STUDY PLAN TO COLLECT SUPPLEMENTAL DATA TO ASSESS THE POTENTIAL EFFECTS OF THE BELL BEND PROJECT ON WATER QUALITY OF BACKWATER AREAS USED BY FRY AND YOUNG-OF-THE-YEAR SMALLMOUTH BASS

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FEBRUARY 2012

(DRAFT FOR DISCUSSION)

CONTENTS

TABLES

FIGURES

ABBREVIATIONS

Abbreviation	Meaning
°F or °C	Degrees Fahrenheit or Celsius (water temperature)
7Q10	Seven-day, consecutive low flow once on average every ten years.
ACOE	U.S. Army Corps of Engineers
ADCP	Acoustic Doppler Current Profiler, instrument to measure velocity at varying depths
ADF	Average Daily Flow computed on an annual basis
AMD	Abandoned Mine Drainage
BBNPP	Bell Bend Nuclear Power Plant
BBNPP ER	Bell Bend Nuclear Power Plant Environmental Report submitted to the Nuclear Regulatory Commission
cfs	Cubic feet per second; 1 cfs = 0.646 mgd
COLA	Combined Construction and Operating License Application
CORMIX	Cornell Mixing Zone Expert System, mixing zone model
DO	Dissolved oxygen
EFDC	Environmental Fluid Dynamics Code, 3-D hydrodynamic and water quality model
EMA	Eastern Middle Anthracite Fields
ERM	Environmental Resources Management, Inc.
GEMSS®	Generalized Environmental Modeling System for Surfacewater, 3-D hydrodynamic and water quality model
HSC	Habitat Suitability Curve, index used to indicate fish preferences for microhabitat variables (e.g., water velocity, depth, substrate/cover);expressed on a scale of 0 (least suitable) to 1 (optimum)
IFIM	Instream Flow Incremental Methodology, habitat-based methodology to estimate available aquatic habitat under changing flow conditions; based on the premise that stream-dwelling organisms prefer a certain range of microhabitats (velocity,depth,and substrate/cover)
mgd	Million gallons per day; 1 mgd = 1.55 cfs
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
PADEP	Pennsylvania Department of Environmental Protection
PFBC	Pennsylvania Fish and Boat Commission
PHABSIM	Physical Habitat Simulation, model integrates outputs of hydraulic model(s) and species micro-habitat preferences (depth, velocity, and substrate/cover)
PLS	Professional Land Surveyor
PPL BellBend	PPL Bell Bend, LLC; sponsor of the BBNPP project
RHABSIM	Customized version of PHABSIM
Sonde	Device that measures DO, temperature, pH and conductivity; French for “probe”
SRAFRC	Susquehanna River Anadromous Fish Restoration Commission
SRBC	Susquehanna River Basin Commission
SSES	Susquehanna Steam Electric Station
TMDL	Total Maximum Daily Load
TRPA	Thomas R. Payne and Associates
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WUA	Weighted Usable Area, an index of available habitat

1. INTRODUCTION

PPL submitted a report to the SRBC entitled, *"Potential Effects of the Bell Bend Project on Aquatic Resources and Downstream Users, Proposed Bell Bend Nuclear Power Plant Site, Luzerne County, Pennsylvania,* dated June, 2011. Subsequent to the submittal of that report, SRBC provided comments in a letter dated December 21, 2011 to Mr. Michael J. Caverly, VP-Financial Nuclear Development. In that correspondence, SRBC provided a number of comments with the following primary concerns:

1. There is a need for additional sampling of backwater and shoreline areas for dissolved oxygen (DO) and water temperature where fry ($\leq$25 mm) and young smallmouth bass (YOY SMB) are known to occupy so that a more complete evaluation of the effects of consumptive use can be made.
2. Shallow inshore locations are critical habitats for YOY SMB and are of concern and should be the primary focus.
3. The study should determine the size and location of these areas at low flow conditions.
4. Since lowest DO levels were recorded at Sonde #1 at Goose Island, additional data are required to determine the extent and magnitude of the low DO levels.
5. Data are required from other backwater areas such as the backwater areas in the Rocky Island vicinity.

This study plan has been developed in light of these comments with a primary focus on obtaining additional water quality data from backwater and shoreline areas.

1.1. OBJECTIVE

The objective of this study is to assess the potential impact associated with reduced river flow and stage due to BBNPP (Figure 1-1) consumptive use on dissolved oxygen (DO) and temperature, primarily focusing on backwater and shoreline areas that may be occupied by YOY SMB.

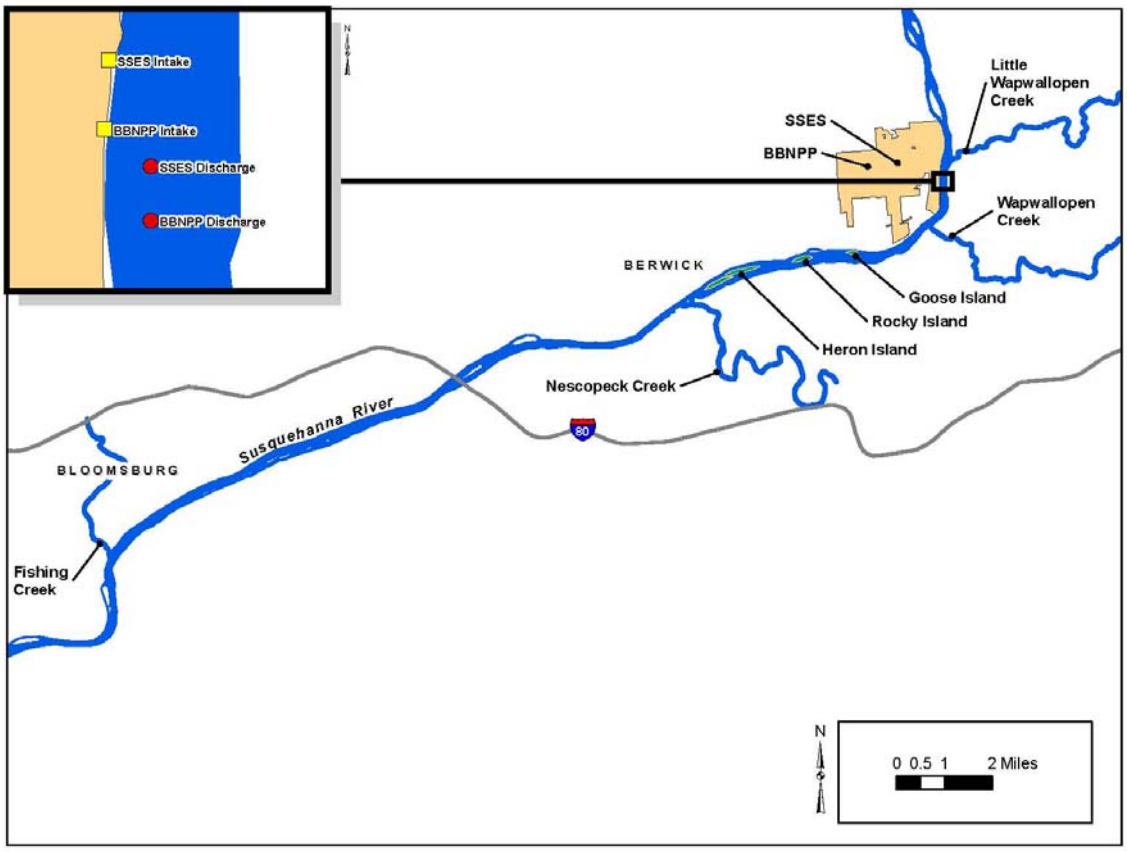

Figure 1-1: Map showing intake and discharge locations for the proposed Bell Bend Nuclear Power Plant (BBNPP) on the Susquehanna River, Luzerne County, PA. Source: Normandeau Associates, et al. 2011.

The 2012 data gathering and analysis will provide a comprehensive data base for a more complete evaluation of these areas. The study reach for this data collection is approximately 2.6 mi between the upper tip of Goose Island and the lower tip of Heron Island; the upper tip of Goose Island is approximately 2.5 mi downstream of the proposed BBNPP discharge location.

1.2. PLANNED FIELD WORK AND ANALYSIS

The work will consist of collecting additional observations on SMB spawning activity (nesting, fry emergence, rearing, and nursery) DO, water temperature, pH, and depths data at six backwater and shoreline areas including the portion of the Susquehanna River near Rocky Island. Continuous depth measurements were not collected during 2010. The plan assumes that there is sufficient flexibility to respond to changing and/or prevailing hydrological and meteorological conditions.

The data collection is proposed to cover the period from mid-April to mid-August 2012. A temperature impact analysis will be conducted in a manner similar to that performed on the 2010 data. The 2010 temperature impact analysis was evaluated using a 0-dimension Temperature Calculation module of the Generalized Environmental Modeling System for Surface waters (GEMSS®) software package. This method uses hourly meteorological data to develop temperature change (ΔT) based on the maximum induced depth change as calculated by the flow analysis. The changes in temperature are then applied to the sonde data.

For the 2012 data analysis, the data will be assessed for event frequency and duration using the same methodology as the 2010 data. The thermal model will also be applied using the 2012 data and corresponding hourly meteorological data and ΔTs reported on an hourly basis with the same diagnostics and summaries as with the 2010 data. In addition, the 2012 data collection will also include a depth transducer that will collect depth data on an hourly basis that corresponds to the water quality data. This will allow a direct comparison of depth, and thus flow variation and how temperature is statistically related to flow. Based again on diagnostics, a correlation or regression analysis can be completed to determine the existence of a statistically significant relationship and the strength of any relationship. It may also allow evaluation of the relationship on an hourly basis, again based on the data diagnostics. The hourly measurements are expected to provide a large sample size for these types of analyses.

PPL Bell Bend intends to submit a study report by the end of the 3rd quarter 2012. The sections below provide details of the study plan along with the specific objectives.

2. RELEVANT DATA AND PRIOR STUDIES

This section of the study plan summarizes relevant and readily available hydrologic and water quality data. Relevant data sources and reports are outlined in Table 2-1.

Table 2-1 Summary of Relevant Prior Studies and Data

Source	Reports and Data
Ecology III	Currently conducts quarterly water quality sampling at five sites; measures daily temperature and water surface elevation; performs electrofishing and seining. Macro-invertebrate, mussel, and impingement/entrainment investigations were also conducted. Annual reports are available beginning in 1971 with occasional special studies (e.g., thermal plume surveys) published separately. Reports include summary of water quality parameters (pH, DO, temperature, alkalinity, conductance, hardness, TDS, nutrients and metals).
EPA	Published two TMDL's (Susquehanna River and Nescopeck Creek) which summarize water quality data (pH, alkalinity and metals: aluminum, iron and manganese). Primary source of data are the sampling done in support of TMDL's (AMD-related TMDL for both Susquehanna River reach upstream of the BBNPP and Nescopeck Creek, and PCB-related TMDL for the Susquehanna River).
PPL Bell Bend	Published the BBNPP Environmental Report which is not a primary source, but contains a summary of available water quality parameters (pH, DO, temperature, alkalinity, conductance, hardness, TDS, nutrients and metals). Primary source of data are two SSES sampling locations used since 1968 and additional sampling performed during 2008.
USGS	Measures stage and discharge on various streams and the Susquehanna River itself. Several water quality parameters (pH, nutrients, metals, minerals, hydrocarbons and TDS) measured at USGS station near Hunlock Creek and Danville.
Normandeau Associates, et al., 2011	Potential Effects of the Bell Bend Project on Aquatic Resources and Downstream Users Proposed Bell Bend Nuclear Power Plant Site, Luzerne County, Pennsylvania

2.1. HYDROLOGY

This section presents background information on flows in the Susquehanna River relevant to this study.

2.1.1. USGS Gaging Sites and Records

The USGS gaging sites of importance to this study are shown in Table 2-2, below.

Table 2-2 USGS gaging sites

Location	USGS No.	Drainage Area (sq. mi)	Period of Record
Susquehanna River at Wilkes-Barre	01536500	9,960	Daily discharge, 4/1899-present
Susquehanna River at Danville	01540500	11,220	Daily discharge, 4/1905-present
Nescopeck Creek at Nescopeck	01538600	171	Periodic measurements since 1949

The Wilkes-Barre river gage is the nearest river gage upstream from the study reach; the study reach encompasses an area between the upper tip of Goose Island and the lower tip of Heron

Island. River flow data from this gaging site were used for all previous calculations of habitat flow relationships (Normandeau Associates, *et al*. 2011).

The drainage area at SSES/BBNPP is 2.8% greater than at the Wilkes-Barre gage. Wapwallopen Creek at Wapwallopen is the only active gage on a stream entering the river between the Wilkes-Barre gage and SSES/BBNPP; the Wapwallopen Creek gage has a drainage area of only 43.8 square miles. For the purposes of this supplemental data collection study, river flow as measured and recorded at the Wilkes-Barre gage will be considered to represent the flow in the study reach. Recorded daily river flows at Wilkes-Barre for the period April 1899 (beginning of record) through March 2011 will be used to evaluate the occurrence of the potential impacts of BBNPP consumptive water use[1]. Table 2-3 presents selected statistics of the daily river flow at Wilkes-Barre from April 1899 through March 2011.

Table 2-3 Selected daily river flow statistics at Wilkes-Barre (USGS gage # 01536500), April 1899- March 2011

	Daily flow (cfs)			
Month/season[2]	Minimum	Median	Average (mean)	Maximum
Jan	1,010	9,100	14,500	210,000
Feb	1,060	8,800	14,900	179,000
Mar	2,100	22,100	30,400	229,000
Apr	5,210	24,000	31,000	206,000
May	2,000	12,000	16,300	206,000
Jun	1,350	5,775	9,400	329,000
Jul	787	3,480	5,600	142,000
Aug	716	2,440	4,200	95,300
Sep	532	2,290	4,600	244,000
Oct	658	3,360	7,200	151,000
Nov	627	7,540	11,500	123,000
Dec	860	10,200	14,500	184,000
Annual	532	7,400	13,700	329,000
Jan-Mar	1,010	12,100	20,100	229,000
Apr-Jun	1,350	13,000	18,900	329,000
Jul-Sep	532	2,670	4,800	244,000
Aug-Oct[3]	532	2,570	5,400	244,000
Oct-Dec	627	6,720	11,100	184,000

[1]SRBC has requested that daily river flows for the entire period of record be used for this study. (Pers. Communication with A. Dehoff.)

[2]Other "seasons" (e.g., May-June) may be appropriate for evaluation of potential habitat loss for certain species-life stage combinations.

2.2. WATER QUALITY

This section of the study plan describes the water quality of the Susquehanna River in the vicinity of the BBNPP.

2.2.1. Susquehanna River Water Quality

Susquehanna River water quality has been monitored by the Susquehanna SES Environmental Laboratory from 1971 through the present, with modifications to the program over the years. Table 2-4 summarizes the sampling periods, frequency, locations, and programs.

Table 2-4 Ecology III Susquehanna River water quality monitoring program

Year	Sample period	Sample frequency	Sample locations	Programs
1971	Aug-Dec	Twice a month	6-9 locations Falls, PA to Berwick, PA	
1972	Apr-Dec	Daily	SSES	Various analyses
		Monthly	SSES	Diurnal
		Semimonthly	Falls to Berwick	River Run
		Quarterly	SSES to Columbia	Extended River Run
1973	Jan-Dec	Daily	SSES	Various analyses
		Monthly	SSES	Diurnal
		Semimonthly	Falls to Berwick	River Run
		Quarterly	SSES to Columbia	Extended River Run
1974	Jan-Dec	Semi-weekly	SSES, Bell Bend	Various analyses
		Mar, May, Jul, Sep	SSES	Diurnal
		Feb, May, Jul, Sep, Dec	Falls to Berwick	River Run
1975	Jan-Dec	Weekly (Jan-Feb)	SSES, SSES-A[4]	Various analyses
		Weekly (Mar-Dec)	SSES-A	Various analyses
		Apr, May, Jun, Jul, Aug, Sep	SSES-A	Diurnal
1976	Mar, Oct-Dec	Semimonthly	SSES-A	Various analyses
	Apr-Jun	Semiweekly		
	Jul-Sep	Weekly		
1977	Apr-Sep	Semiweekly	SSES-A	Various analyses
	Jan-Mar, Oct-Dec	Semimonthly		
1978-1985	Apr-Sep	Semiweekly	SSES**, Bell Bend	Various analyses
	Jan-Mar, Oct-Dec	Weekly		
1986-2004	Apr-Sep	Weekly	SSES, Bell Bend, Bell Bend I	Various analyses
	Jan-Mar, Oct-Dec	Semimonthly		
2005-present		Quarterly	SSES, Bell Bend	Various analyses
1974-present	Constant monitor for river level and river temperature			

Ecology III has measured water temperatures 1,620 feet upstream of the SSES intake structure on the west bank of the Susquehanna River daily since 1974 (Ecology III, Inc. 2008). A maximum water temperature of 86.5°F was recorded on 15 Aug 1988 and on 4 Aug 2007. A minimum water temperature of 32.0°F was recorded numerous times in January. Other statistical summaries, for example, monthly mean and maximum temperatures, can be developed from this daily record. The Susquehanna River adjacent to the BBNPP is designated as a Warm Water Fishery (WWF). Specific water quality criteria (Pa. Code, Chapter 93.Water Quality Standards, § 93.7.Specific water quality criteria) for DO and pH are as follows:

> "DO_2 (applicable to WWF): Minimum daily average 5.0 mg/l; minimum instantaneous 4.0 mg/l."

[4]Same sampling location from 1975 to present. SSES-A was renamed SSES.

> "pH (applicable to WWF): range between 6.0 and 9.0 inclusive"

Pennsylvania provides the following criteria for temperature (Pa. Code, Chapter 93. Water Quality Standards, § 93.7. Specific water quality criteria):

> "Maximum temperatures in the receiving water body resulting from heated waste sources are regulated under Chapters 92, 96 and other sources where temperature limits are necessary to protect designated and existing uses. Additionally, these wastes may not result in a change by more than 2°F during a 1-hour period."

Table 2-5 summarizes the temperature limits by "critical use period" applicable to WWF streams. These values represent the maximum allowable water temperatures (cross-sectional average) at an unspecified distance downstream of the discharge where fully-mixed conditions occur.

Table 2-5 Temperature limits applicable to Warm Water Fishery streams

Source: Pa Code, Chapter 93, § 93.7

Critical Use Period:	Temperature (°F)
January1-31	40
February1-29	40
March1-31	46
April1-15	52
April16-30	58
May1-15	64*
May16-31	72*
June1-15	80*
June16-30	84*
July1-31	87*
August1-15	87**
August16-30	87**
September1-15	84
September16-30	78
October1-15	72
October16-31	66
November1-15	58
November16-30	50
December1-31	42

* Critical Period for Fry per Chaplin (2009)
**Additional Period to be evaluated by this Study

A search of USGS records for recent dissolved oxygen measurements in Susquehanna River shows that Hunlock Creek (USGS No. 01537700) is the nearest water quality station upstream of SSES and that Danville (USGS No. 01540500) is the nearest water quality station downstream of SSES. There were76 samples taken at Danville and 15 samples at Hunlock Creek since January 2001. DO values for all samples were within the range of 7 mg/l to 15 mg/l. The DO values were consistently above the applicable DO criterion (DO_2). The pH values ranged from 6.4 to 8.9. The pH values were consistently within the required standard.

The water quality of the Susquehanna River upstream of the BBNPP has also been studied as part of two TMDL investigations. The first TMDL study (PADEP 1999; USEPA, 1999) focused on polychlorinated biphenyls (PCBs). The second TMDL (PADEP 2009; USEPA 2009) focused on mine drainage-affected segments for metals (iron, aluminum, and manganese), pH, and alkalinity. These Susquehanna River TMDL studies provide measured water quality parameters (pH, alkalinity and metals: iron, aluminum, and manganese).

3. WATER QUALITY ASSESSMENT OF BACKWATER AREAS USED BY FRY (≤25 MM LONG) AND YOUNG-OF-THE-YEAR SMALLMOUTH BASS (YOY SMB)

"Diseased" YOY SMB have been observed by Ecology III staff biologists in the river during the summers of 2005 and 2010, periods of low river flow and high water temperature (Brian Mangan, personal communication). The summer of 2005 was also the period when the Pennsylvania Fish & Boat Commission biologists first observed mortality of young YOY SMB with lesions but apparently not in the area near the BBNPP site. A recent report by Chaplin *et al.* (2009) postulated that sub-optimal dissolved oxygen (DO), particularly during the nighttime and in combination with relatively warm temperatures in habitats of YOY SMB, may have played a role in predisposing the fish to the bacterial infections. The bacterium (*Flavobacterium columnare*) is common in soil and water and causes secondary infections in stressed fish (PFBC 2005).

Microhabitats in which such sub-optimal DO and warm temperatures may occur are typically in side channels or backwaters and are characterized by relatively low velocities (<0.1 ft./sec) and shallow depths (<2 ft.) compared to the main river channel. These microhabitats, occupied by YOY SMB, can be subject to wide fluctuations in DO and elevated water temperature. For illustrative purposes, an example photo of a backwater area from the southeast shore of Goose Island on the Susquehanna River with abundant aquatic vegetation is provided as Figure 3-1; it shows a shallow, low velocity area away from the main river channel.

Figure 3-1 Example of backwater habitat at Southeast shore of Goose Island on the Susquehanna River with abundant aquatic vegetation. Photo taken in July 2010.

Shallow areas are more susceptible to heating by solar radiation than the main channel of the Susquehanna River and also may show larger fluctuations in DO over a 24-hour period. Backwaters are relatively calm, shallow areas or channels around islands that are cut off from the dominant flow of a river, particularly in late spring and summer as seasonal low flow approaches. This period may coincide with fish rearing and nursery activities. YOY SMB utilizing these habitats during a sustained extreme low river flow may be subject to potentially stressful, low DO concentrations at night and elevated water temperature during the day.

3.1. FIELD DATA COLLECTION

A program of continuous monitoring of DO, pH, water temperature, and depth in off-channel habitats, combined with visual observations (hydrological conditions permitting) of potential SMB spawning areas along the shore lines will be conducted. Six sondes will be deployed in the vicinity of Goose and Rocky Islands for 17 weeks from 15 April through 15 August, meteorological and hydrological conditions permitting. Two back-up sondes will be available in case of any malfunctions with the field units. If spawning activity is observed or emerging (black) fry are noted, the frequency of depth measurements and visual observations will be increased in these areas. These observations may also be used to adjust the locations of the continuous monitoring locations described below. Also, water quality and depth data will be

collected at various locations within the SRBC designated study reach (between the upper tip of Goose Island and lower tip of Heron Island) when conditions deem necessary. In addition, observations of potential areas where mussels may be vulnerable to exposure will also be recorded.

To supplement the above data, periodic electrofishing surveys[5] will be conducted primarily to examine YOY SMB for symptoms of disease (e.g., lesions, open wounds/injury, etc.), particularly in August when the bacterial disease has been reported to be most prevalent.

Continuous monitoring of DO, water temperature, depth, and pH in backwater areas near Rocky Island (Figure 3-2) and Goose Island will be conducted during a period likely to coincide with high water temperature and low nighttime DO values and recommended by SRBC. All these locations are at least 2.5 mi downstream of the proposed BBNPP discharge and cover both shorelines. This period would also coincide with the SMB spawning, rearing, and nursery in backwater areas. This monitoring program will document whether stressful water quality conditions occur during the critical nursery and rearing times of fry and YOY SMB and the extent of these conditions.

The locations were selected for accessibility, ease of servicing, and representativeness of potential backwater habitat and a main channel location near Goose Island. The proposed sampling scheme utilizes a total of six locations to be monitored. Five of the six field sondes will be positioned near-shoreline and backwater locations at and around the two islands. These locations will provide data in areas with the potential of having stressful water quality conditions for YOY SMB. One backwater location is a repeat at Goose Island backwater area and another within the vicinity of Goose Island in the main channel to be used as a reference site (Figure 3.2). The third location will be near the downstream end of Rocky Island and the fourth location will be at a suitable microhabitat within the riffle area located near Rocky Island. The last two locations will be along the east and/or west shoreline where YOY SMB frequently inhabit.

Unlike the Chaplin *et al.* (2009) and Normandeau Associates *et al* (2011) studies where paired sondes were deployed in both a backwater area and a corresponding main channel location to monitor DO and water temperature, this proposed study is designed to sample water quality parameters (water temperature, DO, pH, and depth) at five low velocity and/or backwater areas and one main channel habitat near Goose Island (Figure 3-2); the latter will be used as a reference location. Again these locations, particularly low velocity areas, are selected based on where YOY SMB occur and can become susceptible to the bacterium (*Flavobacterium columnare*) within the SRBC designated study reach.

[5]PFBC has offered to coordinate with PPL Bell Bend to perform YOY SMB electrofishing in the study area in August in order to determine the incidence of disease.

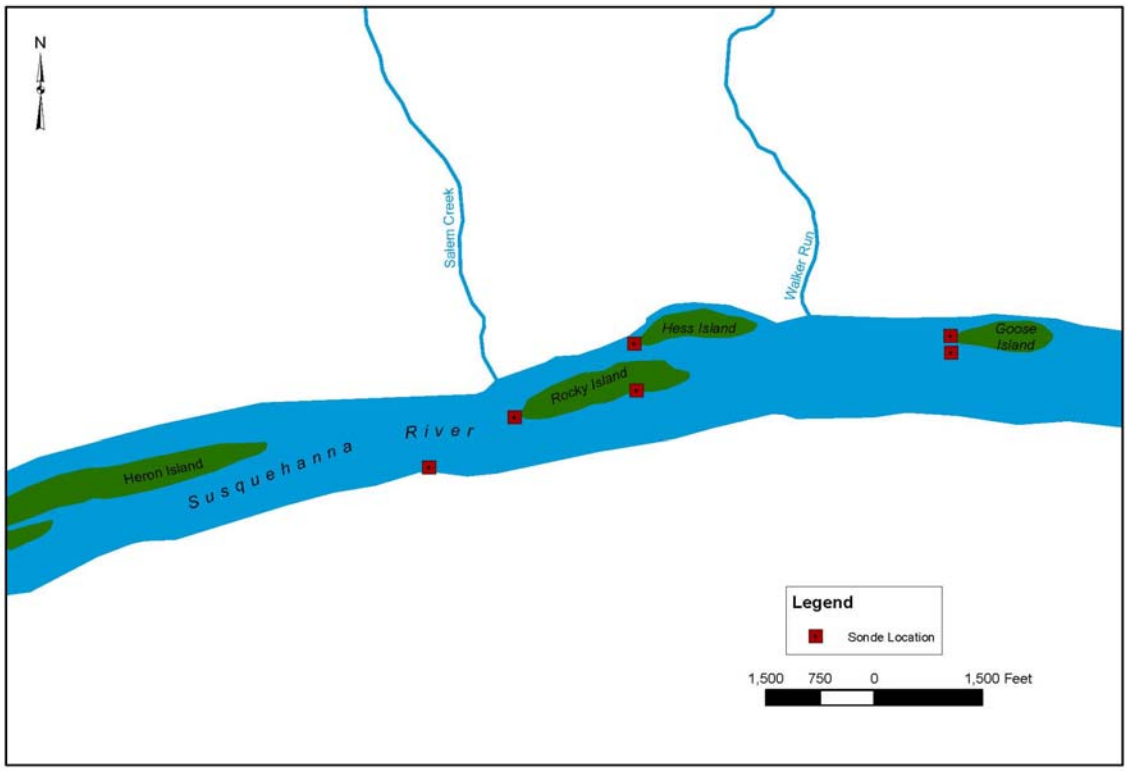

Figure 3-2 Proposed sampling locations of backwater temperature and DO in the study area. One (lower) of the two sondes at Goose Island is positioned in the main channel to serve as a reference location.

3.2. QA/QC OF SONDE PERFORMANCE

Personnel will utilize boat(s) to service the sondes and calibration will be done either in the field or at the Susquehanna SES Environmental Laboratory, approximately 4 miles upriver from the islands. Meteorological and hydrological conditions permitting, the sondes will be serviced once a week during the monitoring period to allow corrective action in a timely fashion. Should some continuous data collection be interrupted, manual measurements will be taken, particularly during nighttime low DO periods.

Continuous water quality data will be collected at continuous monitoring locations with a HACH Hydrolab DS5X data sonde equipped with sensors to measure temperature, DO, pH, and depth. The temperature sensors are set at the factory and all other parameter sensors will be calibrated per manufacturer's requirements on a weekly basis. The DO sensor will employ the luminescence dissolved oxygen (LDO) technology which uses blue and red light-emitting diodes (LEDs) to measure DO in water. The LDO sensor was chosen over traditional techniques out of

concern that passive fouling (*e.g.*, algae growth on sensor) could occur. The LDO sensor does not consume oxygen so passive fouling will not affect DO readings. The luminescence dissolved oxygen (LDO) technology is specifically designed for long term continuous monitoring; any incidental algae or biological growth on the meter will not affect the accuracy of the sensor. The continuous monitor probes will be visually inspected for biological growth weekly and cleaned as necessary.

QA/QC measures will include regular (weekly) downloads and calibration of the continuous monitors per manufacturer's instructions. The LDO sensor will be equipped with a self-cleaning wiper to decrease the potential for fouling by debris or algae. Calibration records for the continuous monitors will be kept and provided in the report. Performance of the sondes will be checked against a calibrated field DO and temperature meter according to the procedures developed by Ecology III.

As in the Chaplin *et al.* (2009) study, freshly calibrated water quality meters will be positioned with the deployed sonde to collect side-by-side measurements of DO and water temperature. The deployed sonde will be cleaned and returned to the river and a second set of side-by-side readings will be recorded. Following these checks, the deployed sondes will be retrieved and the data downloaded to a field data logger. The recorded sonde measurements will be adjusted for any drifts between the two side-by-side readings. Dissolved oxygen (DO), water temperature, pH, and depth data averaged for hourly parameter values) will be collected for 17 weeks (15 April-15 August), meteorological and hydrological conditions permitting.

The LDO, pH, and depth sensors on the continuous monitors will be calibrated prior to deployment, per manufacturer's specifications and on a weekly basis thereafter. In-river DO, water temperature, and pH will be checked against the continuous monitor using calibrated portable instruments; these values will be recorded on data sheets as performance check measurements. Once the continuous data is retrieved, the performance check measurements will be compared to the continuous monitor data set for accuracy. The raw data collected from the continuous monitor will be reviewed and approved by field scientists prior to reporting. Spurious and other data that is considered inconsistent or unreasonable based on observed trends will be highlighted for exclusion from further analysis.

3.3. SMALLMOUTH BASS (SMB) SPAWNING ACTIVITY, FRY (≤25 MM LONG), AND YOUNG OF THE YEAR (YOY) MONITORING

Observations on initiation of smallmouth bass spawning activity and emergence of fry with subsequent development into YOY life stage will begin in mid-April 2012 or earlier if the river water temperature warms to 50 F. An attempt will be made to document the time and location of pre-spawning activity as was observed in early spring of 2010. For 2012, an approximation of the size of the area where spawning activity is observed will also be documented. This shore-line schooling behavior of adult SMB gives a good indication of where spawning will actually occur. These observations will be centered where sondes have been deployed in the vicinity of Goose and Rocky Islands and on the eastern shoreline (Figure 3-2). Once spawning begins

around the first week in May, weekly observations will be made to try to locate nests and subsequent schools of SMB fry. In 2010, SMB fry were seen hatching from nests and swimming directly into the shoreline to seek cover from the river current.

A portable sonde will be used to record river water temperature; DO, pH, and depth at the location of fry schools, particularly if they are not near a sonde. These instantaneous measurements will not take the place of the continuous sonde data, but they should provide some information about habitat preference. As fry grow into YOY, their location and habitat will also be noted weekly. Photographs will be taken to document the habitat of both fry and YOY SMB along with depth and current measurements. Some backpack electrofishing and seining is planned in July, provided river conditions are suitable, to document possible habitat changes of YOY SMB (see footnote 5 on page 11).

3.4. DATA ANALYSIS

The water quality analysis will focus on the relationship among flow, depth, temperature, dissolved oxygen (DO) and possibly pH. The previous 2010 data were limited by time frame since the deployment of the sondes occurred in late June, so actual data from the beginning of the SRBC period of interest beginning May 1, were not available. The sonde data did, however, capture the highest temperature period of the year and we are confident that it captured all events above the 84°F thermal threshold. The 2012 data collection season is scheduled to begin mid-April and continue to mid-August, fully capturing the pre-spawning, fry and juvenile activity periods.

3.4.1. Smallmouth Bass Prespawning and Fry Period 2012

When field observations indicate that the fry period is over, the collected 2012 data will be analyzed. Initially, the data will be assessed for event frequency and duration similar to the 2010 data.

Unlike the 2010 data collection, the 2012 data collection will also include a depth transducer that will gather depth data on an hourly basis with corresponding water quality data. This will allow a direct comparison of depth, and thus flow variation and if temperature is statistically related to flow. Based again on diagnostics, a correlation or regression analysis will be completed to determine the existence of a statistically significant relationship and the strength of any relationship. It may also allow evaluation of the relationship on an hourly basis, again based on the data diagnostics. If the depth analysis is inconclusive we will then apply the thermal model used for the 2010 data analysis using the 2012 data and corresponding hourly meteorological data and ΔTs reported on an hourly basis with the same diagnostics and summaries as with the 2010 data.

3.4.2. YOY SMB Period 2012

Once the full data collection event is complete, all the data will be assessed using the same procedural outline as for the pre-spawning and fry period described above. At this time, the data will also be assessed to determine if any other, particularly statistical analysis, will be useful to a

comprehensive understanding of the data and incremental effects. The scope and nature of those assessments cannot be determined until all the data are available and have been mined.

The final data analysis will also, to the extent mathematically justified, place the data and analyses in context of flow statistics to capture more extreme low flow events than 7Q10, however, the nature of historical flow data will limit this to daily averages.

3.4.3. Dissolved Oxygen and pH 2012

Since thermal changes can affect dissolved oxygen, we will then extend the analysis to the dissolved oxygen data and assess dissolved oxygen concentration effects based on a threshold concentration of 4.0 mg/l. All the analyses will be based on hourly data and hourly increment analysis, consistent with the time step used in data collection and will include frequency and duration of events below 4 mg/l. This will be a complex analysis and the nature of the data will dictate the details and direction of the analysis. The main reason this analysis is so complex lies primarily in the strong diurnal signal that is dominated by photosynthetic activity, which drives DO into high super-saturation conditions into the mid- to late afternoon with corresponding nighttime lows in dissolved oxygen. As part of weekly observations, the type of aquatic vegetation will be visually identified and its density estimated.

The analyses will be presented in various tabular and graphical forms to demonstrate frequency, intensity and duration and describe the diurnal patterns and the oxygen dynamics that drive the patterns.

Chaplin et al 2009 as well as other references on *Flavobacterium columnare* discuss other factors such as pH on the virulence of the bacteria. We will complete parallel assessments of other parameters and to the extent that sonde data are available, compare incremental effects of flow reduction on those parameters. This portion of the analysis will have certain limitations based on the time step available for historical flow data (daily averages) which we will attempt to reconcile with the hourly sonde and meteorological data.

4. REPORTING AND SCHEDULE

The fry period data analysis will be complete by the end of July or early August 2012, depending on when the end of fry activity is noted in the field. The final comprehensive analysis will be completed approximately 2 weeks after the end of data collection, and compiled in the study report at the end of the first week of September 2012.

An electronic database will accompany the report. This database will provide all data sources used in the analysis, photographs from site visits, documentation of sampled locations with time and dates, and computer model inputs and outputs.

Table **4-1** below describes the planned schedule for this project. The tasks shown are those that relate directly to deliverables to agencies and the expected review cycles on work products.

Table 4-1 Proposed Schedule

Submit to SRBC for Review	Fri 4/6/12
Hold Agency Meeting	Wed 4/11/12
Finalize Scope	Wed 4/18/12
Undertake Additional Data Collection as Needed	Thu 9/6/12
Prepare and Submit Report * Assumes no additional data collection is necessary.	Thu 9/6/12*

LITERATURE CITED

Chaplin,J.J., J.K. Crawford, and R.A. Brightbill.2009. Water quality monitoring in 2008 in response to young-of-the-year smallmouth bass (*Micropterus dolomieui*) mortality in the Susquehanna River and major tributaries, Pennsylvania, U.S. Geological Survey, Reston, VA.

Ecology III, Inc. 2008. Environmental studies in the vicinity of the Susquehanna Steam Electric Station. Annual Report prepared for PPL LLC, Allentown, PA.

Ecology III, Inc. 2008."River temperature method of analysis, 1974-2008".804 Salem Blvd., Berwick, PA 18603. Prepared for PPL LLC, Allentown, PA.

Normandeau Associates Inc., Ecology III, and T. R. Payne Associates. 2011. Potential effects of the Bell Bend Project on aquatic resources and downstream users. Proposed Bell Bend Nuclear Plant Site, Luzerne County, Pennsylvania. Draft for agency review. Prepared for PPL Bell Bend, LLC, Allentown, PA.

Pennsylvania Department of Environmental Protection.2009. Final Susquehanna River metals TMDL Luzerne County. February.

USEPA.2009. Decision Rationale Total Maximum Daily Loads For Acid Mine Drainage Affected Segments Susquehanna River Luzerne County, Pennsylvania.

USGS 2010. Stream Stats online at http://water.usgs.gov/osw/streamstats/pennsylvania.html