4.0 DISCUSSION

4.1 OVERVIEW

Results of the modeling efforts indicate that at river flows near or below 1,300 cfs, the cross-channel occupied by Green Floaters become isolated from the main channel and the wetted area becomes significantly smaller. This is likely due to a combination of natural and man-made geology in the river. The bedrock ledge at the entrance to the channel naturally cuts off this channel from the main river at low flows. This effect is dampened by the eel weir (Number 5) just downstream of the channel that increases water elevations at the channel entrance, allowing more water to enter the cross channel than would otherwise occur. Similarly, eel weirs on the north side of the river and natural controls in the channel itself act to back up water in places, creating a series of large pools that keep some portions of the channel wetted, even at 7Q10 flow levels.

A review of flow statistics from the Wilkes-Barre gage station (USGS Number 01536500) from 1899 through 2011 shows that flows of 1,300 cfs or less occur approximately 5% of the time on an annual basis (Table 4.1-1). On a monthly basis flows of less than 1,300 cfs are most likely to occur in August and September and have historically occurred on approximately 15-20% of these days on an annual basis.

TABLE 4.1-1. PERCENT OF TIME THAT DAILY AVERAGE FLOW OF 1,300 CFS IS EXCEEDED (1899-2011).

MONTH	% TIME 1,300 CFS DAILY AVERAGE FLOW EXCEEDED[2]
Jan	99.36
Feb	99.70
Mar	>99.9
Apr	>99.9
May	>99.9
Jun	>99.9
Jul	95.38
Aug	85.74
Sep	81.38
Oct	87.95
Nov	96.66
Dec	98.86
ANNUAL	**95.39**

[2] Equivalent to 1236.6 cfs at the Wilkes-Barre USGS Gage

4.2 Fish Host Species

The model indicates that under both existing 7Q10 conditions (843 cfs) and future 7Q10 flows (800 cfs) as modified by the proposed project, there is no change in habitat suitability, and thus availability of fish hosts, in the cross channel. At 7Q10, neither the cross channel, nor areas immediately adjacent to the cross channel, are suitable for most adult fish, particularly larger species (*e.g.*, smallmouth bass).

However, habitat suitability in these areas is higher for some species of fish that tolerate shallow water (*i.e.* juveniles of some species, and both juvenile and adult cyprinid and darter species). The model shows that flows higher than 1,300 cfs are required to exceed the elevation of the bedrock outcrop that controls flows into the cross channel. Although it is beyond the scope of this model to quantify, it is reasonable to assume that flows higher than 1,300 cfs likely increase habitat suitability for all life stages of most fish species in the cross channel by increasing depth and velocities.

These data suggest that at times when flows recede and the cross channel begins to be isolated, fish represented by the habitat guilds in this model would either need to evacuate the cross channel and seek refuge in deeper areas nearby, or have the ability to endure isolation until the flows increase and the cross channel re-fills. Stagnant water, increasing water temperatures, increased predation risk by herons and other predators, and stranding are all significant risks during this period. Although species such as darters and chubs generally make only limited, localized excursions in fluvial systems, the close proximity of suitable habitat suggests that this movement is likely for at least some of the population, and that these individuals may quickly recolonize the channel once flows increase. This dynamic will be the same at either 843 cfs or 800 cfs.

The persistence of the Green Floater population in the cross channel suggests that the species may not be limited by low habitat suitability for fish. It is not certain that the Green Floater requires a fish host. If true, absence of fish during 7Q10 events has no consequence to the mussel. If Green Floater does require fish hosts, the seasonal timing, frequency, and duration of 7Q10 events may not necessarily coincide with critical times in the Green Floater's life cycle, such as the spawning (*e.g.*, glochidia release) season, or when glochidia excyst from their hosts.

4.3 GREEN FLOATER AND OTHER MUSSEL SPECIES

Most of the Green Floater observed in the cross channel were found at locations that are predicted to be dewatered at 7Q10 flows. Other mussel species also occur in areas expected to become dewatered, but the threat is greater for Green Floater that appear to have a distinct affinity for shallow nearshore areas. Similarly, some of the largest concentrations of mussels, particularly Yellow Lampmussel and Elktoe, observed during qualitative surveys also occur in areas expected to become dewatered at 7Q10 flows.

The amount of dewatering predicted to occur at 7Q10 puts mussels at risk of mortality from desiccation, thermal stress, and predation. To survive during 7Q10 flows, mussels would either need to move horizontally into deeper water, or move vertically deep into the substrate where they might survive long enough for flows to rise and the channel to re-fill. The magnitude, timing, and duration of these low flow periods are critical for determining what proportion of the mussel population survives, and may also affect reproductive success for the year.

Despite the challenges of living in the cross channel, this is the only location where live Green Floater were found after a total of 36 semi-quantitative surveys in the Susquehanna River around Heron, Swan, Goose, Hess, and Rocky islands (Normandeau 2012, this report). The benefits of living in the cross channel compared to the main river—such as a greater proportion of fine sediments, slower flow velocities, less shear stress, and larger amounts of nearshore habitat complexity (*e.g.*, aquatic vegetation, woody debris, algal cover, tires)—might offset some of the risks posed by low flow conditions.

Admittedly, very little is known about the ecology and stress tolerance of Green Floater, its distribution and abundance in a broader reach of the Susquehanna River, or population trends. Therefore, conservation importance, population stability, vulnerability to flow-related habitat changes of the Green Floaters in the cross channel is still not well understood. But what appears to be clear from the data presented in this report is that the proposed consumptive use of up to 43 cfs will have negligible effects on mussels or mussel habitat in this section of the Susquehanna River.

5.0 CONCLUSIONS

Based on the analysis in this report, we conclude that the proposed consumptive use of up to 43 cfs will have negligible impacts to mussel populations and host fish species in the river. The presence of eel weirs and bedrock ledges in the river in this area have created an area in the cross-channel between Swan and Heron Islands that is suitable for Green Floater colonization. This area is insulated from high scouring flows by the presence of the upstream island and buffered from extreme low flows by ridges and weirs that serve to maintain a wetted channel at 7Q10 and lower flows. Because this channel becomes hydraulically separate from the main river channel at a flow of 1300 cfs or less, the incremental change from 843 cfs to 800 cfs has no discernible impact to the area where Green Floater mussels have been found. The withdrawal may cause a slight increase in the amount of times this channel becomes isolated, but the fact that this isolation has clearly occurred in the past and the Green Floater population continues to persist here indicates that this would not necessarily result in any clear impact to mussels or host fish species.

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APPENDIX A

STUDY PLAN PROPOSAL AND PHONE CONVERSATION SUMMARIES

Kleinschmidt

August 7, 2012

VIA ELECTRONIC MAIL

Mr. Gary Petrewski
Environmental Manager
PPL Bell Bend, LLC
2 North Ninth Street
Allentown, PA 18101-1179

Bell Bend Nuclear Power Plant Project
Proposal - Low Flow Impact Analysis – Green Floater Mussel (Kleinschmidt No. 565065)

Dear Gary:

Kleinschmidt is pleased to present this proposal to assist you in evaluating the impacts of a proposed consumptive water use of 43 cubic feet per second (cfs) at the proposed Bell Bend Nuclear Power Plant (BBNPP) on mussel species and habitat in the Susquehanna River near Berwick, Pennsylvania during low flow events.

Our current understanding is that the green floater mussel has been found in a channel area between Swan and Heron Islands over an approximate 60' by 300' area. Resource agencies have asked whether proposed plant operations during low flow periods would dewater some of this area, impacting mussels and mussel habitat. Flow splits due to the presence of the in-river islands, and hydraulic controls created by historic eel weirs upstream and downstream of the channel area of interest make it difficult to easily assess potential changes in water levels and flow distributions from the proposed water use, particularly at low flows. Cross section averaging approaches utilized in standard 1-dimensional models cannot account for the variable distribution of flows within the channel, especially when considering the eel weirs influence. To more appropriately define the flow distributions between two different river flow rates, we recommend implementing a 2-dimensional modeling effort that would more accurately predict changes in water surface elevation. Figure 1 shows the study area.

Our Proposed Work Scope is outlined below, along with budget estimates for each task. This approach is based on our current understanding of the area and would be refined in discussions with PPL and the Resource Agencies and pending a detailed review of all available existing information including mussel studies and PHABSIM data.

TASK 1 - CREATION OF A 2D RIVER MODEL

Figure 1 displays the proposed boundary area of a 2D model. The 2D model would essentially cover the area from upstream of the islands to a point below the islands. It is paramount to maintain boundaries sufficiently away from the area of interest to reduce the influence of inflow or downstream boundary conditions. Features well away from the area of concern may influence flow distributions and need to be accounted for in the modeling study. Available PHABSIM transect and calibration data will be reviewed to determine the utility of this data relative to the construction of the planned 2D model. As an example, upstream and downstream model boundaries may be adjusted to existing PHABSIM transect locations provided that available data can be field verified and satisfy model development needs.

The 2D model will incorporate an unstructured mesh allowing reduced resolution in areas of low concern or small spatial variability, and also allow higher resolution around critical areas and features (such as at the upstream end of the islands, between the islands and around the eel weir structures). This approach is equivalent to prior River 2D hydraulic modeling by others as part of the previously completed Bell Bend IFIM studies.

Kleinschmidt would propose to complete the hydrodynamic modeling using the TELEMAC[1] software package V6.1 with the TELEMAC2D Finite Element module. TELEMAC-2D was developed by the National Hydraulics and Environment Laboratory (Laboratoire National d'Hydraulique et Environnement - LNHE) of the Research and Development Directorate of the French Electricity Board (EDF-R&D), in collaboration with other research institutes. It has been successfully used for a number of years as a proprietary model, but is now an open source model.

The TELEMAC-2D code solves depth-averaged free surface flow equations as derived first by Barré de Saint-Venant in 1871. The main results at each node of the computational mesh are the depth of water and the depth-averaged velocity components. The main application of TELEMAC-2D is in free-surface maritime or river hydraulics and the program is able to take into account the following phenomena:

- Propagation of long waves, including non-linear effects
- Friction on the bed
- The effect of the Coriolis force
- The effects of meteorological phenomena such as atmospheric pressure and wind
- Turbulence
- Supercritical and subcritical flows
- Influence of horizontal temperature and salinity gradients on density
- Cartesian or spherical coordinates for large domains
- Dry areas in the computational field: tidal flats and flood-plains
- Entrainment and diffusion of a tracer by currents, including creation and decay terms
- Particle tracking and computation of Lagrangian drifts
- Treatment of singularities: weirs, dikes, culverts, etc.
- Inclusion of the drag forces created by vertical structures
- Inclusion of porosity phenomena

[1] http://www.opentelemac.org/

- Inclusion of wave-induced currents (by link-ups with the ARTEMIS and TOMAWAC modules)
- Coupling with sediment transport

Pre and Post-processing would be completed using the BlueKenue[2] software, Visualization & Analysis for Hydraulic Modeling, by the Canadian Hydraulics Centre/National Research Council, V.3.2.31. Additional visualization and processing of results will be completed using GIS ESRI ArcMap tools; an example may be to subtract the depth surfaces between the two flow rates to develop a depth change figure.

TELEMAC-2D coupled with BlueKenue pre and post-processing has certain advantages over River 2D in terms of data presentation that we believe would be of value to the resource agencies with respect to the interpretation of study results. Though we are recommending using this model we would want concurrence from the resource agencies before beginning model efforts. Our team is also very experienced with MIKE 21 and believes this model would also be a suitable choice for this application.

FIELD DATA COLLECTION

Bathymetry data would be collected throughout the study area by a combination of single beam fathometer coupled with a Trimble GPS from a small boat, as well as a wading survey using traditional survey techniques in shallower critical areas. Kleinschmidt proposes to utilize a SonarMite by Ohmex fathometer. Single-beam echosounders utilize sonar as well as smart technologies (software and periphery hardware components) that are commonly used for shallow-water surveys and are highly accurate due to their narrow beam width. The SonarMite specifically uses a single 200-kHz 4o beam that yields a depth accuracy of ±1-cm per 0.1% of depth. The SonarMite can effectively be operated in depths as shallow as 1-foot of water (0.3m).

Data would be collected during low flow months (August-September); data in the overbank that may be flooded during higher flows is of less concern as the water use issue is only related to periods of historically low flow (*i.e.*, flows less than those present during the completed mussel presence or absence studies).

The spatial resolution of points collected in the field will vary throughout the modeling domain. In locations further from the area of concern, or away from the eel weirs or other field identified potential hydraulic controls, fewer points will be collected. This allows the critical features to be defined more accurately while reducing the collection of non-critical information. The cross channel area between the islands would be surveyed in detail as the model resolution should be highest in this area.

The density of bathymetry data points determines the accuracy of the surface that is interpolated between each of the survey points. A semivariogram may be used to assess the spatial covariance of field points within a neighborhood subset. This process produces two important parameters: the 'nugget' and the 'range'. The nugget is reviewed to assess the measurement

[2] http://www.nrc-cnrc.gc.ca/eng/ibp/chc/software/kenue/blue-kenue.html

errors and the microvariance between abutting points. The range determines the distance at which two points may be considered correlated, and can vary with direction. This information will be used to assess the quality of a developed surface for a certain grid size within a region of collected data. When multiple points are collected within a region, ideally the density of the points is greater than the required cell size and averaging techniques may be employed, otherwise interpolation will be utilized, and point validation will be used to check the surface.

As a surface becomes increasingly homogenous (*i.e.* smooth flat bottom river) the semivariogram range will also increase for an acceptable variance, which allows a reduction in the survey point density. When spatial variability increases, the range decreases and an increasing survey point density is required for an accurate surface. Data will be collected under the guidance and direction of the modeling team to make sure that data collection efforts are focused appropriately.

Field efforts will also entail quantifying flow distributions through the channels by measuring total river flows, flows on each side of the island, and the split between the islands. Velocity and water surface profile information would be collected as part of this effort. This survey would need to be completed while river flows are uniform, and ideally as low as possible to mimic the low flow conditions and distributions we are trying to model. Additional information collected in the field would include photo-documentation of the river, islands, weirs and cross-channel areas. Subjective information and observations would also be collected which provide critical insight into flow patterns, eddys, and vegetation. Substrate will also be defined generally allowing the delineation of areas of cobble, gravels, sands or organics with vegetation. Not only does this allow spatial variation of channel roughness values, but it provides insight into typical velocities and flow patterns in the channel, which provides a valuable aid to model calibration.

Data Filtering and Model Runs

Field data would be processed and checked before building the unstructured meshes. The points are utilized to interpolate the surface onto the unstructured mesh, which is constructed independently of the survey point locations. The mesh in the model will incorporate an unstructured triangulated network (TIN) with variable cell size (side length). Within regions of interest, such as the inter-channel opening or near the fish weirs, a reduced cell length of 1m or less may be required. With increased distance from these areas of interest, the cell length may increase to 10m or greater. Review of the channel bathymetry, in-stream features and intended uses of the model will help assist the mesh development efforts.

There are three separate model runs proposed. Initially, the model would be calibrated using the lowest measured flow information from the previous field studies conducted for the PHABSIM model, once we have verified the applicability of the data. This calibration would be supplemented and potentially replaced by field observations and measurements conducted as part of the model data collection effort. Runs would then be made of the 7Q10 flow (843 cfs) and the 7Q10 at the withdrawal flow (800 cfs) as a condition representative of a low flow period of impact. These proposed model run flow levels can be readily adjusted based on additional discussions with the resource agencies. The results would be compared to show differences in water elevation, wetted area in the channel where the green floater mussels are present, and the potential for impact to the species based on the presence of suitable habitat, the ability of the mussels to move, and other factors. Kleinschmidt would prepare a report presenting:

- Field collection efforts and results
- Model geometry development
- Calibration process and results
- Model runs
- Tables and Figures of results

TASK 2 – MUSSEL FIELD STUDIES

Kleinschmidt proposes conducting additional mussel surveys in the study area to familiarize our team with the mussel population in the area and better understand the potential for impacts. We would subcontract work associated with additional mussel surveys to Biodrawversity LLC under the direction of Ethan Nedeau, who is on the USFWS/PFBC list of approved mussel surveyors for the Susquehanna River. Site reconnaissance would be completed during a very low flow period, if weather cooperates, by a two-person team from Biodrawversity. Mr. Nedeau would be available to assist in impact analysis on as needed basis.

It is Kleinschmidt's understanding that prior quantification of green floater mussels in the area of concern, illustrate a low mussel density. It is also our understanding that prior quantification methods have been questioned by the resource agencies. As a result, and if a reanalysis is required, Biodrawversity would conduct a quantitative survey of the mussel compartment area identified in previous studies. We have assumed this would be done using 150 1m square quadrants in a systematic design with multiple random starts and double sampling (excavation). Counts of surface vs. buried mussels will be recorded for each quadrat, along with microhabitat parameters (water depth, percent cover of each substrate type, and qualitative estimate of flow velocity). These methods would be discussed and confirmed with resource agencies. A budget for this optional task is not included as part of this work scope.

KEY PERSONNEL

This project effort would be managed by Timothy J. Oakes, a Senior Regulatory Coordinator at Kleinschmidt. Mr. Oakes was Project Manager for Kleinschmidt's support of the Wallenpaupack relicensing and Holtwood redevelopment projects for PPL and has considerable experience with multi-disciplinary impact analyses of this nature as well as working with the resource agencies involved in this Project. Hydrodynamic 2D model development and runs would be performed by Mr. Jon Quebbeman, P.E., P.H., who has significant experience conducting and running 2D models of this nature. He will also guide the field data efforts, process and QC the bathymetry, and prepare the model results. Kleinschmidt would be responsible for collecting all bathymetry data for use in the 2D model. Dan Gessler, Ph.D., of Alden Labs, will assist in model development and review. Brandon Kulik, a senior fisheries scientist with Kleinschmidt, would provide support as needed to this project for issues related to PHABSIM modeling, fish/mussel interactions, and fluvial geomorphology. Mr. Nedeau would summarize field observations of mussels and mussel habitat and provide expert opinion and interpretation of results with respect to potential mussel impacts.

SCHEDULE

Work would begin upon award and fieldwork would be conducted in late August to early September, preferably at a very low flow level. If river levels trend higher due to storm events or abnormally high precipitation, the work could still be performed, though the mussel work may be scaled back and the bathymetry work would be primarily boat-based. Model runs would be completed within four weeks after fieldwork was completed with a final report goal of October 15, 2012.

We look forward to the opportunity to work with PPL on this project. Please call me at (717) 687-7211 if you have any questions about this proposal or need additional information.

Sincerely,

KLEINSCHMIDT ASSOCIATES

Timothy J. Oakes
Renewable Group Leader

Scott R. Ault *(reviewed)*
Vice President/Department Manager

TJO:NLP
Attachments: Figure 1
Resumes
Category Rates
cc: Proposal Distribution

FIGURE 1

Susquehanna River
11
93
339
Legend
Model Boundary
Eel Weirs
500 0 500 1,000
SCALE IN FEET
Kleinschmidt
Energy & Water Resource Consultants
400 Historic Drive P.O. Box 278
Strasburg, PA 17579
Telephone: (717) 687-7211
Fax: (717) 687-7266
www.KleinschmidtUSA.com
ACCT - PPL_TACCT
SCALE - PPL_TSCALE
BY - PPL_TBY
PPL Bell Bend, LLC.
Bell Bend Nuclear Plant
Project Proposal
Mussel Impact Analysis
Model Boundary
PPL CORP.
PPL DRAWING NO
SHEET NO
REV
REFERENCE TITLE
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G:_Client_Data\PPL\BellBend\MXD\MusselImpactArea.mxd
FILE NAME

RESUMES

Kleinschmidt

PROFESSIONAL RESUME

TIMOTHY J. OAKES

RENEWABLE GROUP LEADER
SENIOR REGULATORY COORDINATOR

BACKGROUND

Tim Oakes received a B.A. in English, with a concentration in science from the University of Richmond (1988). Tim has over 23 years of experience in environmental consulting and Federal Energy Regulatory Commission (FERC) licensing and has been with Kleinschmidt since 1996. His responsibilities include project management and strategic planning for FERC Licensing efforts throughout the U.S., management of Kleinschmidt's Licensing Group, and development of our office in Pennsylvania. He is responsible for the marine renewable energy practice, focusing on wave, tidal and offshore wind power. Mr. Oakes has been the chair of the National Hydropower Associations' Research and Development Committee in the past and served on the Board of Directors (2009-2012).

Mr. Oakes has extensive experience with the National Environmental Policy Act (NEPA), environmental permitting, and the design and conduct of environmental studies. He has been involved in reviewing and commenting on Bureau of Ocean Energy Management (BOEM) regulations for offshore wind and has worked with industry groups such as the American Wind Energy Association and the Offshore Wind Development Coalition to streamline the NEPA process for offshore wind. He has presented and moderated panels on licensing issues, NEPA, and renewable energy at numerous national conferences.

RECENT PROJECT EXPERIENCE

BOEM responses for MA, RI, & NJ Calls for Interest
Fishermen's Energy, LLC – Atlantic City, NJ
Project Manager for submittals to BOEM in 2011 on behalf of Fishermen's Energy for development of offshore wind off the coasts of Massachusetts, New Jersey, and Rhode Island. These submittals involved environmental and engineering appraisal of the study area and use of geospatial analysis and GIS tools to determine optimum selection of OCS blocks.

Roosevelt Island Tidal Energy Project
Verdant Power, LLC – New York, NY
Project Manager and strategic advisor for preparation and submittal of a draft and final Hydrokinetic Pilot License application, including developing an Environmental Report in NEPA format and agency consultation, for a tidal energy project on the East River. The final license was issued in early 2012 and is the first pilot project license that FERC issued for a commercial tidal power plant in the U.S.

Yards Creek Project
PSEG/FirstEnergy – Blairstown, NJ
Project Manager for relicensing of a 400 MW pumped storage hydroelectric project in northern New Jersey. Current license expires in 2013 and Project is utilizing FERC's new ILP process – which integrates NEPA scoping into pre-filing consultation. Work has included developing strategic plan, agency and stakeholder consultation, preparing background documents, developing the FERC approved study plan for the Project, managing environmental studies for the relicensing, and submitting final license application. A new license is expected to be issued in 2012.

Holtwood Hydroelectric Project
Susquehanna River, PA
PPL Holtwood, LLC – Allentown, PA
Project Manager for major environmental studies and permitting associated with this 100+ MW hydroelectric expansion project – one of the largest in the country. Consulted with Federal, state, and local agencies and other project stakeholders, led preparation of draft NEPA documents and FERC license amendment and 401/404 applications. $400+ Million construction project is currently underway and is expected to be completed in 2013. Managing environmental compliance and monitoring activities and mitigation project construction.

Wallenpaupack Hydroelectric Project
PPL Holtwood, LLC – Allentown, PA
Project Manager/lead technical consultant to PPL for successful alternative relicensing of 44 MW hydro facility. Managed preparation of FERC/NEPA documents, environmental field studies and specialty subcontractors; facilitated meetings; and provided strategic advice to PPL. Resolved unique water quality issues through use of expert panel and innovative solutions.

Kleinschmidt

PROFESSIONAL RESUME

JONATHAN A. QUEBBEMAN, P.E., P.H.

WATER RESOURCES ENGINEER

Mr. Quebbeman obtained a B.S. in Civil Engineering from the University of Iowa (1999) and a M.S. Degree in Water Resources Engineering from Colorado State, Fort Collins, Colorado (2010).

PROFESSIONAL REGISTRATION

Licensed Professional Engineer in Maine
Licensed Professional Engineer in Illinois
Licensed Professional Engineer in New York
Licensed Maine Site Evaluator
Professional Hydrologist

BACKGROUND

At Kleinschmidt, Mr. Quebbeman focuses on evaluation of hydraulic structures, hydrologic studies, non-point source studies, open channel hydraulics, reservoir operations and management, and river hydraulic and sediment modeling. Projects include hydrologic assessments of frequency events up to the probable maximum flood (PMF), calibration of hydrologic models, and evaluation of stream flow data and statistics. Mr. Quebbeman uses GIS capabilities and extensions in performing these evaluations, which aids in assessing data, but also in presentation to clients and agencies.

PROJECT EXPERIENCE

Neponset River T&H Dam Removal & Flood Study
Department of Environmental Restoration – Boston, MA
Massachusetts is removing a dam on the Neponset River in South Boston to encourage upstream fish passage and help restore the natural flow regime to the river. A HEC-RAS model was spatially georeferenced and used to assess the changes in flood profiles between existing and proposed dam removed conditions. The study showed potential impacts to habitats during low flow conditions if unabated.

Merced River Fish Habitat & Sediment Armoring Study
Pacific Gas & Electric – San Francisco, CA
Reviewed studies of hydropower operations, and the fluvial geomorphic response of armoring in the channel. Study included assessing in-situ surface and sub-surface sediment classes, review of seasonal flow records, and the development of recommendations to address armoring and the effects on fish habitat.

Prairie du Sac Fish Attraction Flow Modeling
Alliant Energy – Madison, WI
Represented the client during upstream fish elevator testing with 3-dimensional CFD modeling. Included assisting in field collection efforts, development of model bathymetry and processing, and development of boundary conditions. Reviewed model results for effectiveness in meeting fish attraction and passage criteria.

Milford Dam Fish Attraction Flow Modeling
Black Bear Hydro – Milford, ME
Developed a 2-dimensional model of the tailrace to assess various unit operation scenarios and the affects to attraction velocities. Considered the addition of a new fish elevator and attraction velocities under various water level conditions.

Saco River Hydrologic Model Development
University of New England – Biddeford, ME
Developed a hydrologic model of the Saco River watershed to assist in a coastal circulation water quality model. Variables include storm routing, and assessment of pollutant source and transport in the watershed with considerations of upstream development.

Bowman Dam Sediment Transport & Fish Habitat Assessment Model
Portland Gas & Electric – Portland, OR
A 2-dimensional model was developed for the Bowman Dam tailrace where a new powerstation is proposed. Hydrodynamics of the tailrace were modeled under a range of river and operating conditions to determine impacts to fish habitat. The study included substrate sampling, habitat surveys, and evaluation of changes to total critical fish habitat area in the study reach.

Channel Design Analysis for Holtwood Dam
PPL Generation, LLC – Allentown, PA
Both 1-dimensional and 2-dimensional modeling was completed in the Holtwood tailrace to assess various excavation options during redevelopment, and the effects of fish velocity barriers. Channel design options discourage passage in portions of the channel by creating high velocity zones, while facilitating upstream passage elsewhere in designed lower velocity zones.

Dresden Island Lock & Dam Hydroelectric Development
Northern Illinois Hydropower – Chicago, IL
Developed 2-dimensional coupled hydrodynamic and sediment transport model to assess impacts of a new powerstation on downstream channel conditions and in-stream habitat. Various excavation options were considered to improve channel bank stability, long term channel stability, and limit impacts to mussel habitats downstream.

ALDEN

DANIEL GESSLER, P.E., PH.D., D. WRE
Civil Engineering, Hydraulics/Fluid Mechanics
Vice President

PRESENT POSITION

Dr. Gessler generally oversees the numeric and physical hydraulic modeling activities at Alden. He is responsible for hydraulic modeling using computational fluid dynamic (CFD) models and one and two dimensional hydraulic models, including sediment transport models. In addition to working on numeric models, he provides technical expertise on physical models involving sediment transport. Dr. Gessler also manages Alden's Colorado office, and strives to provide engineering recommendations and valuable engineering options for the projects in which Alden is involved.

EXPERTISE

- Hydraulic modeling and computational fluid dynamics
- Hydraulic modeling and fish passage at hydroelectric power plants
- Physical and numeric modeling of hydraulic structures
- Analysis of cooling water intake and discharge systems for nuclear power industry, including sedimentation impacts and mitigation measures
- Erosion and Sedimentation

PROJECT EXPERIENCE

Dr. Gessler has over 20 years of experience in numeric modeling. Since joining Alden in 2002, he has served as a senior hydraulic modeler using computational fluid dynamics and physical models to investigate a broad range of hydraulics and river mechanics problems, including complex sedimentation studies and spillway studies. He became Director of Numeric Modeling and is now Vice President and Principal. Prior to joining Alden, he worked as a research scientist and assistant professor at Colorado State University, working on three dimensional hydrodynamic sediment transport modeling for the corps of engineers.

SELECTED PROJECTS

Smithland Lock and Dam Sediment Model - A proposed power house at Smithland Lock and Dam on the Ohio River will change the flow patterns downstream of the dam. The 2D sediment transport model MIKE21-C was used to predict how changes in flow patterns will affect sediment deposition patterns and how those changes may affect dredging. This 2D model study was completed in conjunction with a 1:120 scale physical model used to evaluate impacts on navigation and sedimentation. Dr. Gessler served as the lead numeric modeler and evaluated sediment transport aspects of the physical model.

Cowlitz River - Columbia River Confluence Model - Sediment originating from Mt. St. Helens is transporting down the Cowlitz River to the confluence with the Columbia River. The sediment source is the debris avalanche created in the 1980 eruption. The sediment is depositing in the Cowlitz River, raising the river bed level and reducing the flood capacity of the river. The 2D sediment transport model MIKE21-C is being used to model the existing condition and proposed alternatives to reduce sediment deposition. The model includes the Columbia and the Cowlitz River, all model boundaries are time dependent and the Columbia river boundary includes tidal fluctuations.

Holtwood Hydroelectric Plant – The proposed expansion of the Holtwood hydroelectric plant involves doubling the plant capacity through the installation of additional turbines. Alden developed four 3-dimensional models and two 2-dimensional models to evaluate various aspects of fish passage, forebay design, spillway flow, tailrace design, fishlift approach and trash sluicing. The models were also used to considered impacts on recreational boating due to the proposed modifications. Dr. Gessler served as the lead hydraulic modeler.

Spillway Model - An existing spillway in Hawaii was significantly damaged during a recent discharge event. Alden developed a three dimensional CFD model using FLOW-3D to model flow through the existing spillway and help develop necessary information for the redesign of the replacement spillway. The spillway has a unique design for which CFD or a physical model is required to compute the super elevation in the spillway chute.

Modeling Hydraulic Structures - Computational fluid dynamics is used to determine the performance of hydraulic structures outside of their design envelope and optimize the performance of new designs. Particular applications include predicting structure performance under greater than design flows due to changes in the probable maximum flow or global climate change. Hydraulic structures are being optimized for various criteria, including projects to minimize the structure footprint, maximize mixing efficiency in potable water applications (Blue Hills covered storage tank) and minimize headloss (New Orleans drainage canals)

Coastal Power Plant – The two dimensional model MIKE21 was used to simulate the long term (90 day) movement of water in a tidal estuary on the east coast to support the relicensing of a power plant. The model showed flow patterns around the plant and the entrainment probability of fish larvae originating in the tributary river. The information is necessary to quantify the environmental impact of a water intake.

Erosion and Sedimentation – Erosion and sedimentation is of interest at many power plants, riverine and coastal environments. In each case, sediment which deposits in undesirable locations must be mechanically removed, affecting the operating costs of a structure or predicted water surface elevations. Two and three dimensional modeling has been used on numerous projects to address sedimentation in riverine and coastal environments.

Nuclear Power Plant Cooling Water Systems – Cooling water systems for nuclear power plants have been modeled at various plants throughout the US. Models have been used to reduce sedimentation and maintenance dredging requirements, evaluate the effects and movement of accumulated air in cooling water backup systems, and to assess the environmental impacts of discharge plumes and water intakes. In addition, physical models are being used to determine the hurricane driven wave forces on essential plant components.

EDUCATION

B.S., Colorado State University, 1988, Civil Engineering
M.S., Colorado State University, 1993, Civil Engineering / Hydraulics
Ph.D., Colorado State University, 1993, Civil Engineering / Hydraulics
Various courses on computational fluid dynamics, flow visualization, turbomachinery, erosion and sedimentation, design of dams, hydraulic structures.

REGISTRATION

Professional Engineer, Colorado, 30926 and Michigan, 6201057915

PROFESSIONAL ACTIVITIES/AWARDS

Member, American Society of Civil Engineers
Invited visiting professor, Swiss Federal Institute of Technology, Lausanne, Switzerland, 2000
Public Education Committee K-12, ASCE 1998 to 2002
ASCE Task Committee on Computational Hydraulics 2005-2007

SELECTED PUBLICATIONS/PRESENTATIONS

Gessler, D., (2011). *"Use of Numeric Modeling in Fish Passage at Hydroelectric Projects",* HydroVision Brazil, Rio De Janeiro, Brazil. No co-authors.

Gessler, D., Biedenharn, D, Watson, C., Nygaard, C., Peters, M.., (2011) *"Two Dimensional Modeling of the Cowlitz - Columbia River Confluence",* Joint Federal Interagency Sedimentation Conference, Las Vegas, NV.

Gessler, D, Peters, M., Dickerson, P., Martin, M., (2011) *"Two Dimensional Modeling of the Upper North Fork Sediment Plain",* Joint Federal Interagency Sedimentation Conference, Las Vegas, NV.

Darby, S.E., Gessler, D., Thorne, C.R., (2000*). "Computer Program for Stability Analysis of Steep Cohesive Riverbanks"*, Earth Surface Processes and Landforms, No. 25, pp. 175-190. (Technical and Software Bulletin).

Gessler, D., Hall, B., Spasojevic, M., Holly, F., Pourtaheri, H., Raphelt, N., (1999). "Application of 3-Dimensional Mobile Bed, Hydrodynamic Model", Journal of Hydraulic Engineering, ASCE, vol 125, No. 7. pp. 737 - 749.

Gessler, D., Gessler, J. Watson, C.C., (1998). "*Prediction of Discontinuity in Stage-Discharge Rating Curves*", Journal of Hydraulic Engineering, ASCE, vol 124, No. 3. pp. 243 - 252.

Gessler, D., Mead, J. J., Stacy, P., (2006). "*Full Scale Modeling of Air Entrainment and Transport*", American Nuclear Society, Winter Meeting, Albuquerque, NM.

Gessler, D., (2005). *"CFD Modeling of Spillway Performance",* ASCE, EWRI national conference, Anchorage, AK.

Carney, S.K., Bledsoe, B.P., Gessler, D., (2004). "*Computational Fluid Dynamics Investigation of the Influence of Bank Vegetation on Open Channel Flow*", AWRA Summer Specialty Conference, Riparian Ecosystems and Buffers: Multi-Scale Structure, Function, and Management, Olympic Valley, CA.

Carney, S.K., Bledsoe, B.P., Gessler, D., (2003). *"Shear Stress Distribution in Streams with High Bank Roughness"*, AGU Hydrology Days, Colorado State University, Fort Collins, CO 80523.

Gessler, D., (2003). *"Using CFD to Define the Hydraulic Zone of Influence at Cooling Water Intake Structures"*, AGU Hydrology Days, Colorado State University, Fort Collins, CO 80523.

Gessler, D., (2002). *"Predicted and Measured Flow Patterns in Channels using CFD and Flume Data"*, AGU Hydrology Days, Colorado State University, Fort Collins, CO 80523.

Mussetter, R.A., Gessler, D., Wolff, C.G., (2002). *"Modeling of Potential Dam Removal Impacts to Habitat, Flooding and Channel Stability on the Carmel River, California*", AGU Hydrology Days, Colorado State University, Fort Collins, CO 80523.

Gessler, D., (2000). *"Discontinuity of Stage-Discharge Rating Curves Due to Dunes"*, AGU Hydrology Days, Colorado State University, Fort Collins, CO 80523.

Kleinschmidt

PROFESSIONAL RESUME

BRANDON H. KULIK

SENIOR FISHERIES BIOLOGIST

Brandon Kulik joined Kleinschmidt in 1986 as a Senior Fisheries Biologist. He graduated from Colby College (1976) with a B.A. in Environmental Studies and an M.S. in Aquatic Zoology from DePauw University (1978). Mr. Kulik is trained in U.S. Fish and Wildlife Service Fish Passageways and Diversion Facilities, Instream Flow Incremental Methodology (IFIM), including Physical Habitat Simulation (PHABSIM) computer modeling.

Mr. Kulik designs, performs, and reviews environmental studies pertaining to fish passage, ecology, instream flow, and aquatic habitat. Primary responsibilities include leading agency consultation for scoping, design, and execution of study plans; negotiation of resolutions for aquatic habitat and fish passage issue; managing collection and analysis of scientific data; preparation of environmental exhibits for license and permit documents and providing biological input to the design of fishways. Mr. Kulik has provided significant expert witness testimony on instream flow and fish passage issues. He is an active member of the American Fisheries Society, past president of the Atlantic International Chapter of AFS, taught Ichthyology at Unity College, and serves on the Sheepscot Valley Conservation Association and the Sebasticook Regional Land Trust. He has published and presented papers at professional meetings on instream flow regulation, fish entrainment and passage, habitat protection, riverine fish community dynamics, and served as a peer reviewer for the journal *Rivers* (1999), *North American Journal of Fisheries Management*, several *EPRI* reports on fish entrainment (1996-97), and the *Congressional Office of Technology Assessments*' "Fish Passage Technologies" (1995), and *Barrier Removal Monitoring Guidelines* (NOAA, 2007).

Prior to joining Kleinschmidt, Mr. Kulik directed studies for the Indian Point (NY) Nuclear Generating Station , fish passage and aquatic studies at hydroelectric sites for Normandeau Associates, Inc. Prior to that, he held similar positions at Ichthyological Associates (Middletown, DE) and Southern California Edison (Los Angeles, CA).

PROJECT EXPERIENCE

Atlantic Salmon Fish Passage Litigation
Nextera Energy Maine - Hallowell, ME
Expert witness to defend client in litigation pertaining to fish passage impacts to migratory Atlantic salmon populations of the Androscoggin and Kennebec rivers. The plaintiff asserted that the client's dam were undermining species recovery and thus violating the Endangered Species Act. Responsible for scientific analysis of scientific data pertaining to population biology, species management, habitat use and site-specific fish passage requirements of Atlantic salmon at a network of dams, preparation of expert opinion, and providing expert testimony, and advising legal counsel.

3-D Salmon Smolt Migration Model, Narraguagus River
NOAA Fisheries - Orono, ME
Worked with interagency science team to track smolt migration in coastal habitat, using VEMCO sonic tags and stationary receivers. Collected tide and physical water quality data to correlate movement patterns with ambient environmental conditions. Data were entered into a custom-designed spatial data analyzer prepared by Baird Associates that displays movements on a 3-D simulated landscape of the river, estuary and offshore environment. Coordinated field data, contributed to model design and analysis.

Kennebec River Fishery and Habitat Studies,
Lockwood Project, FPL Energy - Augusta, ME
Responsible for study design, study plans and supervision of data collection and analysis for fish distribution, population analysis of target species, habitat use and water quality studies in the Kennebec River, and determination of fish passage needs for newly-restored anadromous species in the river below Waterville, Maine.

Saco River Atlantic salmon passage effectiveness study plan, FPL Energy, Augusta, ME
Scoped fish passage study to assess downstream passage effectiveness of existing fishways for post-spawned (adult) Atlantic salmon. Developed methodology for selecting representative study sites so that cost-effective studies

Fish Passage Studies, Benton Falls Project, Benton Falls Associates - Benton ME Conducted downstream fish passage effectiveness studies of alewives via a fishway and alternative gates and spillage at a hydroelectric site on the Sebasticook River, Maine. Designed study, supervised data collection, analysis and reporting.

Eel Passage Effectiveness Study,
Madison Paper Industries, Madison, ME
Developed advanced hydroacoustic remote sensing technology to integrate hydroacoustic detection of silver eel downstream migration with passage activation at a run-of-river hydroelectric project on the Kennebec River, Maine. Study pioneered utilization of DIDSON ultrasound imaging with conventional split-beam acoustic monitoring. Responsible for study design, technical direction, field supervision, data analysis, report preparation coordination with agencies and licensee.

Ethan Jay Nedeau

Address: 433 West Street, Amherst, MA 01002
Phone: (413) 253-6561. Email: ethan@biodrawversity.com

EDUCATION

Michigan State University, 1996 – 1998. *M.S., Entomology (Concentration: Stream Ecology)*
University of Massachusetts Amherst, 1992 – 1996. *B.S., Wildlife and Fisheries Conservation, summa cum laude*

CURRENT EMPLOYMENT

Biodrawversity LLC. Sole Owner and Senior Scientist. 1998 - present

- Built a small, efficient, and multidisciplinary ecological consulting and communications company.
- Responsible for building lasting relationships with a broad and growing client base in public and private sectors.
- Consulting services include endangered species surveys, ecological assessment, and ecological monitoring. Specific skills include aquatic macroinvertebrate sampling and taxonomy, malacology, stream ecology, biological assessment of aquatic environments, study design, GPS data collection and GIS analysis, and reporting. Maintain a fully licensed and equipped SCUBA team.
- Prequalified by both state agencies and the U.S. Fish and Wildlife Service to conduct studies of federally endangered and state-listed freshwater mussel species in Maryland, Delaware, New Jersey, Pennsylvania, New York, Connecticut, Massachusetts, Vermont, New Hampshire, and Maine.
- Communications services include professional writing, editing, graphic design, illustration, and publishing for environmental science topics. Particularly adept at assimilating and synthesizing complex ecological information and creating publications.

ENVIRONMENTAL CONSULTING PROJECTS

Led nearly 250 ecological consulting projects in northeastern North America (Pennsylvania to Maine), mostly focused on aquatic invertebrate studies and ecological monitoring. The following are some recent examples:

- Freshwater Mussel Research, Relocation, and Monitoring for the Penobscot River Restoration Project in Maine: Removal of the Great Works Dam and Veazie Dam. 2010-Present.
- Qualitative and Qualitative Assessment of the Freshwater Mussel Community in the Susquehanna River Downstream of the Conowingo Dam. 2012.
- Baseline Assessment of Stream Salamanders and Aquatic Macroinvertebrates in Headwater Streams of Lowell Mountain (Vermont) Prior to Upland Disturbance from Commercial Wind Power Development. 2011-2012.
- Dwarf Wedgemussel (*Alasmidonta heterodon*) Survey in the Connecticut River for the Vernon, Bellows Falls, and Wilder Hydroelectric Facilities. 2011.
- Two-phase Qualitative and Quantitative Surveys to Determine the Distribution, Abundance, and Demographics of the Brook Floater (*Alasmidonta varicosa*) in the Pleasant River and Sheepscot River in Maine, the West River in Vermont, and the Lamprey and Exeter Rivers in New Hampshire. 2010-2012.
- Threatened and Endangered Mussel Survey and Habitat Evaluation of the Castleton and Poultney Rivers (Fair Haven, Vermont) for a Proposed Biomass Facility. 2010.
- Biological Monitoring of Aquatic Macroinvertebrates, Algae, Macrophytes, and Fish in the Taunton River Watershed in Eastern Massachusetts. 2010.
- Assessment of Native Freshwater Mussels, Benthic Littoral Macroinvertebrates, and Zebra Mussels in Five Hydroelectric Facilities in the Housatonic River in Connecticut. 2010-Present.
- Relocation and Monitoring of Dwarf Wedgemussel (*Alasmidonta heterodon*) Populations in the Ashuelot River in the Impoundment of the Homestead Woolen Dam Before and After Dam Removal. 2010.
- The Potential Spread of Zebra Mussels in Western Massachusetts: Physical, Chemical, and Biological Surveys of Lakes and Rivers in the Housatonic and Connecticut River Watersheds of Massachusetts. 2009-2010.
- Qualitative and Quantitative Surveys of the Yellow Lampmussel (*Lampsilis cariosa*) in the Impoundment and Bypass Reach of the Holyoke Dam (Connecticut River) and the Holyoke Power Canals. 2009.
- Freshwater Mussels of the Housatonic River Watershed in Massachusetts: 2009 Field Studies and Comprehensive Report. 2009.
- Quantitative and Qualitative Assessment of Five Endangered Mussel Species in the Lower Winooski River (Colchester, Vermont), Development of a Mitigation Plan for Bank Stabilization, and Mussel Relocation and Monitoring. 2009-Present.
- Endangered Species Surveys and Ecological Characterization of Areas of the Shetucket River Influenced by the Scotland Hydroelectric Dam (Windham County, Connecticut). 2008-2009.
- Effects of Docks, Recreation, and Shoreline Development on a Regionally Important Freshwater Mussel Assemblage in Johns Pond (Mashpee, Massachusetts). 2008-2009.

REPRESENTATIVE REGIONAL PUBLICATIONS

- Nedeau, E.J. 2008. *Freshwater Mussels and the Connecticut River Watershed.* Connecticut River Watershed Council, Greenfield, MA.
- Zimmerman, J., A. Lester, K. Lutz, C. Gannon, and E.J. Nedeau. 2008. *Restoring Ecosystem Flows in the Connecticut River Watershed.* The Nature Conservancy, Connecticut River Program, Northampton, MA. 20-page report.
- Gulf of Maine Council on the Marine Environment. 2007. *American Eel: Restoring a Vanishing Resource in the Gulf of Maine.* Fact sheet.
- Massachusetts Riverways Program. 2005. *Massachusetts Stream Crossings Handbook.* Massachusetts Executive Office of Environmental Affairs, Department of Fish and Game. 11 pages.
- Nedeau, E.J., M. McCollough, and B. Swartz. 2000. *Freshwater Mussels of Maine.* Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

CATEGORY RATES

From:	Petrewski, Gary
To:	Petrewski, Gary; "Ballaron, Paula"; "Naugle, Pat"; "Hartle, Mark"; "hgalbraith@usgs.gov"; "lora_zimmerman@fws.gov"; "wholtsmast@pa.gov"; "hbiggs@pa.gov"; "mmurphy@anchorqea.com"; "c-nwelte@pa.gov"
Cc:	Wise, Bradley A; Kuczynski, George J; Caverly, Michael J; Sgarro, Rocco R; Tim Oakes; "John Dulude"; "Dan Gessler"; Jon Quebbeman; Brandon Kulik; "ethan@biodrawversity.com"
Subject:	RE: Bell Bend Mussel Studies 8-10 Conference call summary
Date:	Thursday, August 16, 2012 1:27:00 PM

The following is a recap of Tuesday's(8/14) 1 PM call. If you have any corrections, please let me know.

The following items stemming from Friday's(8/10) call were reviewed for concensus agreement. Confirmation, actions, or new items are noted in red. Green text are residual items not discussed.

1). No requantification of green floaters in the 60x300 foot area (All agencies on phone per below attendance concurred). Confirmed by 8/14 attendees as listed below.
2). We will get Normandeau to memorialize in the presence or absence report the dispute over methods. Confirmed, Petrewski will discuss with Normandeau.
3). Modeling approach is in line with agency thinking subject to clarification of items below. Confirmed by 8/14 attendees as listed below.
4). Modeling will be limited to low flow periods. Agencies will define the expected range. This is needed before field work commences as it will effect data collection.
Flow range will be from 7Q10 to something in the range of 2000 cfs. Upper bound will be determined by SRBC and will be based on additional discussions with Mark Hartle if he is available. Could be a P90 or P95 number. This is high priority as this information is needed to commence field work.
5). Scope of mussel impact analysis will be broadened beyond the 60x300 green floater area to capture flow effects on other mussel species found by Normandeau in the vicinity of Swan and Heron Island. This work will not extend beyond the proposed model boundaries shown in red in the figure attached to the scope. Confirmed by 8/14 attendees as listed below. Based on agency review of item 6) information below, focus areas will include:
a). Entire area between Heron and Swan Islands
b). Swan 3 area from Normandeau Figure D3
c). Above bridge shallows - Ethan Nedeau will survey shallow habitat above bridge to determine if there is any meaningful mussel presence in this area, and it will be a focus area if found to be suitable mussel habitat.
d). Other locations to be determined byititial survey by Ethan Nedeau (assuming any are found). Question: Is agency confirmation required, or is this left to Ethan's judgement.

Pat will forward his field notes related to prior survey work. Complete and attached (Thank you Pat).
6). PPL will secure from Normandeau field data and a map showing location of mussel presence around Swan and Heron Islands so that impact focus areas can be agreed to before start of data collection. I will try to have this before Tuesday's call. Complete and provided via e-mail to agencies on 8/13.
7). Consideration in impact analyses will be given to flow effects to mussel host species - Answer the question - How does flow change effect availability of habitat to hosts?
Additional discussions are needed on mussel species to be evaluated and how to handle fish host impact analysis. Yellow Lampmussel, Triangle floater and Elktoe are key additional mussel species to focus on. Agencies will further advise on host fish and try to limit selection to common hosts. This information is not required in support of field data collection, but PPL is requesting a target date for this determination.
8). Agencies will further consider desired model, TELEMAC 2D or Mike21 and advise on preference. This is not needed before data collection commences, but is needed before analysis commences. SRBC will advise later this week by 8/17.
9). Potential differences between hand-held data collection and fathometer data collection needs to be appropriately considered. Potential error in model and as it effects results needs to be kept in mind. Pat to forward professional Surveyor magazine article link(?). Kleinschmidt to pay attention to data

issues in model development.
10). Agencies on this call, that will not be on Tuesday's call, will advise SRBC of any missed issues so that they can be captured on Tuesday's call. No isssues, complete.
11). Bathymetry data collection will be sufficient to characterize all hydraulic controls relevant to the planned impact analysis, not just eel weirs. Confirmed, complete

Based on these discussions Kleinschmidt will Rev the study scope as an interim document to capture agreements to date and note pending discussion on unresolved matters.

Attendees:Brad Wise PPL
Gary petrewski PPL
George Kuczynski PPL
Tim Oakes Kleinschmidt
Jon Quebbeman Kleinschmidt
Ethan Nedeau Biodrawversity
Paula Ballaron SRBC
Pat Naugle SRBC
Nevin Welty PFBC
Heather Galbraith USGS

From: Petrewski, Gary
Sent: Monday, August 13, 2012 12:13 PM
To: 'Ballaron, Paula'; 'Naugle, Pat'; 'Hartle, Mark'; 'hgalbraith@usgs.gov'; 'lora_zimmerman@fws.gov'; 'wholtsmast@pa.gov'; 'hbiggs@pa.gov'; 'mmurphy@anchorqea.com'; 'c-nwelte@pa.gov'
Cc: Wise, Bradley A; Kuczynski, George J; Caverly, Michael J; Sgarro, Rocco R; 'Tim Oakes'; 'John Dulude'; 'Dan Gessler'; 'Jon.Quebbeman@KleinschmidtUSA.com'; 'Brandon.Kulik@KleinschmidtUSA.com'; 'ethan@biodrawversity.com'
Subject: RE: Bell Bend Mussel Studies 8-10 Conference call summary

All: as requested, attached are several figures where Normandeau has numbered mussel search areas. Also attached are two files providing tables showing mussels found in each of the numbered search areas. The figures represent the entire range of areas examined in the prior Normandeau survey work. For your consideration relative to tomorrow's planned 1 PM call.

As a reminder the conference line is 1-888-238-2971, passcode 2205996#. Notes from last Friday's call are below.

From: Petrewski, Gary
Sent: Friday, August 10, 2012 1:45 PM
To: Petrewski, Gary; 'Ballaron, Paula'; 'Naugle, Pat'; 'Hartle, Mark'; 'hgalbraith@usgs.gov'; 'lora_zimmerman@fws.gov'; 'wholtsmast@pa.gov'; 'hbiggs@pa.gov'; 'mmurphy@anchorqea.com'; 'c-nwelte@pa.gov'
Cc: Wise, Bradley A; Kuczynski, George J; Caverly, Michael J; Sgarro, Rocco R; 'Tim Oakes'; 'John Dulude'; 'Dan Gessler'; 'Jon.Quebbeman@KleinschmidtUSA.com'; 'Brandon.Kulik@KleinschmidtUSA.com'; 'ethan@biodrawversity.com'
Subject: RE: Bell Bend Mussel Studies 8-10 Conference call summary

One more correction. I forgot to list Mark Hartle, PFBC as an attendee

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From: Petrewski, Gary
Sent: Friday, August 10, 2012 12:49 PM
To: Petrewski, Gary; 'Ballaron, Paula'; 'Naugle, Pat'; 'Hartle, Mark'; 'hgalbraith@usgs.gov'; 'lora_zimmerman@fws.gov'; 'wholtsmast@pa.gov'; 'hbiggs@pa.gov'; 'mmurphy@anchorqea.com'; 'c-nwelte@pa.gov'

Cc: Wise, Bradley A; Kuczynski, George J; Caverly, Michael J; Sgarro, Rocco R; 'Tim Oakes'; 'John Dulude'; 'Dan Gessler'; 'Jon.Quebbeman@KleinschmidtUSA.com'; 'Brandon.Kulik@KleinschmidtUSA.com'; 'ethan@biodrawversity.com'
Subject: RE: Bell Bend Mussel Studies 8-10 Conference call summary

One other item that I just thought of for completeness:

11). Bathymetry data collection will be sufficient to characterize all hydraulic controls relevant to the planned impact analysis, not just eel weirs.

From: Petrewski, Gary
Sent: Friday, August 10, 2012 12:31 PM
To: 'Ballaron, Paula'; 'Naugle, Pat'; 'Hartle, Mark'; 'hgalbraith@usgs.gov'; 'lora_zimmerman@fws.gov'; 'wholtsmast@pa.gov'; 'hbiggs@pa.gov'; 'mmurphy@anchorqea.com'; 'c-nwelte@pa.gov'
Cc: Wise, Bradley A; Kuczynski, George J; Caverly, Michael J; Sgarro, Rocco R; 'Tim Oakes'; John Dulude; Dan Gessler; Jon.Quebbeman@KleinschmidtUSA.com; Brandon.Kulik@KleinschmidtUSA.com; ethan@biodrawversity.com
Subject: Bell Bend Mussel Studies 8-10 Conference call summary

http://www.pplweb.com/ppl-generation/ppl-holtwood/expansion-project/public-documents.aspx

Above is a link to the Holtwood website illustrating use of the Mike21 model. If you scan down the list of Public Documents you will See Reports 1 through 4 showing 2D model results. The graphics in these reports generally show depth, velocity, velocity vectors. The barrier dam report also shows some time sequencing results. I didn't see anythig on partical tracking in these 2D models, but apparently, that can be done as well. I think some of the 3D reports show some partical tracking. My understanding is that similar graphis can be produced from either Mike21 or TELEMAC, but modelers need to confirm that. Happy Reading

Once again, thank you for taking the time to talk to us today.

Regarding today's call, here is my additional takeaway (beyond the Holtwood model link above) for further discussion on Tuesday at 1 PM.

1). No requantification of green floaters in the 60x300 foot area (All agencies on phone per below attendance concurred).
2). We will get Normandeau to memorialize in the presence or absence report the dispute over methods.
3). Modeling approach is in line with agency thinking subject to clarification of items below.
4). Modeling will be limited to low flow periods. Agencies will define the expected range. This is needed before field work commences as it will effect data collection.
5). Scope of mussel impact analysis will be broadened beyond the 60x300 green floater area to capture flow effects on other mussel species found by Normandeau in the vicinity of Swan and Heron Island. This work will not extend beyond the proposed model boundaries shown in red in the figure attached to the scope.
6). PPL will secure from Normandeau field data and a map showing location of mussel presence around Swan and Heron Islands so that impact focus areas can be agreed to before start of data collection. I will try to have this before Tuesday's call.
7). Consideration in impact analyses will be given to flow effects to mussel host species - Answer the question - How does flow change effect availability of habitat to hosts?
8). Agencies will further consider desired model, TELEMAC 2D or Mike21 and advise on preference. This is not needed before data collection commences, but is needed before analysis commences.
9). Potential differences between hand-held data collection and fathometer data collection needs to be appropriately considered. Potential error in model and as it effects results needs to be kept in mind.
10). Agencies on this call, that will not be on Tuesday's call, will advise SRBC of any missed issues so that they can be captured on Tuesday's call.

On Tuesday (1 PM) we will solicit confirmation of above from other agencies not present on the call. Also, if I missed anything, please advise. Thanks.

Call Attendees:

Gary Petrewski PPL
George Kuczynski PPL
Brad Wise PPL
Tim Oakes Kleinschmidt
Jon Quebmann Klienschmidt
Brandon Kulick Kleinschmidt
Ethan Nedeau Biodrawversity
Dan Gessler Alden Labs
Paula Ballaron SRBC
Pat Naugle SRBC
Lora Zimmerman USFWS
J R Holtsmaster DEP

From: Petrewski, Gary
Sent: Tuesday, August 07, 2012 2:42 PM
To: 'Ballaron, Paula'; 'Naugle, Pat'; 'Hartle, Mark'; 'hgalbraith@usgs.gov'; 'lora_zimmerman@fws.gov'; 'wholtsmast@pa.gov'; 'hbiggs@pa.gov'; mmurphy@anchorqea.com; c-nwelte@pa.gov
Cc: Wise, Bradley A; Kuczynski, George J; Caverly, Michael J; Sgarro, Rocco R; Tim Oakes
Subject: Bell Bend Mussel Studies

Enclosed for agency consideration is a revised mussel impact study plan for the Bell Bend project. Based on prior discussions, PPL has sought alternative consultant services and is forwarding our selected proposal from a combination of Kleinschmidt Associates, Alden Labs, and Biodrawversity to complete the desired green floater mussel impact studies. We are hopeful based on prior discussion that this proposal will fully meet agency study requirements.

We would like the opportunity to present and discuss this proposal in person, however, we recognize that participation by phone for some will be necessary. I have spoken to Paula at the SRBC and she has advised that SRBC is available for a meeting/call on the following dates: Friday 8/10, Tuesday 8/14 in the PM, or Thursday 8/16.

Please advise ASAP of your availability to meet or to call in on these dates. If you won't be able to participate, it would be helpful if you can provide any comments or questions to the SRBC. We expect to meet in the Harrisburg area. A location will be selected once the date is finalized.

The information contained in this message is intended only for the personal and confidential use of the recipient(s) named above. If the reader of this message is not the intended recipient or an agent responsible for delivering it to the intended recipient, you are hereby notified that you have received this document in error and that any review, dissemination, distribution, or copying of this message is strictly prohibited. If you have received this communication in error, please notify us immediately, and delete the original message.

MEMORANDUM

TO: Gary Petrewski, PPL Bell Bend, LLC

FROM: Brandon Kulik, Tim Oakes; Kleinschmidt

DATE: October 4, 2012

RE: Planned Bell Bend Aquatic Habitat Suitability Indices

INTRODUCTION

Habitat suitability for applicable species and lifestages of host fish residing in the study area will be included as part of the Bell Bend Nuclear Power Plant (BBNPP) water withdrawal model because certain fish species resident in the study area may serve as host species for the larval lifestage (*glochidia*) of freshwater mussel species of concern. The goal of this analysis will be to estimate the extent to which host species may co-inhabit the study area, based upon habitat suitability changes in the study area between a flow of 843 cfs (7Q10) and 800 cfs (*the flow resulting from the proposed increased water withdrawal at BBNPP under 7Q10 conditions*) under existing and proposed conditions.

According to Ethan Nedeau (*personal communication*) the following mussel/fish host associations are possible in the study area:

Elktoe: White sucker, northern hogsucker, shorthead redhorse, rockbass, and warmouth.

Yellow Lampmussel: White perch and yellow perch confirmed. Potential species: banded killifish, chain pickerel, white sucker, smallmouth bass, largemouth bass.

Triangle floater: Blacknose dace, longnose dace, common shiner, fallfish, largemouth bass, longnose dace, pumpkinseed sunfish, slimy sculpin, white perch, white sucker, central stoneroller, fantail darter, northern hogsucker, and rosyface shiner.

Green Floater: Unknown (also: *simultaneous hermaphrodite, might be capable of self-fertilization, might not need a host fish*).

The existing 2D hydraulic model may be populated with specific Habitat Suitability Curves (HSC) to quantitatively rate habitat suitability under a range of conditions. The purpose of the memo is to describe the specific HSC indices planned for application to the Bell Bend hydraulic model.

Host fish species may successfully serve as vectors by existing in close proximity to spawning mussels during the mussel spawning season, and by inhabiting suitable mussel habitat during the time of year when glochhidia may abandon their host and take up residence in the river substrate. The focal point of mussel habitat in this study is comprised of riffle and run habitat comprised of sand, gravel and small cobble substrates in the immediate vicinity of Heron and Swan islands near Nescopeck, Pennsylvania.

Following discussion with Ethan Nedeau, we plan to use the following species for habitat analysis:

- Northern Hogsucker (*can also be used as a guild representative for white sucker*)
- Smallmouth Bass (*can also be used as a guild representative for rock bass, warmouth and pumpkinseed sunfish*)
- Tessellated Darter (*can also be used as a guild representative for other benthic and cryptic fish species*)
- River chub (*can also be used as a guild representative for other cyprinid species*)

PROPOSED HSC INDICES

A recently completed Instream Flow Study was conducted in the study area (NAI 2012). We propose to adopt a subset of applicable HSC indices from that study as they can be used as a habitat guild (Bovee, *et al*., 1998) to reflect habitat use by other similar indigenous fish species in the study area. This study provides indices that have been previously reviewed and approved by agency staff. Based on the ecology of the mussel species of interest, we propose to assess the following species and lifestages:

TABLE 1. PROPOSED SPECIES AND LIFESTAGES FOR HABITAT SUITABILITY ASSESSMENT.

Smallmouth bass	Adult and juvenile
Northern hogsucker	Adult
Shorthead redhorse	Adult and juvenile
River chub	Adult/juvenile (one curve)
Banded darter	Adult and juvenile
Tessellated darter	Adult/juvenile (one curve)

Attachment A includes detailed graphic and tabular coordinates for depth, velocity and substrate rating values for the above species and lifestages based on NAI (2012). If time allows we would like concurrence from resource agencies on these species and life stages before beginning analysis. We can potentially use additional species and lifestages, provided that suitable HSC indices are readily available.

LITERATURE CITED

Bovee, K.D., B.L. Lamb, J.M. Bartholow, C.B. Stalnaker, J. Taylor, and J. Henriksen. 1998. Instream habitat analysis using the instream flow incremental methodology. U.S.Geological Survey, Biological Resources Division Information and Technology Report. USGS/BRD-1998-0004. viii + 131 pp.

Normandeau Associates, Inc., 2012. Potential effects of the Bell Bend Project on aquatic resources and downstream users. Report Number: 21665.001-LFHC4. Vol. II, Appendices. NAI, Inc. Moncks Corner, SC.

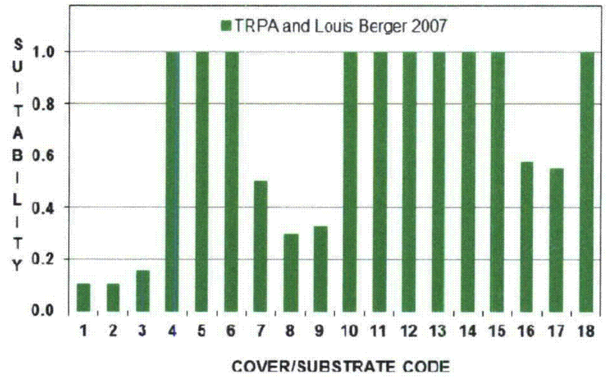
ATTACHMENT A

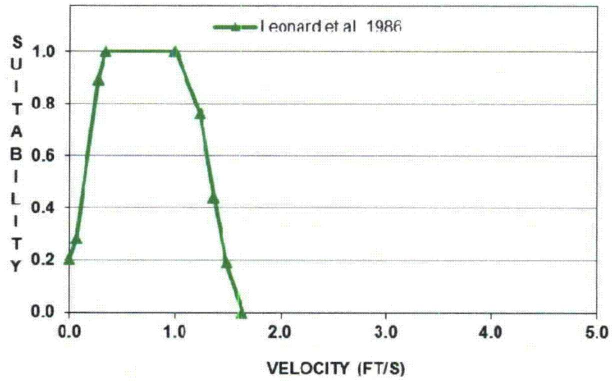
PROPOSED HSC CRITERIA

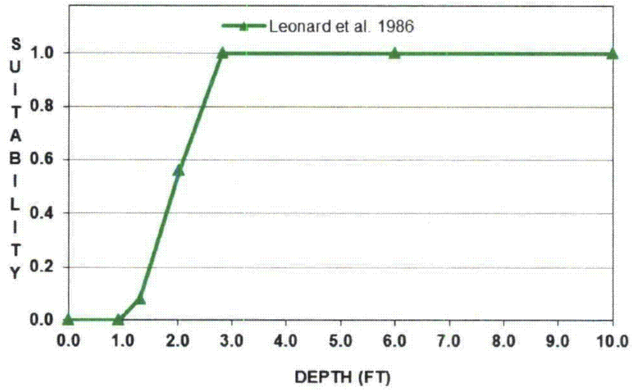
TABLE 1. SUBSTRATE AND COVER CODING AND DEFINITIONS.

CODE	COVER	SUBSTRATE
1	No Cover	silt or terrestrial vegetation
2	No Cover	sand (<0.1")
3	No Cover	gravel (0.1-3.0")
4	No Cover	cobble (3.0-12.0")
5	No Cover	small boulder (12-36")
6	No Cover	boulder, angled bedrock, or WD
7	No Cover	mud or flat bedrock
8	Overhead Veg	terrestrial vegetation
9	Overhead Veg	gravel
10	Overhead Veg	cobble
11	Overhead Veg	boulder, angled bedrock or WD
12	Instream	cobble
13	Instream	boulder, angled bedrock or WD
14	Proximal	cobble
15	Proximal	boulder, angled bedrock or WD
16	Inst/Prox	gravel
17	Inst/Prox/Ovh	silt or sand
18	Aquatic Veg	macrophytes

SMALLMOUTH BASS *(Adult)*



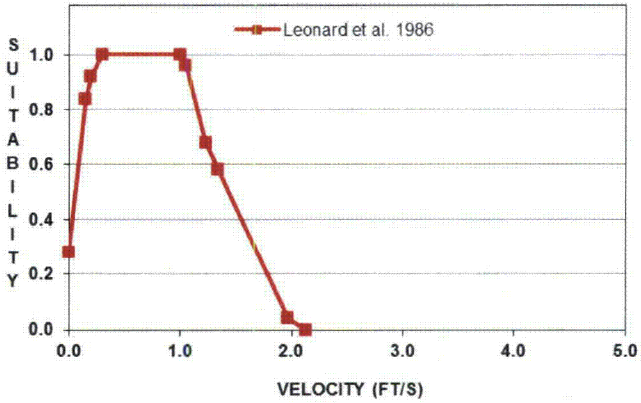


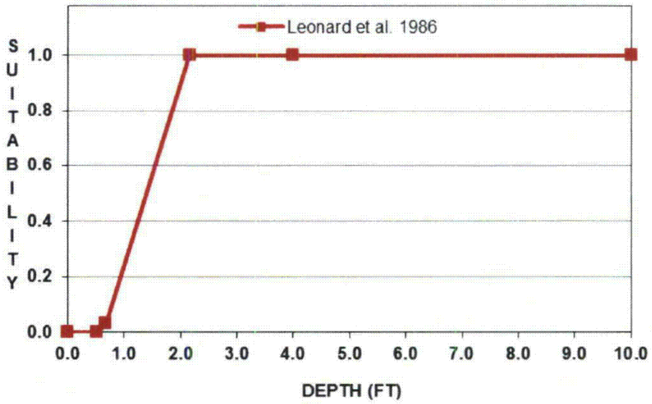


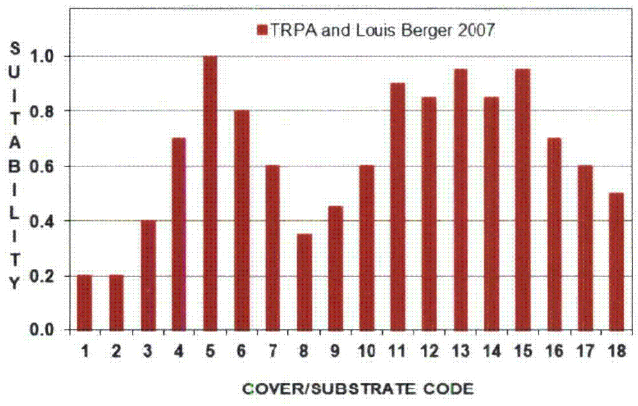
SMALLMOUTH BASS (*Adult*)

VEL A	VEL B	DPTH A	DPTH B	SUBS A	SUBSRT B
0.00	0.20	0.00	0.00	1.00	0.10
0.07	0.28	0.92	0.00	2.00	0.10
0.27	0.89	1.31	0.08	3.00	0.15
0.34	1.00	2.03	0.56	4.00	1.00
1.00	1.00	2.82	1.00	5.00	1.00
1.24	0.76	6.00	1.00	6.00	1.00
1.37	0.44	10.00	1.00	7.00	0.50
1.49	0.19	100.00	1.00	8.00	0.30
1.64	0.00			9.00	0.33
10.00	0.00			10.00	1.00
				11.00	1.00
				12.00	1.00
				13.00	1.00
				14.00	1.00
				15.00	1.00
				16.00	0.58
				17.00	0.55
				18.00	1.00

SMALLMOUTH BASS (*Juvenile*)



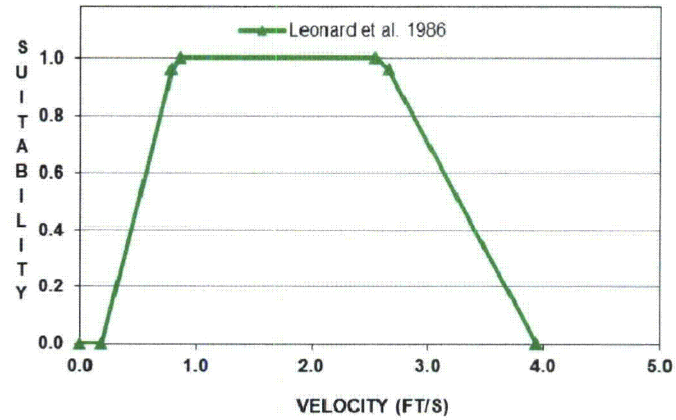


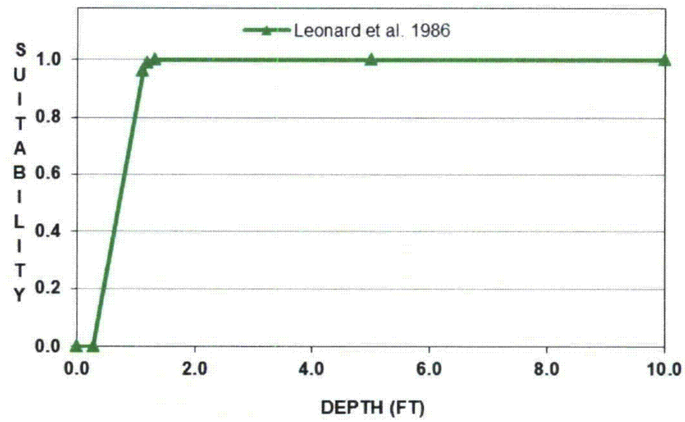


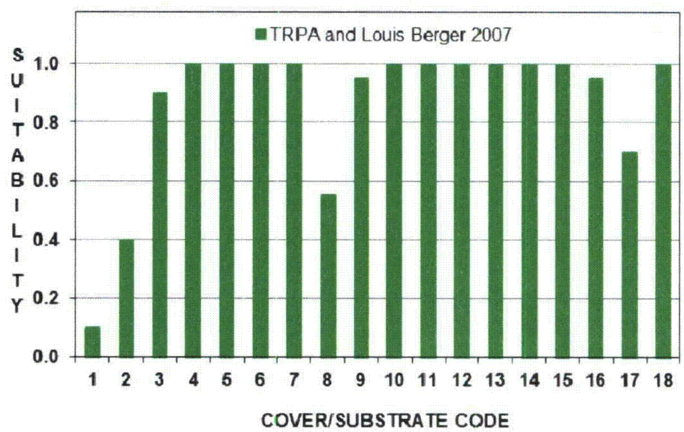
SMALLMOUTH BASS (*Juvenile*)

VEL X	VEL Y	DPTH X	DPTH Y	SBST/CVR X	SBST/CVR Y
0.00	0.28	0.00	0.00	1.00	0.20
0.15	0.84	0.52	0.00	2.00	0.20
0.20	0.92	0.67	0.03	3.00	0.40
0.30	1.00	2.15	1.00	4.00	0.70
1.00	1.00	4.00	1.00	5.00	1.00
1.05	0.96	10.00	1.00	6.00	0.80
1.23	0.68	100.00	1.00	7.00	0.60
1.34	0.58			8.00	0.35
1.97	0.04			9.00	0.45
2.13	0.00			10.00	0.60
10.00	0.00			11.00	0.90
				12.00	0.85
				13.00	0.95
				14.00	0.85
				15.00	0.95
				16.00	0.70
				17.00	0.60
				18.00	0.50

NORTHERN HOGSUCKER (*Adult*)







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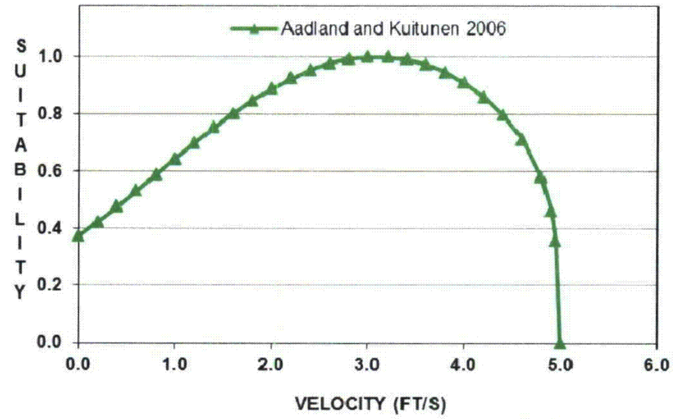
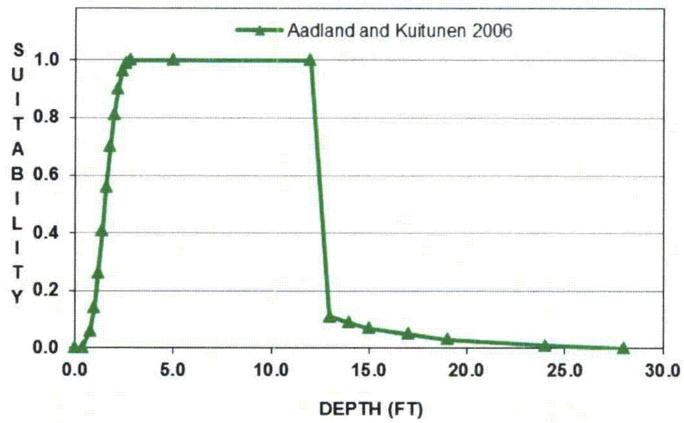
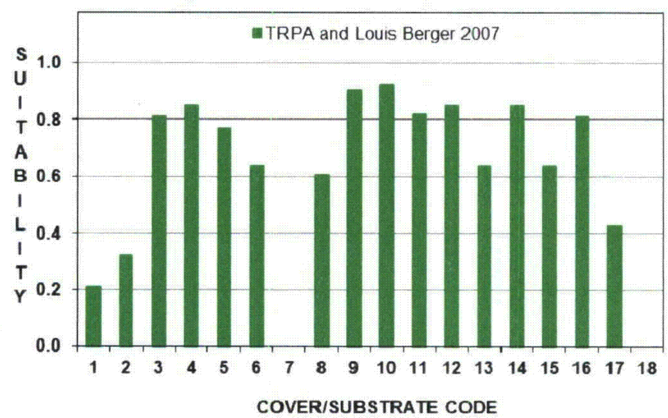
NORTHERN HOGSUCKER (*Adult*)

VEL X	VEL Y	DPTH X	DPTH Y	SBST/CVR X	SBST/CVR Y
0.00	0.00	0.00	0.00	1.00	0.10
0.19	0.00	0.28	0.00	2.00	0.40
0.79	0.96	1.11	0.96	3.00	0.90
0.86	1.00	1.18	0.99	4.00	1.00
2.55	1.00	1.31	1.00	5.00	1.00
2.66	0.96	5.00	1.00	6.00	1.00
3.94	0.00	10.00	1.00	7.00	1.00
10.00	0.00	100.00	1.00	8.00	0.55
				9.00	0.95
				10.00	1.00
				11.00	1.00
				12.00	1.00
				13.00	1.00
				14.00	1.00
				15.00	1.00
				16.00	0.95
				17.00	0.70
				18.00	1.00

SHORTHEAD REDHORSE *(Adult)*



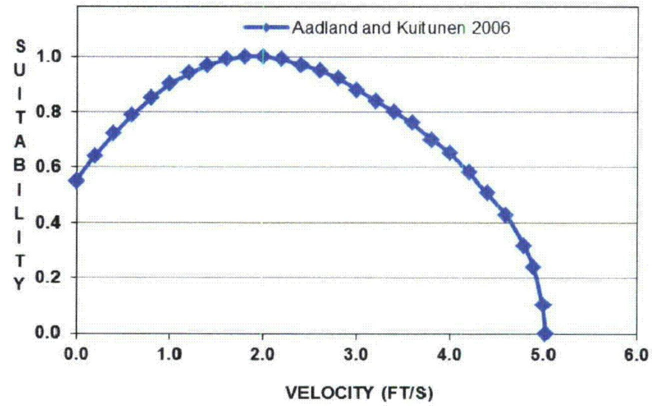


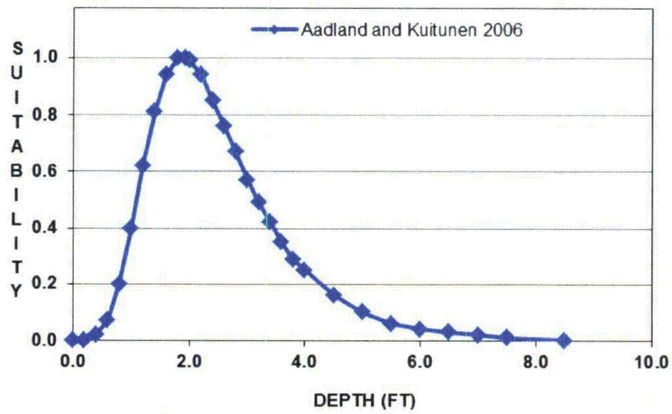


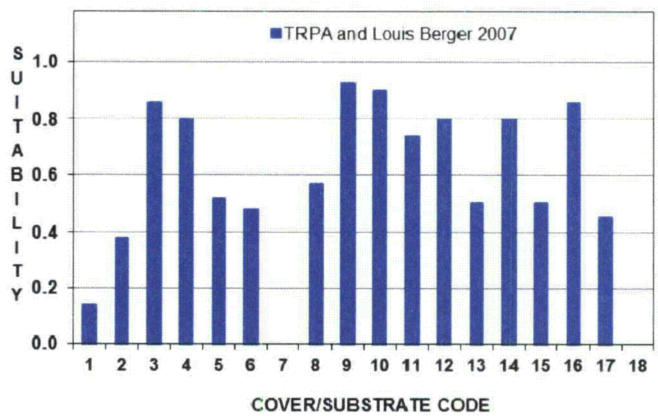
SHORTHEAD REDHORSE *(Adult)*

VEL X	VEL Y	DPTH X	DPTH Y	SBST/CVR X	SBST/CVR Y
0.00	0.37	0.00	0.00	1.00	0.21
0.20	0.42	0.40	0.00	2.00	0.32
0.40	0.48	0.80	0.06	3.00	0.70
0.60	0.53	1.00	0.14	4.00	0.74
0.80	0.59	1.20	0.26	5.00	0.52
1.00	0.64	1.40	0.41	6.00	0.57
1.20	0.70	1.60	0.56	7.00	0.31
1.40	0.75	1.80	0.70	8.00	0.45
1.60	0.80	2.00	0.81	9.00	0.70
1.80	0.85	2.20	0.90	10.00	0.74
2.00	0.89	2.40	0.96	11.00	0.63
2.20	0.92	2.60	0.99	12.00	0.74
2.40	0.95	2.80	1.00	13.00	0.79
2.60	0.98	5.00	1.00	14.00	0.74
2.80	0.99	12.00	1.00	15.00	0.79
3.00	1.00	13.00	0.11	16.00	0.85
3.20	1.00	14.00	0.09	17.00	0.69
3.40	0.99	15.00	0.07	18.00	0.00
3.60	0.97	17.00	0.05		
3.80	0.95	19.00	0.03		
4.00	0.91	24.00	0.01		
4.20	0.86	28.00	0.00		
4.40	0.80	100.00	0.00		
4.60	0.71				
4.80	0.58				
4.90	0.47				
4.95	0.36				
5.00	0.00				
10.00	0.00				

SHORTHEAD REDHORSE *(Juvenile)*







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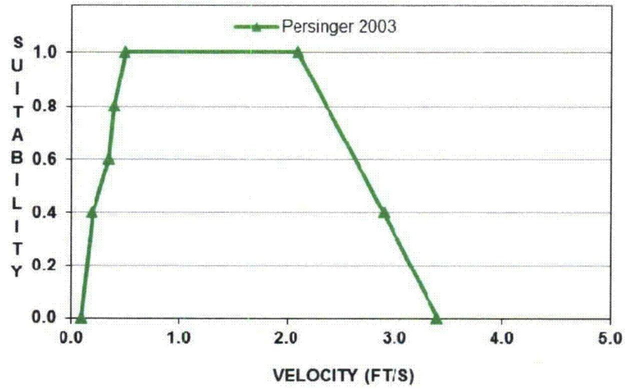
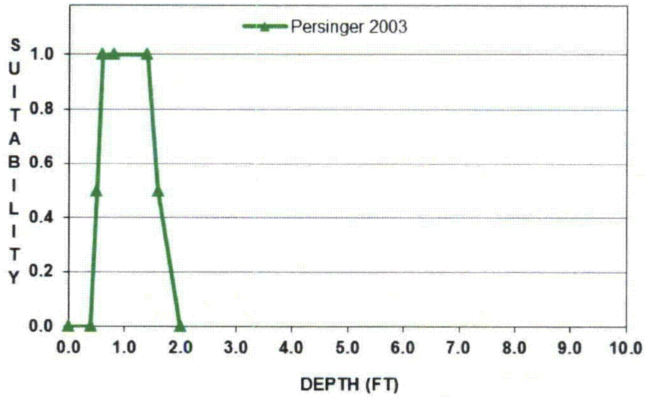
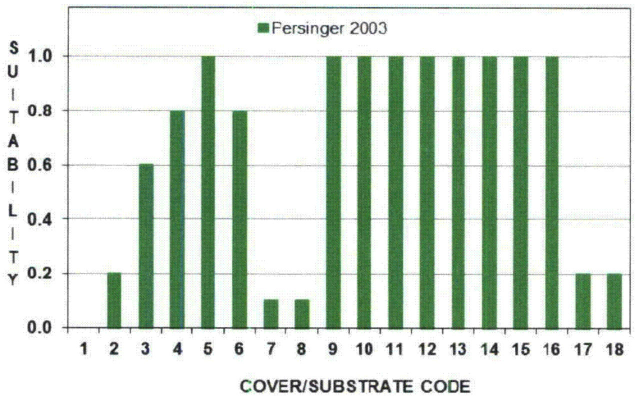
SHORTHEAD REDHORSE *(Juvenile)*

VEL X	VEL Y	DPTH X	DPTH Y	SBST/CVR X	SBST/CVR Y
0.00	0.55	0.00	0.00	1.00	0.06
0.20	0.64	0.20	0.00	2.00	0.26
0.40	0.72	0.40	0.02	3.00	0.55
0.60	0.79	0.60	0.07	4.00	0.66
0.80	0.85	0.80	0.20	5.00	0.57
1.00	0.90	1.00	0.40	6.00	0.49
1.20	0.94	1.20	0.62	7.00	0.31
1.40	0.97	1.40	0.81	8.00	0.30
1.60	0.99	1.60	0.94	9.00	0.55
1.80	1.00	1.80	1.00	10.00	0.66
2.00	1.00	1.92	1.00	11.00	0.52
2.20	0.99	2.00	0.99	12.00	0.66
2.40	0.97	2.20	0.94	13.00	0.75
2.60	0.95	2.40	0.85	14.00	0.66
2.80	0.92	2.60	0.76	15.00	0.75
3.00	0.88	2.80	0.67	16.00	0.78
3.20	0.84	3.00	0.57	17.00	0.63
3.40	0.80	3.20	0.49	18.00	0.00
3.60	0.76	3.40	0.42		
3.80	0.70	3.60	0.35		
4.00	0.65	3.80	0.29		
4.20	0.58	4.00	0.25		
4.40	0.51	4.50	0.16		
4.60	0.43	5.00	0.10		
4.80	0.32	5.50	0.06		
4.90	0.24	6.00	0.04		
5.00	0.10	6.50	0.03		
5.03	0.00	7.00	0.02		
10.00	0.00	7.50	0.01		
		8.50	0.00		
		100.00	0.00		

RIVER CHUB (*Adult/Juv*)



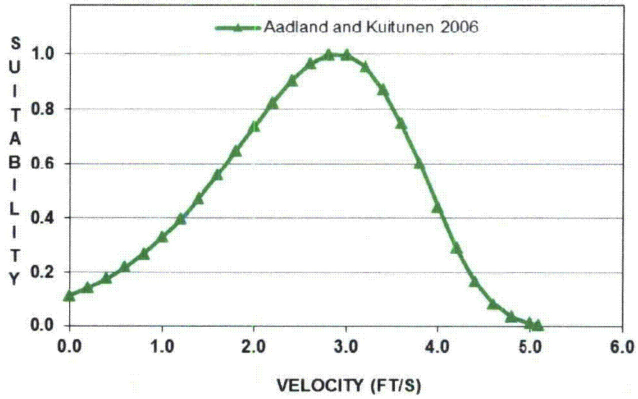


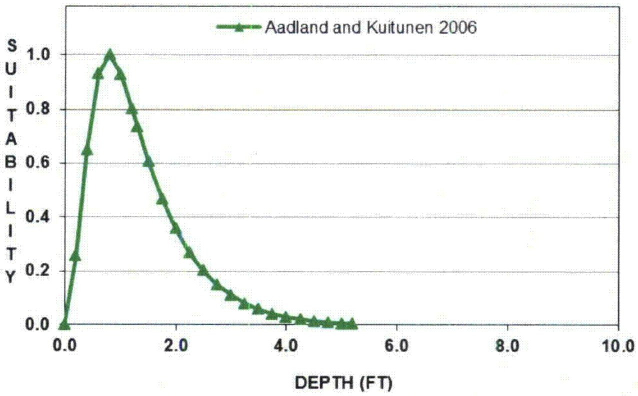


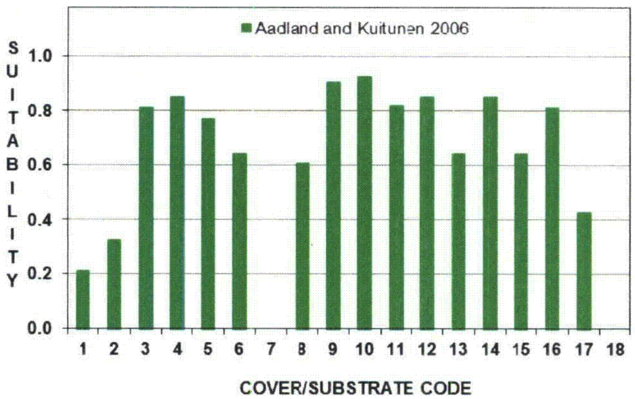
RIVER CHUB (*Adult/Juv*)

VEL X	VEL Y	DPTH X	DPTH Y	SBST/CVR X	SBST/CVR Y
0.00	0.20	0.00	0.00	1.00	0.00
0.03	0.20	0.30	0.20	2.00	0.10
0.16	0.50	0.39	0.50	3.00	0.50
0.39	1.00	0.59	1.00	4.00	1.00
1.77	1.00	1.71	1.00	5.00	1.00
2.30	0.50	2.10	0.50	6.00	0.50
3.08	0.20	2.79	0.20	7.00	0.20
3.61	0.00	3.28	0.00	8.00	0.00
10.00	0.00	100.00	0.00	9.00	0.75
				10.00	1.00
				11.00	1.00
				12.00	1.00
				13.00	1.00
				14.00	1.00
				15.00	1.00
				16.00	0.75
				17.00	0.55
				18.00	0.00

BANDED DARTER (*Adult*)



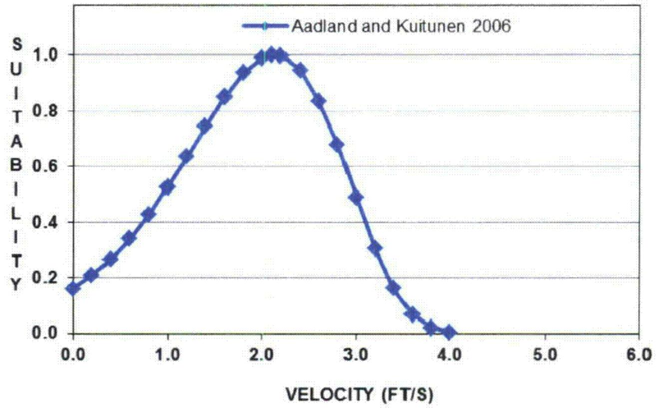


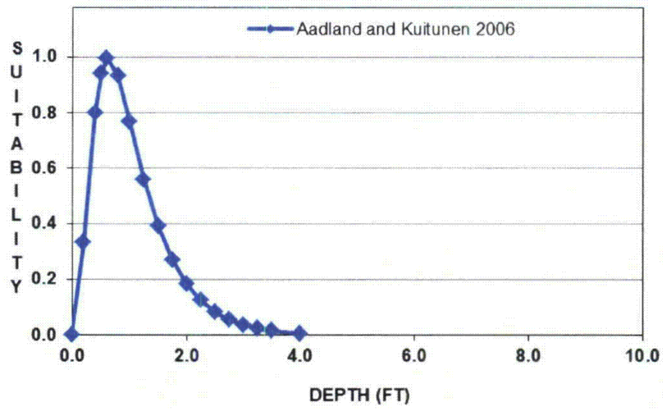


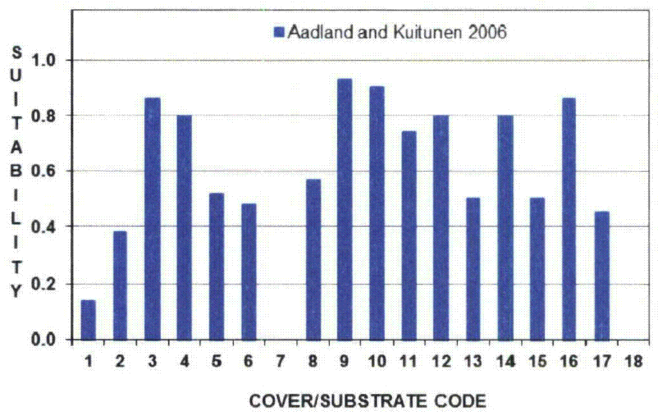
BANDED DARTER (*Adult*)

VEL X	VEL Y	DPTH X	DPTH Y	SBST/CVR X	SBST/CVR Y
0.00	0.11	0.00	0.00	1.00	0.21
0.20	0.14	0.20	0.26	2.00	0.32
0.40	0.18	0.40	0.65	3.00	0.81
0.60	0.22	0.60	0.93	4.00	0.85
0.80	0.27	0.80	1.00	5.00	0.77
1.00	0.33	1.00	0.93	6.00	0.64
1.20	0.40	1.20	0.80	7.00	0.00
1.40	0.47	1.30	0.74	8.00	0.61
1.60	0.56	1.50	0.61	9.00	0.91
1.80	0.65	1.75	0.47	10.00	0.93
2.00	0.74	2.00	0.36	11.00	0.82
2.20	0.83	2.25	0.27	12.00	0.85
2.40	0.90	2.50	0.20	13.00	0.64
2.60	0.96	2.75	0.15	14.00	0.85
2.80	1.00	3.00	0.11	15.00	0.64
3.00	0.99	3.25	0.08	16.00	0.81
3.20	0.95	3.50	0.06	17.00	0.43
3.40	0.87	3.75	0.04	18.00	0.00
3.60	0.75	4.00	0.03		
3.80	0.60	4.25	0.02		
4.00	0.44	4.50	0.01		
4.20	0.29	4.75	0.01		
4.40	0.17	5.00	0.01		
4.60	0.08	5.20	0.00		
4.80	0.03	100.00	0.00		
5.00	0.01				
5.10	0.00				
10.00	0.00				

BANDED DARTER (*Juvenile*)



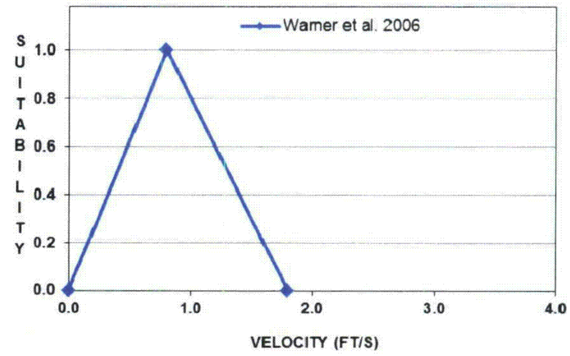


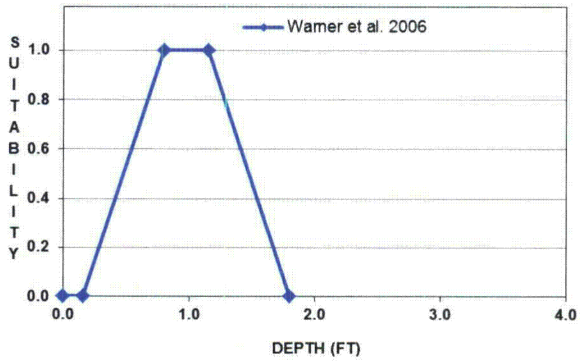


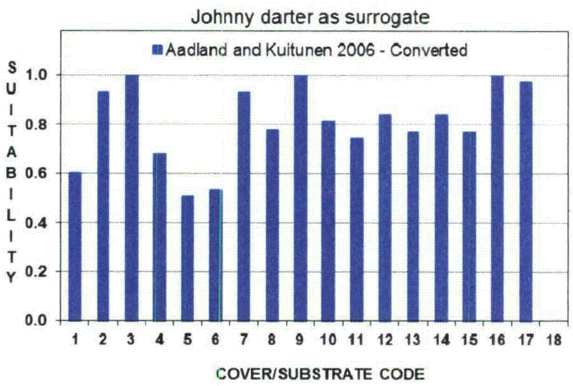
BANDED DARTER (*Juvenile*)

VEL X	VEL Y	DPTH X	DPTH Y	SBST/CVR X	SBST/CVR Y
0.00	0.16	0.00	0.00	1.00	0.14
0.20	0.21	0.20	0.33	2.00	0.38
0.40	0.27	0.40	0.80	3.00	0.86
0.60	0.34	0.50	0.94	4.00	0.80
0.80	0.43	0.60	1.00	5.00	0.52
1.00	0.53	0.80	0.93	6.00	0.48
1.20	0.63	1.00	0.77	7.00	0.00
1.40	0.74	1.25	0.56	8.00	0.57
1.60	0.85	1.50	0.39	9.00	0.93
1.80	0.94	1.75	0.27	10.00	0.90
2.00	0.99	2.00	0.18	11.00	0.74
2.10	1.00	2.25	0.12	12.00	0.80
2.20	1.00	2.50	0.08	13.00	0.51
2.40	0.95	2.75	0.05	14.00	0.80
2.60	0.84	3.00	0.04	15.00	0.51
2.80	0.68	3.25	0.02	16.00	0.86
3.00	0.49	3.50	0.01	17.00	0.46
3.20	0.31	4.00	0.01	18.00	0.00
3.40	0.16	4.25	0.00		
3.60	0.07	100.00	0.00		
3.80	0.02				
4.00	0.00				
10.00	0.00				

TESSELLATED DARTER *(Adult/Juv)*







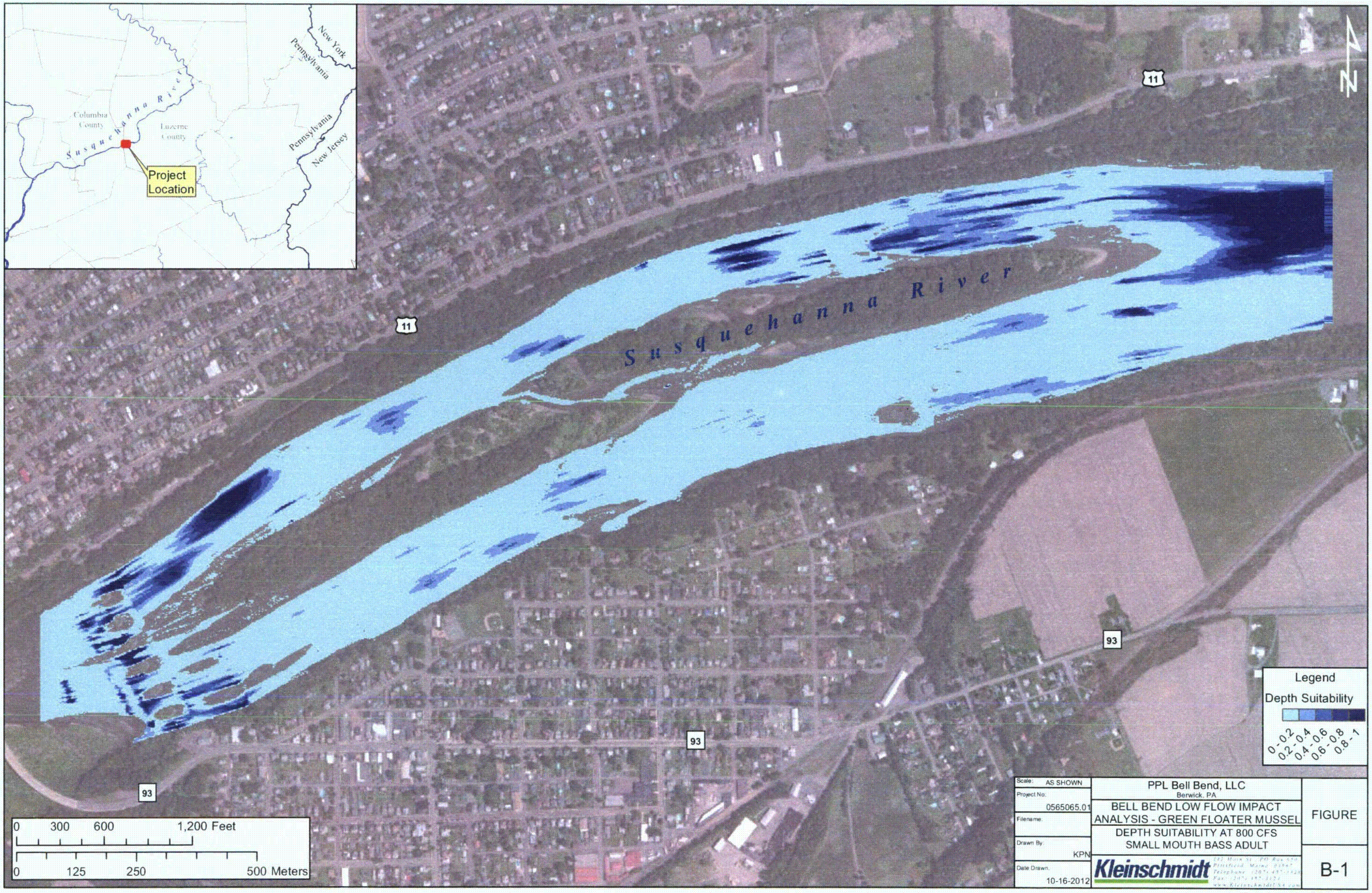
Kleinschmidt

TESSELLATED DARTER *(Adult/Juv)*

VEL X	VEL Y	DPTH X	DPTH Y	SBST/CVR X	SBST/CVR Y
0.00	0.00	0.00	0.00	0.00	0.00
0.80	1.00	0.16	0.00	1.00	0.60
1.80	0.00	0.80	1.00	2.00	0.93
		1.15	1.00	3.00	1.00
		1.80	0.00	4.00	0.68
				5.00	0.51
				6.00	0.53
				7.00	0.93
				8.00	0.78
				9.00	1.00
				10.00	0.82
				11.00	0.74
				12.00	0.84
				13.00	0.77
				14.00	0.84
				15.00	0.77
				16.00	1.00
				17.00	0.97
				18.00	0.00

APPENDIX B

HABITAT SUITABILITY FIGURES
DETAILED MUSSEL RESULT TABLES



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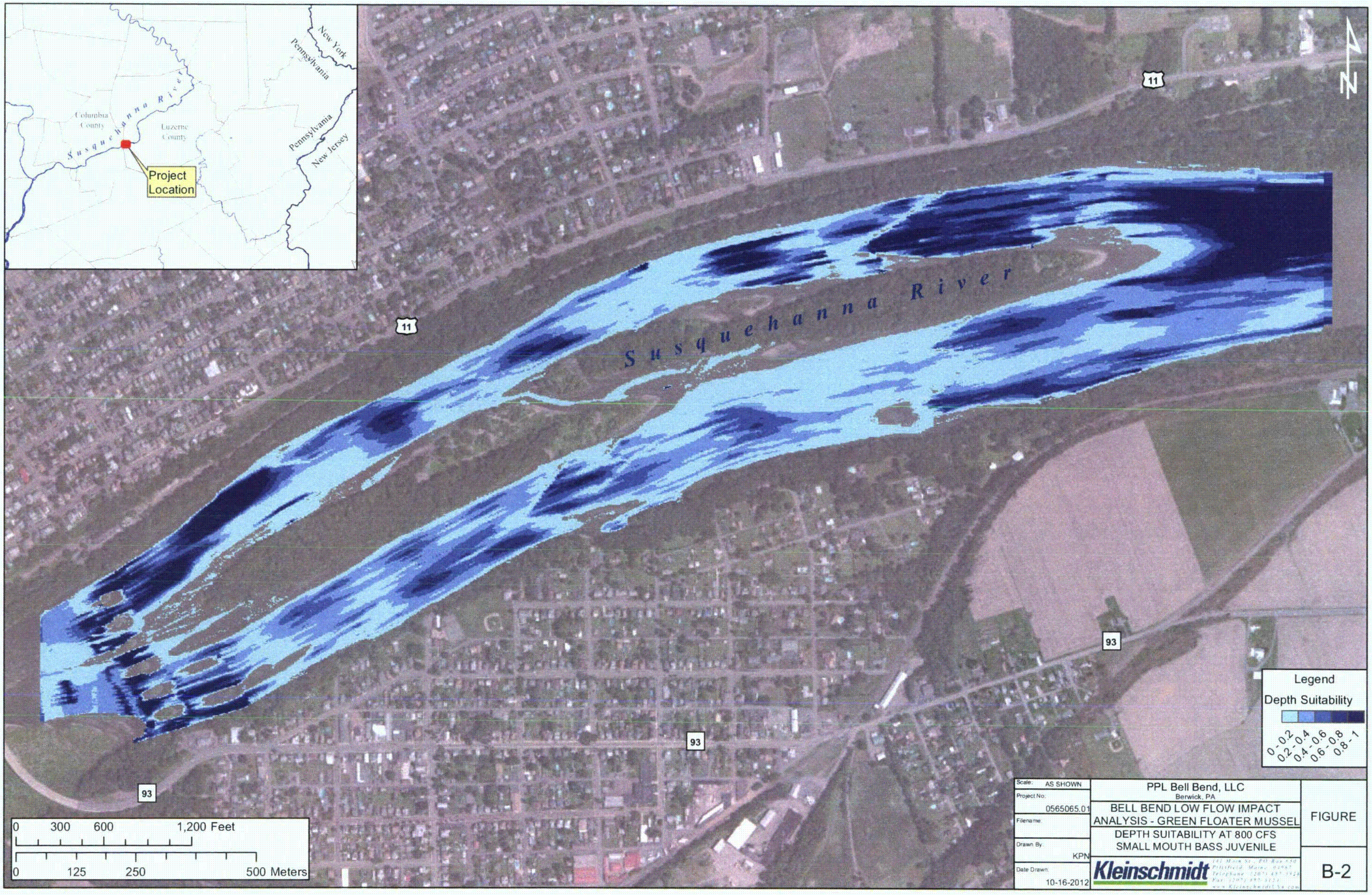

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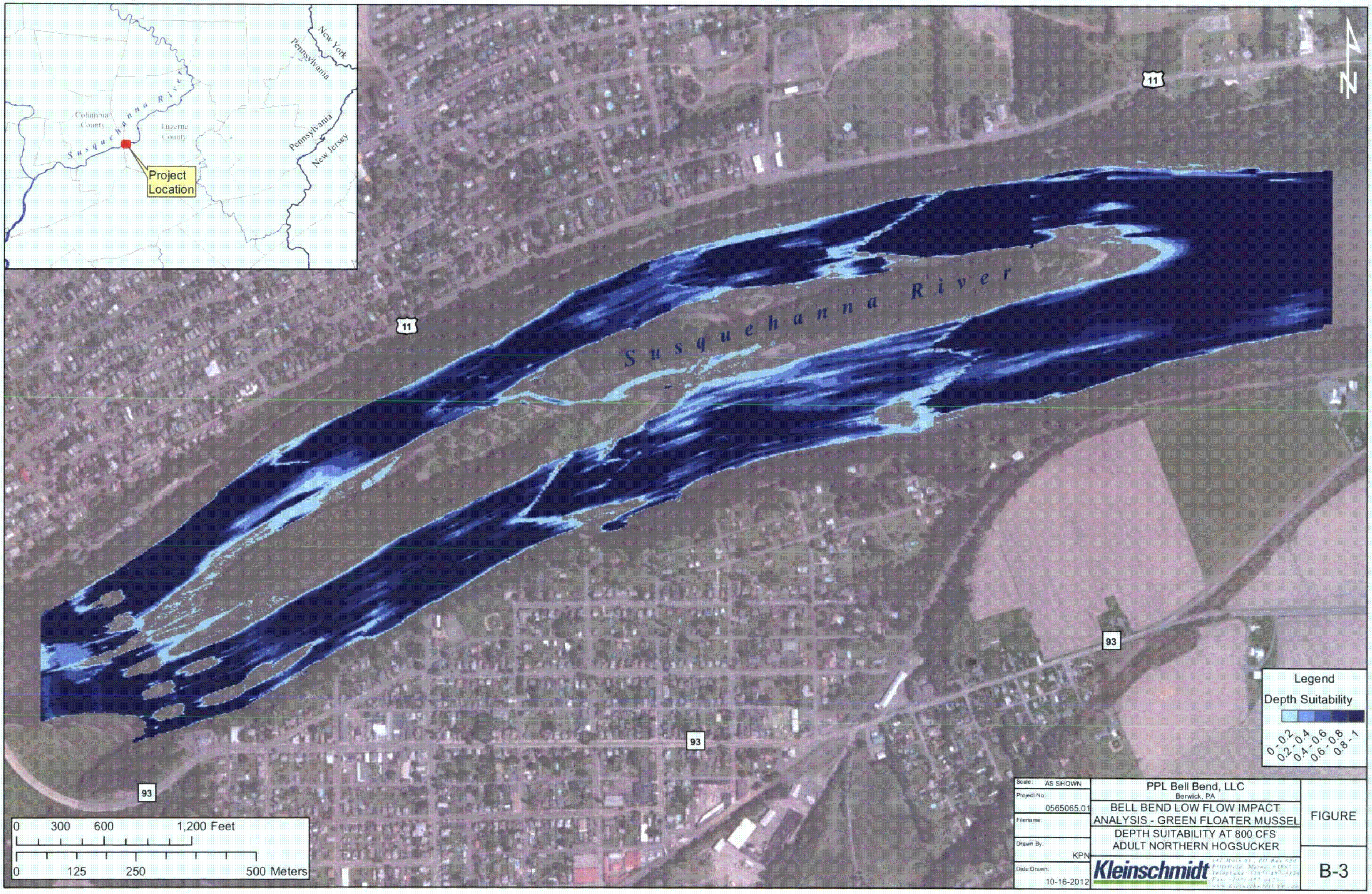

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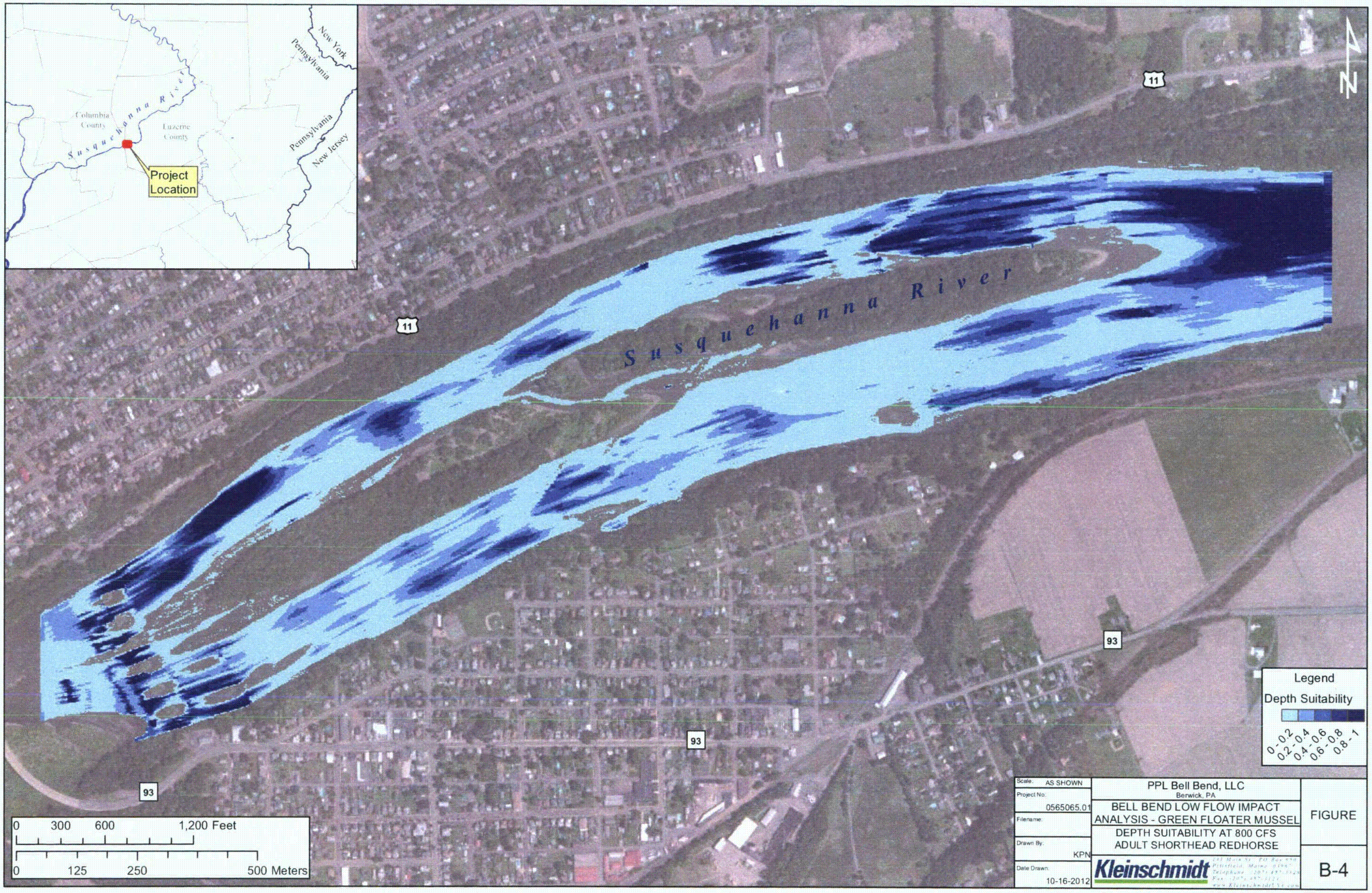

Scale: AS SHOWN	PPL Bell Bend, LLC Berwick, PA	FIGURE
Project No: 0565065.01	BELL BEND LOW FLOW IMPACT ANALYSIS - GREEN FLOATER MUSSEL	
Filename:	DEPTH SUITABILITY AT 800 CFS ADULT SHORTHEAD REDHORSE	
Drawn By: KPN	Kleinschmidt	B-4
Date Drawn: 10-16-2012		

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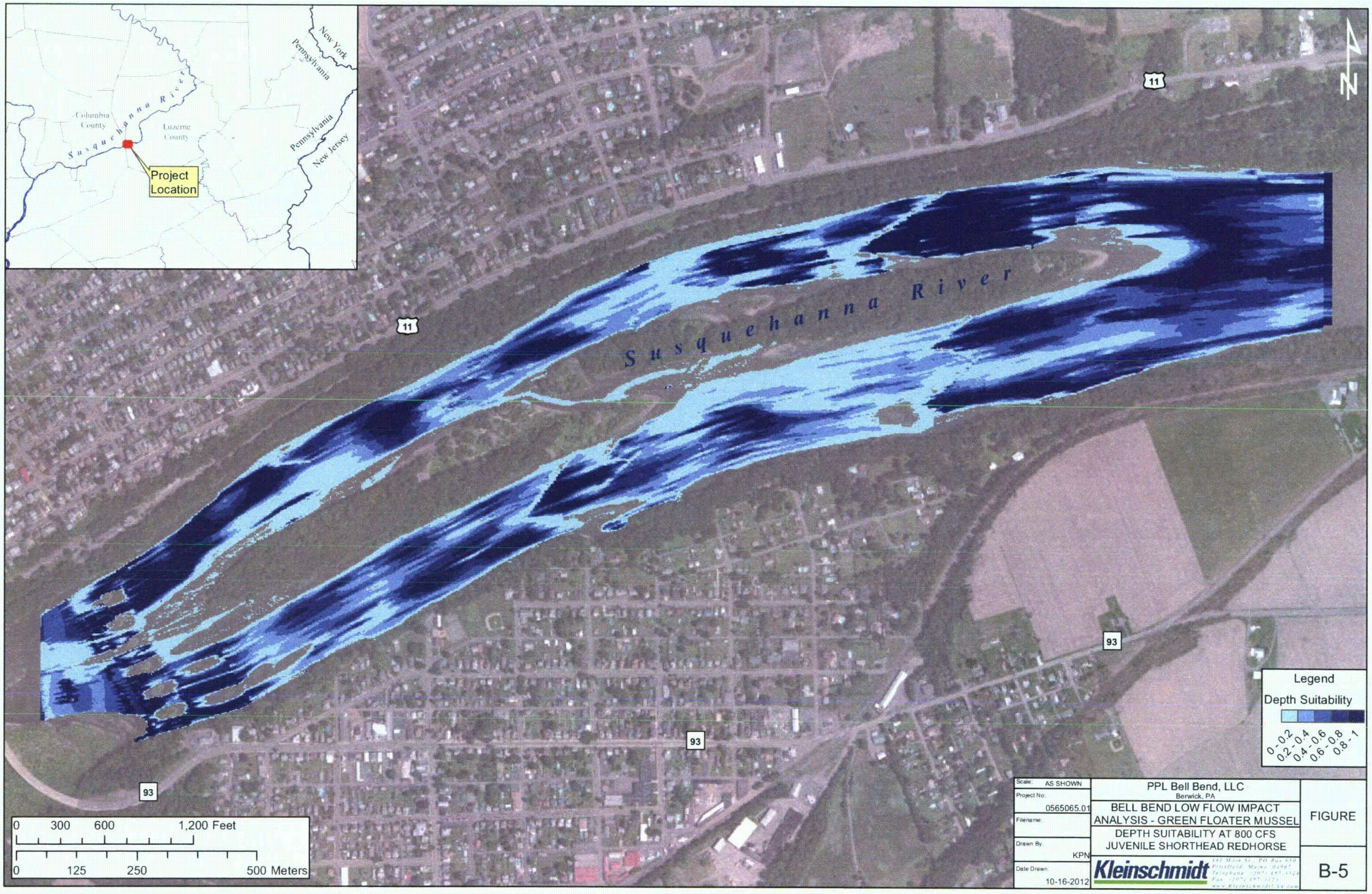

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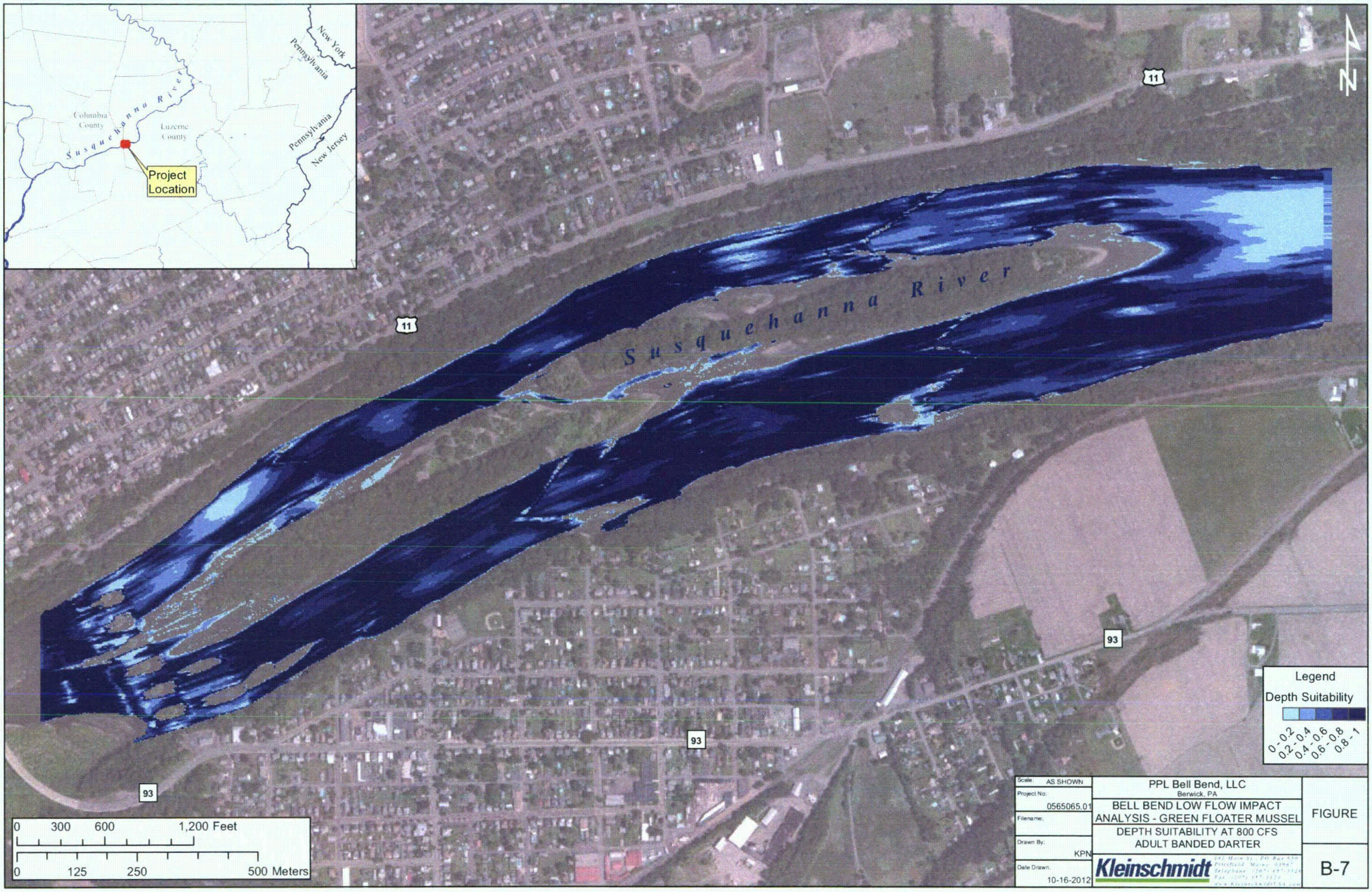

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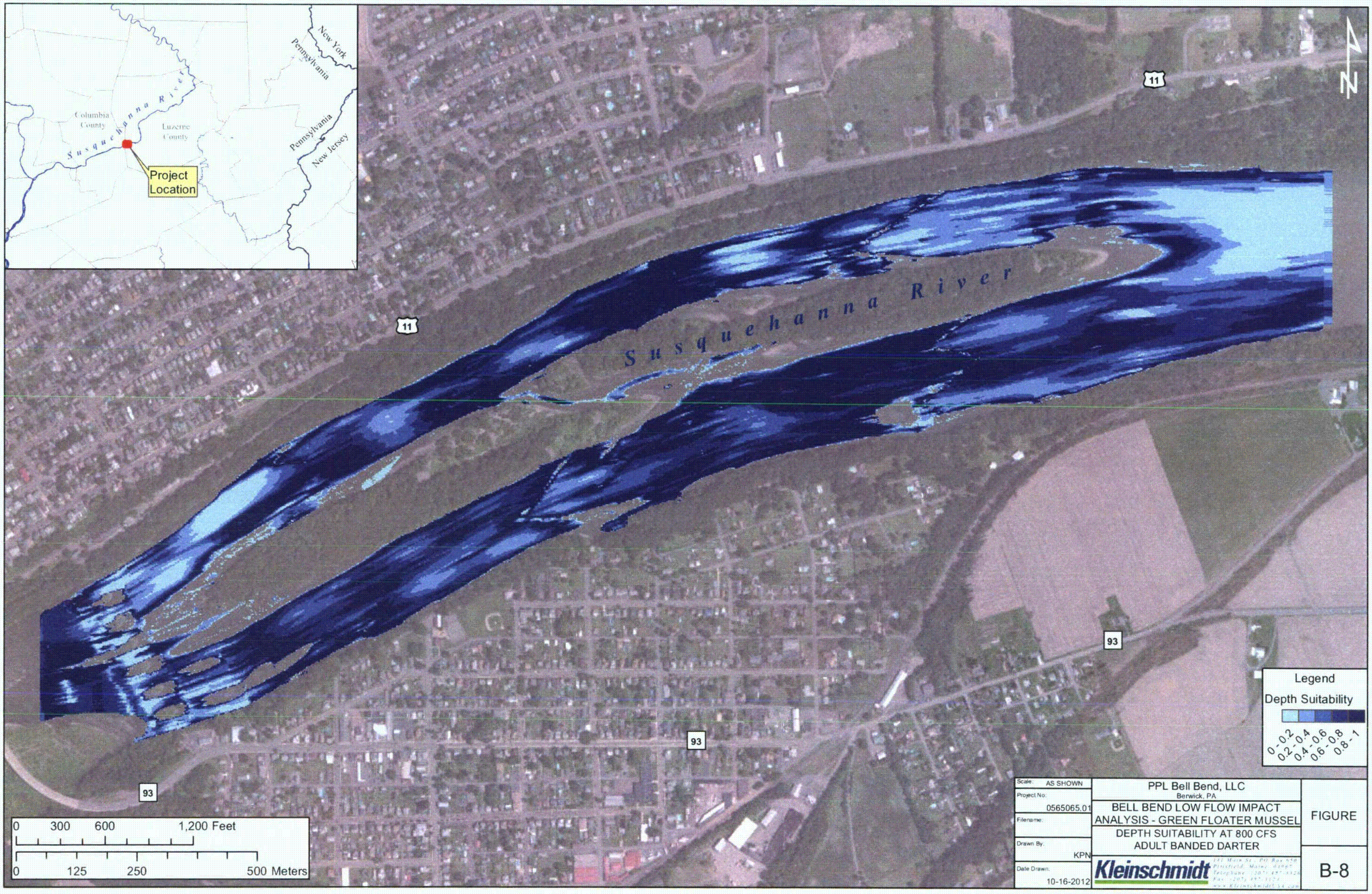

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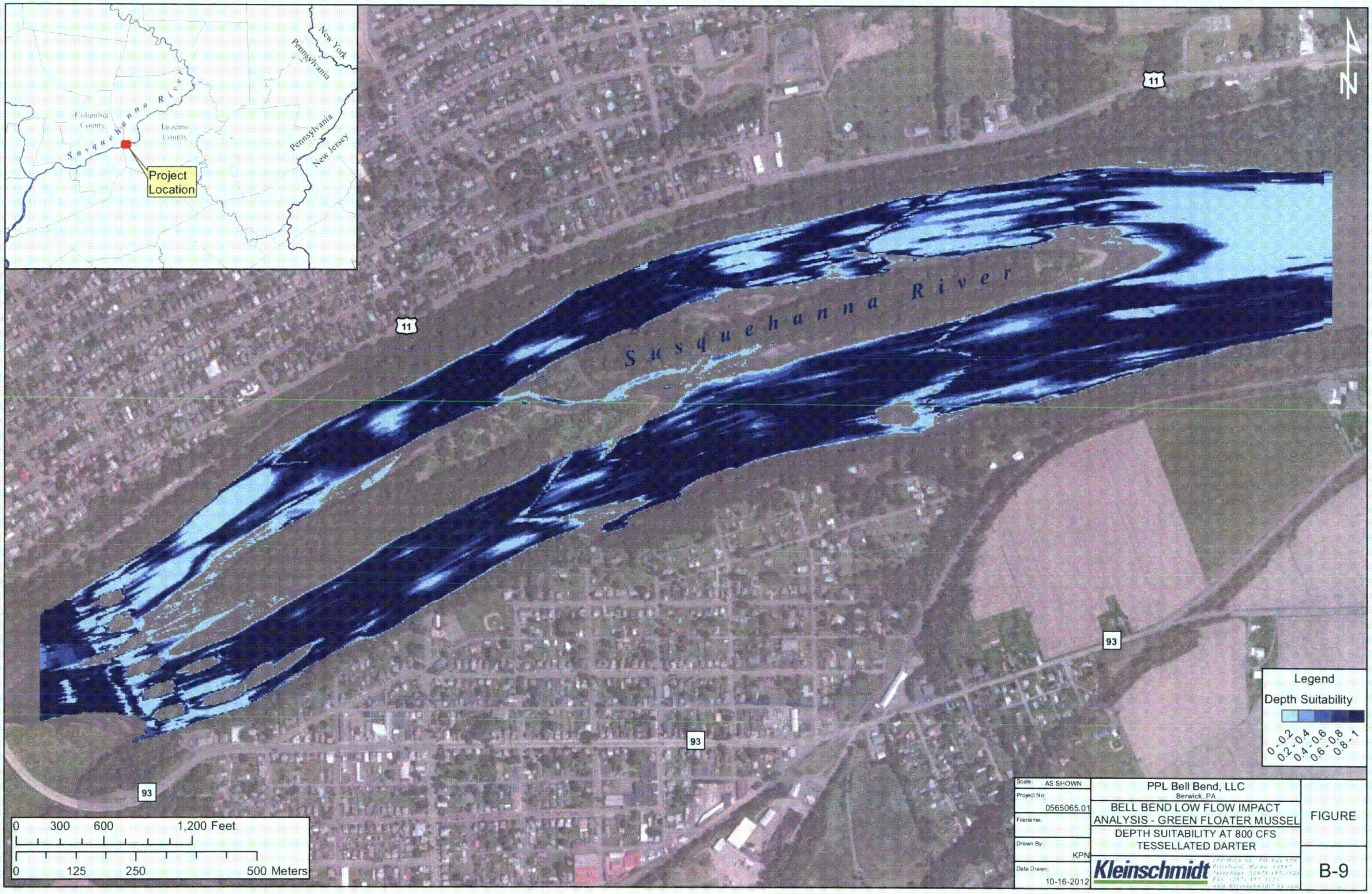

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