment slurries: These incubations involve diluting volumes of sediment with 5-20 fold more water (anoxic) in a serum bottle held at the appropriate temperature. These work especially well with freshwater sediments because such environments produced methane which is readily measured from the bottle headspace. A time course of decomposition is followed, generally for 1-6 months. In this program, UMCES would look at changes in carbon (CO_2 + CH_4), nitrogen (NH_4^+), and soluble reactive phosphorus (SRP). The potential for enhancement of rates by slurrying has been suggested (Burdige, 1989).

- Tube packing: In this, homogenized sediment is put in multiple centrifuge tubes which are sacrificed over time with solute analysis after centrifugation. This approach has been used in model calibration in the northern Chesapeake Bay and has been employed by UMCES in San Francisco Bay and elsewhere. In several instances, some heterogeneity between different tubes has been observed and this technique does not allow sampling for the CH_4 generated in freshwater sediments.

- Suspension of intact core sections in larger volumes of water (Aller and Mackin 1989): While this approach has some advantages over slurries, it may not scale up to the number of analyses anticipated.

For this program, UMCES will use sediment slurries. It is optimal for freshwater environments, but works just as well in salt water. UMCES anticipates that a given sample, either sediment or concentrated suspended materials, would be incubated for ~180 days, with sampling at 0.5, 2, 4, 8, 12, 16 and 26 weeks for NH_4^+, SRP, CO_2 and CH_4 at each time point. UMCES would also assess dissolved iron and sulfide at the end of the experiment, as well as make a final determination of dry sediment mass. Especially at the early stages, UMCES will also use a fiber-optic oxygen system to make sure the system was driven anoxic (FireStingO_2 system, Pyro Science, Inc.). UMCES will also compare the speciation of solid phase inorganic and organic P at the beginning and end (Aspila et al. 1976). Methane will be measured on the headspace by gas chromatography (Shimadzu FID GC), DIC (CO_2) will be measured in the water by syringe gas stripping followed by TCD gas chromatography (Stainton 1973), and both ammonium and SRP by colorimetry (Parsons et al. 1984). Replicate incubations will be made on 10% of samples.

UMCES will also conduct long-term decomposition experiments on several Conowingo Pond suspended sediments, with the water kept aerobic (by bubbling or on a shaker with a headspace). This will provide information on whether there are any aerobic water column releases of N or P in time frames relevant to initial inputs to the Bay, prior to permanent deposition. Both fresh and salt water experiments will be conducted.

The general numbers of incubations for diagenesis/reactivity are described in each section. This program will consist of 50-60 incubations for the long cores, ~40 for the surficial sediments from the reservoir flux program, and ~150 for the suspended sediment characterization (inflow to Conowingo Pond, efflux from the Pond, Exelon tributary sampling, and suspended and bottom sediments in the Bay). The large sample load and associated logistics of collecting this disparate suite of samples will require a high level of project coordination.

SFM Modeling

A sediment biogeochemical model (SFM) has been successfully applied as a stand-alone tool for analysis of biogeochemical processes associated with measured sediment-water solute fluxes and for simulating consequences of changing environmental conditions for a wide variety of Chesapeake Bay sites across the full salinity gradient (Brady et al. 2013, Testa et al. 2013). SFM is a two-layer representation of sediment biogeochemical processes that simulates carbon, nitrogen, phosphorus, oxygen, silica, and sulfur dynamics. SFM has been successfully utilized in diverse Chesapeake Bay environments under different conditions (e.g., temperature, salinity, oxygen, and depth) to understand sediment responses to particulate matter deposition (Testa et al. 2013, Brady et al. 2013). The model is also designed to simulate biogeochemical processes in non-tidal freshwater environments such as ponds, reservoirs and lakes (DiToro 2001). UMCES has recently validated this model against observations to reproduce observed seasonal, spatial, and inter-annual variability in the sediment-water fluxes of oxygen, ammonium, nitrate, phosphate, and dissolved silica. Recently, model formulations for key processes, such as denitrification and solid-dissolved phase phosphorus dynamics, have been improved to yield greater predictive skill across habitats and conditions in Chesapeake Bay (Testa et al. 2013). At the core of this modeling approach is the dynamic simulation of the depth of the aerobic layer, which allows for a quantification of aerobic and anaerobic processes occurring in response to the deposition of both particulate material containing organic and inorganic forms of carbon, nitrogen and phosphorus. The model is forced by particle deposition rates and overlying water conditions, making it an ideal tool to simulate sediment biogeochemical processes for particulate material trapped behind the Conowingo Dam and discharged to the upper Chesapeake Bay.

UMCES will apply SFM to understand rates and controls on nutrient storage, biogeochemical transformation, and release for sediments trapped behind the Dam. Sediment model simulations will be calibrated with measurements of sediment-water fluxes of oxygen and dissolved nutrient, porewater chemistry, and organic matter reactivity. SFM will be used to understand the underlying processes regulating nutrient retention and release for sediments in Conowingo Pond. To accomplish this task, UMCES anticipates the need to assess key aspects of sediment biogeochemistry including the parameterizations of phosphorus solid-particle interactions and kinetic controls of nitrogen cycle processes (e.g., ammonium regeneration, nitrification and denitrification) that occur in this unique freshwater environment.

The modeling activities described above will provide two essential components to the overall Program. First, the models will analyze and synthesize the biogeochemical and geological measurements made as part of the Program, and thus maximize the utility of this new information about the water quality impacts of discharges from the Pond. Secondly, the sediment biogeochemical model simulations will test the importance of key processes rates (e.g., phosphorus cycling), reaction coefficients (organic matter decay), and particulate nutrient pools that can inform the modeling scenarios simulations done by the Chesapeake Bay Program (e.g., Cerco et al. 2013). Overall, the model simulation described will integrate, analyze, and extrapolate the observations made by the other components of this Program to achieve a system-wide understanding of particulate nutrient dynamics in Conowingo Pond.

The primary boundary and forcing conditions for SFM include particulate organic matter (POC, PON, POP) deposition rates and overlying water nutrient and oxygen concentrations, as well as salinity and temperature. These data will be derived from multiple sources. Observations of POM deposition rates which have been made in Conowingo Pond previously (Boynton et al., unpublished) will be used to initiate an optimization routine that estimates the POM deposition rate by minimizing the model-observation mismatch using the NH_4^+ fluxes. Overlying water concentrations and conditions will be linearly interpolated to represent the year based on observations made during the 5 biogeochemistry field campaigns, as well as measurements made at a long-term monitoring station (CB1.0) just south of Conowingo Pond. Sediment concentrations of particulate and dissolved nutrients will be initialized with a 15-year simulation using a repeated annual simulation based on long-term conditions at CB1.0 and the previously-observed POM deposition rates.

Table 3-3: Sediment-Water Exchange Incubation Procedures

Core Collection	Direct insertion of 4" id tube into sediment, capped underwater with a PVC insert with an o-ring seal. Cores were kept out of sun in cooler on deck. Cores are translucent PVC, allowing acid cleaning if needed.
Water collection	Whole water collected in 20 L carboys
Incubator	Temperature controlled room at Horn Point Laboratory
Pre-Incubation	Upon arrival at lab, cores are placed into the incubator. Filtered overlying water is added to the chamber to a level above the cores. T-shaped bubblers are added to pump water from cores into overlying water bath water, circulating and aerating the water. This promotes oxygen saturation and thermal equilibrium. The pre-incubation period is generally overnight, though periods as short as 2 h work well.
Setting up the experiment	The cores are capped with o-ring sealed spinning tops; the spinners consist of Teflon-coated magnets. Care is taken to exclude bubbles. When the tops are in place, the input ports on the top are attached to tubes leading from the replacement water tank, whose bottom is placed ~1.5' higher than the core tops. A magnetic turntable is switched on to commence stirring. Between sample points, a black plastic sheet is put over the top to shield the cores from light.
Gas Sample Collection	At appropriate intervals, samples are collected for gas analysis. An 8" tube is attached to the outlet of the core, the replacement water valves are opened, and a 7 mL ground glass stoppered tube was filled to overflowing, from the bottom of the tube, using gravity to push water out of the core. Sample tubes are overflowed with approximately 2 sample volumes and the 3rd volume was the sample to be analyzed. 10 µL of 50% saturated $HgCl_2$ was added as a preservative. The samples are kept under water in a cooler until analysis; the temperature was ≤ ambient temperature. Samples are analyzed within 1 week of return to Maryland.
Solute Collection	A 20 mL syringe barrel is attached to the core outlet, the replacement water valves are opened, and the barrel filled to the top. The plunger is inserted and the syringe removed. All valves are closed. Samples are filtered through 0.4 µm pore size 25 mm diameter syringe filters. Samples are frozen immediately after collection and kept frozen until analysis.

Table 3-4: Pore Water and Solid Phase Chemistry

Analyte	Technique	Reference
Pore Water		
SRP - orthophosphate	Phosphomolybdate colorimetry	(Parsons et al. 1984)
NH_4^+	Colorimetry	(Parsons et al. 1984)
$NO_3^- + NO_2^-$	In freshwater, ion chromatography In salt water, colorimetry	(USEPA 1979)
Fe	Colorimetry	(Gibbs 1979)
SO_4^{2-}, Cl^-	Ion chromatography	(USEPA 1979)
H_2S	Colorimetry	(Cline 1969)
Solid Phase		
Total C, N	CHN analyzer	(Cornwell et al. 1996a)
Total and inorganic P	Acid extraction, colorimetry	(Aspila et al. 1976)
Inorganic C	Acidification, gas chromatography	(Stainton 1973)
Coal C	HCl hydrolysis, peroxide oxidation followed by CHN analysis	(Johnson and Bustin 2006)
FeS, FeS_2	Acid, Cr(II) extraction, H_2S titration	(Cornwell and Morse 1987)
Percent water	Drying @ 65°C	

Table 3-5: Long Core Biogeochemistry

Procedures/Measurements – Long Cores	Rationale/Concerns	Methodology
Site selection	A suite of 13 sites have been identified by the overall assessment group.	Choices reflect depositional and erosional environments throughout the reservoir
Collection procedures	Long profiles will provide a window into sediment chemistry of deposits that may be eroded or permanently buried	A contractor will use gravity/vibracoring to obtain 3-4 m long cores
Subsampling	After visual examination of the sediment profile, UMCES will select 6 depths for analysis of pore water/solid phase chemistry and use 4 of those depths for sediment "diagenesis" workup. Profiles will be photographed.	UMCES will split the core open and subcore with cutoff plastic syringes that are immediately placed into a N_2 filled glove bag for subsequent analysis.
Pore water chemistry	Will aid in modeling, will help in assessing direct ammonium inputs via resuspension	A glove bag will be used to minimize Fe oxidation and allow dissolved P analysis. The suite of parameters is in Table 3-4.
Solid phase chemistry	The carbon, iron, phosphorus, coal contents will be determined to aid in interpretation of diagenesis results. Percent water and grain size will be determined.	UMCES will measure coal, via HCL + peroxide digestion followed by CHN analysis. See Table 3-4.
Diagenesis	These will be carried out at greater depths (> 0.15 m) since UMCES will use less disturbed box coring for diagenesis samples <0.5' during the short core sampling operation.	Detailed in text
Total program	With 13 cores, UMCES will analyze ~52 sections for diagenesis, 78 for pore water and solids. With 7 time points, UMCES will have 363 diagenesis time point samples for 5 analytes.	

Task 2B – Suspended Particle Characterization

This UMCES program is designed to assess the character of the particulate materials that are exiting past the Conowingo Dam under moderate high flow conditions (>100,000 cfs) and is a key part to the overall physical/geological/biogeochemical program. This task includes 2 parts; the first is the experimental determination of settling velocity on suspended sediments exiting the Conowingo Dam while the second is the characterization of particulate phosphorus from USGS and Exelon collected sediments and measurement of the rates of organic matter decomposition and nutrient release from sediments collected from upstream inputs, tributary inputs, and exiting the Conowingo Dam. Specifically, UMCES will work in concert with USGS and Exelon as they collect particulate samples to get a maximum value from each of the particulate sample sets. This program is a key link between the biogeochemical-sedimentological characterization of deposits behind the Conowingo Dam and understanding the behavior of these particulates once they enter the Chesapeake Bay.

Logistics

The logistics will be shared by the two UMCES principal investigators (PIs) assigned to this task. Given the need to mobilize efforts during high flow events, UMCES will have both PIs and two faculty research assistants available for sampling. During summer months, interns will also be available as "extra" personnel. USGS and Exelon will be sampling each event once per day over the course of the event, UMCES will have at least 1 person on site for the duration of their sampling. While chemistry work can be done with samples brought to UMCES, the settling work (performed only on Conowingo Dam collections) requires on-site rapid processing. UMCES will work with USGS to assure that UMCES personnel return with all settling experiments and sample from all collections, including the two upstream sites. UMCES will work with USGS and Exelon personnel to assure that UMCES personnel return with samples from all settling experiments and all bulk water collections, including the two upstream sites.

Nutrient Analyses

The UMCES chemistry program is designed to enhance the USGS analytical suite, with analyses of both total and inorganic P, as well as extractable iron. All samples from all Exelon/USGS particulate collections (~108 samples) will be analyzed, as well as the rapid/slow settling components derived from the settling tube experiments (an additional 24 samples analyzed for 2 splits). The USGS originally was planning on sending the total P analyses to the CBL Analytical Services Laboratory; those analyses will now be carried out at UMCES HPL with two key additions: inorganic P and HCl-Fe. The inorganic P component will allow a determination of the split between organic and inorganic components of the sediment; these two components have very different biogeochemical pathways. It is expected that the dominant form of P will be inorganic P associated with Fe oxides (Hartzell et al. 2010), consistent with observations UMCES has made in the tidal Potomac River (Cornwell 2007). The iron analysis will help interpreting the form of P association with the sediment. UMCES will also characterize the carbon and nitrogen content of the fast and slow settling experiments with CHN analysis at the Horn Point Laboratory (http://www.umces.edu/hpl/analytical-services). Phosphorus analyses will be replicated at the 10% level. Analyses will be cross-compared on 5% of samples with analyses at the Chesapeake Biological Laboratory (where MDNR and USGS have analyses carried out).

Further analyses of some of the particulate material will be carried out identically to the Conowingo/Chesapeake Bay sediment analysis program and will include selected analyses of citrate-dithionate reducible Fe and P (Cornwell 2007, Jordan et al. 2008), as well as estimates of the production rate of dissolved N and P from incubated particulates (Aller and Mackin 1989, Burdige 1991, Cornwell and Owens 1999). Dissolved inorganic carbon and methane production will also be assessed in these experiments, providing carbon to nitrogen decomposition ratios. These decomposition experiments will be carried out over 6 months, with sampling at 0.5, 2, 4, 8, 12, 16, and 26 weeks.

This measurement program will provide key information linking the character of short and long-term storage of sediments in the Conowingo Pond with the material moving across the Dam. The chemical characterization of slow and fast-settling particles will also be key in considering what sediment components are likely to reach the mid-Bay, where iron associated phosphorus is highly like to be released (Boynton 2000, Cornwell et al. 2000).

Suspended Sediment Biogeochemical Characterization

A description of the components of this sub-task can be found in Table 3-6.

Settling Velocity Analyses

One of the most important factors controlling the fate of suspended sediments flowing over Conowingo Dam is the rate at which they settle, which is determined by the sediment settling velocity distribution. Slowly settling particles travel a long distance before deposition, while rapidly settling particles deposit as soon as the flow slows (e.g., leading to the formation of the sandy, shallow Susquehanna Flats delta). Knowledge of suspended sediment disaggregated grain size under different flow conditions (already part of the USGS sampling program) helps to address this question, but it is inadequate by itself to determine settling behavior because of ubiquitous clumping, or flocculation, of fine particles. Present sediment transport models have used available information to assign settling velocities to modeled sediment particles to achieve reasonable agreement with downstream observations, but there are no independent data on settling velocities to which assumed distributions may be compared.

Settling velocity distributions will be estimated for each of the event hydrograph samples obtained by the Exelon/USGS Conowingo Dam sampling program. As planned, this will be 4 times per event over 6 events; however, depending on the duration of the event it may be more or less than 4 times. Settling velocity distributions are determined by employing 2 versions of an Owen-style settling tube, both of which have been employed successfully in previous upper Bay studies (Sanford et al. 2001, Malpezzi et al. 2013). Two 5 L suspended sediment samples will be required for each set of experiments. Settling experiments will be performed within minutes of obtaining the samples to avoid further changes in flocculation state. The experiments take approximately 80 min each, with bottom withdrawals occurring at geometrically spaced time intervals. Data analyses will follow recent techniques (Malarkey et al. 2013, Malpezzi et al. 2013) based on the original technique developed by (Owen 1976). The more frequently sampled experiment offers higher resolution of the settling velocity distribution but insufficient sample size for determination of biogeochemical properties associated with different settling velocity classes. The less frequently sampled experiment only resolves fast and slow settling fractions, but collects sufficient material to enable biogeochemical characterization. Comparison of the settling velocity distributions measured with the settling tubes to those estimated based on disaggregated PSD measurements determined concurrently by the USGS (Task 1) will allow estimation of the effects of flocculation.

Analysis of the settling velocity distributions and comparisons to grain size, river flow, and particle biogeochemistry will allow better estimation of the number of modeled particle classes required, appropriate parameterizations for their settling velocities, and relative concentration distributions to assign to each class. Collecting data over a range of flow conditions will allow extrapolation to higher flows than are expected to be observed. These analyses will allow better modeling of particulate nutrient and geochemical transport. An important part of this study will be review of existing data on flow, concentration, and grain size, to extend the direct results.

Table 3-6: Suspended Sediment Biogeochemical Characterization

Analysis	Description	Reference
Total and Inorganic P	Total P is analyzed on ashed sediment, with a HCl extraction. The extract is analyzed colorimetrically (phosphomolybdenum blue). Inorganic P analysis is similar, without the ashing. The difference between the two techniques is an estimate of organic P.	(Aspila et al. 1976). We have extensively used this technique on Chesapeake Bay sediments (Cornwell et al. 1996) and will be comparing these numbers directly to bay sediment numbers.
HCl-Fe	1 N HCl extraction, AAS. This is a measure of the total available Fe in the sediment and mostly consists of iron oxides.	(Leventhal and Taylor 1990)
Diagenetic production of NH_4^+, SRP, CH_4 and DIC	Slurry experiments will provide volumetric and vertical profiles of the production of these species.	(Aller and Mackin 1989, Burdige 1989, 1991, Cornwell and Owens 1999)

Task 2C – Estuarine Physics/Modeling/Biogeochemistry

The biogeochemical impacts of suspended sediments entering the Chesapeake Bay over Conowingo Dam depend on their nutrient content and bioavailability, but also on where these sediments are deposited. If most of the sediments are trapped inside the Estuarine Turbidity Maximum (ETM) zone in the upper Chesapeake Bay, their biogeochemical and water quality impacts are likely limited; however, if they are transported beyond the ETM and reach the mid-Bay where summer hypoxia occurs regularly they could exacerbate water quality problems significantly.

Flood Response Field Studies

The core of the field studies proposed here are a sequence of rapid-response cruises through the upper Chesapeake Bay during 2 of the 6 proposed event samplings. These cruises are purposely limited in number because they are expensive, difficult to organize, and potentially dangerous. They will take place on the UMCES research vessel Rachel Carson, pending availability and safety assessments for each potential event. As soon as possible after initiation of the chosen events, the Rachel Carson will transit to Sandy Point State Park, where it will be met by members of the science party. A sequence of transits up and down the upper Bay will be carried out.

On the way up the Bay, UMCES will maximize spatial resolution and minimize transect duration by stopping at approximately 12 stations for Conductivity-Temperature-Depth (CTD) casts and rapid water samples. The CTD instrument measures salinity, temperature, turbidity, fluorescence, pH, and DO profiles through the water column. Water samples will be collected on the up-Bay transect primarily for calibration of the various sensors on the CTD. On the way down the Bay, UMCES will stop at several (~4) locations to carry out detailed measurements of rate processes and particle characteristics. These will include data on particle settling characteristics, size distributions, and turbulence. Settling tube samples will be collected to determine nutrient distributions on particles settling at different rates (similar to those carried out at the base of the Dam). Water samples will be collected for analysis of a full suite of nutrient concentrations, suspended sediment, POC, radionuclides, and chlorophyll concentrations at 2-3 depths. Velocity profile information will collected using a downward-looking Acoustic Doppler Current Profiler (ADCP) mounted in the ship's hull. Two up-Bay and down-Bay transects will be completed during each cruise.

The VIMS profiler, equipped with a minimum of a Particle Imaging Camera System (PICS), a Laser In-Situ Scattering Transmissometer (LISST), a CTD instrument, and a submersible pump, will be deployed at the 4 anchor stations during the return trips down the Bay, for a total of 8 profiles per cruise. During each profile at least 2 depths will be sampled with the PICS, LISST, CTD and submersible pump, one in the top half of the water column and one in the bottom half. The profiler is kept at each sample depth for approximately 2.5 minutes to collect LISST "bursts". With a sample rate of 1.5 Hz, at least 100 records will be collected to allow for burst averaging. The LISST measures the volume concentration particle size distribution from 2.5 to 500 microns. Within the time period of each sample "burst", a water sample will be collected using the submersible pump and later analyzed for suspended solids concentration (weight/volume). The sample inlet will be at the same height on the profiler as the LISST. Prior to starting the LISST burst, just as the profiler reaches sample height, the ball valves will be closed to capture water for the PICS. The PICS measures particle size and settling velocity distributions of particles greater than 30 microns on a volume concentration basis. The particle size distributions are combined with LISST measurements to obtain the full spectrum of particle sizes. The observed relationship between particle size and settling speed in the PICS allows calculation of particle bulk density as a function of size, which in turn can be used to estimate the particle size distribution on a mass concentration basis.

Because of the expected complexity of the flood response cruises and the importance of obtaining high quality data in both cruises, a "shake-down" cruise will be carried out as early as possible following initiation of the Program. This cruise will follow all of the proposed protocols for the flood response cruises, but will only complete 1 up-Bay transect and 1 set of down-Bay anchor stations. This cruise will also provide comparative data under normal flow conditions.

Following the rapid-response water column cruises, coring cruises will be carried out in the upper Bay and mid-Bay to characterize the spatial patterns of sediment, particulate nutrient, and POC deposition at the end of each event, and to provide sediment samples for biogeochemical flux experiments (sediment- water exchange). One high deposition site will be monitored during fair weather as part of a Maryland Sea Grant program that involves several of the UMCES PI's; that program will provide estimates of sediment-water exchange prior to floods. After flooding, this high deposition site plus 5-6 will be sampled for sediment-water exchange and characterization of surficial flood deposits. UMCES will use a HAPS corer (http://www.kc-denmark.dk/products/sediment-samplers/haps-corer/haps-core.aspx) for sampling deposits to 20 cm. Sediment will then be analyzed for grain size, organic content, and the presence of naturally occurring radioisotopes. In particular, ^{7}Be will be used as an indicator of recently eroded terrestrial material, as in Palinkas et al. (2014).

Figure 3-4 denotes the proposed locations where the Bay cores will be collected. Sites are based on proximity to long-term sediment study sites and previous work by UMCES on flood thickness (right panel of figure). At each location a shallow (<5 m) and deep (>5 m) core location will be selected, both using a HAPS box corer.

Figure 3-5 shows representative down-core profiles from a site in the upper Bay taken after Tropical Storm Lee. As shown in the figure, there is a ~4-cm layer with uniform ^{7}Be, finer grain size (as compared to historical data near the site), and physical stratification in x-radiographs. These are the signatures of flood sedimentation established by many studies around the world and in Chesapeake Bay (Sommerfield et al. 1999, Allison et al. 2000, Dellapenna et al. 2003). Thicknesses of "new" sediment established with these signatures will then be interpolated in ArcGIS to broadly characterize spatial patterns of deposition. This interpolation, though general, is helpful when comparing model simulations to field observations of sediment deposition. Figure 3-5 shows such an interpolation based on coring studies following Tropical Storm Lee.

Bioavailability of Conowingo N and P in Chesapeake Bay Sediments

UMCES will carry out experiments, using their flux core setup to assess the flux of nutrients out of Chesapeake Bay sediments after experimental deposition of Conowingo sediment to the sediment surface. For the flux cores, sediments are sectioned under N_2 gas to minimize oxidation artifacts (Bray et al. 1973). The sediment sections are placed in centrifuge tubes, centrifuged, and the water is filtered prior to storage for analysis. Solids are preserved by freezing and analyzed either after drying at 65°C or from the frozen state (iron sulfide minerals).

UMCES has carried out similar experiments in an anoxic sediment environment near the Chesapeake Bay Bridge (Cornwell et al. 2000). The use of intact cores more readily simulates the conditions after flood sediments are deposited on top of Bay sediments. In previous UMCES experiments the efflux of P after adding 2 and 10 cm of sediment to anoxic cores was simulated, with both water column controls and sediments with no amendment. For this work, UMCES proposes to:

- Collect box cores at 3 Bay locations, bracketing salinities of 0, 2-4 and 6-10, corresponding to existing Bay Program sampling stations and coinciding with station choices for flood response with the upper two sites being aerobic and the lower site having limited overlying water oxygen (in summer). A minimum of 8 cores will be collected at each site, with 1-2 used for initial pore water and solid phase profiles.

- Using bottom water from each site, do an initial sediment flux experiment to ensure that the cores are showing similar rates within a site (based on oxygen demand).

- Add Conowingo Pond sediments to the core surface at a depth consistent with either Hurricane Lee levels or predicted levels from the ROMS modeling. Three cores will receive additions, 3 will be control cores.[16]

- Incubate the cores with appropriate field temperatures and dissolved oxygen, with flux measurements made at intervals of 1, 2 and 4 weeks. The low oxygen set of cores will have anoxic water pumped through them to maintain anoxia. Measurements will include fluxes of SRP (phosphate), ammonium, DIC (dissolved inorganic carbon), nitrate, oxygen (in aerobic cores) and N_2-N.

- At 1 week, sacrifice one control and one experimental core for pore water (nutrients, sulfide, iron) and solid phase chemistry (iron sulfides, forms of P, C and N). At 4 weeks, repeat this to see the long-term effects of sediment addition on sediment composition. UMCES will evaluate 0_2 penetration for aerobic incubations using Unisense oxygen microelectrodes.

This work will be coordinated with the SFM modeling needs. The product of this will be an estimate of how much additional P, and possibly N, are released from Conowingo Pond sediment in different environmental conditions. Site locations will correspond to locations that have long-term bottom water chemistry as well as a history of benthic flux measurements by Boynton and colleagues over many years (Boynton and Bailey 2008).

SFM Modeling of Conowingo-Impacted Chesapeake Bay Sediments

The biogeochemical impacts of Susquehanna River-transported suspended particles trapped in Conowingo Pond and/or transported downstream to Chesapeake Bay depend on their nutrient content and bioavailability, as well as on the local environmental conditions where they are deposited. Because the varied environmental conditions (e.g., salinity, temperature, dissolved oxygen and boundary-layer shear) in different depositional areas exert strong influences on subsequent release of dissolved inorganic N and P, sediment biogeochemical models are necessary for analyzing, interpreting, integrating and extrapolating the ecological effects of these suspended particles after they are deposited.

UMCES analyses and simulations will provide a quantitative analytical and predictive approach for understanding how the *bio-reactivity* of the particulate material and the local environmental conditions in the estuary influence the magnitude of sediment oxygen uptake and nutrient release to overlying water. This is important because the location and timing of the particulate nutrient deposition will impact the potential influence of the material on Bay water quality. For example, material deposited in the northern reaches of the Bay may have a minimal impact on overall estuary health, because these areas of the Bay are generally nutrient-replete (Fisher et al. 1999) and sediment-water fluxes of N and P fluxes are relatively low (Testa et al. 2013). If the material is relatively nonreactive, the effect will be even smaller. On the other hand, if bio-reactive material flowing over the Dam reaches the mesohaline segments of the Bay, where nutrient-limitation is more severe and low-oxygen/high-sulfide conditions occur in summer, efficient recycling of nutrients from sediments (Kemp et al. 1990, Cowan and Boynton 1996) could lead to negative impacts on water quality. Thus, nutrient and oxygen effects from Pond sediments may be large or small depending on particle accumulation rates, particle reactivity, and local environmental conditions.

UMCES will use SFM (as previously described) to simulate and analyze sediment-water fluxes of oxygen, nitrogen, and phosphorus at the sites where sediment biogeochemical measurements are made in the Bay. This application of SFM will require refinements of model processes to improve representations of iron

[16] In addition to the proposed scope, Conowingo Pond sediments may also be added to the core surface at depth's less than those observed during Hurricane Lee or predicted from the ROMS modeling. In the event that this expanded analysis is conducted additional cores would also be collected.

availability and phosphorus-binding capacity and of interactions with sulfur along the salinity gradient of the Bay. The model will also be adapted to include a second pool of particulate organic matter to be processed in sediments. SFM currently has a single pool of POM that represents algal material, which has 3 distinct reactivity fractions that range from *labile* (65% of POM) to *nonreactive* (15% of POM). Because the material originating from Conowingo Pond will be a mix of newly-produced and older material, these reactivity fractions are likely to be different. Thus, this second POM pool will represent the mixed reactivity of this material.

Finally, the recently implemented and tested Chesapeake Bay sediment transport model described below (Cheng et al. 2013) will allow for SFM to receive 2-dimensional depositional fields to predict spatial patterns of sediment-water fluxes and quantify whole-Bay sediment responses to discharge, transport, and deposition of Conowingo-derived particulate matter.

ROMS-CTSM Model Investigations

The proposed coupled hydrodynamic-sediment-transport modeling (ROMS-CSTM) investigation will help determine the river flow, tidal, and wind conditions at which the ETM ceases to trap riverine sediments. Additionally the modeling will predict the transport and deposition of material flowing over the Dam under these conditions. The fine-resolution model predictions of sediment deposition over the estuary's bed will enable the SFM and EPA water-quality model to produce more accurate predictions for the biogeochemical impacts of enhanced sediment loading during storms. UMCES model configuration and model results will be made available to the Corps and the Chesapeake Bay Program. They in turn may consider incorporating the improvements in their next-generation model.

UMCES recent modeling study has shed new insights on the trapping mechanism of the ETM in the upper Chesapeake Bay (Cheng et al., 2013). The creation of ETM has traditionally been attributed to convergence of gravitational circulation (Festa and Hansen, 1978), and estuarine stratification that enhances the trapping of suspended sediment on the seaward side of the salt front (Geyer 1993). However, Sanford et al. (2001) proposed that flood-ebb asymmetries in tidal resuspension and transport are mainly responsible for the maintenance of the ETM in the upper Chesapeake Bay. UMCES model results are consistent with this understanding and shows that the temporal and spatial variations of sediment resuspension and advection lead to a bottom sediment pool near the upper limit of salt intrusion and high suspended sediment concentration in the ETM. In contrast, large river flows such as those experienced during Tropical Storm Lee (2011) pushed the salt front downstream and fundamentally changed the flood-ebb tidal flow patterns. The fine sediments were suspended in the surface layer and transported downstream by seaward estuarine currents. Based on this new understanding of the ETM bypassing in the upper Chesapeake Bay, UMCES proposes to conduct a series of numerical experiments over a range of river flows and determine the threshold conditions beyond which the ETM ceases to be an effective trapping mechanism for riverine sediments.

These numerical experiments will take advantage of the data on particle size, settling velocity, and concentration collected during field sampling efforts to test parameterizations for settling and suspended sediment loading that respond to flood events but return to normal ETM trapping behavior appropriately. The data on suspended sediment, salinity stratification, and flow collected during the upper Bay flood sampling cruises will provide a unique opportunity for comparison to the spatial and temporal distributions predicted by the model. The data on net sedimentation rates collected during the post-flood coring studies will allow comparisons to predictions of deposition from the model as in Palinkas et al. (2014).

Figure 3-4 Proposed Locations of Bay Cores

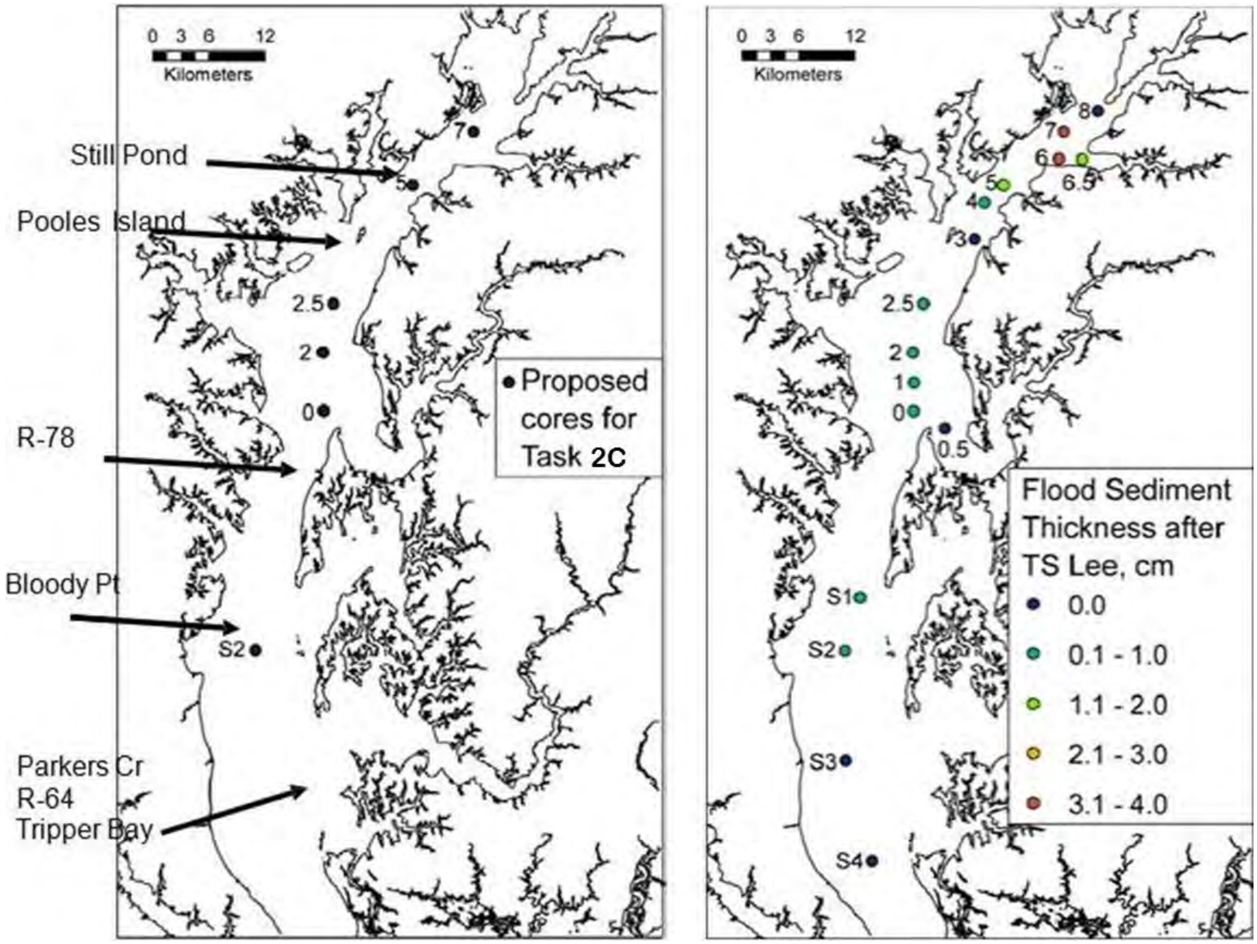
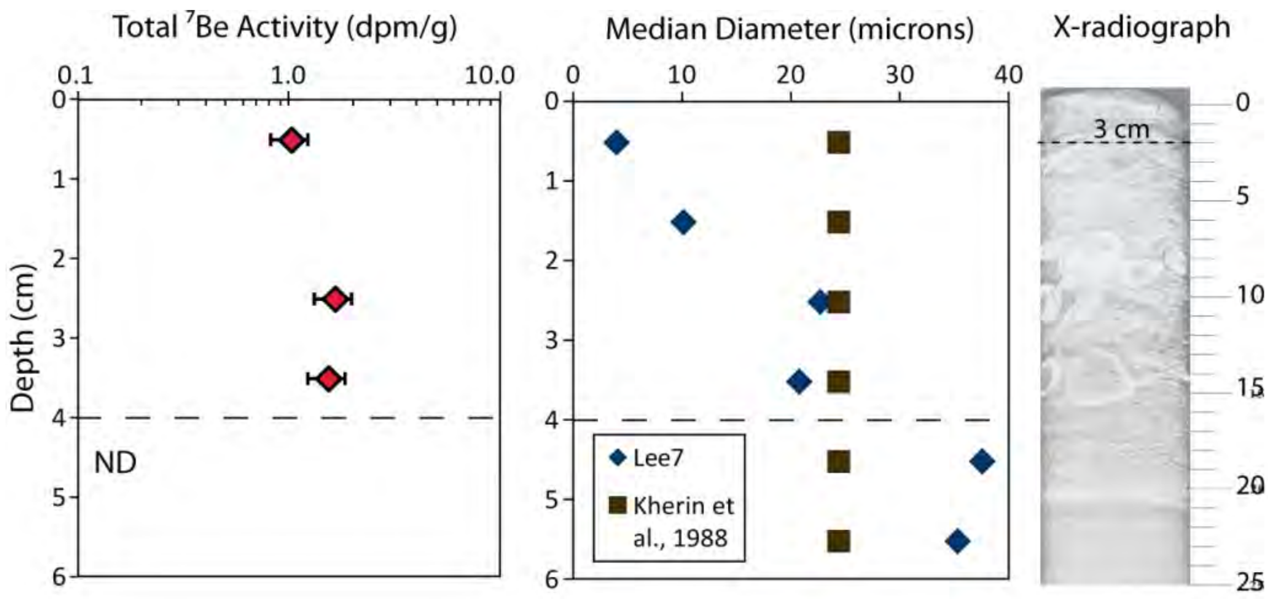


Figure 3-5 Down Core Profile Example



Down-core profiles of ^{7}Be (left) and grain size (middle, median diameter) observed following Tropical Storm Lee at a site in the upper Bay (Lee7). Note that grain size in [Kerhin et al. (1988)] is from a surface grab that would tend to mix the upper ~5 cm of sediment; those data are shown as a sediment layer with uniform grain size though down-core differences likely exist. Grain-size data at Lee7 are from discrete 1 cm intervals. An x-radiograph of the core is shown on the right.

TASK 3.0 – SEDIMENT CORE COLLECTION AND ANALYSES

A combination of long and short cores will be collected in Conowingo Pond and Chesapeake Bay as part of Task 1.0 and Task 2.0. Sediment cores collected as part of this effort will be used 1) to determine the dry bulk ρ of sediment (needed for SSL calculations) and 2) for various biogeochemical analyses to improve our understanding of nutrients in Conowingo Pond and Chesapeake Bay. Details of the biogeochemical analyses can be found under Task 2.0.

<u>Conowingo Pond Cores</u>

Coring Site Selection

A protocol was implemented by the Parties to decide on coring locations (long and short), number of cores (long and short), and the target depths for long cores. Existing GIS layers of Pond section boundaries (upper, middle, lower), LSRWA Adaptive Hydraulics Model (ADH) modeling results (areas of erosion and deposition), bottom bathymetry, bed morphology (in-thalweg and out-of-thalweg), and locations of previously collected cores were used as criteria to constrain preliminary site selection. Program partners agreed on 13 co-located long core and short core sites. These sites represent erosion and deposition areas and are expected to encompass the variability of measured parameters longitudinally in the Pond, at a cross-section, and with depth below the sediment surface.

The preliminary set of coring sites is shown in Figures 3-6 and 3-7. Figure 3-6 depicts the core locations overlaid on the elevation terrain for the 2013 Conowingo Pond bathymetry survey. Figure 3-7 depicts the core locations overlaid on the results of the ADH model scour run. The results of the 2014 side scan sonar survey data will be used to further refine these locations in advance of core collection. Side scan sonar data will be examined to gain a better understanding of the bed morphology at the proposed locations and to ensure proper placement of the cores.

Coring Depth

The Parties agreed that a target depth of 10 feet below the sediment surface for long cores was adequate to meet the objectives of the Program. A comparison of 2008 and 2011 bathymetric surveys suggest recent storm event erosional and depositional areas may are bracketed between -4 and +8 feet. It is believed that 10 feet would characterize material that may be eroded or deposited as a result of a storm event. Cores extracted for biogeochemical analysis will be ≈ 1 ft long.

Coring Methodologies

Long Cores

Coring devices used to retrieve a minimum of 4 feet (whether gravity cores, piston cores, or vibracores) will disturb the continuous record representative of *in situ* conditions to some extent. Disturbances may be due to shortening (the difference between depth of sediment penetration and core length); frictional drag (of sediment against core tube); dewatering; compaction; flow-in distortion (suction at entrance of corer); surface disturbances; and more.

Given the variable sediment types to be encountered in Conowingo Pond (sand, silt, and clay) and water depths (less than ten feet to greater than 30 feet) the Parties agreed the best practical option is to collect the long cores using the vibracore method. Piston cores will not penetrate sands and have limited free fall ability in shallow water. Alpine Ocean Seismic Survey, Inc. (Alpine) will be contracted to collect the long cores throughout the Pond. Alpine will initially deploy the coring device as a gravity core using vibration only as needed thereby reducing unnecessary disturbance. Core disturbance will be assessed and included in the analysis of error and uncertainty.

The laboratory testing of dry bulk ρ to be performed by Exelon is not compatible with the analysis proposed by UMCES. That is, Exelon will have cores cut horizontally while UMCES will split cores length-wise. The UMCES subsampling techniques remove material and do not preserve volume, a parameter which is necessary for measuring dry bulk ρ. Thus, the Parties agreed that two long cores should be collected per vibracore site.

Short Cores

Short cores will be collected from UMCES research vessels using a pole coring device in shallower waters or a lightweight box core (Soutar corer) in water depths >10 ft. Pole coring devices will allow sampling in areas which may have coarser sediments which are more difficult to core. Box cores will be sub-cored with 2.5-inch id (< 1 ft long) acrylic core liners; the pole corer uses these for direct insertion. Thirteen sites will be cored in fall or spring, 13 in late summer, and 3 additional event-related sampling events (*i.e*., before scour, after scour, 6-8 weeks after scour) will occur at 8 sites.

Laboratory Analysis

Geotechnical Analysis of Long Cores (Exelon)

The suspended sediment loads in the Susquehanna River mainstem and its tributaries will be measured directly as a dry mass [in grams or pounds] by multiplying sediment concentration [mass per unit volume] by discharge [volume per unit time] by time interval of the event of interest. To derive the corresponding dry mass of sediment scoured during the event of interest it will be necessary to estimate the dry bulk ρ (dry mass per wet volume) of discrete scoured areas. Dry bulk ρ values measured from sediment cores collected as part of this Program will be used to convert the volume of scoured sediment (wet volume) calculated from pre- and post-storm bathymetry surveys to a dry mass (load).

The mass of scour computed for the sediment budget can be quantified by: 1) applying a uniform value for dry bulk ρ to the total volume of scour or 2) applying different dry bulk ρ values to discrete scoured locations and/or depths based on the empirically measured bulk ρ variability of Pond sediment. To evaluate the appropriate way to apply dry bulk ρ variability in this system (*i.e*., use one value or several), the down-core dry bulk ρ variability will be characterized at each core location as follows:

1. The overall bulk ρ of the entire core will be calculated by measuring overall dimensions and weight.

2. Extruded cores will be visually described.

3. The core will be divided into sections down-core and dry bulk ρ will be calculated for each section.

4. Standard index testing (water content, liquid and plastic limit, particle size, specific gravity, organic content) on the materials from each section will be performed. The ASTMs to be used are D2216, D4318, D422, D854, and D2974, respectively.

Table 3.7 contains a summary of all laboratory analyses to be conducted by Exelon. ASTM D422 will be followed for the particle size analysis with the exception that a #230 sieve will be used to separate sand from mud (silt and clay) at 62.5 microns. The Udden-Wentworth grain size classification scheme will be used to describe particle size.

Biogeochemical Analysis of Long Cores (UMCES)

After visual examination of the sediment profile the core will be subsampled for the analysis of pore water chemistry, solid phase chemistry, dry bulk density, percent water and particle size (at 0.25, 0.5 and

1 m in the upper core and at 2-3 more depths in the deeper core). Diagenesis experiments will be conducted at 4 depths > 0.5 ft. Table 3.7 contains a summary of all laboratory analyses to be conducted by UMCES.

Biogeochemical Analysis of Short Cores (UMCES)

Sediment-water exchange (flux), pore water chemistry, and diagenesis experiments will be conducted on the short cores. In addition, sediment age dating will be accomplished with the use of short-term radionuclides. Table 3.7 contains a summary of all laboratory analyses to be conducted by UMCES.

Coal

Cores collected by USGS in 2000 and analyzed by MGS demonstrated coal is a major component of the sediments deposited in each of the lower Susquehanna River reservoirs.[17] MGS found that coal affected particle size distributions. Sediment studies of Chesapeake Bay have also shown that particulate coal from the Susquehanna River is present in upper Bay sediments and contributes to organic carbon content and elevated carbon concentrations there.[18][19][20]

The Parties agreed that the potential effects of coal should be considered when assessing analytical results. The specific gravity, organic content, and grain size measured in the geotechnical assessment of long cores will provide information on the influence of coal content on measured dry bulk ρ. Additionally, the solid-phase chemistry analysis of long cores and short core slurries (top 2 cm) will include measurements of non-reactive coal carbon (see above), using HCl/peroxide digestion with subsequent CHN analysis (Johnson and Bustin 2006).

CHESAPEAKE BAY CORES

Sediment cores will be taken in the upper Bay as part of the flood response field studies as described in Task 2.0.

A Haps corer will be used to retrieve sediment cores up to 20 cm long. Sediment will then be analyzed for grain size, organic content, and the presence of the naturally occurring radioisotope ^{7}Be. The short-lived nuclide, ^{7}Be will be used as an indicator of recently eroded terrestrial material. At each site a shallow (<5 m) and deep (>5 m) core location will be selected.

Box cores will be collected at 3 Bay locations for nutrient flux experiments. A minimum of 8 cores will be collected at each site, with 1-2 used for initial pore water and solid-phase profiles. Three cores will receive Conowingo Pond sediments and three cores will be control cores. Table 3.7 contains a summary of all laboratory analyses to be conducted by UMCES.

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[17] Hill, J.M. et al. 2006. *Characterization of Bed Sediment Behind the Lower Three Dams on the Susquehanna River*. In: SRBC Publication 239. Appendix A.

[18] Ryan, J.D. 1953. *The Sediments of Chesapeake Bay*. Maryland Department of Geology, Mines, and Water Resources. Bulletin 12.

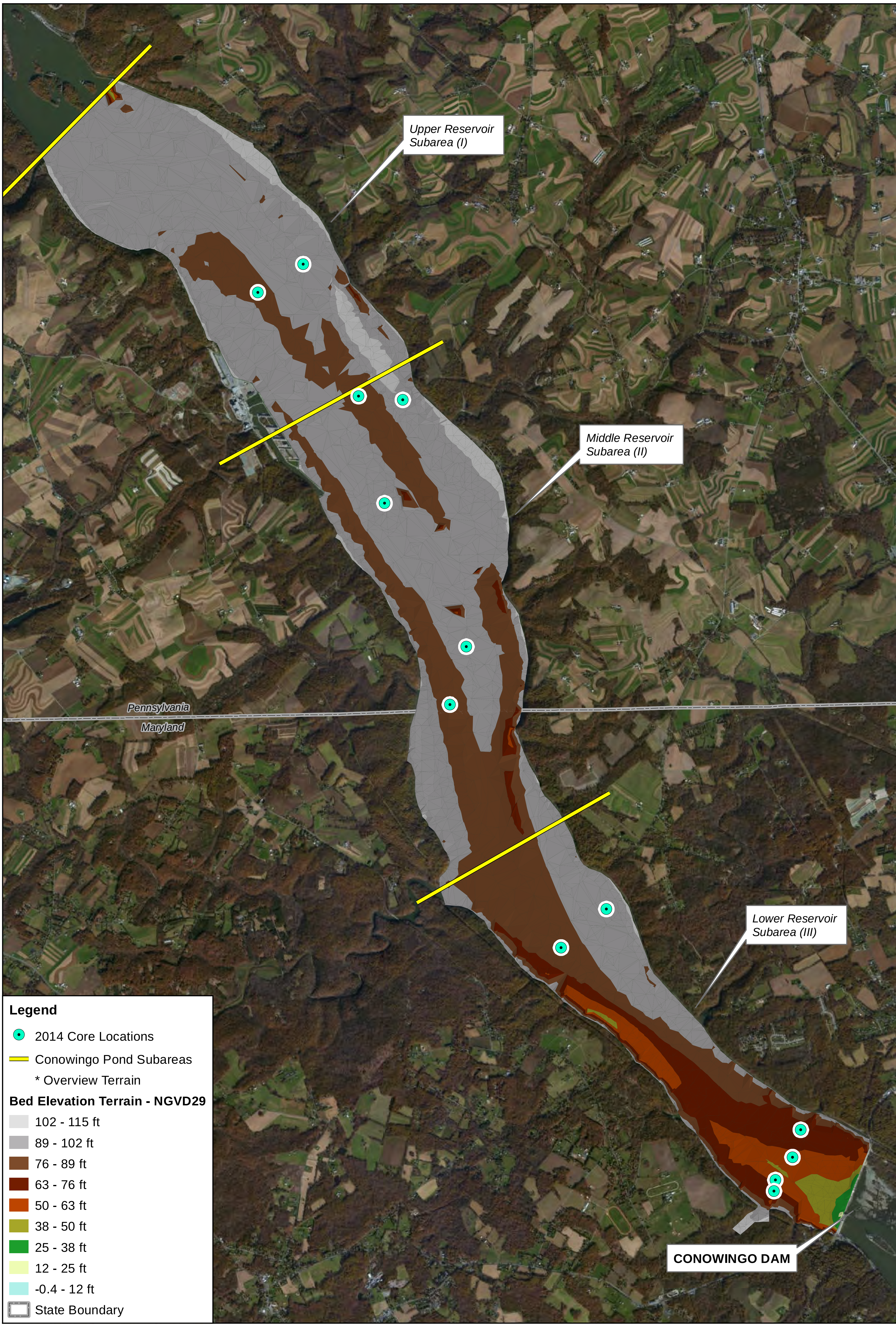
[19] Hennessee, E.L. et al. 1986. *The distribution of organic carbon and sulfur in surficial sediment of the Maryland portion of Chesapeake Bay*. Journal of Sedimentary Petrology 56(5):674-683.

[20] Kerhin, R.T. et al. 1988. *The Surficial Sediment of Chesapeake Bay, Maryland: Physical Characteristics and Sediment Budget*. Maryland Geological Survey. Report of Investigations No. 48.

Table 3.7 Summary of Laboratory Analyses

Type	Parameters	Entity	Core
Conowingo Pond			
Pore Water Chemistry	• SRP - orthophosphate • NH_4^+ • NO_3^- + NO_2^- • Fe • SO_4^{2-}, Cl^- • H_2S	UMCES	Long
Solid Phase Chemistry and Physical Properties	• Total C, N • Total and inorganic P • Inorganic C • Coal C • FeS, FeS_2 • Percent water • Grain size • Dry bulk density.	UMCES	Long
Diagenetic (Decomposition) Rates	N and P bioavailability/reactivity	UMCES	Long
Geotechnical Properties	• Dry bulk density • Liquid and plastic limit • Specific gravity • Organic content • Percent water • Grain size	Exelon	Long
Pore Water Chemistry	• SRP – orthophosphate • NH_4^+ • NO_3^- + NO_2^- • Fe • SO_4^{2-}, Cl^- • H_2S	UMCES	Short
Solid Phase Chemistry and Physical Properties	• Total C, N • Total and inorganic P • Inorganic C • Coal C • FeS, FeS_2 • Chlorophyll *a* • Percent water • Grain size	UMCES	Short
Diagenetic (Decomposition) Rates	N and P bioavailability/reactivity	UMCES	Short

Chesapeake Bay			
Pore Water Chemistry	• SRP – orthophosphate • NH_4^+ • $NO_3^- + NO_2^-$ • Fe • SO_4^{2-}, Cl^- • H_2S	UMCES	Short
Solid Phase Chemistry and Physical Properties	• Total C, N • Total and inorganic P • Inorganic C • Coal C • FeS, FeS_2 • Chlorophyll *a*? • Percent water • Grain size • Short-term radionuclide Dating – ^{7}Be	UMCES	Short
Diagenetic (Decomposition) Rates	N and P bioavailability/reactivity	UMCES	Short



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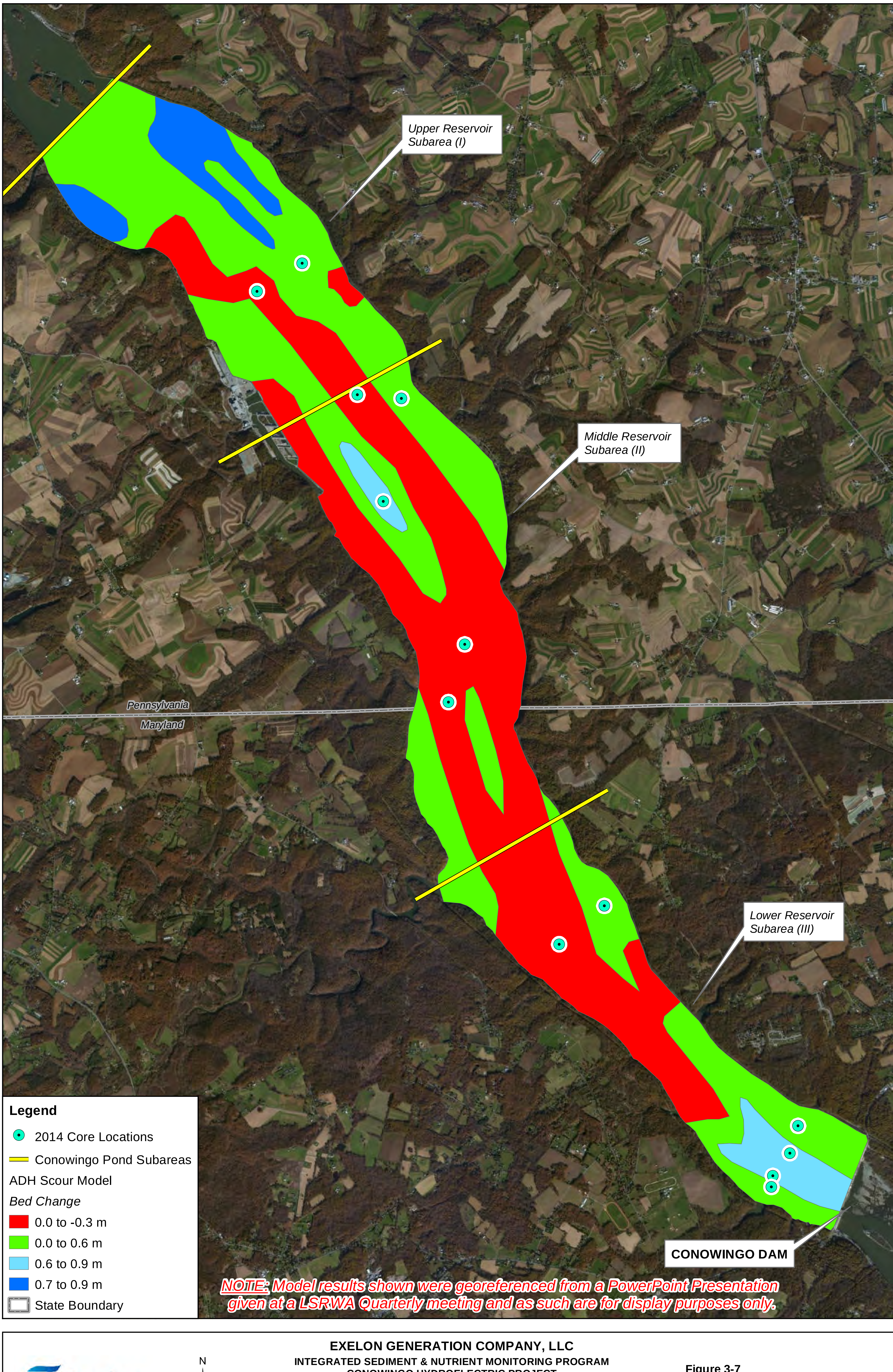
INTEGRATED SEDIMENT & NUTRIENT MONITORING PROGRAM
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Exelon.

Figure 3-6
2014 Core Locations -
2013 Conowingo Pond Bathymetry

Path: X:\GISData\Sediment Monitoring Plan - 12.04.2013\Integrated Sediment Monitoring Program\Figure 3-6 Integrated Plan Core Locations - Terrain - 11 x 17.mxd



Exelon.

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PROJECT NO. 405

Figure 3-7
2014 Core Locations -
ADH Scour Model Results

Path: X:\GISData\Sediment Monitoring Plan - 12.04.2013\Integrated Sediment Monitoring Program\Figure 3-7 Integrated Plan Core Locations - ADH - 11 x 17.mxd

4 DATA MANAGEMENT AND REPORTING

All water samples and field data will be collected in accordance with standard practices as outlined in various QAPPs, standard operating procedures, or national field manuals that have been developed for this or similar efforts. Specific QA documents relevant to the Program protocols can be found in Appendix C. As part of Program QA/QC, and due to the number of different laboratories and field personnel that will be utilized, split samples from a given sampling location(s) will be provided for select events to the Parties upon request. Split samples will then be submitted to a Program approved laboratory for analysis and comparison of results.

All samples collected as part of this effort will be preserved and submitted to a Program approved laboratory in accordance with Program and laboratory requirements. The list of Program approved laboratories that will be utilized include:

- USGS Sediment Laboratory;
- USGS National Water Quality Laboratory;
- Pennsylvania Department of Environmental Protection (PADEP) Bureau of Laboratories;
- MD Department of Health and Mental Hygiene Laboratory;
- UMCES Chesapeake Biological Laboratory; and
- UMCES Horn Point Laboratory

Table 4-1 contains detailed laboratory information for each sampling location. In addition, UMCES will be responsible for their own analyses of water samples as discussed in Task 2.0 and the UMCES QAPP found in Appendix C.

Following completion of all laboratory analyses, laboratory reports, results, and any raw data or output files generated during analysis will be provided by the laboratory directly to all Parties regardless of sampling location. MDNR will conduct QA/QC on laboratory nutrient and sediment data analyzed by CBL and Horn Point Laboratory for the Conowingo Pond tributaries as they have the software programs in place to review for outliers, merge field and lab results, and process data in a format that is acceptable and compatible for the Chesapeake 2017 Mid-point Assessment.[21] CBL is contracted by MDNR to analyze all MD Chesapeake Bay Mainstem and Tributary water quality monitoring stations. Monitoring data will be submitted to Exelon, their consultants, and the EPA Chesapeake Bay Program as soon as it has processed. Exelon and their consultants will receive the original data from the labs as well as the processed, QA/QC'd, and formatted results for all sampling locations. The results of all UMCES experiments and analyses will be provided directly to Exelon at which time Exelon will distribute to the Program Parties.

Exelon reserves the right to conduct its own QA/QC of all laboratory data. If discrepancies between the MDNR and Exelon QA/QC'd datasets are found the Parties will work with one another resolve the discrepancy(s) as needed.

[21] See Footnote 7 on page 8

Table 4-1: Sediment and Nutrient Monitoring Laboratories

Sampling Location	Responsible Party	Analyses[22]	Laboratory	Laboratory Location
Marietta, PA	USGS (PA)	SSC, PSD	USGS Sediment Laboratory	Louisville, KY
		Nutrients	USGS National Water Quality Laboratory	Denver, CO
Holtwood / Norman Wood Bridge	USGS (PA)	SSC, PSD	USGS Sediment Laboratory	Louisville, KY
		Nutrients	USGS National Water Quality Laboratory	Denver, CO
Conowingo Tailrace	USGS (MD)	SSC, PSD	USGS Sediment Laboratory	Louisville, KY
		Nutrients	USGS National Water Quality Laboratory	Denver, CO
Conowingo Spillway	Exelon[23]	SSC, PSD	Chesapeake Biological Laboratory UMCES Horn Point Laboratory (PSD)	Solomons, MD Cambridge, MD
		Nutrients		
Muddy Creek	USGS (PA)[24]	SSC, PSD	USGS Sediment Laboratory	Louisville, KY
		Nutrients	PADEP Bureau of Laboratories	Harrisburg, PA
Broad Creek	Exelon	SSC, PSD	Chesapeake Biological Laboratory UMCES Horn Point Laboratory (PSD)	Solomons, MD Cambridge, MD
		Nutrients		
Fishing Creek	Exelon	SSC, PSD	Chesapeake Biological Laboratory UMCES Horn Point Laboratory (PSD)	Solomons, MD Cambridge, MD
		Nutrients		
Peters Creek	Exelon	SSC, PSD	Chesapeake Biological Laboratory UMCES Horn Point Laboratory (PSD)	Solomons, MD Cambridge, MD
		Nutrients		
Conowingo Creek	Exelon	SSC, PSD	Chesapeake Biological Laboratory UMCES Horn Point Laboratory (PSD)	Solomons, MD Cambridge, MD
		Nutrients		
Octoraro Creek	USGS (PA) SRBC	SSC, PSD	USGS Sediment Laboratory	Louisville, KY
		Nutrients	PADEP Bureau of Laboratories	Harrisburg, PA
Deer Creek	MDNR	SSC, PSD	USGS Sediment Laboratory	Louisville, KY
		Nutrients	Department of Health and Mental Hygiene Laboratory	Baltimore, MD

[22] Nutrient analysis will include: total nitrogen, total dissolved nitrogen, particulate nitrogen, nitrate, nitrite, nitrate plus nitrite, total phosphorus, total dissolved phosphorus, orthophosphate, particulate phosphorus, total particulate carbon, and total organic carbon.
[23] See Footnote 7 on page 8. Same comment for all Exelon sampling sites.
[24] Exelon will also be conducting ISCO sampling at Muddy Creek during major tributary events (i.e. those events which correspond with a mainstem event). Water samples collected from the ISCO will be submitted to CBL for analysis of SSC and nutrients. If PSD data is desired, Exelon will also submit water samples to the Horn Point Laboratory for analysis.

5 IMPLEMENTATION & SAMPLING MOBILIZATION

While portions of this Program are already underway, full implementation of this Plan is not expected to occur until fall 2014/spring 2015. Once implemented, sampling will occur as outlined in this Plan during 6 storm events when flows equal or exceed 100,000 cfs. It is anticipated that these sampling events will span the 2014 and 2015 field seasons while potentially extending into the early 2016 field season. Program Parties will alert each other as soon as the decision to sample has been made in order to coordinate sampling events at all sampling locations. Notification will be provided via email and/or phone to the appropriate contact(s) from each entity.

Due to the robust nature of the sampling program, the logistics involved with coordinating and implementing all sampling protocols, and the geographic extent of the study area it is expected that this Plan will be adaptive in nature, evolving over time based on lessons learned during preliminary sampling events. Any changes in sampling and/or analysis protocols will be discussed with, and agreed upon by, the Program Parties prior to implementation.

Sampling teams deployed to Conowingo Dam (tailrace and spillway) will alert the Station of their sampling schedule and the duration of the sampling event with as much advance notice as possible. Sampling teams working on the spillway will communicate with Station Operations and Maintenance staff in advance of the spill event to coordinate which gates will be open during the spill event to ensure successful and safe sample collection. All sampling at Conowingo Dam will be conducted in accordance with the Program Safety Plan developed in coordination with the Station. All personnel sampling at Conowingo will be required to complete the Exelon Vendor Safety Training prior to commencing field activities. Personnel will be equipped with all required personal protective equipment (PPE) as determined by the Station (e.g., fall protection, hard hat, glasses, etc.). The USGS, Exelon, and UMCES will coordinate all Conowingo Dam sampling (tailrace and spillway) to ensure samples are collected as close to the same time as possible for direct comparison.

In order to determine the representativeness of "plunge" sampling at open gates, one sampling well will be installed to the abutment between crest gates 15 and 16; which will be open for all spill events for the duration of this program. Appendix B contains design drawings of the sampling well. If it is found that the water is stratified, additional infrastructure may be installed along the headworks to allow for depth-integrated sampling; however, if it is found that the water is well mixed, all future sampling will be conducted via the "plunge" sample method.

Installation of the test sampling well is expected to be completed by mid-October 2014. If a storm event(s) were to occur prior to installation of the sampling well, "plunge" samples will be collected (if safe sample collection is possible) from the open gates. If it is determined that sampling cannot be safely executed from the headworks given the existing railing infrastructure, the sampling team will work with the Station to install additional railings or fall protection.

6 PROGRAM COST ESTIMATE 2014-2015

The Lower Susquehanna River Integrated Sediment and Nutrient Monitoring Program is a three year study that will be conducted collaboratively by Exelon, MDNR, MDE, USGS, UMCES, the EPA Chesapeake Bay Program, and the US Army Corps of Engineers. Table 6-1 provides an upset limit cost estimate for executing and implementing this Program based on the tasks previously discussed in this Plan as well as feedback received from MDNR, USGS, and UMCES. Please note when reviewing the cost estimate that only those field activities, analyses, and experiments that are scheduled to occur in 2014 and 2015 are included. Costs associated with data integration and model updates occurring in 2016 and 2017 are not included in this cost estimate. As indicated in discussions with MDNR the Chesapeake Bay Program and its partners will be responsible for all costs associated with that portion of the Program. Exelon will work with MDNR and the Chesapeake Bay Program on data integration and interpretation of modeling results.

Table 6-1: Lower Susquehanna River Integrated Sediment and Nutrient Monitoring Program Cost Estimate

Task	Budget Item	Responsible Party	Year	Estimated Cost	Notes / Assumptions
Task 1.0 - Sediment Monitoring (Exelon)	Sampling Well Fabrication & Installation (1 well)	GSE, Exelon	2014	$90,000	Fabricate and install 1 test sampling well between crest gates 15/16 on upstream face of headworks.
	Railing Fabrication & Installation @ 2 gates	GSE, Exelon	2014	$85,000	Fabricate and install additional railings and fall protection at test gate
	Spider platforms - 10 gates *(if needed)*	GSE, Exelon	2015	$415,000	Install Spider platforms at up to 10 gates - *only necessary if water is found to be well mixed & depth-integrated sampling is not required*
	Depth-integrated sampling sleeve Fabrication & Installation - 9 gates *(if needed)*	GSE, Exelon	2015		Install sampling sleeves at up to 9 gates for depth-integrated sampling - *only necessary if water is found to be stratified*
	Additional railing Fabrication & Installation - 9 gates *(if needed)*	GSE, Exelon	2015		Fabricate and install additional railing infrastructure at gates where depth-integrated sampling will occur - *only necessary if water is found to be stratified*
	Equipment Purchase	GSE	2014	$25,000	Misc. replacement parts, water quality sondes (3), and turbidity sonde (2) *(if needed)*
	Equipment Installation	GSE, URS, NA	2014 2015	$7,000	Installation of trib water level loggers (4) - 2014 & 2015
	Maintenance Site Visits	NA, URS	2015 2015	$22,000	Water level logger site visits - assumes 12 visits/year
	Sampling Training	GSE, URS	2014	$32,000	4 teams of 3 people plus 2 "roamers", assumes 2 - 12 hour days
	Fishing, Peters, and Conowingo Creek Sampling	URS, GSE	2015 2015	$210,000	8 trib sampling events, 3 sites, 2 teams of 3 people plus 1 "roamer," 3 - 12 hr days/event. 5 low flow velocity data collection events, 1 team of 3 people, 2 - 10 hr days/event
	Broad Creek Sampling	URS, GSE	2014 2015	$95,000	8 trib sampling events - 1 team of 3 people, 3 - 12 hr days/event. 5 low flow velocity data collection events, 1 team of 3 people, 1 - 10 hr day/event
	Conowingo Dam Spillway Sampling	URS, GSE	2014 2015	$80,000	8 spillway sampling events. 1 team of 3 people, 3 - 12 hr days/event
	Lab Fees (CBL)	URS, GSE	2014 2015	$110,000	Assumes 120 tributary samples (6 events, 5 sampling rounds/event), 174 ISCO tributary samples, and 320 spillway samples (6 events, 5 sampling rounds/event at up to 10 gates) for a total of 614 samples. $150/sample for CBL analysis of nutrients and PSD (all samples). $100/sample for Cindy Palinkas analysis of PSD (only those samples collected at peak of hydrograph and during sampling well testing (174 samples)).
	Bathymetry Surveys	GSE, URS	2014 2015	$225,000	5 Conowingo Pond surveys - $45,000/survey
	Data Management, Validation, and QA/QC	GSE, URS	2014 2015	$50,000	Assumes review of 8 trib and spillway sampling events. URS data validation - $2,200/event, GSE data review, upload, and management - $1,500/event, Sr. Programmer time for database setup
	Reporting	GSE, URS	2014 2015	$60,000	Sampling event reporting, year-end reporting, misc reporting requirements
	PM, Admin, Meetings, Calls, etc.	GSE, URS	2014 2015	$60,000	
			SUB-TOTAL	***$1,566,000***	
Task 1.0 - Sediment Monitoring (USGS/MD)	MGS side-scan survey	MGS	2014	$36,000	1 side scan sonar, bathymetry, and seismic survey of Conowingo Pond – survey was conducted October 2014.
	USGS Sampling	USGS	2014 2015	$230,245	
	Non-tidal Network Sites - Lab fees	MDNR	2014 2015	$0	Lab fees associated with samples collected at Non-tidal Network sites will be covered under the budget for that program
	USGS Kentucky Lab	USGS	2014 2015	$11,000	Analysis of SSC and PSD at the USGS Kentucky lab for the Exelon split samples. Up to 10% of total samples collected (60) x $175/sample

	MDNR Expenses	MDNR	2014 2015	$31,975	Price represents 5% markup for salary and fringe, overhead costs, and administrative costs
			SUB-TOTAL	***$309,220***	
Task 2.0 - Nutrient Monitoring, Experiments, & Modeling (UMCES)	Task 2A: Characterization of Pond Sediment Deposits	UMCES	2014 2015	$333,204	Characterizes Conowingo Pond sediment deposits
	Task 2B: Suspended Particle Characterization			$256,856	Characterizes suspended sediments and nutrients
	Task 2C: Estuarine Physics/Modeling/Biogeochemistry			$624,417	Analyze biogeochemistry of sediments from cores in Chesapeake Bay, Field survey and physical property measurements, Model how much N and P are released from Conowingo Pond sediment under different conditions, and ROMS model of upper Bay to better understand fate of particles around the ETM.
			SUB-TOTAL	***$1,214,477***	*UMCES Contract with Exelon*
Task 2.0 - Nutrient Monitoring, Experiments, & Modeling (Exelon)	Data Analysis & Reporting	HDR	2014 2015	$50,000	Jim Fitzpatrick and technical team review of UMCES work
			SUB-TOTAL	***$50,000***	
Task 3.0 - Geotechnical Program	Deep Core	GSE, URS	2014	$75,000	13 Vibracores collected throughout Conowingo Pond – one time
	Shallow/Box Core	UMCES	2014 2015	$0	Price for collection of 60 box cores is included in UMCES cost estimate
			SUB-TOTAL	***$75,000***	

SUB-TOTAL	**$3,214,697**
7.65% Contingency	$245,924
TOTAL	**$3,460,621**

7 DATA INTEGRATION

The Chesapeake Bay Program modeling team currently utilizes a suite of models to examine the water quality of the Bay as part of the Bay TMDL. Models currently utilized by the modeling team include an Airshed Model, Land-use/Change Model, Phase 6 Watershed Model (Bay Watershed Model), and Water Quality/Sediment Transport Model (WQSTM or Bay Water Quality Model). Typically these models are the result of various sub-models or the integration of multiple models (e.g. the Airshed Model is actually the result of two sub-models).

The models are linked together so that the output of one simulation provides input data for another model. The outputs of the Airshed and Land-use/Change Models, combined with precipitation, meteorological, elevation, and soils data, are used as inputs to the Bay Watershed Model. Outputs of the Bay Watershed Model then provide estimates of watershed nitrogen, phosphorus, and sediment loads resulting from various management scenarios. These outputs are then used as inputs to the Bay Water Quality Model in order to predict Bay water quality resulting from various management scenarios and to ensure allocations under the Bay TMDL are being met (USEPA, 2010). Table 7-1 provides more information on the function(s) of the various models.

The Bay TMDL Midpoint Assessment is currently scheduled to occur in 2017. The Midpoint Assessment will include reviewing, and potentially incorporating, the latest science, data, tools, Best Management Practices (BMP), and lessons learned to determine if the strategies currently in place will result in water quality standard attainment in the Bay by 2025. Included in the Midpoint Assessment will be a review and update of the existing suite of Bay Watershed and Water Quality Models. The results of the Integrated Sediment and Nutrient Monitoring Program will be used to update various components and parameters of the existing Bay models. Table 7-2 provides detailed information regarding specific Program deliverables and the model(s) which will be updated.

Table 7-1: Existing Chesapeake Bay Watershed and Water Quality Models

Model	Model Output / Function
Bay Airshed Model	Provides estimates of wet and dry atmospheric deposition to the Bay Watershed and Bay Water Quality Models.
Bay Land Change Model	Provides annual time series of land uses to the Bay Watershed Model as well as projects land uses out to 2030.
Phase 6 Bay Watershed Model	Simulates loading and transport of nitrogen, phosphorus, and sediment from pollutant sources throughout the Bay watershed. Provides estimates of watershed nitrogen, phosphorus, and sediment loads resulting from various management scenarios.
Bay Water Quality/Sediment Transport Model (WQSTM)	Simulates estuarine hydrodynamics, water quality, sediment transport, and key living resources such as algae, microscopic animals, bottom sediment dwelling worms and clams, underwater grasses, and oyster and menhaden filter feeding. Predicts Bay water quality resulting from various management scenarios. Ensures allocated loads under the Bay TMDL will meet the jurisdictions' Bay water quality standards.

(USEPA, 2010)

Table 7-2: Program Data Deliverables and Existing Models with which Integrated[25]

Deliverable	Model
MARIETTA, PA	
Sediment Load	Phase 6 Watershed Model, HEC-RAS model (maybe). Calibration and Baseline model
Nutrient Load	
PSD	
Nutrient Production (decay rates)	
HOLTWOOD DAM / NORMAN WOOD BRIDGE	
Sediment Load	Phase 6 Watershed Model, HEC-RAS model (maybe). Calibration and Baseline model
Nutrient Load	
PSD	
Nutrient Production (decay rates)	
SIGNIFICANT POND TRIBUTARIES *(Muddy, Broad, Fishing, Peters, and Conowingo Creeks)*	
Sediment Load	Phase 6 Watershed Model (maybe)
Nutrient Load	
PSD	
Nutrient Production (decay rates)	
CONOWINGO DAM	
Sediment Load	Phase 6 Watershed Model – Calibration and Baseline model. Inform starting point of WQSTM. ADH Model.
Nutrient Load	
PSD	
Nutrient Production (decay rates)	
Conowingo Pond Bathymetry Surveys	ADH Model – check on sediment load calculations.
COMBINED OCTORARO AND DEER CREEKS	
Sediment Load	Phase 6 Watershed Model – Calibration and Baseline model. Inform starting point of WQSTM. ADH Model.
Nutrient Load	

[25] This table was developed by the attendees of the Sediment and Nutrient Monitoring Workshop held on April 8-9, 2014 in Baltimore, MD.

Deliverable	Model
PSD	Phase 6 Watershed Model – Calibration and Baseline model. Inform starting point of WQSTM. ADH Model.
Nutrient Production (decay rates)	
CONOWINGO POND NUTRIENT ANALYSES & EXPERIMENTS	
Conowingo Pond Nutrient Flux & Denitrification	Phase 6 Watershed Model – Update ammonia and phosphorus flux parameters from Conowingo sediment as well as estimates of denitrification
Conowingo Pond Diagenesis Experiments	WQSTM informing the labile-refractory splits during storm events
CHESAPEAKE BAY NUTRIENT ANALYSES & EXPERIMENTS	
Phosphorus Release and SOD Experiments	SFM and WQSTM
Real-time Cruise and Settling Measurements	WQSTM or ROMS-CSTM

8 LITERATURE CITED

Aller, R. C., and J. E. Mackin. 1989. Open-incubation, diffusion methods for measuring solute reaction rates in sediments. Journal of Marine Research **47**:411-440.

Allison, M. A., G. C. Kineke, E. S. Gordon, and M. A. Goni. 2000. Development and reworking of a seasonal flood deposit on the inner continental shelf off the Atchafalaya River. Continental Shelf Research **20**:2267-2294.

Andrieux-Loyer, F., X. Philippon, G. Bally, R. Kerouel, A. Youenou, and J. Le Grand. 2008. Phosphorus dynamics and bioavailability in sediments of the Penze Estuary (NW France): in relation to annual P-fluxes and occurrences of Alexandrium Minutum. Biogeochemistry **88**:213-231.

Appleby, P. G., and F. Oldfield. 1978. The calculation of ^{210}Pb dates assuming a constant rate of supply of unsupported ^{210}Pb to the sediment. Catena **5**:1-8.

Aspila, K. I., H. Agemian, and A. S. Y. Chau. 1976. A semi-automated method for the determination of inorganic, organic and total phosphate in sediments. Analyst **101**:187-197.

Bennett, R. H., and D. N. Lambert. 1971. Rapid and reliable technique for determining unit weight and porosity of deep-sea sediments. Marine Geology 11:201-207

Bianchi, T. S. 2007. Biogeochemistry of Estuaries. Oxford University Press, Oxford.

Boynton, W. R. 2000. Impact of nutrient inflows on Chesapeake Bay. Pages 23-40 *in* A. N. Sharpley, editor. Agriculture and Phosphorus Management: The Chesapeake Bay. Lewis Publishers, Boca Raton.

Boynton, W. R., and E. M. Bailey. 2008. Sediment Oxygen and Nutrient Exchange Measurements from Chesapeake Bay, Tributary Rivers and Maryland Coastal Bays: Development of a Comprehensive Database & Analysis of Factors Controlling Patterns and Magnitude of Sediment-Water Exchanges. UMCES Technical Report Series No. TS-542-08. University of Maryland Center for Environmental Science.

Boynton, W. R., and W. M. Kemp. 1985. Nutrient regeneration and oxygen consumption by sediments along an estuarine salinity gradient. Marine Ecology Progress Series **23**:45-55.

Brady, D. C., J. M. Testa, D. M. Di Toro, W. R. Boynton, and W. M. Kemp. 2013. Sediment flux modeling: Calibration and application for coastal systems. Estuarine Coastal and Shelf Science 117:107-124.

Bray, J. T., O. P. Bricker, and B. N. Troup. 1973. Phosphate in interstitial waters of anoxic sediments: oxidation effects during the sampling procedure. Science **180**:1362-1364.

Bryner, J. R. 2000. The effects of iron and sulfur on phosphorus dynamics along a tidal gradient in fresh/oligohaline marshes. M.S. University of Maryland, College Park.

Burdige, D. J. 1989. The effects of sediment slurrying on microbial processes, and the role of amino-acids as substrates for sulfate reduction in anoxic marine sediments. Biogeochemistry **8**:1-23.

Burdige, D. J. 1991. The kinetics of organic matter mineralization in anoxic marine sediments. Journal of Marine Research **49**:727-761.

Callender, E. 1982. Benthic phosphorus regeneration in the Potomac River estuary. Hydrobiologia **92**:431-446.

Cerco, C. F., S. C. Kim, and M. R. Noel. 2013. Management modeling of suspended solids in the Chesapeake Bay, USA. Estuarine Coastal and Shelf Science **116**:87-98.

Cheng, P., M. Li, and Y. Li. 2013. Generation of an estuarine sediment plume by a tropical storm. Journal of Geophysical Research-Oceans 118:856-868.

Cline, J. D. 1969. Spectrophotometric determination of hydrogen sulfide in natural waters. Limnology and Oceanography **14**:454-458.

Conley, D. J., W. M. Smith, J. C. Cornwell, and T. R. Fisher. 1995. Transformation of particle-bound phosphorus at the land-sea interface. Estuarine, Coastal and Shelf Science **40**:161-176.

Cornwell, J. C. 2007. Development of an estuarine phosphorus sub-model for incorporation into the next-generation Potomac River environment model: phosphorus data and laboratory experiments. UMCES Technical Series TS-563-07. Support from Limno-Tech, Inc. under contract of MWCOG. Cambridge MD.

Cornwell, J. C., P. M. Glibert, and M. S. Owens. 2014. Nutrient fluxes from sediments in the San Francisco Bay Delta - online Jan 2014. Estuaries and Coasts. 37:1120-1133.

Cornwell, J. C., W. M. Kemp, and T. M. Kana. 1999. Denitrification in coastal ecosystems: environmental controls and aspects of spatial and temporal scale. Aquatic Ecology **33**:41-54.

Cornwell, J. C., and J. W. Morse. 1987. The Characterization Of Iron Sulfide Minerals In Anoxic Marine-Sediments. Marine Chemistry **22**:193-206.

Cornwell, J. C., M. Owens, T. M. Kana, E. M. Bailey, J. Barnes, and W. R. Boynton. 2008. An Assessment of Processes Controlling Benthic Nutrient Fluxes in the Caloosahatchee River and Estuary and the St. Lucie River and Estuary. UMCES Technical Series Contribution TS-552-08, Cambridge, MD.

Cornwell, J. C., and M. S. Owens. 1999. Benthic Phosphorus Cycling in Lake Champlain: Results of an Integrated Field Sampling/Water Quality Modeling Study. Part B: Field Studies. June 1999. 34B, UMCES Horn Point Laboratory, Cambridge Maryland.

Cornwell, J. C., and M. S. Owens. 2011. Quantifying Sediment Nitrogen Releases Associated with Estuarine Dredging. Aquatic Geochemistry **17**:499-517.

Cornwell, J. C., M. S. Owens, and L. Pride. 2000. Nitrogen and Phosphorus Releases During Dredging: Assessing Potential Phosphorus Releases and Refinement of Ammonium Release Estimates. University of Maryland Center for Environmental Science Final Report to Maryland Environmental Service TS-230-00

Cornwell, J. C., and P. A. Sampou. 1995. Environmental controls on iron sulfide mineral formation in a coastal plain estuary. Pages 224-242 *in* M. A. Vairavamurthy and M. A. A. Schoonen, editors.

Geochemical Transformations of Sedimentary Sulfur. American Chemical Society, Washington, DC.

Cornwell, J. C., J. C. Stevenson, D. J. Conley, and M. Owens. 1996b. A sediment chronology of Chesapeake Bay eutrophication. Estuaries **19**:488-499.

Cowan, J. L. W., and W. R. Boynton. 1996. Sediment-water oxygen and nutrient exchanges along the longitudinal axis of Chesapeake Bay: Seasonal patterns, controlling factors and ecological significance. Estuaries **19**:562-580.

Deborde, J., P. Anschutz, G. Chaillou, H. Etcheber, M. V. Commarieu, P. Lecroart, and G. Abril. 2007. The dynamics of phosphorus in turbid estuarine systems: Example of the Gironde estuary (France). Limnology and Oceanography **52**:862-872.

Dellapenna, T. M., S. A. Kuehl, and L. C. Schaffner. 2003. Ephemeral deposition, seabed mixing and fine-scale strata formation in the York River estuary, Chesapeake Bay. Estuarine Coastal and Shelf Science **58**:621-643.

DePinto, J. V., T. C. Young, and S. C. Martin. 1981. Algal-available phosphorus in suspended sediments from lower Great Lakes Tributaries. Journal of Great Lakes Research **7**:311-325.

Di Toro, D. M. 2001. Sediment Flux Modeling. Wiley Interscience, New York.

Ellison, M. E., and M. T. Brett. 2006. Particulate phosphorus bioavailability as a function of stream flow and land cover. Water Research **40**:1258-1268.

Festa, J. F. and D. V. Hansen (1978). "Turbidity maxima in partially mixed estuaries: a two-dimensional numerical model." Estuarine and Coastal Marine Science 7(4): 347-359.

Fisher, T. R., A. B. Gustafson, K. Sellner, R. Lacoutre, L. W. Haas, R. L. Wetzel, R. Magnien, D. Everitt, B. Michaels, and R. Karrh. 1999. Spatial and temporal variation of resource limitation in Chesapeake Bay. Marine Biology **133**:763-778.

Gao, Y., J. C. Cornwell, D. K. Stoecker, and M. S. Owens. 2012. Effects of cyanobacterial-driven pH increases on sediment nutrient fluxes and coupled nitrification-denitrification in a shallow fresh water estuary. Biogeosciences **9**:2697-2710.

Geyer, W. R. 1993. THE IMPORTANCE OF SUPPRESSION OF TURBULENCE BY STRATIFICATION ON THE ESTUARINE TURBIDITY MAXIMUM. Estuaries **16**:113-125.

Gibbs, M. M. 1979. A simple method for the rapid determination of iron in natural waters. Water Research **13**:295-297.

Hartzell, J. L. 2009. The fate of phosphorus along estuarine salinity gradients. George Mason University, Fairfax VA.

Hartzell, J. L., and T. E. Jordan. 2012. Shifts in the relative availability of phosphorus and nitrogen along estuarine salinity gradients. Biogeochemistry **107**:489-500.

Hartzell, J. L., T. E. Jordan, and J. C. Cornwell. 2010. Phosphorus Burial in Sediments Along the Salinity Gradient of the Patuxent River, a Subestuary of the Chesapeake Bay (USA). Estuaries and Coasts **33**:92-106.

Johnson, R., and R. M. Bustin. 2006. Coal dust dispersal around a marine coal terminal (1977-1999), British Columbia: The fate of coal dust in the marine environment. International Journal of Coal Geology 68:57-69.

Jordan, T. E., J. C. Cornwell, W. R. Boynton, and J. T. Anderson. 2008. Changes in phosphorus biogeochemistry along an estuarine salinity gradient: The iron conveyer belt. Limnology and Oceanography **53**:172-184.

Kana, T. M., J. C. Cornwell, and L. J. Zhong. 2006. Determination of denitrification in the Chesapeake Bay from measurements of N-2 accumulation in bottom water. Estuaries and Coasts **29**:222-231.

Kana, T. M., C. Darkangelo, M. D. Hunt, J. B. Oldham, G. E. Bennett, and J. C. Cornwell. 1994. Membrane inlet mass spectrometer for rapid high-precision determination of N_2, O_2, and Ar in environmental water samples. Analytical Chemistry **66**:4166-4170.

Kerhin, R. T., J. P. Halka, D. V. Wells, E. L. Hennessee, P. J. Blakeslee, N. Zoltan, and R. H. Cuthbertsen. 1988. Surficial Sediments of Chesapeake Bay, Maryland: Physical Characteristics and Sediment Budget.

Leventhal, J., and C. Taylor. 1990. Comparison of methods to determine degree of pyritization. Geochimica Et Cosmochimica Acta **54**:2621-2625.

Liebezeit, G. 1991. Analytical phosphorus fractionation of sediment trap material. Marine Chemistry **33**:61-69.

Malarkey, J., C. F. Jago, R. Hübner, and S. E. Jones. 2013. A simple method to determine the settling velocity distribution from settling velocity tubes. Continental Shelf Research **56**:82-89.

Malpezzi, M. A., L. P. Sanford, and B. C. Crump. 2013. Abundance and distribution of transparent exopolymer particles in the estuarine turbidity maximum of Chesapeake Bay. Marine Ecology Progress Series **486**:23-35.

Middelburg, J. J. 1989. A simple rate model of organic matter decomposition in marine sediments. Geochimica Et Cosmochimica Acta **53**:1577-1581.

Nelson, B. W. 1967. Sedimentary phosphate method for determining paleosalinities. Science **158**:917-920.

O'Keefe, J. A. 2007. Sediment biogeochemistry across the Patuxent River estuarine gradient: geochronology and Fe-S-P interactions. University of Maryland, College Park.

Owen, M. W. 1976. Determination of the settling velocities of cohesive muds. Hydraulics Research Wallingford, Wallingford, UK.

Owens, M. S., and J. C. Cornwell. 2010. Nutrient Flux Study: Results From the Murderkill River – Marsh Ecosystem. Final Report to Kent County (DE) Levy Court. Chesapeake Biogeochemical Associates, Sharptown MD.

Pacini, N., and R. Gachter. 1999. Speciation of riverine particulate phosphorus during rain events. Biogeochemistry **47**:87-109.

Palinkas, C. M., J. P. Halka, M. Li, L. P. Sanford, and P. Cheng. 2014. Sediment deposition from tropical storms in the upper Chesapeake Bay: Field observations and model simulations. Continental Shelf Research 86:6-16.

Parsons, T. R., Y. Maita, and C. M. Lalli. 1984. A Manual of Chemical and Biological Methods for Seawater Analysis. Pergamon Press, New York.

Revsbech, N. P., B. B. Jorgensen, and T. H. Blackburn. 1980. OXYGEN IN THE SEA BOTTOM MEASURED WITH A MICROELECTRODE. Science **207**:1355-1356.

Ruttenberg, K. C. 1992. Development of a sequential extraction method for different forms of phosphorus in marine sediments. Limnology and Oceanography **37**:1460-1482.

Sanford, L. P., S. E. Suttles, and J. P. Halka. 2001. Reconsidering the physics of the Chesapeake Bay estuarine turbidity maximum. Estuaries **24**:655-669.

Sommerfield, C. K., C. A. Nittrouer, and C. R. Alexander. 1999. Be-7 as a tracer of flood sedimentation on the northern California continental margin. Continental Shelf Research **19**:335-361.

Stainton, M. P. 1973. A syringe gas-stripping procedure for gas-chromatographic determination of dissolved inorganic and organic carbon in fresh water and carbonates in sediments. Journal of the Fisheries Research Board of Canada **30**:1441-1445.

Testa, J. M., D. C. Brady, D. M. Di Toro, W. R. Boynton, J. C. Cornwell, and W. M. Kemp. 2013. Sediment flux modeling: Simulating nitrogen, phosphorus, and silica cycles. Estuarine Coastal and Shelf Science **131**:245-263.

USEPA. 1979. United States Environmental Protection Agency. Methods for chemical analysis of water and wastes. USEPA-600-79-020.

USEPA. 2010. Chesapeake Bay TMDL – Section 5 Chesapeake Bay Monitoring and Modeling Frameworks. U.S. Environmental Protection Agency, Chesapeake Bay Program Office, Annapolis, MD. December 2010.

Uusitalo, R., M. Yli-Halla, and E. Turtola. 2000. Suspended soil as a source of potentially bioavailable phosphorus in surface runoff waters from clay soils. Water Research **34**:2477-2482.

Wazniak, C. E., M. R. Hall, E. M. Bailey, D. M. Boward, W. R. Boynton, J. F. Bratton, T. J. B. Carruthers, R. J. Chalmers, L. W. Cole, J. C. Cornwell, B. Fertig, P. M. Glibert, A. B. Jones, T. E. Jordan, J. McCoy, M. McGinty, R. J. Shedlock, J. Sherwell, R. B. Sturgis, J. E. Thomas, T. M. Trice, and D. V. Wells. 2009. Chapter 13. Water quality responses to nutrients. Pages 249-291 *in* W. C. Dennison, J. E. Thomas, C. J. Cain, T. J. B. Carruthers, M. R. Hall, and Jesien, editors. Shifting Sands. Environmental and cultural change in Maryland's Coastal Bays. UMCES, Cambridge MD.

Williams, J. D. H., J. K. Syers, S. S. Shukla, R. F. Harris, and D. E. Armstrong. 1971. Levels of inorganic and total phosphorus in lake sediments as related to other sediment parameters. Environmental Science and Technology **5**:1113-1120.

Zimmerman, A. R., and E. A. Canuel. 2002. Sediment geochemical records of eutrophication in the mesohaline Chesapeake Bay. Limnology and Oceanography **47**:1084-1093.

APPENDIX A – MEETING MINUTES

Targeted Lower Susquehanna River Monitoring, Analysis, and Modeling
April 8th and 9th 2014
Hilton Baltimore BWI Airport Hotel
Linthicum, MD

Attendees:

Bruce Michael (MDNR)	Jeff Cornwell (UMCES)	Brian Banks (USGS)^
Joel Blomquist (USGS)^	Mike Langland (USGS)	Lee Currey (MDE)
Cindy Plinkas (UMCES)^	Jeremy Testa (UMCES)^	Mike Kemp (UMCES)^
Shaw Seaman (MDNR)	Pete Dunbar (MDNR)^	Larry Sanford (UMCES)^
Rich Batiuk (USEPA)	Lew Linker (USEPA)	Carl Cerco (USACE)
Ken Poletti (Exelon)^	Bob Lynch (Exelon)^	Mark Velleux (HDR)^*
Jim Fitzpatrick (HDR)	Bryan Strawn (URS)	Marjie Zeff (URS)
Tom Sullivan (GSE)	Kim Long (Exelon)	Gary Lemay (GSE)
Tim Sullivan (GSE)	Steve Scott (USACE)^*	Colleen Hicks (Exelon)^
Rich Ortt (MGS)	Nick Nidzieko (UMCES)^*	Kevin Mager (USEPA)

** Indicates person called in ^Indicates person only attended first day*

April 8th 2014

Meeting Minutes:

- Bruce Michael opened the meeting with introductions and his view on the purpose of the meeting. Reviewed the agenda for the workshop.
- Tom Sullivan gave a brief overview of Exelon's view of the workshop. He stated that Exelon's objectives are to 1) design a field sampling plan to determine any impacts of storm events on Conowingo Pond; and 2) to determine how Maryland anticipates using the information in the 401 proceeding. Bruce indicated that many in this room have the same objectives, and that we want this meeting to be an open dialogue to help better understand any impacts to Chesapeake Bay and how to better protect and restore the Bay.
- Bruce provided a PowerPoint presentation on preliminary findings and recommendations of the LSRWA report (to be distributed June 2014):
  - Scour threshold has been reduced from 427,000 cfs to 330,000 cfs (using LSRWA results).
  - There isn't much more available sediment reduction possible via BMPs; remaining BMPs are very expensive
  - Dredging with placement in upland sites appears feasible
  - Conowingo Dam is planned to be re-evaluated as part of the 2017 mid-point assessment
  - Would like to fill critical data gaps related to nutrient impacts to ensure Bay WQS can be met
  - Objectives:
    1) Where does the material go into the Bay and what are the impacts to Bay water quality?
    2) What material is behind the dam that is likely to be scoured?

3) Two other objectives

- Need to invest in long-term sediment and nutrient monitoring and modeling that will allow evaluation of system changes and responses to management actions. Including bathymetry, continuous turbidity monitoring below all reservoirs, targeted monitoring at Marietta, DS of Holtwood and DS of Conowingo Dam to assess storm events greater than 100,000 cfs.
- Senator Cardin is having a hearing on May 5 at Conowingo Dam.
- Tom was wondering if other options for reducing nonattainment have been investigated. Bruce said that this will be done as part of the mid-point assessment. In particular, they would like to focus more specifically on nutrients as opposed to sediments as those are the real drivers.
- Rich Batiuk said that they would be focusing on a revision of the watershed model (version 6) and that Lee Currey and others will be participating in how these revisions to the model will be made. They are looking to establish a team to investigate shallow waters better and other components that the WQSTM has not captured particularly well. They may be reallocating nutrient TMDL portions depending on the result of the mid-point assessments. It will be up to the states to determine how to best implement the reductions that must be achieved.
- Bruce said they are bringing in new information on land use, BMP efficiencies, and other components and reevaluating everything.
- Rich said they would like to lay out the timing of everything tomorrow, as well as which models they specifically would like to update, and how we can tie these research pieces into the TMDL. Wants to make sure that they can incorporate all of the research that is being done into the model impacts. Rich wants to be clear on the timeframe, connections and specific action items. He wants to see how parallel models can be incorporated as well. There are timelines for 2015, 2016 and 2017 that must be met, and they will discuss these as part of the workshop.

- Joel Blomquist gave a PowerPoint presentation regarding the USGS's proposed Sediment Monitoring Program. Presentation was titled: "Characterizing changes in SSC and size distribution along the Susquehanna reservoir system."
  - Scope of the USGS work is to characterize changes in SSC and particle size distribution along the Susquehanna reservoir system, with a particular emphasis on Conowingo Pond.
  - Noted that as sediments age, they function differently with time. Hirsh has said more sediment and phosphorus appear to be passing Conowingo Dam during storm events. Joel indicated the existing monitoring network isn't really capturing these changes well.
  - Past records have focused on the outflow from Conowingo Dam, and not the inflow. This does not allow Conowingo in particular to be isolated from everything else.
  - There is still a lot of sediment transported to and through Conowingo Dam during some non-scour events (200,000 cfs to 400,000 cfs).
  - The USGS had some ideas on how they could do a "Cadillac" monitoring plan to fully understand the dynamics of nutrients and sediment in Conowingo, but the cost and difficulty to implement would be very high. They will focus on changes in sediment character to support modeling assessments instead of a complete sediment budget.

- Marietta sampling will be along the Columbia Bridge, plus a continuous turbidity monitor will be installed and maintained by USGS PA.
- Holtwood Dam/Norman Wood Bridge will be conducted from the catwalk and along the Norman Wood Bridge if possible. Will install a vented pressure transducer and a turbidity monitor at or just downstream of Holtwood Dam, maintained by USGS PA.
- Conowingo Dam sampling will be conducted at the catwalk. A multi-parameter (continuous turbidity and nitrate) meter will be installed about 0.5 miles downstream of the dam and will be maintained by the USGS MD office.
- Mike Langland indicated that PPL has given them permission to access the catwalk (turbine outfall) as well as along the spillway wall.
- The final plan will include 3 sampling locations, stage/flow at Conowingo and Marietta, stage at Holtwood, and continuous turbidity at each site. 6 events with sampling at all three sites. 4-6 samples per event. Analysis for dissolved and particulate nutrient content, SSC, sand-fine split, 5-break fines analysis.
- Mark Velleux asked if the sand fraction will be broken down at all. Joel indicated that it won't be at this time, since there wasn't much sand in previous sampling events.
- Lew Linker indicated that any continuous turbidity/SSL calculated would be very useful for the watershed model component of the TMDL.
- Tom discussed establishing an acceptable criteria ahead of time for a successful turbidity-SSC relationship

- Tim Sullivan gave a PowerPoint presentation pertaining to Exelon's proposed Sediment and Nutrient Monitoring Program
  - When discussing potential core locations, Lew mentioned that Steve Scott's ADH model would be good to help inform the bulk density coring locations.
  - When discussing the representativeness of sampling at spillway gate sampling wells Joel indicated you can use a portable turbidity meter to see if there are noticeable variations in depth or space (i.e., at surface in mid-gate)
  - Shawn asked why Exelon is only proposing to monitor 3 out of 16 potential Conowingo Pond tribs. Asked if Exelon could explore expanding their monitoring locations or at least provide rationale for why each location was or wasn't selected.
  - Bruce indicated that the State/USGS is already monitoring Octoraro and Muddy Creeks therefore it seems unnecessary for Exelon to do so as well. He also indicated Deer Creek could be monitored by the State as well.
  - Shawn asked if Exelon could then identify other tribs to sample since they would no longer be sampling Muddy, Deer, or Octoraro Creeks
  - Joel mentioned that perhaps Vicksburg or other technical experts can comment on how the design of the proposed sampling wells can be optimized. Also may be worth trying to strategically place the wells so that we can get something analogous to an equal discharge sample. He likes this idea as opposed to no data.

- Joel indicated the USGS could turn around a review of the sampling well designs in 2-3 weeks, but a meeting on site would be useful after that before coming to a conclusion.
- Lew asked if any sampling should be done under pre-spill conditions.
- Lew thinks bathymetry is very valuable even if it is a check on other data.

Lunch Break

- UMCES gave a presentation on the state of the Bay and their proposed nutrient analyses and experiments.
  - Mike Kemp mentioned that denitrification in the pond may be reducing nutrient loads to Chesapeake Bay, with Conowingo Pond acting as a sink. Lew Linker indicated the observations indicated this may be minimal, but he would like to see more information on this.
  - Carl Cerco noted that the model does not represent iron-bound phosphorus desorption as is. Any model update to this would require an expansion of the model.
- After completion of the various program presentations (Exelon, UMCES, USGS, MDNR), the afternoon discussion turned toward integration of the various plans. Integration agreements reached included:
  - Agreement that State/USGS will continue monitoring at Octoraro, Deer, and Muddy Creeks
  - Agreement on sampling at Conowingo Dam from tailrace and spillway. Agreement on moving forward with installing sampling wells
  - Agreement that Exelon will move forward with monitoring the Conowingo Pond tribs as proposed (Fishing and Peters Creeks)
    - Once USGS gage is up and running, Exelon will stop monitoring Muddy Creek
  - Agreement the USGS will continue to monitor at Holtwood. Will explore options to get a full river cross-section hopefully from Norman Wood Bridge (pending PennDOT approval). Looking for full river cross-section 1 or 2 events to determine if Holtwood is representative.
    - Mike thinks it would take USGS 2 hrs to sample across Norman Wood Bridge
  - Agreement that Jeff Cornwell and Jim Fitzpatrick (maybe Carl and Lew also) will get together and develop one sampling text to highlight Nutrient Program for group review
- Integration discussion included:
  - Develop a small workgroup of representatives from the various entities to hammer out the details of an integrated plan. Small workgroup representatives would include:
    - USGS: Mike Langland and Joel Blomquist
    - UMCES: Jeff Cornwell, others?
    - MDNR: Bruce Michael
    - MDE: Lee
    - Exelon: Kim Long, Tom Sullivan, Jim Fitzpatrick, some combo of Tim Sullivan, Gary Lemay, Bryan Strawn, Marjie Zeff

- MD currently samples their tribs monthly and then 8 events per year, 2 per quarter.
- The State already monitors Deer Creek but they don't monitor storms on it. They could expand and monitor storms on it.
- Bruce advocated for Exelon to use the same labs as what the State/USGS uses.
- Exelon to provide justification as to why tribs were or weren't chosen. Shawn expressed concern that outflow from Holtwood would be incorrectly overestimated if only some tribs were monitored. If Exelon isn't doing Octoraro and Muddy Cr. Shawn wanted to know if additional tribs could be monitored.
- USGS will do some sampling at Conowingo Tailrace when they aren't spilling to get rising limb
- USGS isn't going to be sampling at Holtwood tailrace. Samples will be collected at either Inner Bay(?) or Outer Bay(?) at Holtwood
- Turbidity-SSC Relationship: Exelon could collect supplemental data at existing locations to "calibrate" or sanity check the regression.
- Bathymetry combined with coring would be useful. Bathymetry by itself or only at low, medium flows would probably not be as useful as it would introduce error (Langland). It all depends on how much you trust the bathymetry data and the accuracy of the equipment (Langland/Ortt).
- Best way to go about determining Conowingo Pond inflow (aka Holtwood outflow) would be to try all approaches at first, then compare results, and move forward with the best, representative method (Langland).
- Small group questions: 1) Methods to get the best results and accuracy possible; 2) what is an appropriate threshold to initiate post-storm bathymetry
- Coring: Workgroup – 1) where should cores be collected; 2) How will they be collected/what method (e.g. Vibracore); and 3) When and how often

Action Items:

1. Develop a small workgroup of representatives from the various entities to hammer out the details of an integrated plan. Schedule call with group within next 2-3 weeks
2. Exelon to work with USGS to finalize design of sampling wells. Comments due from USGS within next 2 weeks
3. Exelon to schedule meeting at Conowingo Dam with USGS to go over Sampling Wells within next 2 weeks
4. USGS would like/hope to install a continuous turbidity monitor(s) at/inside one Sampling Well
5. USGS will explore options to get a full river cross-section at Holtwood (hopefully from Norman Wood Bridge, pending PennDOT approval).
6. Determine how a successful turbidity-SSC relationship will be defined (small workgroup item)
7. Exelon to provide justification as to why tribs were or weren't chosen

8. GSE to bring Coring maps with an overlay of the results of Steve Scott's ADH deposition/scour location results to small workgroup meeting

April 9th 2014

<u>Meeting Minutes:</u>

- Bruce Michael provided a recap of the discussion & action Items from the previous day:
    - Mike Langland will keep everyone posted as to site visit schedule at Holtwood to determine where continuous turbidity monitor will go (sometime next week)
    - MDNR will look into reactivating Deer Creek to be a full blown monitoring site (similar to Octoraro and Muddy)
    - State would like Exelon to use one of their approved labs for all sampling
    - Tom and Bruce discussed developing a QAPP that would exist for all sampling. Bruce indicated different components of the sampling are part of various QAPPs but acknowledged there is not one comprehensive QAPP for this effort yet
    - Mike Langland specifically asked about adding Broad Creek to the sites that Exelon will monitor
    - Bruce will coordinate with Tom to setup next conference call within next two weeks
    - EPA has QAPPs in place for the Bay modeling efforts. MDNR has QAPPs as well. The various agencies will provide QAPPs that have already been developed to be included as Appendices to the comprehensive, integrated plan.
- Rich Batiuk & Lew Linker presented a PowerPoint discussing the 2017 TMDL Mid-Point Assessment. Rich gave first half of presentation:
    - TMDL included using Conowingo at a 1991-2000 status prior to it achieving Dynamic Equilibrium. Now that it has achieved Dynamic Equilibrium it will cause non-attainment in certain segments of the Bay. Because of this the agencies need to reexamine (mid-point assessment) the changed dynamic at Conowingo Dam to see how it effects the Bay and how they can achieve attainment
    - 1% non-attainment as modeled by the Corps. at 400,000 cfs. When other model runs have been done (by Lew and others) at lower flow thresholds the % of non-attainment has been shown to actually be higher than 1%.
    - Jim Fitzpatrick: How do you account for the fact that the Dam still acts as a BMP during non-storm event years?
    - Lee Currey: One of main focuses of the Mid-Point Assessment is understanding and quantifying how the system has changed since the TMDL was established. One of the biggest changes is the status of Conowingo Dam reaching Dynamic Equilibrium. We need to understand that and then examine how we will make policy changes accordingly.
    - Lee/Rich: Anticipating that the system will be more flashy given that the Dam has reached Dynamic Equilibrium. It wouldn't necessarily return to a natural state, it will probably be more flashy which we need to better understand

[Bullets below are from Lew's portion of the presentation]

- Suite of models/tools being enhanced for Mid-point Assessment:
    1. Chesapeake Bay Airshed Model
        - Actually 2 models
    2. Phase 6 Chesapeake Bay Watershed Model
        - Integration of multiple models
    3. Chesapeake Bay Water Quality/Sediment Transport Model
        - Linked series of models/sub-models
    4. Chesapeake Analysis and Scenario Tool (CAST)
        - Suite of jurisdiction specific tools
    5. Chesapeake Bay Scenario Builder
- Enhancements to the Bay WQ/STM:
    1. Shallow water model simulation
    2. Climate Change
    3. Conowingo *(reaching dynamic equilibrium)*
    4. Filter Feeders
    5. James River
- Tom: Just Conowingo or are you going to look at all LSR Reservoirs?

  Rich: Watershed model will take advantage of all new data collected going up to Marietta and Holtwood
- Rich: Invited Exelon to sit on modeling workgroup with Lee

  Tom: Agreed that would be good, would run it by Exelon leadership

  Lee: Agreed it would be good to have Exelon on the workgroup
- Jim: Will recalibration be done of the ADH model with new data if it is going to be used in the reassessment?

  Rich: I think so; it would be very useful in reassessment

  Lew: If the partnership feels it would be useful and important then it could be

  Carl Cerco: How are we going to use this data to do all this recalibration and updating given the current Mid-point assessment schedule (Models done by December 2015). Does not think it is realistic that all this data can be implemented to the level people are talking about in keeping with the schedule currently laid out.

  Jim: We could use it quantitatively to do some simple analysis to back check things as opposed to running a full blown recalibration
- Tom: How do you calibrate a model(s) that will use various time periods in the same model?

  Carl: Hadn't really thought of that but it is could be a problem and needs to be thought about

  Lee: We've discussed this same question with the Modeling Workgroup

- Lew reviewed how the EPA envisions using the new data in existing models:
    - USGS collected data will be used to:

        - Enhance model simulation of Conowingo Pond (AdH, Phase 6 Bay Watershed Model)
        - Improving parameterization of Bay WQ/STM
    - Data from Marietta and Holtwood will be used to:
        - Development, calibration, and validation of Phase 6 Bay Watershed Model
    - Data from Conowingo Dam will be used to:
        - Development, calibration, and validation of Bay WQ/STM
        - Good integrator of total sediment and nutrients from Conowingo spill (gates) and discharge (turbines)
    - Exelon Program:

      Sediment
        - Enhance Model Simulation of Conowingo Pond
        - Improved simulated loads transmitted through the Dam and used as inputs for Bay WQ/STM
        - Sediment Core and Bathy Survey(s)
            - Would improve understanding of scoured storm loads from the Reservoir/Dam system

      Nutrients
        - Enhancing model simulation of the Pond (AdH, Phase 6 Bay Watershed Model)
        - Improving the loads transmitted through the Dam and used as inputs to the Bay WQ/STM
        - Enhancement of the Bay WQ/STM's parameterization of nutrients and their relative bioavailability
    - UMCES:
        - Measurement of settling velocity distributions
            - Enhances the Bay WQ/STM directly
            - Use in the ROMS-Sed model and its application in parallel to inform enhancements to the Bay WQ/STM
        - Biogeochemical work on cores:
            - Direct application in refining the parameterization of the Bay WQ/STM

- Carl indicated that he has concerns about how any of this data will be used (from 2014/2015) considering the model doesn't run past 2011. Additionally, he said even if it's qualitative, it will be tough to correctly incorporate all of this new data (which will have to be on a qualitative basis) into any updated model runs which will be due by December 2015.

- Tom and Jim asked how historic land uses and other variables are updated over time. Carl indicated that this needs to be addressed. Lew said that for the TMDL runs they use current land uses for historic hydrology.

- Lew indicated that CB4 deep channel is the model's most sensitive model segment, and it is the hardest to achieve WQS attainment. He indicated that UMCES work is particularly relevant to Conowingo's impact on CB4, as there are many complex interactions going on in that segment.

- Tom asked Carl what components of his model can be updated based on the results of the UMCES ROMS model.

- Jeff, Carl and Rich explained that step 1 of Jeff's work is to collect field data. They then feed this info into a sediment flux model to come up with nutrient parameters for Carl's model. Carl said he would then plug it into his model, which would hopefully just work.

- Jeff said the value of the sediment transport model would then provide information on where the particles would land within the bay. He said the sediment transport model will allow better ideas of where sediments from the Susquehanna are deposited.

- Tom: If we didn't do the UMCES parallel model, how would this be done?

  Lew: We'll go in with the best information we have available. Even without the UMCES study it would be better than what they've had in the past. The UMCES model would be the fastest path to get data into the WQ/STM because it would allow for someone else to work on it in parallel while Lew/Carl work on the other stuff.

  Tom: It seems like we have 2 Sediment Transport models as proposed right now, what are the differences? Do you have to have the UMCES model to achieve the goals? If we have two separate models, do we have time with the given schedule, to incorporate the parallel model back into the Bay WQ/STM model?

  Jeremy: Carl's model could do it

  Carl: Carl's model could do it but he supports the idea that it is more efficient for UMCES to do the parallel modeling

  Jeff: Don't need the UMCES Sediment Transport model for what UMCES is proposing, would be nice to have but not critical if we don't have it

- Carl indicated that the UMCES sediment transport model will not "drop in" like Jeremy's sediment flux model could into the existing Bay model. Carl said it may "inform" the WQSTM, but they will be fundamentally different on some level.

Lunch Break

- The group discussed and came to agreement on how the deliverables from each component of the potential integrated plan would then be used with existing models. A table was developed mapping each deliverable to a specific model

  - Marietta sediment, nutrient load, Marietta PSD, Marietta Nutrient Production/decay rates – will be incorporated into Phase 6 watershed model eventually. In the short term, this would be projected backward into the mid-point assessment in some form (maybe qualitative?), but eventually this would be incorporated into the long-term watershed model in the long-term future. All data could also potentially be used to further refine the HEC-RAS model in the future if desired.

  - Conowingo data (sediment load, nutrient loads, Marietta PSD, Nutrient Production of sediments/nutrients passing the dam) would be used in the watershed model in a similar fashion.

- Carl mentioned that there is little available information on size classes passing Conowingo, so the PSD/size classes at Conowingo for different flows could be particularly helpful for his model. The WQSTM goes right up to the face of Conowingo Dam. The model takes a time series of sed/nutrient/flows from Conowingo Dam. Octoraro and Deer Creeks are added as a separate nutrient/sediment time series into the WQSTM.

- Carl indicated that ADH has a separate Susquehanna flats grid. This was run, but has not really been incorporated into the WQSTM runs. Carl indicated that there is an order of magnitude difference between the WQSTM scale and the ADH grid.

- All sediment/nutrient/PSD data will be used to calibrate the watershed model.

- Conowingo Pond Nutrient Flux and Diagenesis experiment (would include bioavailability and denitrification rates) would be used in the phase 6 watershed model. This experiment will result in updated ammonia and phosphorus flux parameters, but the denitrification parameter may not be able to be changed because it's not currently represented in the HSPF model.

- The diagenesis experiments will inform the labile/refractory split during storm events. This will be applied to the time series input into the WQSTM. Lew noted that the watershed model does not track this level of detail (it can't), so the labile/refractory split can't be included in the watershed model.

- Phosphorus release experiments will inform how phosphorus is released into the water column once the sediment has entered the Bay. This experiment will feed into the sediment flux model (SFM) and the WQSTM model eventually.

- Tributary sediment and nutrient loads, plus the PSD information will inform the watershed models. Carl mentioned that the existing watershed model has several (2 or 3) sub-watersheds in Conowingo Pond already, but it's unlikely that individual tribs have been added to the model.

- The real-time cruise and settling measurements would result in settling velocities. This would inform the WQSTM or UMCES sediment transport model. Carl is unclear how the settling velocity data will be used in the WQSTM. Not that it can't be used, it is possible, he just doesn't want to make any promises considering how long it took to get the sediment transport model going during the last go-around.

- Lewis showed us the watershed breakdown. It appears that Muddy Creek and Broad Creek are explicitly in there. Lew indicated that if there is enough information then it's possible that a new model segment for Peter's or Fishing or Conowingo Creek could be added into the model. He also noted, however, that there is typically longer-term monitoring data (25+ years) for most model segments.

- Tim Sullivan also asked about how bathymetry would be useful. It would primarily be in the ADH model. Gary Lemay noted it would be also used as a check/second method for calculating long-term sediment loads or deposition at Conowingo Dam.

- Lew mentioned that the watershed model is on an hourly time step.

- Tom and Bruce discussed bathymetry. They agreed that a higher flow threshold (perhaps 250,000 cfs or 300,000 cfs) would be used to trigger a data collection event. There would still be annual pre-hurricane season bathymetry surveys.

- Rich (MGS): Should we collect Side Scan with the Pond Bathymetry surveys? MGS has Side Scan equipment they could be put on the boat when Exelon conducts bathymetry surveys. Low cost, high gain.

Action Items:

1. Bruce to provide a list of State approved labs and parameters to Exelon for review
2. Exelon to develop a QAPP for their monitoring activities
3. Exelon to look into adding additional Conowingo Pond tribs, providing rationale for tribs not included
4. Exelon to create one comprehensive, integrated plan for group review
5. Jim and Jeff to work on integration of Nutrient portion of plan then provide to Tim for inclusion in comprehensive plan
6. UMCES team to regroup next week regarding Sediment Transport questions. UMCES will provide an updated proposal end of next week, beginning of following week
7. Small working group to meet within the next 2-3 weeks. Conference call first meeting, in person after as needed
8. Tom to inform Exelon Leadership within next few days. Funding request to them following receipt of additional information
9. USGS to review sampling well design drawings within next 1-2 weeks
10. Mike Langland to inform Exelon of Holtwood site visit schedule
11. Exelon to provide list of Action Items and Deliverable Table to group
12. Exchange PowerPoint presentations between the various groups. GSE to provide access to ftp site for group if needed.

Integrated Sediment & Nutrient Monitoring Program – Planning Meeting
August 20, 2014
USGS Offices, Baltimore, MD

Attendees:

Tom Sullivan (GSE)	Tim Sullivan (GSE)	Gary Lemay (GSE)
Lana Khitrik (GSE)	Kim Long (Exelon)	Jim Fitzpatrick (HDR)
Bryan Strawn (URS)	Marjie Zeff (URS)	Bruce Michael (MDNR)
Joel Blomquist (USGS)	Larry Sanford (UMCES)	Cindy Palinkas (UMCES)
Rich Ortt (MGS)	Mike Owens (UMCES)	Jeff Cornwell (UMCES)*
Lee Currey (MDE)*	Mike Langland (USGS)*	Lew Linker (EPA)
Carl Cerco (Corps)*		

* *Indicates participation via phone*

Meeting Minutes:

- Bruce Michael opened the meeting with introductions. Hopefully final meeting before getting contracts finalized and work can begin, as the data that will be collected plays a large part in the 2017 mid-point assessment. MD's main goal is to determine impact of Conowingo reaching dynamic equilibrium in regard to Bay water quality.

- Tom Sullivan provided an overview of the agenda. Also provided a status update of where things currently stand including status of sampling well at Conowingo Dam.

- Kim Long provided status update regarding contracts: 1) Cianbro (in good shape), 2) PPL access agreement (PPL has not been responsive to Kim's repeated contacts) – Joel to follow-up 3) Bulleted scopes were sent to MDNR and UMCES for their review. These scopes will then be used in the contracts. Need the scopes to be accepted/finalized by MDNR and UMCES. Bruce and Kim will continue to work together to resolve MDNR (USGS) contract(s). Bruce asked if Exelon would have one contract with UMCES for Horn Point and for CBL. Kim confirmed that is the case. Tom indicated, as a heads up, that there will also be a legal document sent along to MDNR and MDE that will accompany the scopes of work and the contracts. Bruce acknowledged and agreed as did Lee Currey. Larry Sanford asked about timeline for contracts. Tom indicated we are really only waiting on finalizing scopes; as quick as we can get through that we can issue contracts. Larry indicated UMCES is at a standstill until the contract has been finalized. Larry mentioned UMCES will actually be doing some hiring for this effort and they cannot do anything until the contract has been finalized.

- A few logistics questions were raised. Tom indicated that after this meeting a logistics meeting for all field leads would be very beneficial.

- Joel Blomquist provided an update on the continuous monitor downstream of Conowingo. It is being installed this week and should be operational by the end of the week.

- Tom began page turn of the latest version of the Lower Susquehanna River Integrated Sediment and Nutrient Monitoring Plan.

INTRODUCTION:

- Tom provided background and rationale for change in Introduction language. Bruce acknowledged he is ok with changes.

GENERAL APPROACH:

- Reviewed addition to last bullet. Tom raised question whether having added language is appropriate. Bruce indicated that water clarity is a MD WQS as well. Right now they don't see an impact on clarity but don't know under lower flow event the dynamics of clarity. Bruce would like to include water clarity.

- Tom asked if there is anything in current scope that explicitly looks at clarity. Lew Linker indicated model runs can be made that would look at this information. Kim indicated that from Exelon's perspective this is tangential to the original question that was asked by MDNR. Kim said that this addition makes her concerned that in the future we may get into an argument that now we need to look into other components that we haven't answered as a part of this study. Bruce wants to be complete and look at all the potential WQ impairments including DO and clarity. Joel suggested modified wording to capture this. Larry indicated the current wording discussed a "better understanding" not that it will be explicitly modeled.

- Tom reiterated his specific question: is there anything specifically in the data collection program that will lead to capturing data that will be collected for those additional WQ parameters? This is different from modeling. Bruce indicated models look at all three components, mid-point assessment all three components. Everything will be updated, not just from this effort but from others as well. The Bay program will access all WQ components.

- Rich Ortt and Bruce indicated that the tributary monitoring and the turbidity monitoring will capture clarity during these events. Exelon agreed to include clarity in the objectives. Discussion then centered on chlorophyll.

- Jim Fitzpatrick noted that chlorophyll data is not being collected but instead relying on the model completely, therefore why would it be in the objectives? Jim proposed adding some language. Tom's proposed change of wording: "…on Bay DO and better inform analysis of clarity and chlorophyll in the upper Bay."

FIELD DATA COLLECTION AND ANALYSES

INTEGRATED PLAN - TASK 1:

- Joel – Travel time – Dye study vs. estimates. USGS design relies on the continuous monitoring of turbidity. Exelon will work with Joel on language for time varying loads based on SSL vs. turbidity. Joel will provide language to Exelon for next draft of Integrated Plan.

- Larry requested that the document be updated to get rid of references for early summer sampling.

- Tim Sullivan & Joel reviewed the USGS component of Task 1 – USGS intends to sample on a daily basis at Marietta, Holtwood, and Conowingo over entire storm. USGS needs to analyze sediment graphs after storms – USGS will edit and reissue. Okay not to sample at night because of continuous turbidity data. Tim will work up language for the Integrated Plan describing the sampling that will be done at the mainstem location (in terms of frequency), with input from Joel and Mike Langland. Tim asked if there are two teams or three teams. Joel said there are at least two teams, but there may be more if necessary. Joel noted that it may be worth identifying each of the mainstem samples differently than the rest of the sampling sites.

- Norman Wood Bridge – Is sampling once for the entire Program enough? Mike – they are planning on 2 samples at Norman Wood. Sampling will require closing down one lane of the Bridge, USGS has a traffic control contractor. Lane closure will be for four hour windows. They can do more if they need to. Try to do the two events up front if possible. Joel also indicated that there is a chance that they go out twice and fail both times. Joel also said that there is the possibility that they really don't have too many problems and want to integrate more samples from Norman Wood Bridge. Tim asked what amount of prep work would be needed to be ready. Joel said they are gathering equipment. Mike said they are in progress but did not give a projected 'ready' date.

- Bruce – Concerned about having Chesapeake Biological Laboratory (CBL) doing SSC and PSD analysis. They would rather have Exelon collected water samples submitted to the USGS Kentucky lab. Exelon could deliver samples to MDNR who could then submit to the USGS Kentucky Lab. Joel indicated they would need to look into this further.

- Mike will provide Exelon with specs of new turbidity meter. Marjie Zeff asked a few questions about the turbidity measurements. Marjie then asked if placing the turbidity meter in the Holtwood forebay would be appropriate, and indicated it's imperative that we assess the representativeness of the turbidity meter location. Joel reiterated that the Holtwood/Norman Wood Bridge location is a tough location to sample, and that they included Marietta in the plan as a backup. Tom indicated that Exelon has some issues with using Marietta as a backstop. Marjie indicated that Exelon's view is that a better understanding of Holtwood outflows is imperative in order to understand what is happening inside of Conowingo Pond, the input to Conowingo Pond is very important to Exelon. Joel indicated that the USGS scope's purpose is to characterize the changes in suspended sediment concentration and makeup across the three-reservoir system. The final objective of isolation mid-reservoir changes was a minor objective for them and their study was not focused as closely on that point. Tom indicated that Exelon's interest is getting a sediment budget of Conowingo Pond. Tom recognizes that Conowingo inflow is hard to characterize, but bathymetry data combined with core data can be used as a backup plan. After some discussion, Exelon agreed to investigate installing a second turbidity meter somewhere in a potentially more representative location downstream of Holtwood Dam.

- Gary Lemay asked at what flows does Holtwood shutdown as that could affect the representativeness of the turbidity monitor. Mike indicated that PPL stated they never shut down. USGS and Exelon agreed to look into this further.

- Larry asked who will make the mobilization call. Tim said the plan will be reviewed and updated to concretely state who does this. Bruce said that Mike and Joel typically make the call for them, but the parties will work together to identify a protocol.

- Tim then moved discussion to the tributary sampling protocol, after Joel mentioned that some of the tributaries may have risen and fallen by the time a decision is made on mainstem sampling. Bruce said they will be sampling most tributary events as part of their non-tidal sampling regardless. Bruce noted that since they have a good historical record of the tributaries, the non-tidal network sites are focused on getting a single point on each of their tributaries. Since the tributaries Exelon is responsible for don't have a historical record, Exelon may want to consider gathering multiple data points on each storm. Tom said he doesn't understand how the historic data replaces having a rigorous sampling frequency during the target storms. Joel said that if he needed the exact events coupled, then he would be doing turbidity sampling meters at each of the important sites. If we don't do that, then he would focus on high-quality measurements during potentially 'extra' events so that we don't miss any mainstem events. Tom asked if the Muddy Creek station is collecting turbidity. Mike indicated that they are not collecting turbidity data at Muddy Creek. Joel said that we really need to be measuring turbidity if we are going to be interested in specific storm events. Bruce and Joel agreed that temporal monitoring of turbidity in the tributaries would be beneficial. Mike indicated another option could be the ISCO samples. Joel indicated that typically they assume variability in time is greater than variability in nutrient content, based on the data they have seen. The USGS prefers to fill in temporal gaps in data by using turbidity. Tom asked if 36 data points would be enough to establish a curve. Joel indicated if they are appropriately targeted, that seems like a reasonable number. Exelon will look at establishing a way to continuously monitor the tributaries during storm events, potentially using turbidity/SSC relationships. Tom also noted, however, that MDNR/USGS should come up with a similar approach for Muddy Creek.

- Joel mentioned that although the USGS is tracking water levels at Holtwood, there is not an established streamflow gage. Tom mentioned that PPL records flow data, although it is unclear what they use to estimate the flow data. Joel indicated that the group will want to take a look at the accuracy of flow estimates at Holtwood and Conowingo. Joel indicated it may be easier to measure tributary flow and 'subtract' them from the Conowingo USGS gage measurements as opposed to getting flow data at Holtwood.

- Tim confirmed that Exelon understands that the MDNR sites (non-tidal network) will have samples collected once per storm. Bruce agreed with this.

- Tim asked Mike what SRBC will be doing for their Octoraro Creek sampling. Mike indicated that SRBC will follow whatever decisions are made for this project. Bruce said Kevin McGonagall is the SRBC contact for any sampling. Tim asked if there will be any need for establishing a separate contract with SRBC, Bruce and Mike said they don't anticipate that being necessary.

- Larry noted that the lab descriptions on page 9 of the Integrated Plan may need to be updated. After some discussion, Mike noted that PA USGS will sample Octoraro and Muddy Creek data (PA DEP lab for nutrients only, USGS lab for sediment data), and Bruce said Deer Creek goes to MDNR's lab.

- Bruce and Tim came to agreement that the labs will provide raw and QA/QC'd data to both parties and that MDNR would be responsible for QA of all lab data. Tim also indicated that Exelon would conduct their own QA of lab data and that any disagreements or interpretive assessments of the data will be discussed and worked through collaboratively.

  - Lana Khitrik asked if MDNR could provide the structure of the MDNR database to Exelon for Exelon's data management development purposes. Lana will follow up with Bruce regarding this.

  - Tim then asked about the proposed side-scan sonar survey. Tim is wondering what benefit this will provide to the study. Rich indicated that the side-scan survey will provide a map of surface sediment variability. Rich said this data can be used to make sure that any sediment cores are not placed in a non-representative location within the Pond. Rich indicated MGS can also collect bathymetry data at the same time. Rich also indicated that if MGS were to run a post-scour survey they can then see which areas may have scoured based on the sediment makeup. Rich said he scoped the work as a single event; the cost estimate would need to be doubled for a pre and post-storm comparison. Tom mentioned that this discussion may fit better as part of the coring selection discussion since it appears that the objective of the side-scan work would be to better inform the coring locations.

INTEGRATED PLAN - TASK 2:

- Page 20, Comments 19 and 20 – 1-3 meters deep will be sufficient for what Exelon needs. Is taking 1 core and sub-sampling that going to give enough material? Or should paired cores with subsampling be collected? Jeff Cornwell indicated UMCES doesn't need a huge volume of material. 1 core should be more than sufficient to do the necessary analysis and still have enough to archive. Marjie asked if it matters if the cores are collected in areas of scour or deposition.

- Jim Fitzpatrick asked frequency of collecting deeper cores, if pre- and post-storm deep core collection would be necessary. Jeff stated that box cores would be the ones used for before and after; hadn't really thought about doing longer cores before and after. Need to think about that.

- Rich cautioned against measuring bulk density from a vibracore. Rich suggested that a piston core would be better for bulk density. Use vibracore for UMCES data collection, long core. Then do a shallow piston (1 m) to do cores for bulk density. Rich recommended changing the scope to explicitly state 3m core. Vibracore great for getting to depth, safety, but has a lot of compaction. Piston Core – first 1 m is essentially useless due to how it's collected. Safety issues with piston coring operation. Gravity core – cheapest alternative. Marjie asked about matching with CPT's. Rich recommended if a piston core is being collected to take a gravity core at the same time; should be minimal added cost to do that since rig is already there. Gravity cores can go 75 cm deep regardless of depth of water, piston cores can go way down but need to be in water that is 2x as deep as the depth of the core (10 ft core = 20 feet of water) due to safety considerations. They are scary to use, people don't want to use them if they can avoid them. Vibracore can get up to 10 ft. Gravity cores are extremely accurate. Piston core will limit where you can geographically take a sample due to water depth requirements. Marjie indicated she believed that a Shelby tube with vacuum shouldn't disturb the top meter.

- Tom – what does UMCES need the deep cores for? Jim/Jeff - Bioreactivity experiments at 1m, 2m, and 3m. Slice the top portion of the core to do incubation experiments. Need to also know where you are in time when reviewing the core so that you know the sediment history. That's where the radionuclides come in. Long-core depth needs to be 3 m. Jeff – UMCES will collect all box cores themselves from their own vessel. Rich – vibracore requires using a lot of art as opposed to science when determining how much compaction occurred and how to handle it. Tom – vibracore will be fine for what UMCES needs but will be challenging for bulk density. Gravity cores would be better for bulk density but could not go to the depth of scour. Rich – very high error bars for using bulk density to convert a wet volume to a dry weight. Tom – if we can use piston cores, would piston cores be sufficient for what UMCES needs? Jeff – yes.

- Recap – 3 meter core is length needed for long core. UMCES can live with either a piston core or a vibracore. Exelon needs to determine what method can be used to best get dry bulk density. Bulk density value options: vibracore being very careful with compaction or combination of piston and gravity cores. Exelon will investigate the methods and draft them as a scope which we'll get quotes on. Exelon will report back to the group their findings.

- Page 22 - No. of incubations: Jeff – budget currently accommodates up to 150 incubations. Still unsure exactly how many will be needed. For tributaries only do a couple of seasons. 80-100 in sediment, 50-70 in suspended sediment.

Page 22:

- Geochronology: Jim – sees value of ^{210}Pb but unclear on value of surface investigations. Cindy Palinkas – surface investigations will tell you where you have deposition or erosion. Will confirm what was seen during bathymetry surveys or model results. Depth of ^{7}Be will tell you deposition rate. Radionuclides tell you what has happened over time; examine sediment history not just in space but also in time.

- Jim – presented slides on how labile (G1), refractory (G2), and inert (G3) pools are used in the model and the potential problem that could be encountered if the UMCES results show that the majority of the bed material is inert. The model would essentially be counting inert nutrients as refractory and thus overestimating carbon and nitrogen. Phosphorus is different.

- Lew – radionuclide would give information on G3. Knowing how old the inert material is and quantifying how long it has been there is important to the model. Inert material that is 5 years old may not be the same as inert material that is 10 years old. In the "Scenario mode" as opposed to "calibration mode" the modelers will have to represent it as best as they can as opposed to how they do it now with Carl Cerco's current assumptions. Lew acknowledge this has to be accounted for in the WQSTM.

- Carl Cerco stated that he does not have the answer on hand. Jim has raised some issues that need to be discussed and resolved. The model will soon take into account inert but how they divide the load into those pools is problematic and has not been determined. The group may need to wait and see what the results of UMCES's study are. Not sure the Corps is going to look at age at all. Once something is inert it doesn't get more inert or less inert. Measurements of reactivity with depth are the most important thing for updating the model.

- Conversation again centered on the UMCES radionuclide work. Larry noted that knowing the context of sedimentary history will help a great deal in understanding what is going into and out of the system. Can be used as a back check if budgets don't line up, can back up bathymetry and show in greater detail deposition rates, can interpret the context of the core data and show where core locations should occur.

- Carl stated that Larry makes good points but we don't want to make this so complicated that we end up not having any answers. Not going to know the reactivity of every piece of sediment that goes over the dam.

- Tom – Exelon will digest the radionuclide discussion and close the loop with the larger group.

Page 24:
- Jeff will find out if data referenced in text addition is available.

- Comment JF27: Jeff will follow up with Jeremy Testa about that question.

- Larry – settling tube analyses need to be conducted on site at Conowingo immediately (within minutes). Each experiment would take an hour and a half once UMCES received the water. Larry will need 10L of water total, Jeff and Cindy will also need additional water. Larry would want a 10L composite from the spillway and then a 10L composite from the tailrace. Cindy needs 20L from the spillway and 20L from the tailrace. To start UMCES will need this quantity of water each day of the storm event (e.g., if the storm event is 6 days, 30L per day). Jeff and Mike need 20L from the spillway and 20L from the headworks. USGS needs 7L for their analyses. 57 L total of samples for each day. 1st storm will be that quantity collected for each day. Subsequent events will be reexamined to see if they need that much water.

- Potential compromise – take a composite of spillway and tailrace, agitate and measure settling vel.

- Joel – need to look at discrete samples not composites in order to determine if in fact the spillway and tailrace are different and if so, how different. Analyze each gate individually and each segment on the tailrace individually to do statistical analysis to determine difference between the two. USGS would then use this information to determine how far off they may have been with past measurements. Indicated USGS is looking into isokinetic sampling from a boat downstream of Conowingo to get a robust dataset that complements the spillway and tailrace sampling. Individual, discrete samples would only need to be analyzed for SSC and PSD, not nutrients. Composite samples would be analyzed for everything.

Page 25:
- Tom – Exelon is striking the Peach Bottom language. No objections.

- Cindy – elaborated on Comment TS32. Comparing Pond core data and Conowingo water sample data with cores collected downstream of the Dam. Distinction would be made between sediment that sat on the bottom of the bed vs. what was suspended and "fresh" from the watershed. Wouldn't be able to tell which reservoir the bed sediment came from just that it came from the bed of a reservoir.

- Tom – If UMCES does their analyses at the Dam and then in the Bay 1 day later do they think the plume will actually have made it to the Bay by then? Need to know travel time of plume based on previous storms so that UMCES can time their Bay data collection accordingly. UMCES needs to go back to the existing data and conduct the travel time analyses.

- How will this data be used in the models?

- Larry – the data has never existed this would be the first time that this data could be collected and that funding would already be in place ahead of time. This would be a validation exercise to validate model predictions. If they find that field results do not match up with model predictions various model parameters could be updated to improve the model calibration.

- Tom – requested UMCES (Larry) provide a purpose for why this is necessary and what this will be used for. Same comment for radionuclide. UMCES should also talk to Lew and Carl to determine if the parameters that would need to be adjusted could in fact be adjusted.

- Page 27, Comment TS38: UMCES to provide clarification/elaborate how sites will be selected. Tom – need to look at Ming's model, need to look at Carl's model, need to look at field data and based on that. Cindy – need flexibility to be able to move if UMCES finds in the field that a predetermined location is not adequate. Tom – provide a clear explanation at bottom of page 27.

Page 28:
- Comment TS39 affects Jeremy's model as well as Carl's model (distribution of pools (G1, G2, G3)).

- Comment JF40: Jim – unclear what this paragraph is attempting to do specifically the 2-D depositional fields. Larry - Jeremy will run multiple SFM condition model runs.

INTEGRATED PLAN - TASK 3:
- See previously agreed upon items from morning discussion.

- Marjie – will anyone need cores right away for analysis purposes? UMCES will have a need for receiving the cores within 1-2 days of collection. Temp can't change dramatically and cores can't dry out during this time.

- Rich – if no need for stratigraphic analyses no need to x-ray them. If need for stratigraphic will need to x-ray them.

- Cindy – photograph and describe them prior to any splitting. Not sure x-ray is needed for anything UMCES needs.

- Tom – Document and photo, physical changes (color, sand lenses, etc.), subsample at different stratigraphic areas, physical parameters (dry weight bulk density, PSD, stratigraphy), ½ core then done with, other ½ of core sent to UMCES.

- Marjie – what about coal? How will that be handled, how will it affect things? Rich – from the physical size of sediment he recommends removing the coal. Cindy – unsure right now how coal will impact their experiments. Tom – should coal be in for dry weight bulk density. Marjie – Yes it should be due to the fact that it is the existing material. Rich said he would prefer to remove it from the analysis. Cindy said she wasn't sure, but she was planning on looking at some other cores next week that will also contain coal. Tom proposed the following sequence: recover cores, split the cores, photograph them, conduct stratigraphy, and then ship one half of the core to UMCES. For the half that Exelon has, a bulk density analysis will occur, followed by a PSD breakdown. Joel asked if there is a list of what will be measured from the cores, and suggested a table is added to the plan to specify what is done with core half #1 and core half #2.

- Mike recommended putting it on dry ice to freeze it so that it can be transported without being corrupted. Rich recommended doing everything on site if possible.

- Integrated plan needs to be updated to include a table of what will be measured, who will do what, Core ½ 1 and Core ½ 2 for UMCES vs. physical properties.

- Joel - What breakpoints will be used for PSD? Mike then asked if UMCES is looking at organics on the clays, or silt/clays, as this may impact how the PSD breaks are done. Jeff indicated he didn't have any specific size break needs, and Larry said the same, so neither needs specific size breakdowns. Tom then re-iterated the core sequence: boring, split, sketch/photograph, half to Exelon, half to UMCES. Tom wondered if the cores need to get to UMCES within a day of removal, how will it get there in time? Rich suggested UMCES come on site to take the cores. Marjie suggested a second core collected at the same site that way one core goes to UMCES and a second core to Exelon. Rich suggested on-site sub-sampling the cores, and then immediate disposal. There may be some concerns with doing this, as there will be no archive leftover.

- Marjie - 62.5 microns Silt/Sand, 4 microns for clay

- Joel – USGS does it differently. Further discussion should occur about breakpoints. USGS is fine with Exelon using our own lab (URS lab or commercial) for PSD and physical parameters so long as the methods are comparable.

- Jeff – need to collect long cores sooner rather than later. Need to do it prior to onset of cold weather. Field mobilization in mid-October at latest would be preferable.

- Rich – Permit required for core collection in Maryland; 4-6 month turnaround time to get a permit. Don't think PA would need a permit. UMCES does not need a permit, look into having UMCES coordinate contract of long core.

- Tom – schedule conference call with smaller group as soon as possible to finalize core components.

IMPLEMENTATION/MOBILIZATION SECTION:

- Joel – need to add adaptation paragraph that plan will adapt over time and be collaborative. Add to Implementation section.

WRAP UP/RECAP:

- Send contact list back to Bruce for storm mobilization
- Exelon to distribute meeting action items to group

Integrated Sediment and Nutrient Monitoring Program
August 20, 2014 Meeting
USGS Offices – Baltimore, MD

ACTION ITEM	DUE DATE
Exelon to update Integrated Plan based on areas of agreement at meeting.	Completed
USGS (Joel or Mike) to follow up with PPL regarding access agreement with Exelon for installation of turbidity sonde on forebay skimmer wall.	Completed, contract in works
USGS (Joel) to provide Exelon (Tim S.) with updated language regarding how turbidity data will be used to account for the travel time of water, sediment through the reservoir system.	Completed
Exelon to update Integrated plan to remove all references to "early summer" sampling	Completed
Exelon to update Integrated Plan to reflect USGS mainstem sampling frequency at Marietta, Holtwood (including Norman Wood Bridge), and Conowingo.	Completed
USGS to continue gathering equipment needed to sample from the Norman Wood Bridge	Completed
MDNR (Bruce) and **USGS** (Joel) will reach out to USGS Kentucky laboratory to see if it is possible for Exelon to submit all water samples for analysis of SSC and PSD to the USGS lab. Exelon will still use CBL for all nutrient analyses.	Completed
USGS (Mike) to provide Exelon (Marjie) with updated specs on turbidity sondes that will be used during this Program.	Completed
USGS (Mike and Joel) to reach out to Holtwood/PPL to determine how Holtwood operates during a storm event and at what flows the Station is shut down.	Completed
Exelon to work with USGS to look into installing an additional turbidity sonde at a location downstream of Holtwood as an additional check on the sonde installed in the Holtwood forebay.	Completed
Exelon to reexamine tributary sampling program to potentially incorporate ISCO samplers or turbidity sondes in addition to depth and width integrated sampling. Exelon will work with USGS to discuss sampling protocols at Muddy Creek.	Completed
USGS to check with PPL regarding how flow data is recorded at Holtwood and if that data would be made available for this program.	Completed
Coring conference call with smaller group on Thursday September 4th from 10:00-12:00. **Exelon** to send out meeting invitation and call-in information. Purpose of call will be to discuss: core collection methods, locations of cores, timeframe, core analysis needs of each group, how coal will be handled, permitting requirements, side scan survey(s), and how cores will be processed after collection. Exelon and USGS to exchange methods on core PSD breakpoints/methods.	Completed
Exelon to update coring section of the Integrated Plan once scope of coring program is more clearly defined. This update will include a table outlining what analyses will be done using the long cores.	Completed
Exelon to further evaluate the need for proposed radionuclide and radioisotope experiments/analyses and regroup with MDNR/UMCES	Completed

ACTION ITEM	DUE DATE
UMCES (Jeff) to provide Exelon with Boynton's reservoir POM data	Completed
UMCES to provide clarification on how Jeremy will be collecting data for SFM	Completed
USGS and Exelon to examine how practical or realistic it will be to collect 57 L of water for each sampling event and work with UMCES to determine if less water could be collected while still meeting their needs. Exelon to work with UMCES on logistics for conducting settling analyses onsite at the Station.	Further discussion required
UMCES to provide a description of where Bay sediment samples will be collected.	Completed
UMCES to develop a QAPP discussing all aspects of their work (field data collection up to laboratory analyses and experiments) and provide to larger group.	Outstanding
Exelon to complete their QAPP/SOP's and provide to larger group.	Completed
UMCES to complete Exelon Vendor Safety training prior to any field activities occurring at Conowingo. UMCES to provide a single point of contact who Exelon (Kim) can work with to schedule the training.	Outstanding
Exelon to add a paragraph on adaptive nature of the Program to the Integrated Plan	Completed
Schedule a logistics workshop with larger group and field leads to finalize details and logistics of sampling mobilization and protocols.	Pending completion of Integrated Plan and execution of contracts
Exelon to provide MDNR with updated list of contact information for sampling personnel.	Completed
Interim, short-term sampling logistics conference call (i.e. sampling prior to contracts being in place) with larger group scheduled for Thursday September 4th from 1:00-2:30. **Exelon** to send out meeting invitation and call-in information.	Completed
Exelon to continue to work with UMCES, MDNR, Cianbro, and PPL to finalize contracts and access agreements. Finalizing contracts depends on finalizing Integrated Plan and scopes of work.	Ongoing
Exelon (Lana or Tim) to follow up with MDNR (Bruce) regarding their existing database structure and data formats.	Outstanding

APPENDIX B – SAMPLING WELL DESIGN DRAWINGS - CEII

CEII – Critical Energy Infrastructure Information

APPENDIX C – QUALITY ASSURANCE PROJECT PLANS

LINK TO APPENDIX C