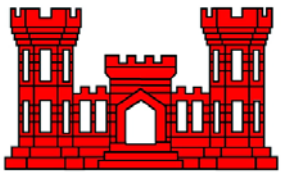
Volume 3
Part 6.1

Model Certification Review Report for EnviroFish



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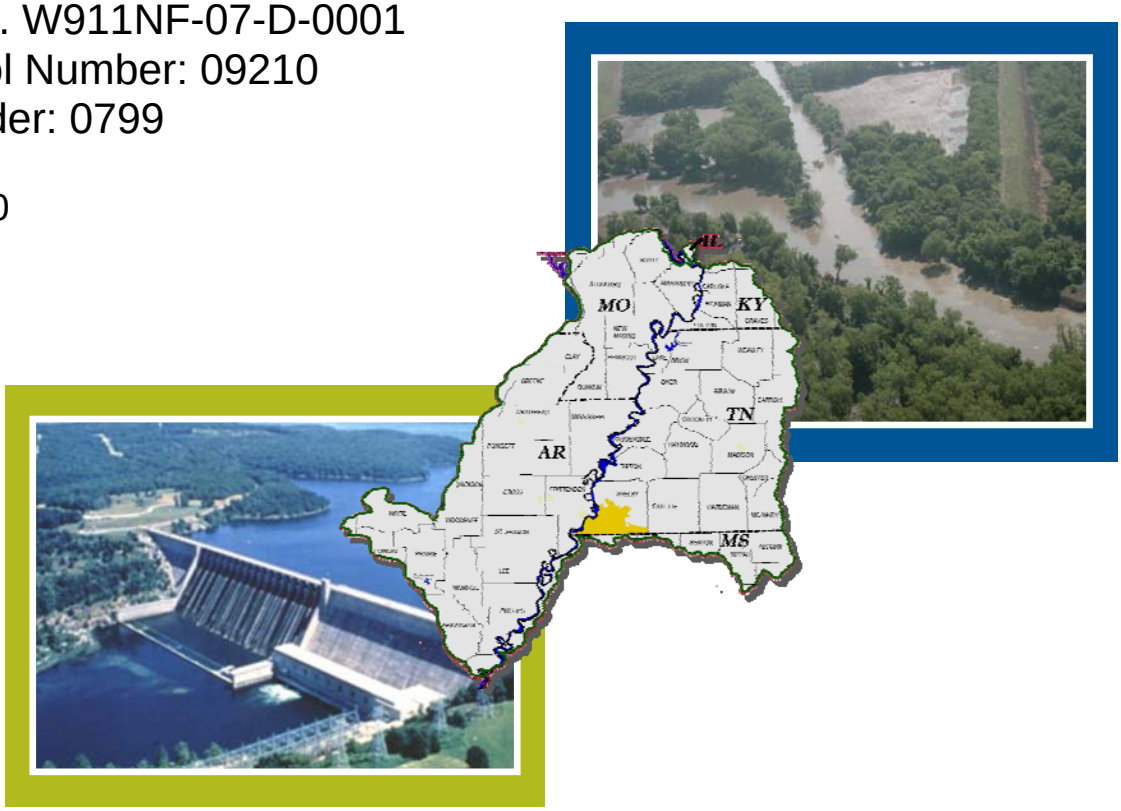
Final Model Certification Review Report for the Enviro Fish Model, Version 1.0

Prepared by
Battelle Memorial Institute

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Mississippi Valley Division

Contract No. W911NF-07-D-0001
Task Control Number: 09210
Delivery Order: 0799

March 5, 2010



SHORT-TERM ANALYSIS SERVICE (STAS)

Final Model Certification Review for the Enviro Fish Model, Version 1.0

Prepared by:

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Scientific Services Program

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FINAL MODEL CERTIFICATION REVIEW REPORT
for the
Enviro Fish Model, Version 1.0

EXECUTIVE SUMMARY

An independent external peer review of the Enviro Fish Version 1.0 User's Manual and software was conducted for the U.S. Army Corps of Engineers (USACE) Ecosystem Restoration Planning Center of Expertise (ECO-PCX) under Contract Number W911NF-07-D-0001, Task Control Number 09210, to support the process for the certification of the Enviro Fish planning model. The Enviro Fish model is a tool used to evaluate potential changes in available floodplain spawning and rearing habitat for riverine fishes in the Alluvial Lower Mississippi River Valley. It models Average Daily Flooded Area (ADFA) for a project landscape over a given period of time, to which Habitat Evaluation Procedures (HEP) can be applied. HEP was developed by the U.S. Fish and Wildlife Service (USFWS) and other agencies to evaluate the impacts of development projects on fish and wildlife resources, and is now also used to evaluate the impacts and benefits of ecosystem restoration, mitigation, and flood risk management projects, as well as other similar projects that result in changes in ecological habitat. By applying HEP to Enviro Fish model results, changes in potential spawning and rearing opportunities can be measured as a function of changes in ADFA and/or suitability of fish spawning and rearing habitats, reflecting changes in potential spawning and rearing opportunities.

The USACE Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of USACE planning models and to assure that high quality methods and tools are available so that informed decisions on investments in the Nation's water resources infrastructure and natural environment can be made. The main objective of the PMIP is to carry out "a process to review, improve and validate analytical tools and models for USACE Civil Works business programs" (USACE EC 1105-2-407, May 2005). In accordance with USACE's *Planning Models Improvement Program: Model Certification* (EC 1105-2-407, May 2005), certification is required for all planning models developed and/or used by USACE. The objective of model certification is to ensure that models used by USACE are technically and theoretically sound, computationally accurate, and in compliance with USACE planning policy.

As a 501(c)(3) nonprofit science and technology organization with experience in establishing and administering peer review panels for USACE, Battelle was engaged to conduct the model certification review for the Enviro Fish Version 1.0 User's Manual and software. Independent, objective peer review is regarded as a critical element in ensuring technical quality, system quality, and usability of the models. Five subject matter experts (i.e., model reviewers) were selected to serve on the model review panel from more than 37 candidates identified. As appropriate for the technical nature of the Enviro Fish model, the technical expertise of the five selected reviewers included a Habitat Evaluation Procedures (HEP) specialist, two fishery biologists, a hydraulic engineer, and a Java expert.

The model reviewers were provided with an electronic version of the Enviro Fish Version 1.0 User's Manual and the associated Enviro Fish software, along with a charge (included with Attachment A) that solicited their comments on specific aspects of the documentation and model software. The charge questions solicited comments regarding key technical quality, system

quality, and usability criteria that are critical for model review as described in USACE's *Protocols for Certification of Planning Models* (July 2007). A teleconference between the model reviewers and model developers was facilitated by Battelle at the beginning of the review to discuss how to use the Enviro Fish software. Although not strictly prohibited, there was no other communication between the model reviewers and the model developers during the peer review of the Enviro Fish User's Manual and software.

Approximately 140 individual comments were received from the model reviewers in response to 37 charge questions. Following the individual reviews of the model documentation and spreadsheets by the model reviewers, a model review teleconference was conducted to discuss comments on the key model review criteria, discuss charge questions for which there were conflicting responses, and reach agreement on the Final Panel Comments to be provided to USACE. The findings of the model's independent external peer review regarding its technical quality, system quality, and usability are documented in specific sections of this report, and Final Panel Comments are provided in Appendix B.

This Final Model Certification Review Report for the Enviro Fish Model describes the model review process, describes the model review panel members and their selection, and summarizes the findings and Final Panel Comments of the model reviewers. Comments on the Draft Model Certification Review Report were received from USACE on February 9, 2010 after discussions with USACE and the model reviewers during a teleconference held on January 29, 2010. Model reviewers have also provided specific responses to individual comments in a memo sent on March 5, 2010 accompanying this final report. This final report presents the overall results of the model review and will be taken into consideration for certifying or revising the Enviro Fish Version 1.0 User's Manual and software.

Overall, the model reviewers agreed that the Enviro Fish model is well-suited for its intended purpose of evaluating relative changes in potential fish spawning and rearing opportunities. However, the model is not designed to measure these changes directly and it only models changes in ADFA for various habitats or land use types. The current version of the model code and user's manual should be improved. Although the Enviro Fish User's Manual provides a good general description of the model, several issues were identified with the documentation that affect the user's understanding of the model, it's intended purpose, and how it should be applied. Furthermore, evaluation of the Java model code found an interpolation error, showed that the code could be simplified, and demonstrated that additional error checking should be added that could prevent incorrect use of the model. The model review panel recommends the following actions in order to improve comprehension of the Enviro Fish model outputs, confidence in the ability of the Enviro Fish model to achieve its intended purpose, and model usability:

1. Provide a clearer explanation of the model objectives.
2. Provide a brief description in the user's manual of how the Enviro Fish model fits with contemporary theory.
3. Develop a process that allows repeatable, documented Habitat Suitability Index (HSI) values to be assigned.
4. Provide a more detailed explanation of the model assumptions and limitations.

5. Provide a more clear definition of what constitutes functional floodplain and what biologists should consider when they are delineating these areas.
6. Provide a discussion of code testing and model validation.
7. Provide guidance on the data requirements, how to prepare the data for input, the required data sensitivity and precision, and the specific roles of the multidisciplinary team.
8. Provide guidance on how the user could use the output files to actually compute the final metric of Habitat Units (HUs) or revise the model to calculate HUs and Average Annual Habitat Units (AAHUs).
9. Make the software more user friendly by adding labels to the model's inputs and outputs, returning to the project directory, making the software compatible with the current version of the USACE's HEC-DSSVue utility, changing how constraints are applied in the user interface, and making the software more flexible to facilitate accomplishing multiple runs at a time.
10. Fix errors and issues in the programming code and build additional error checks and warnings into the model.
11. Improve model transparency by partitioning the relative contributions of the different limiting factors (minimum and maximum water elevations, deep and shallow nests) to habitat area in the model output and including an example model run in an appendix to the user's manual.
12. Simplify the code by removing redundancies, better organizing the code and separating it by logic classes, separating computations from the output format, providing additional comments, and using Java's libraries.

Failure to address the issues identified may lead to incorrect interpretation and improper use of Enviro Fish outputs. The current version of Enviro Fish can only be set-up and run by experts. The generality and flexibility of the model, coupled with the minimal guidance provided in the user's manual, leave the user responsible for much of the input preparation. Guidance on the preparation of model inputs is necessary for the proper use of Enviro Fish and, ultimately, for the proper interpretation of the meaning of model outputs by a larger user audience. In addition to guidance on preparing model inputs, interpretation of model results can also be enhanced with: (a) more specific statement of objectives in the manual, (b) better labeling of output files, (c) increased transparency by adding example calculations to the manual and by providing information on which depth constraints cause the changes in computed habitat areas, and (d) modifications to the code to make sensitivity and uncertainty analyses easier.

Many of the issues identified by the model review panel stemmed from limited documentation of the model. The user's manual only described the model itself, and this description was limited. The theoretical and scientific bases were not well-documented, and no guidance was provided on how to develop the input data. The model reviewers also strongly suggest simplifying the code and further developing the documentation of the code for easier maintenance of the model software and comprehension of the various functions. Making the recommended revisions will allow better comprehension of the scientific basis and logic behind the model and better comprehension of the model results, promote model transparency, and allow uncertainty and sensitivity analysis to be easily performed. The model will also be better able to achieve its

intended purpose. This is critical for supporting the selection of project alternatives based on model results.

At a minimum, an interpolation error identified in the code needs to be addressed in order for the model software to produce the correct ouput. The model should not be used until this error is repaired. Once this error in the code is addressed, the model reviewers support immediate conditional use of the model only if the following criteria are met:

1. The HSI values used are defensible and developed specifically to represent the habitats being assessed in the project area.
2. The model developers are the ones who will be running the model.
3. The model users coordinate with the appropriate local experts (biologists and hydraulic engineers).

The model reviewers strongly recommend addressing the remaining review comments before the model is certified for widespread use. The model reviewers concur with some of the USACE model developers responses to the Final Panel Comments that assert some of the issues do not need to be addressed for widespread use of the model, although the model reviewers think adopting the suggested resolutions would be desirable to improve model usability. However, there are other Final Panel Comments that need to be addressed, for example, by adopting the suggested changes to the documentation or model code, before allowing widespread use of the model. The details of USACE responses to the Final Panel Comments and the model reviewers' responses to those comments are provided in a memo submitted with this final report on March 5, 2010. The model reviewers highly recommend the changes recommended in the memo be made as soon as possible in order to allow more widespread use of this useful planning tool.

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Appendix A: Biographic Information for Model Peer Review Panel Experts

Appendix B: Final Panel Comments

1. The model output does not directly calculate Habitat Units (HUs) for a project as presented, but provides the area data needed to complete the HU values needed for a Habitat Evaluation Procedures (HEP) analysis.
2. The development of Habitat Suitability Index (HSI) values is not supported in the documentation.
3. The definition of a functional floodplain needs to be clearly stated.
4. The analytical requirements of the model are identified, but guidance needs to be provided on how to prepare the data for input and the roles of the multidisciplinary team.
5. The limitations on the ability of the model to calculate benefits for project life need to be clearly documented.
6. Errors and issues in the programming code were identified and need to be corrected.
7. Additional error checks and warnings need to be built into the program.
8. Unit testing for the model should be performed if it has not been.
9. Testing of the code and validation of the underlying model needs to be documented.
10. The current model is not a stand-alone product and it is tedious to run for individual or multiple scenarios, rendering it error prone and difficult to use for compensatory mitigation.
11. Checking orphaned nests should apply a constraint, rather than remove a constraint.
12. The assumption that an increase in Habitat Units (HUs) will linearly increase spawning and rearing opportunities is incorrect.
13. The Introduction (Chapter 1) to the Enviro Fish User's Manual should be more informative.
14. While the results of the Enviro Fish model can be understood by a wide range of people, those results can only be generated by experts.
15. The sensitivity of the results is driven by the precision and accuracy of the input data. Unless the precision is known, the sensitivity is unknown.
16. The quality and accuracy of the data required by the model needs to be stated.
17. It needs to be clearly stated that similar input data used for the alternatives analysis should be of the same accuracy and precision.
18. The model is based on well-established habitat suitability theory, but not necessarily contemporary theory.
19. Documentation with the output data should include units of measure.
20. Examples in the fisheries section of the documentation should be expanded to inform decision-makers more about the benefits of the project.
21. The model transparency is limited, and it is difficult to understand why different outputs are generated across scenarios, and this limitation needs to be stated in the documentation.
22. Enviro Fish should be able to work with the current version of DSSVue installed.

LIST OF TABLES

ACRONYMS

AAHU	Average Annual Habitat Units
ADFA	Average Daily Flooded Area
CECW	Corps of Engineers Directorate of Civil Works
CE/ICA	Cost-Effective Incremental Cost Analysis
COI	Conflicts of Interest
DSS	Data Storage System
ECO-PCX	USACE Ecosystem Restoration Planning Center of Expertise
EROS	Earth Resources Observation and Science Center (USGS)
FPC	Final Panel Comments
HEP	Habitat Evaluation Procedures
HGM	Hydrogeomorphic Methodology
HSI	Habitat Suitability Index
HU	Habitat Unit
IEPR	Independent External Peer Review
PCX	Planning Center of Expertise
PMIP	Planning Models Improvement Program
SOW	Statement of Work
STAS	Short Term Analysis Service
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAM	Waterfowl Assessment Methodology
WRDA	Water Resources Development Act

1.0 INTRODUCTION

Planning models are defined as any models and analytical tools that planners use to define water resources management problems and opportunities, formulate potential alternatives to address the problems and take advantage of the opportunities, and evaluate potential effects of alternatives and to support decision-making. The United States Army Corps of Engineers (USACE) Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of planning models in the USACE and to make recommendations to assure that high quality methods and tools are available to enable informed decisions on investments in the Nation's water resources infrastructure and natural environment. The main objective of the PMIP is to carry out a process to review, improve and validate analytical tools and models for USACE Civil Works business programs. The PMIP Task Force collected the views of USACE leaders and recognized technical experts, and conducted investigations and numerous discussions and debates on issues related to planning models. This task force identified an array of model-related problems, conducted a survey of planning models, prepared papers on model-related issues, analyzed numerous options for addressing these issues, and formulated recommendations.

Use of certified models for all USACE planning activities is mandatory. This policy is applicable to all planning models currently in use by USACE, as well as models under development and new models. District Commanders are responsible for providing high quality, objective, defensible, and consistent planning products. Development of these products requires the use of tested and defensible models. National certification of planning models will result in significant efficiencies in the conduct of planning studies and enhance the capability to produce high quality products. The appropriate USACE Planning Center of Expertise (PCX) will be responsible for model certification. The goal of certification is to establish that USACE planning products are theoretically sound, compliant with USACE policy, computationally accurate, based on reasonable assumptions, and are in compliance with the requirements of the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* (Federal Register Vol. 70, No. 10, January 14 2005, pp 2664-2677). The use of a certified model does not constitute technical review of the planning product. Independent technical review of the selection and application of the model and the input data is still the responsibility of the users. Once a model is certified, the PCXs will work with model developers and managers to ensure that documentation and training in model use are available and that model updates comply with certification requirements.

The primary criterion identified for model certification is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of the theory, the certified model should: 1) be based on validated and accepted "state of the art" theory; 2) incorporate USACE policies and requirements; 3) properly incorporate the conceptual theory into the software code; and, 4) clearly define the assumptions inherent in the model. In terms of computational correctness, the certified model should: 1) employ proper functions and mathematics to estimate functions and processes represented; and, 2) properly estimate and forecast the actual parameters it is intended to estimate and forecast. Other criteria for certification are efficiency, effectiveness, usability, and clarity in presentation of results. A certified model will stand the tests of technical

soundness based on theory and computational correctness, efficiency, effectiveness, usability and clarity in presentation of results.

An independent external peer review of the Enviro Fish Version 1.0 Model was conducted for the USACE Ecosystem Restoration Planning Center of Expertise (ECO-PCX) under Contract Number W911NF-07-D-0001, Task Control Number 09210. The objective of the review was to evaluate the technical quality, system quality, and usability of the Enviro Fish model in accordance with *Planning Models Improvement Program: Model Certification* (EC 1105-2-407, dated May 31, 2005) and the *Protocols for Certification of Planning Models* (July 2007). USACE's ultimate goal is to certify the Enviro Fish model for use within the geographic area specified in the model documentation. The review did not include a technical evaluation of the application of the model on a specific project.

1.1 Model Purpose

Enviro Fish was developed over a 15-year period, beginning in the early 1990s, to predict the potential response by fish assemblages to altered flood regimes. Enviro Fish can be used to predict changes in functional reproductive fish habitat over large or small geographic areas. It has been applied in the planning of USACE flood management projects in the lower Mississippi River Valley, and continues to be refined and updated. However, the approach is applicable to any alluvial river system where floodplain fish spawning habitat is being managed. It is a tool intended to be used in the selection of project alternatives based on projected changes in area and suitability of habitat for fish spawning and rearing.

1.2 Model Assessment

The main objective of the USACE PMIP is to carry out "a process to review, improve and validate analytical tools and models for USACE Civil Works business programs" (USACE EC 1105-2-407, May 2005). In accordance with the *Planning Models Improvement Program: Model Certification* (EC 1105-2-407, May 2005), certification is required for all planning models developed for and/or used by USACE. The objective of model certification is to ensure that models used by USACE are technically and theoretically sound, computationally accurate, and in compliance with USACE planning policy. Model assessments are conducted in accordance with the USACE *Protocols for Certification of Planning Models* (July 2007).

The following outlines the basic steps of the USACE model certification process, which are designed to guide the model review. Model development is a multi-step, iterative process, with the number of steps and iterations being dependent upon the complexity of the model. In general, these steps occur in four fundamental stages.

- Stage 1 (Requirements Stage) involves identifying the need for a specific analytical capability and the options for tools to meet the need.
- Stage 2 (Development Stage) involves the development of software programming code or a spreadsheet and testing by the model developer.
- Stage 3 (Model Testing Stage) involves a beta test of the model by selected users whose objective is to validate the model and ensure that it is usable in real-world applications.

- Stage 4 (Implementation Stage) involves providing training, user support, maintenance and continuous evaluation of the model.

The certification procedure depends on the stage of model development. The process may include the following steps.

Model reviewers determine whether project needs/objectives are clearly identified and whether the model described is meeting those needs/objectives.

1. Model reviewers evaluate the technical quality of the models (review of model documentation), including whether:
    a. The model is based on well-established contemporary theory.
    b. The model is a realistic representation of the actual system.
    c. Analytical requirements of the model are properly identified and the model addresses and properly incorporates the analytical requirements.
    d. Assumptions are clearly identified, valid, and support the analytical requirements.
    e. USACE policies and procedures related to the model are clearly identified, and the model properly incorporates USACE policies and accepted procedures.
    f. Formulas used in the model are correct and model computations are appropriate and done correctly.
2. Model reviewers evaluate system quality (review by running test data sets or reviewing the results of beta tests) to determine whether:
    a. The rationale for selection of supporting software tool/programming language and hardware platform is adequately described, and supporting software tool/programming language is appropriate for the model.
    b. The supporting software and hardware are readily available.
    c. The programming was done correctly.
    d. The model has been tested and validated, and all critical errors have been corrected.
    e. Data can be readily imported from/into other software analysis tools, if applicable.
3. Model reviewers evaluate the usability of the model to:
    a. Examine the data required by the model and determine the availability of the required data.
    b. Examine how easily model results are understood.
    c. Evaluate how useful the information in the results is for supporting project objectives.
    d. Evaluate the ability to export results into project reports.
    e. Determine whether training is readily available.
    f. Determine whether user documentation is available, user friendly and complete.
    g. Determine whether adequate technical support is available for the model.
    h. Determine whether the software/hardware platform is available to all or most users.
    i. Determine whether the model is easily accessible.
    j. Determine whether the model is transparent and allows for easy verification of calculations and outputs.

The Enviro Fish model is at Stage 4 in the development process. The model has already been applied for planning projects throughout the Mississippi River Valley. In addition to providing an assessment of the criteria listed above, this review is intended to help with the continued maintenance and evaluation of the model for widespread use. Because Enviro Fish is being reviewed for certification, most of the assessment criteria are being evaluated by independent external peer review; however, some of the assessment criteria can only be evaluated internally by USACE, including whether the model complies with USACE policy and procedures, the model is easily accessible, training is readily available, and adequate technical support is available.

The level of effort for a model review depends on the complexity of the model developed, the risks associated with planning decisions made using the model, and the stage of model development. Enviro Fish has undergone an intermediate level of review based on the model's intermediate level of complexity relative to other planning models. The intermediate level of review, which is the subject of this report, included an Independent External Peer Review (IEPR) of the Enviro Fish User's Version 1.0 and software and limited model testing.

1.3 Contribution to Planning Effort

The USACE planning regulations require that ecosystem restoration benefits be estimated. Benefit results are included in a Cost-Effective Incremental Cost Analysis (CE/ICA) to determine the best project for implementation. As stated in the user's manual, "Enviro Fish has been developed with the intent of making a powerful, physically-based technique for modeling fish spawning and rearing available to a wide range of stakeholders drawn from government, academia, environmental organizations, and the communities for which water resources and environmental projects are planned."

1.4 Report Organization

This report is organized into the following sections:

Section 2.0 Model Description — Describes the applicability of the Enviro Fish model and summarizes the model inputs and components.

Section 3.0 Model Evaluation — Describes the model review approach, including the review process and the criteria used to assess technical quality, system quality, and usability; and describes the results of the model assessment.

Section 4.0 Conclusions — Summarizes the overall conclusions of the model review.

Section 5.0 References — Lists the references used for this model assessment and referenced from the model documentation.

Appendix A – Contains biographic information on the expert model review panel members selected to perform the review of the model.

Appendix B – Contains the Final Panel Comment forms, which include the key comments from the model review as well as each comment's basis, significance, and recommendations for resolution.

Attachment A – This is the Final Work Plan for the Independent External Peer Review for Certification of Four Ecological Models: Enviro Fish, Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, Waterfowl Assessment Methodology (WAM), and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook. This workplan contains the final charge guidance and questions to the model reviewers to guide the review of the models and model documentation.

2.0 MODEL DESCRIPTION

2.1 Model Applicability

Enviro Fish can be used to assess whether a flood control alternative, restoration/mitigation activity, or other water allocation decision would have positive or negative effects on floodplain fish spawning and rearing habitat. Different alternatives can be compared during project planning, which is consistent with standard USACE policy. Provided enough data are available, or may be synthesized, the Enviro Fish approach can be applied to a wide range of project alternatives, including existing conditions, future without project conditions, particular project alternatives, and pristine conditions. If project impacts are to be mitigated within the project landscape, the Enviro Fish approach may be applied to the mitigation area itself to evaluate the value of the mitigation as affected by project-induced changes in hydrology and hydraulics.

2.2 Model Summary

Enviro Fish is both a modeling approach and computer software. The Enviro Fish modeling approach estimates the value of floodplain habitat suitable for fish spawning and rearing under certain hydrologic and hydraulic conditions. The Enviro Fish software is a Java computer program that implements the modeling approach. Enviro Fish integrates the reproductive needs of fish with the reproductive opportunities afforded by a flooded landscape. Reproductive needs are reflected by the reproductive strategy of riverine floodplain fishes, and value is assigned to the different land use types for spawning and rearing of individual fish species, guilds, or the entire assemblage. Reproductive opportunities at a project site are reflected by the hydrology, hydraulics, and the land use types present.

The integration of reproductive requirements with reproductive opportunities is reflected in the model output as average daily flooded area (ADFA) by land use category type. The comparative value of a given land use type is represented by multiplying ADFAs by the weighted reproductive values, called Habitat Suitability Indices (HSIs), assigned to different land use types. This calculation yields the units of measure, Habitat Units (HUs), based on the amount and quality of fish reproductive habitat for each land use type, which culminates in a consolidated measure of habitat for the project landscape as a whole. The response variable, HUs, allows Habitat Evaluation Procedures (HEP) to be used to complete the analysis of project alternatives (USFWS 1980).

2.3 Model Components

The main elements of the Enviro Fish model include:

- The fish species, guild, or assemblage being modeled
- Topography of the project area
- Land use types present
- Water elevation over the floodplain
- Fish spawning requirements
- Fish rearing requirements

Enviro Fish estimates the amount of habitat available for a single species of fish, a guild of fish species with similar reproductive requirements, or for the more general condition of the entire fish assemblage. Topographic information for the area subject to inundation is required to determine how much of the inundated land surface satisfies the adopted habitat constraints for a given water surface elevation. Topography is described by elevation vs. area tables, and suitable reproductive habitat is determined within a contiguous floodplain area as the area of habitat within a selected water depth range during a period of inundation.
The suitability of the area for spawning and rearing within the inundated floodplain is determined by land use type. Land use is categorized to reflect the distribution of surface characteristics across the landscape, and boundaries of the various land uses are delineated on a map of the landscape. When combined with topographic information, elevation vs. land area tables are produced for each land use category. An experienced biologist then classifies land use based on the selected fish species, guild, or assemblage and assigns an HSI value to each land use classification.

Daily changes in water surface elevation during the spawning and rearing seasons determine how much inundated area (by land use type) can be successfully used for spawning and rearing. Analysis over a period of several years is valuable, since the variability between wet, dry, and normal years is reflected in the output.

The spawning period is defined as the total time required for deposition, fertilization, incubation, and hatching of an egg. Fertilization and deposition are considered to occur on Day 1 of the spawning period. Hatching is considered to occur on the final day of the spawning period. The spawning season is defined by the beginning and ending dates, inclusive, on which fertilization and deposition of eggs can be successfully accomplished. This information is combined with information on daily changes in water surface elevation, and minimum and maximum depths required for successful spawning are defined.

Rearing refers to the first period of life of hatchlings, and the rearing season is defined to coincide with the spawning period. Unlike spawning, for which each day of a multi-day spawning period must be satisfactory, each day of rearing is evaluated as an individual instance of a rearing opportunity, without respect to conditions on other days. The Enviro Fish software provides two approaches to model rearing – total rearing depth and restricted rearing depth.

Although the input requirements for Enviro Fish are fairly simple, the preparation of those inputs may be complex. The first body of input required is daily water surface elevations throughout the analysis period for the landscape being analyzed, referred to as "daily elevations." Typically, different project alternatives have different water surface elevation inputs for the same analysis period. The second body of input is a set of elevation vs. area tables, with one table for each category of land use in the landscape. The user sets the habitat constraints, including rearing constraints (maximum and minimum depth), season constraints (period of analysis and spawning period for the species), and spawning constraints (duration, deep nests, maximum depth of deposition, minimum depth of deposition, and orphaned nests).

The outputs produced include daily results for the analysis period (including the date, amount of land area within the floodplain confined by the minimum and maximum rearing depths, daily stage, stage area curves, and daily flooded area) and a summary of results for the entire analysis period (including the averages for restricted rearing, spawning, total rearing, and restricted rearing; minimum and maximum restricted rearing, spawning, stage, and total rearing; and the year corresponding to each season's results). Overall summary results output include averages for season stage, restricted rearing, spawning, and total rearing, as well as maximum and minimum average season stage, restricted rearing, spawning, and total rearing. The Average Daily Flooded Area (ADFA) is the output that is used for the Habitat Evaluation Procedures (HEP) analysis, and this value is multiplied by Habitat Suitability Indices (HSIs) for each land use type present to calculate Habitat Units (HUs) and Average Annual Habitat Units (AAHUs).

3.0 MODEL EVALUATION

USACE requires that planning models be reviewed and certified. The purpose of the review is to evaluate the technical quality, system quality, and usability of the planning models. The results of the model review are used by USACE to determine whether the Enviro Fish Version 1.0 User's Manual and software is of sufficient quality to certify the model for widespread use for projects in the Lower Mississippi River Valley. The ECO-PCX conducted an intermediate level review of Enviro Fish based on its intermediate level of complexity relative to other planning models. It is important to confirm the quality of the model and model results that are being used for making decisions that will ultimately impact the quality of the valuable ecological resources in the study area. As a 501(c)(3) nonprofit science and technology organization with experience in establishing and administering external peer review panels for USACE, Battelle was engaged to conduct the model certification review for the Enviro Fish model and software.

3.1 Model Review Approach

Independent, objective peer review is regarded as a critical element in ensuring the technical quality, system quality, and usability of models used by USACE for planning purposes. Details of the review process and charge guidance are provided in the Revised Final Work Plan for the Independent External Peer Review for Certification of Four Ecological Models: Enviro Fish, Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, Waterfowl Assessment Methodology (WAM), and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook (Attachment A). The review consisted of eight tasks, including:

Task 1	Participate in Kick-off Meeting
Task 2	Prepare Work Plan
Task 3	Prepare and Finalize Charge to Model Reviewers
Task 4	Identify Candidate Model Reviewers and Select and Finalize Contracts with Candidate Model Reviewers
Task 5	Conduct Model Assessment
Task 6	Prepare Draft Report for Model Review
Task 7	Participate in Meeting to Discuss Draft Report for Model Review
Task 8	Prepare Final Report for Model Review

Battelle participated in a kick-off teleconference meeting with representatives from the USACE ECO-PCX and the model developers (Task 1). The purpose of the meeting was to allow Battelle to brief USACE on the approach used to conduct the model review and for USACE to brief Battelle on USACE's specific goals and objectives for the model review. Battelle prepared a draft and final work plan, which included charge questions and guidance to the model review panel that were based on the goals and objectives discussed as well as the USACE Statement of Work (SOW) (Tasks 2 and 3).

Battelle initially identified more than 37 candidate model review panel members for the Enviro Fish model review, evaluated their technical expertise, and inquired about potential conflicts of interest (COI). Of those contacted initially, Battelle chose nine of the most qualified candidates based on background, years of experience, and lack of actual or perceived COI (Task 4) and confirmed their interest and availability. Of those nine candidates, five were proposed for the final model review panel and four were proposed as backup model reviewers. These experts were approved by the USACE ECO-PCX (Task 4). The five proposed primary model reviewers constituted the final model review panel. The remaining candidates were not proposed as model review panel members or backup model reviewers for a variety of reasons including lack of availability, disclosed conflicts of interest, or because they did not possess the precise technical expertise required.

One of the model reviewers was replaced shortly after the review kick-off teleconference and receipt of the model review materials because it was determined that, although a programmer/spreadsheet auditor expert with Java experience was requested for the review in the USACE SOW, a Java expert was more appropriate for the review. With the help of the programmer/spreadsheet auditor, a Java programming expert was identified, asked about interest in participating in the review, evaluated for technical expertise and COI, approved by USACE, and subcontracted to perform the review. The final model review panel included:

- A planner/HEP specialist with experience conducting evaluations of projects to achieve ecological benefits.
- Two fishery biologists with experience evaluating fish habitat suitability and knowledge of the Lower Mississippi River Valley fisheries.
- A hydraulic engineer with experience in estimating the effects of flood protection on floodplain hydrology using the HEC-RAS 1-D Flow and associated DSS (Data Storage System) files and conducting ecosystem restoration output evaluations.

- A software programmer with Java experience and experience testing, debugging and auditing computer programs to check for accuracy of formulas and computer code.

Information on the experts selected for the model review panel is summarized in Table 1, and a short biography for each panel member is provided in Appendix A.

Table 1. Experts Selected for the Enviro Fish Model Review Panel

Name	Affiliation	Location	Education	Years of Experience
Planner\Habitat Evaluation Procedures Specialist				
Richard Stiehl	Independent Consultant	AZ	Ph.D. in Environmental Science/Biology	25+
Fishery Biologist				
Charles Rabeni	University of Missouri	MO	Ph.D. in Zoology	37
Fishery Biologist				
Kenneth Rose	Louisiana State University	LA	Ph.D. in Fisheries	24
Hydraulic Engineer				
Lyle Zevenbergen	Ayres Associates, Inc.	CO	Ph.D. in Earth Science	22
Software Programmer/Auditor				
Robert Burnham	Tuck School of Business, Dartmouth College	NH	M.A. in Urban Affairs	20

After the model reviewers were under subcontract, Battelle conducted a kick-off teleconference to brief the model review panel on the purpose and approach for the review process. Another kick-off teleconference was convened with Battelle, the model reviewers, representatives from the USACE ECO-PCX, and the model developers. This provided the model reviewers an opportunity to be briefed specifically on the model and its intended purpose and provide the model reviewers an opportunity to ask questions directly of USACE. The model reviewers were provided with electronic versions of the review document and software, along with guidance and a charge that solicited their comments on specific aspects of the materials that were to be reviewed.

The following document and software (files names are in *italics*) were provided to the model reviewers for the review.

- Enviro Fish Version 1.0 User's Manual (Draft) (*EnviroFish_User_Manual_10-30-09.pdf)*
- Enviro Fish Version 1.0 software (*envirofish_version_1.0.zip* containing 35 individual files)

Model reviewers were asked to review the Enviro Fish Version 1.0 User's Manual and software. The following additional documents were provided for reference only and were not to be reviewed:

1. Protocols for Certification of Planning Models (http://www.usace.army.mil/CECW/PlanningCOP/Pages/models.aspx)
2. EC 1105-2-407, Planning Models Improvement Program: Model Certification (http://www.usace.army.mil/CECW/PlanningCOP/Pages/models.aspx)

The model reviewers were asked to review the Enviro Fish model and its documentation using guidance and charge questions provided to them. A teleconference with the model reviewers and USACE model developers was facilitated shortly after the model review kick-off teleconference to instruct the model reviewers on how to use the Enviro Fish software because most of the model reviewers had difficulty getting the software to function. It was determined that the underlying problem was that Enviro Fish is not compatible with the most recent version of USACE HEC-DSSVue software, and that an older version of HEC-DSSVue is needed for the Enviro Fish program to work properly. Although not strictly prohibited, there was no other communication between the model review panel and the model developers during the model review process.

The guidance and charge questions are based on the model certification criteria discussed in the USACE *Protocols for Certification of Planning Models* (July 2007). The intent of the charge questions was to focus the review on the assessment criteria that are critical for the certification of planning models. The process and evaluation criteria for the review are outlined in the *Protocols for Certification of Planning Models* (USACE 2007) and described in Section 1.2 of this report.

Thirty-seven charge questions developed by Battelle and approved by USACE were provided to the model review panel in Individual Charge Response Forms to be used by the model reviewers during their review. Following the model reviewers' individual reviews of the Enviro Fish model, Individual Charge Response Forms were compiled into a Merged Charge Response Form that contained all of the model review comments. Approximately 140 individual comments were received.

Battelle identified the key issues based on a review of the 140 comments received. A model review teleconference was facilitated by Battelle to discuss key technical comments and conflicting comments identified in the model review panel's individual comments and reach agreement on the key findings of the review (Final Panel Comments [FPCs]) to be provided to USACE in the Model Certification Review Report. At the conclusion of the teleconference meeting, 34 FPCs had been developed to present the key issues identified during the review of the model software and user's manual. Each of the model reviewers was assigned lead responsibility for developing specific FPCs into a four-part format that included the comment statement, a description of the basis for the comment, the level of significance of the issue, and recommendations for resolution. The model reviewers were also assigned the responsibility of drafting specific sections of the Draft Model Certification Review Report.

With guidance and coordination from Battelle, the model reviewers developed the sections that discuss the results of the model review for the Draft Model Review Report (Sections 3.4 through 3.6). Battelle integrated the individual sections into the report, and the results of the model review are discussed in Sections 3.4 through 3.7 of this final report. Conclusions of the model review are presented in Section 4.0

Battelle also guided the model reviewers on the development the FPCs to ensure that the model reviewers' viewpoints are clearly represented, appropriate for the review, and not duplicated between FPCs. During the development of the FPCs, some of the comment statements were revised, one comment was eliminated, and two of the original FPCs were merged, for a total of 32 FPCs. Final Panel Comments are provided in Appendix B.

Battelle and the model review panel members met via teleconference with the USACE Directorate of Civil Works (CECW) representatives, representatives from the ECO-PCX, and Model Proponents to discuss the Draft Model Review Report at 2:00 EST on January 29, 2010. During the teleconference, the findings of the model certification review, as documented in the draft report and final panel comments, were discussed. Suggested revisions to the draft report have been included in this Final Model Certification Review Report.

3.2 Assessment Criteria

In accordance with the *Planning Models Improvement Program: Model Certification* (EC 1105-2-407, May 2005), the Enviro Fish model was subjected to an independent external peer review. The review was conducted based on guidance in the USACE *Protocols for Certification of Planning Models* (July 2007). As required by USACE (*Protocols for the Certification of Planning Models*, July 2007), this ecological model was reviewed and assessed for technical quality, system quality, and usability. The review of these three criteria is described in the following sections.

3.2.1 Technical Quality

Analytical tools, including models, used for planning purposes need to be technically sound and based on widely accepted contemporary scientific theory. The riverine fish communities in the Lower Mississippi River Valley, and how their spawning and rearing responds to the influence of hydrologic and hydraulic parameters during inundation of the floodplain, must be realistically represented by the model. The architecture of the model calculations must reflect how the system is expected to respond to changes in measured variables based on the application of scientific theory. Formulas and calculation routines that form the mechanics of the models must be accurate and correctly applied, with sound relationships among variables. The model should be able to reflect natural changes as well as the influence of anthropogenic laws, policies, and practices. All model assumptions must be valid and should be well-documented. The analytical requirements of the model must be identified, and the model must address these requirements. The model should also produce robust, reproducible results that stand up to rigorous scrutiny in later stages of the plan formulation process.

3.2.2 System Quality

System quality refers to the quality of the entire system used to develop, use, and support the models, including the software and hardware platform. System quality is generally assessed by testing the hardware and software components, design verification planning for customer acceptance, third party interoperability, compatibility with various hardware and operating systems such as Windows and MacIntosh, and the development of a problem-tracking database. Most of this is done through USACE internal review and tracking. However, some criteria can be evaluated by external peer reviewers. In general, model reviewer evaluation of system quality can include assessing whether supporting software tools/programming language are appropriate for the model, programming is done correctly, software and hardware are available, the model has been tested and validated, and data can be readily imported into other software analysis tools (if applicable). The Enviro Fish model software is a Java computer program, and the review of system quality focused on the accuracy of the code.

3.2.3 Usability

Usability refers to how easily model users can access and run the models, interpret model output, and use the model output to support planning decisions. An assessment of model usability includes evaluating the availability of data required to run the models and the ability of the user to learn how to use the model properly and effectively. Model outputs should be easy to interpret, useful for supporting the purpose of the model, easy to export to project reports, and sufficiently transparent to allow for easy verification of calculations and outputs.

3.3 Approach to Model Testing

Although the model reviewers were not provided with a dataset for testing the use of the Enviro Fish models, limited testing was performed by applying the formulas in the models to sensible and non-sensible test data (i.e., both realistic and impossible variable measures). Some of the formulas were also checked by reproducing the model formulas and calculations in a spreadsheet and evaluating whether the same result could be obtained as with using the Enviro Fish software. Results of the testing approach are discussed in Sections 3.4.7 and 3.5 of this report. The model reviewers' assessment also included a review of the information available in the model documentation and notes associated with the code.

3.4 Technical Quality Assessment

The technical quality assessment was based on an assessment of the criteria described in Section 1.2 of this report. The assessment was based on a review of the Enviro Fish Version 1.0 User's Manual and software provided by USACE. Without knowing all of the relevant USACE policies and procedures, the model reviewers were only able to perform a limited assessment of whether the model properly incorporates USACE policies and procedures. The results of the model reviewers' assessment of the other criteria are summarized in the following sections.

3.4.1 Review of Theory

The Enviro Fish model is based on sound hydrological and ecological theory but would not be considered state-of-the-art in terms of contemporary thinking (FPC #18). This is not considered to be a weakness, as Enviro Fish appears to have been developed as a model that is relatively

simple but realistic enough for most situations and, therefore, widely applicable. Thus, Enviro Fish relies on ideas that are well-established and easy to explain. Contemporary theories are, by definition, still evolving as they are continually being tested and revised. It would be very difficult, if not impossible, to make a state-of-the-art model based on contemporary theory that was widely applicable and easily useable by others. However, it is important that Enviro Fish users know how Enviro Fish fits into the broader picture. The user's manual provides little information about the theory upon which Enviro Fish is based and nothing about how Enviro Fish fits in with contemporary theory. The model reviewers are not suggesting the manual provide a complete, comprehensive discussion of contemporary theory, but additional information should be added to the user's manual that briefly explains the position of Enviro Fish with respect to current thinking about hydrology and fish reproductive responses associated with floodplains. A bibliography would also help for those who want to learn more, and those references cited at the end of this section could be included. When the user and the general audience are more informed, it is more likely that Enviro Fish will be applied and interpreted correctly.

The hydrologic component of Enviro Fish allows for a variety of techniques to be used to generate the model inputs of daily stage and elevation-area relationships because these relationships are determined external to the Enviro Fish code. The use of a standard input format (HEC-DSS) is also helpful because it ensures that, regardless of how the inputs are generated, the appropriate sets of values are used in Enviro Fish (i.e., must conform to the DSS format). Little guidance is provided in the Enviro Fish User's Manual on the various approaches available to generate the daily stage and area-stage relationships. It is up to the user to determine the approach for estimating hydraulic model inputs; thus, if the user uses methods that conform to contemporary theory, then one can say that hydraulics in Enviro Fish are based on contemporary theory. For example, the development of daily stage time series can use, in order of increasing complexity, simple rating curves, normal-depth calculations, HEC-RAS steady-state modeling, HEC-RAS (or other) hydrodynamic modeling, and 2-dimensional and 3-dimensional hydraulic and hydrodynamic modeling. Once the hydraulic modeling is complete, the daily stage record is then easily stored in HEC-DSS format. Similarly, because elevation-area curves are developed externally to Enviro Fish, it is up to the user to generate these values prior to running Enviro Fish. Therefore, as the knowledge base expands and the theoretical basis for what constitutes functional floodplain becomes more complex, the development of the elevation-area curves can become more detailed and involved. Therefore, from the standpoint of hydraulic data requirements, an advantage of the Enviro Fish model is that the level of analysis can range from simple, well-established approaches to very contemporary approaches, depending on the requirements, data availability, and complexities of a specific project.

At a more fundamental level, there are some aspects of the hydraulics of Enviro Fish that, based on contemporary theory, may be too simplified for some applications. For example, if the biological questions and the system being modeled require that the spatial arrangement of the land use types and their proximity to the river (i.e., connectivity) be explicitly considered, then it is difficult to use Enviro Fish. The issue of connectivity as part of contemporary theory has been discussed by others (Bunn and Arthington 2002; Junk and Wantzen 2004; Schiemer 2000). When connectivity is important to the biology, Enviro Fish output would need to be extensively adjusted in post-processing, or more likely, the hydraulics of Enviro Fish, which ignores

connectivity, would likely need to be replaced with spatially-explicit approaches. This would also require extensive data being available to support the spatially-explicit hydraulic and hydrodynamics modeling. Other models being used to generate hydrologic and hydraulic inputs to Enviro Fish are described above. In order for the models to reflect contemporary theory, the other models could replace the hydraulics of Enviro Fish, and essentially the user would not be using the Enviro Fish model but rather a new model based on a different set of assumptions about hydraulics, and likely a different set of calculations to quantify the fish reproduction response.

The biological component of the Enviro Fish model is also based on well-established theories. It is based on habitat suitability theory, which has a long history, and Enviro Fish appropriately accommodates the systems theory ideas that evaluation of fish reproduction involves the explicit linkage between the river and its associated floodplain (i.e., the Flood Pulse Concept, Junk et al. 1989). The Flood Pulse Concept emerged to complement the older River Continuum Concept (Vannote et al. 1980). The Flood Pulse Concept says that the bulk of animal biomass derives directly or indirectly from the floodplain, rather than from downriver transport of organic matter produced elsewhere (Galat and Zweimuller 2001). The use of habitat suitability is appropriate because it reflects the typical data and information available for many projects, and generates results in a form that is useful for decision-making. People have recognized the distinction between habitat and population abundance, so with proper caveats and in the correct situations, habitat suitability is the best available approach. The explicit treatment of rivers connected to floodplains is also appropriate.

Current thinking about fish reproduction and floodplains has evolved somewhat from the simple, original exposition of the Flood Pulse Concept. Four aspects of contemporary theory not treated by Enviro Fish are multi-factor interactions, spatially-explicit modeling, full life cycle effects, and species interactions. As the model developers state, the basis of Enviro Fish goes back to the early 1980s. Enviro Fish appropriately focuses on water depths (i.e., single factor analysis), but has little discussion about how other environmental variables (e.g., temperature) may be important. Fish reproduction can be influenced by multiple factors, which can have variable influence over time and space and interactive effects on reproductive success. For example, water temperature and stage can either be highly correlated or almost completely uncoupled from each other (Junk et al. 1989), and these patterns can greatly influence fish dynamics such as growth (Schramm and Eggleton 2006) and food web structure (Winemiller 2004).

Our ability for mapping bathymetry and handling spatially-resolved data, modeling hydraulics and hydrodynamics, and tagging and following fish on fine spatial and temporal scales has greatly increased in the past decade. Spatially-explicit modeling of fish habitat is now possible that was not feasible 10-15 years ago (Ferrier and Guisan 2006; Boisclair 2001). A spatially-explicit approach allows for the spatial arrangement of different habitat patches relative to each other and relative to the river (i.e., connectivity) to be explicitly considered in the analysis. In some situations, river-to-habitat connectivity and habitat-to-habitat connectivity can be an important determinant of species utilization and productivity and biodiversity (Bunn and Arthington 2002; Junk and Wanrzen 2004; Schiemer 2000). In situations where the system is well-studied or controversial decisions need to be made, a spatially-explicit (perhaps even

population-level) approach should be considered in addition to the application of Enviro Fish. The models would complement each other.

Contemporary theory has also moved from single life stage analyses and single-species approaches to more explicit consideration of population level responses and community and food web dynamics. Enviro Fish is very much a single species (or guild) approach, and is even further limited to certain life stages (eggs and rearing stages). Galat and Zweimuller (2001) caution about focusing on a single life stage too much because of potential bottlenecks in other life stages (e.g., habitat limitation, density-dependence) that would cause the population response to differ from what is expected by Enviro Fish's predictions of changes in reproductive habitat. Arthington et al. (2004) discuss various methods for assessing flow effects on the population level. Concepts such as food web structure and stability (Winemiller 2004), holistic (ecosystem) methodologies (Arthington et al. 2004), and ecological integrity (Schiemer 2000) are being increasingly discussed in the context of flow effects on fish in large rivers and their associated floodplains. Ecological integrity includes measures from individuals (e.g., growth, condition) to populations (e.g., year-class strength) to communities (e.g., biodiversity). Johnson et al. (1995) describe how biological interactions can control local species abundance and resource use at small scales.

The user needs to understand how Enviro Fish fits in the bigger picture. Enviro Fish was purposely designed to be widely applicable, and thus focuses on a few primary factors: water depth, seasonality and substrate (land type), ignoring the spatial arrangement of the land use types within the floodplain. Information that would enable the reader to place Enviro Fish within this broader context of contemporary theory is absent from the user's manual.

The model reviewers are not suggesting that Enviro Fish include additional environmental factors beyond what is presented. The water depth, land use type, seasonality, and life stage foci of Enviro Fish are reasonable because these factors are fundamental variable for measuring suitability of fish reproductive and spawning habitat. Furthermore, modeling multiple factors or population dynamics (full life cycle) is not possible in most situations because of limited data, and this would result in a highly complicated model that would require highly specialized skills to implement. One major advantage to Enviro Fish in its current form is that it is useable and understandable by a wide audience. Dealing with species interactions within the life stage of interest is also difficult because our knowledge about predation and competition is also lacking. But these contemporary theory issues should be discussed in the user's manual so that the user has a clear idea of the benefits and limitations of using only a few important variables for measuring habitat suitability and ignoring connectivity issues, and so the user understands where Enviro Fish fits in within contemporary theory.

Although not a comprehensive list, the following are examples of the literature available on relevant contemporary theory.

Arthington A.H., R.E., Tharme S.O. Brizga, B.J. Pusey, and M.J. Kennard. 2004. Environmental flow assessment with emphasis on holistic methodologies. In: Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Volume II. R. Welcomme and T. Petr (eds.). FAO Regional Office for Asia

and the Pacific, Bangkok, RAP Publication 2004/17, pages 37 to 65.

Boisclair, D. 2001. Fish habitat modeling: from conceptual framework to functional tools. Canadian Journal of Fisheries and Aquatic Sciences 58: 1–9.

Bunn, S.E., and A.H. Arthington. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management 30: 492–507.

Ferrier, S., and A. Guisan. 2006. Spatial modeling of biodiversity at the community level. Journal of Applied Ecology 43: 393–404.

Galat, D.L. and I. Zweimüller. 2001. Conserving large-river fishes: Is the highway analogy an appropriate paradigm. Journal of the North American Benthological Society 20: 266-279.

Johnson, B.L., W.B. Richardson, and T.J. Naimo. 1995. Past, Present, and Future Concepts in Large River Ecology. BioScience 45: 134-141.

Junk, W.J., and K.M. Wantzen. 2004. The flood pulse concept: new aspects, approaches and applications - an update. . In: Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Volume II. R. Welcomme and T. Petr (eds.). FAO Regional Office for Asia and the Pacific, Bangkok, RAP Publication 2004/17, pages 117 to 140.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-floodplain ecosystems. In Proceedings of the International Large River Symposium, D.P. Dodge (ed.). Canadian Special Publications in Fisheries and Aquatic Sciences 106: 110–127.

Schramm, H.L, and M.A. Eggleton. 2006. Applicability of the flood-pulse concept in a temperate floodplain river ecosystem: thermal and temporal components. River Research and Applications 22: 543–553.

Scheimer, F. 2000. Fish as indicators for the assessment of the ecological integrity of large rivers. Hydrobiologia 422/423: 271–278.

Winemiller, K.O. 2004. Floodplain river food webs: generalizations and implications for fisheries management. In: Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Volume II. R. Welcomme and T. Petr (eds.). FAO Regional Office for Asia and the Pacific, Bangkok, RAP Publication 2004/17, pages 285 to 310.

Vannote, R.L., G. W. Minshall, K. W. Cummins, J. R. Sedell and C. E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

3.4.2 Review of Representation of the System

The theoretical basis of a model is closely linked to the ability of a model to accurately represent a particular system, which is an obvious prerequisite for its usefulness. Models explain "how something works" and can be of any level of complexity. Increased complexity is often accompanied by greater accuracy but also requires more specialized knowledge. Models are, by definition, abstractions of real-world systems. As such, they are inherently simpler than the ecosystems they represent.

The Enviro Fish model integrates several factors that affect floodplain-spawning fish. The model itself is relatively simple, but the number of factors that must be considered when developing the input for Enviro Fish are quite large. These include habitat suitability (land use/habitat), spawning and rearing requirements (minimum and maximum water depth, flooding duration, and season), hydrology, and other factors that are collectively grouped into the definition of functional floodplain. The definition of functional floodplain is discussed at more length below. The generality of the Enviro Fish model is a strength because the development of input data can be tailored to the needs of a specific project. Its generality can also be a weakness unless effective guidance can be provided for developing the input data to effectively represent the system being modeled.

The degree of realism afforded by a model depends on the question asked, how well it is implemented (i.e., satisfies assumptions), the quality and quantity of the data and other inputs, and proper interpretation of the model results and outputs by the user. A useful model requires a balance between accurately representing the system being modeled and the ability of the intended audience to comprehend model results. When Enviro Fish is used in appropriate situations, with proper implementation, using sufficient data, and with appropriate interpretation of results, it can be considered a reasonably realistic representation of the actual ecosystem. Because the Enviro Fish model ecosystems are represented using the HEP approach integrated with straightforward hydraulic modeling, the model's conceptual approach and outputs are easily understood by a wide and diverse audience.

However, accuracy can be increased without affecting the understanding of the model outputs. As previously mentioned, the Enviro Fish model is based on the generally-accepted concept of habitat suitability, which has a long history, and Enviro Fish appropriately accommodates the systems concepts that evaluation of fish reproduction involves the explicit linkage between the river and its associated floodplain (i.e., The Flood-Pulse Concept). The model uses the typical data and information available for many projects, and generates results in a form that is useful for making decisions. While the HEP approach, or elements of HEP, has been widely accepted and used for many aquatic situations, especially those involving instream flow analyses, it does rely heavily on ideas that have never been adequately documented to be very accurate in stream/river applications.

Consequently, there are several aspects of the HEP process that can hinder the ability of the model to properly represent the ecosystem. The default HSI values given to the various land types provided with Enviro Fish, which are then multiplied by available acreage to obtain spatially explicit HUs, were obtained primarily from the fisheries literature and professional judgment (a variation of the Delphi Technique). The subjective judgment by biologists of fair,

good, very good, etc., was translated into a score ranging from 0 to1.0 in 0.1 intervals. If empirical evidence is unavailable, an HSI designation of 0.3, for instance, might just as well be 0.2 or a 0.4 because professional judgment cannot be quantified that precisely. A small difference in an HSI value (e.g., 0.1) could result in a 50% difference in HU calculations. This potential subjectivity of HSI values would be problematic if the model were actually used to "estimate the value of floodplain habitat," as stated on page 1-1 of the user's manual, instead of more appropriately for "comparing alternatives" of available floodplain habitat, as stated in other places of the manual. Using the example provided in Chapter 4 to compare outputs, when HSI values were changed in various combinations, there was very little difference in the ratio of existing HUs to alternative HUs. This observation should be incorporated into the user's manual, and it should be clearly stated that the most accurate and useful outputs are those that are used to compare existing conditions with alternatives.

As the U.S. Fish and Wildlife Service (USFWS) recognized when the HEP process was developed, HSIs can be developed three ways: by expert opinion, with use criteria, or with preference criteria. The most accurate method, using preference criteria (more appropriately called "selection" criteria) requires field sampling, preferably at the location of the project. HSIs developed based on expert opinion were always considered by the original USFWS developers as interim measures, as were the default values provided with Enviro Fish, even while they promoted the Delphi technique.

If accurate HSIs are truly valuable, they could be developed for specific projects (FPC #2). A large enough project, such as the one mentioned in the Enviro Fish User's Manual, would justify the relatively small costs to provide the best biological data (i.e., HSI values specific to the taxa and system). If there are ongoing USACE, USFWS, or state assessment programs of floodplain fisheries, it would be simple to organize sampling in a manner to sample replicates of flooded land types over a restricted period using the same gear and methodologies to obtain representative samples so that actual spawning and rearing use, rather than assumed potential spawning and rearing use, of different habitats could be compared to each other on a relative basis. Only then could differences in HSI values (for example, the difference between an HSI of 0.5 and 1.0) be understood in a meaningful way.

Although the Enviro Fish model sufficiently represents the ecosystem being modeled for planning purposes, it should not be misinterpreted as being representative of actual biological conditions or biological potential. Many of the assumptions on which the model and, more specifically, HEP are based are too simplistic to allow estimation of absolute spawning and rearing areas. Enviro Fish should be used to compare changes in areas among alternative scenarios. This needs to be made clear in the user's manual.

It is assumed that an increase in area for any single habitat type with an HSI value greater than 0.0 will linearly increase spawning and rearing opportunities. While technically correct, the implication is that increasing opportunities will increase spawning and rearing and, ultimately, fish abundances. This result has rarely been shown in peer-reviewed literature, but is integral to HEP, where HSI values are multiplied by acreage to obtain HUs (FPC #12). More HUs are considered to be better. There is evidence in the published literature that an increase in favorable

habitat will result in an increase in spawning, but beyond a certain level, the increase in favorable habitat is inconsequential since other factors (fish abundances, food) become limiting.

The general HEP approach also assumes that a large area of poor habitat is biologically equal to a small area of very good habitat. An HSI of 0.1 with 100 acres results in the same potential for fish as 10 acres with a HSI of 1.0. This has not been well substantiated in the peer-reviewed fisheries literature. One HU should not be equal to another in habitat value unless the habitats are exactly the same. In reality, a small area of high-quality habitat is likely to outperform a large number of low-quality habitat areas, even if they both have equal HU values. This assumption allows the potential for rationally choosing a project alternative that provides a lot of corn field stubble and no bottomland hardwood forest over one where bottomland hardwood forest is present in moderate amounts. This assumption precludes the model from organizing the output to maximize the highest quality habitat type.

The model reviewers recognize the value of using the HEP approach but suggest that the user's manual present additional pathways for determining HUs. This suggestion recognizes that, while experienced biologists may not be able to always agree on an exact quantification of habitat value, they likely agree on what is good habitat versus what is poor habitat. In the example provided in the Enviro Fish User's Manual, by default, cropland is considered low quality (HSI=0.1) without any explanation of why it is considered to be low quality and for what fish species. Carp will do well spawning in cornfield stubble, but many other species will not. Enviro Fish should not allow the opportunity to increase lots of acreage of really poor habitat for an alternative or future situation without regard for the absolute acreage of very high quality habitat. It might be more appropriate to calculate total HUs using only habitats with HSIs greater than some minimum value, for example 0.4. Then planning decisions would be based on changes from what is known to be fair/good habitat to other fair/good habitat because the value of HUs would be much more comparable. Other avenues to correct for very poor or very good habitat (e.g., weighting) should also be considered.

Some aspects of contemporary biological theory for floodplain fish ecology that may hinder highly accurate representation of the ecosystem are multi-factor interactions, spatially-explicit modeling, full life cycle effects, and species interactions because they are not addressed by Enviro Fish. These limitations are discussed in detail in Section 3.4.1, Review of Theory.

Some attention to the concept of "functional floodplain" would help with representation of the biological system within the model (FPC #3). Delineating the functional floodplain is at the core of the Enviro Fish method. Therefore, the manual should provide more complete discussion on what constitutes functional floodplain and what biologists should consider when they are delineating these areas. Without clear direction from the biologist, a hydrologist or hydraulic engineer may erroneously apply a very different definition of functional floodplain than the biologist. Similarly, biologists need input from hydrologists when defining the functional floodplain.

From the discussion in the user's manual, it appears that the starting point for defining the functional floodplain may be the 2-year floodplain, although there could be many other factors that limit and define the functional floodplain. These include physical barriers, proximity to the

river (even the 2-year flood may inundate areas remote from the river, rendering them non-functional), flow velocity (some floodplain areas may convey water at velocities too high for spawning). There are probably other factors that should also be identified as considerations when delineating the functional floodplain.

The topic of "capping the functional habitat area" also factors into this discussion. Presumably, an area of bottomland hardwood that is outside the 2-year floodplain would not be included, and only the area within the 2-year floodplain would be included. For example, at elevation X (corresponding to the 2-year water surface) there is an area of Y. At elevation X+1 the actual area would increase, but the elevation-area table is "capped," or limited, to the value of Y.

The model reviewers suggest that a more accurate representation of the functional floodplain could be achieved by describing the factors that should be considered when delineating functional floodplain areas. This includes defining the methods for determining whether an area is functional floodplain, including an example of a moderately complex situation where the functional floodplain could have been incorrectly delineated, and providing an example of "capping" the area.

While the daily time step is reasonable for most applications, a stronger cautionary note is needed that explains that very flashy systems in which water levels can change in hours would not be well-represented by this model. Commenting on the spatial resolution is more involved because land features are not geo-referenced in the analysis. The model software relies on the cleverness of the user(s) to properly set-up and estimate the stage-area relationships.

Ultimately, model validation would have been useful in determining how representative the model is to an actual ecosystem (FPC #9). It is unclear whether the model has been validated, either by a comparison of model predictions of changes in habitat with spatially-referenced field data or the output of a more detailed model (habitat compared to habitat) or by a comparison of predicted changes in habitat to observed changes in fish reproduction (habitat versus biology).

Nevertheless, the biological sections of the user's manual does a good job in merging ecological concepts with the constraints of limited biological information and the multitude of species in the system. The model appears realistic, or realistic enough, if it is appropriately used in planning situations to compare existing conditions with future alternative conditions and between alternatives, and to facilitate communication among a diverse group of constituents.

3.4.3 Review of Analytical Requirements

The analytical objective of Enviro Fish is to calculate the area of habitat suitable for fish spawning and rearing. This is then used for the quantification of HUs. HUs are the product of HSI values and the ADFA. HSI values range from 0.0 to 1.0 based on the suitability of habitat for fish spawning and rearing. ADFA is the average number of acres over which flooding occurs for a given land use based on a large number of constraints that depend on the requirements of fish species.

Determining HSI values requires an in-depth knowledge of fish ecology, particularly the spawning and rearing requirements of floodplain spawning fish species. However, the Enviro

Fish User's Manual provides default HSI values that were developed from the peer-reviewed literature and based on best professional judgment (FPC #2). The analytical requirements for the development of HSIs are not described. The result is default HUs, less meaningful measures of differences between current and future conditions and between project alternatives, and less sensitive HEP results. An additional section discussing the development of HSI values for Enviro Fish should be developed (FPC #2). This section should not put forward "default" HSI values; instead, the user should be advised to consult with a knowledgeable fishery biologist and collect field data associated with the HSI species model (e.g. spawning season water level, water temperature, percent vegetative cover, percent pools, dissolved oxygen level) to develop more meaningful taxa-specific and site-specific HSI values.

Calculating ADFA is an involved process requiring the expertise of several scientific, engineering, and technical disciplines. Enviro Fish is designed to compute the ADFA using daily stage data, area-elevation data, and spawning and rearing requirements for each species. This involves knowledge and skills in hydrology of rivers and associated floodplains, manipulation of spatially-referenced data (e.g., GIS) related to land use, extrapolation and interpolation methods applicable to time series data (e.g., stage records), the ability to fuse data from different sources, and biological knowledge about the reproduction of key fish species (e.g., quality of different land use types and the effects of water depth).

The Enviro Fish method and code do an excellent job of representing how water depth affects the availability of habitat for floodplain-spawning fish species when stage data and elevation-area data by land use type are available. These data are commonly available for many large project evaluations. The model reviewers are concerned that, given the large number of biological requirements and physical processes that Enviro Fish incorporates, the user's manual does not provide sufficient guidance and discussion on correctly developing the input data for an analysis (FPC #4). In other words, the analytical requirements for the data needed for Enviro Fish are not clear. The data that are needed to meet the analytical requirements are listed below in a hierarchical format:

- HSI (Habitat Suitability Index)
    - Relative quality of different land use types in terms of reproductive success for the fish species (or groups) of concern
    - Mobility, tolerances, and sensitivities of life stages for each species related to reproductive success
    - Community structure to identify key species
    - Habitat requirements
    - Habitat structure (e.g., barriers, edge permeability) that may affect heterogeneous habitats
    - Other constraints stipulated by the multi-disciplinary team (e.g., minimum HSI acceptable, minimum area considered, proximity of compensation areas)
- ADFA (Average Daily Flooded Area)
    - Daily Stage Data
        - Daily Flow Data
            - Historic Record, possibly transformed to the project location

        - Historic Record transformed for existing conditions
        - Historic Record transformed for future project alternative conditions
      - Hydraulic Analysis to convert flows at a gage to stage at the project location
  - Elevation-Area Curves
    - Functional Floodplain definition and constraints
      - Proximity to river
      - Barriers
      - 2-year floodplain
      - Flow velocity
      - Capping the area based on water depth
      - Perched depressions (to be eliminated from the analysis)
    - Land-use data
      - Aerial photography (current and historic)
      - GPS survey
      - Ground truth
    - Topographic data
      - USGS Quadrangles or Digital Elevation Models (DEMs)
      - LIDAR
      - Photogrammetry
      - GPS survey
  - Spawning and Rearing Requirements
    - Season Constraints
  - Spawning Requirements
    - Minimum and Maximum water depths constraints
    - Orphaned and Deep nest constraints
    - Number of consecutive flooded days constraint
  - Rearing Requirements
    - Minimum and Maximum water depth constraints

The user's manual provides little guidance on the analytical requirements for these data that are input to the model (FPC #16 and 17). Although the model does not currently compute HUs within the model code, the model reviewers suggest that it should, which would require the user to input HSIs (FPC #1).

The scientific, engineering, and technical disciplines that will be involved in an Enviro Fish analysis include HEP specialists, fishery biologists, riparian ecologists, hydrologists, hydraulic engineers, and GIS specialists. The Table 2 shows the data requirements and the disciplines that would be involved in developing the input data and interpreting model output predictions.

Table 2. Data Requirements and Disciplines Required for Using the EnviroFish Model

Data Required	HEP Specialist	Fishery Biologist	Riparian Ecologist	Hydrologist	Hydraulic Engineer	GIS Specialist
HSI Values	X	X	X			
Daily Stage				X	X	
Functional Floodplain	X	X	X	X	X	X
Land-Use	X	X	X			X
Topography		X			X	X
Spawning and Rearing Requirements		X				

The members of this multi-disciplinary team must be informed about the analytical requirements of the HEP procedure and the biological requirements of the fish species in order to produce the correct input data for the calculation of ADFA. The primary avenues for this communication are the project-specific definition of the functional floodplain and communication of spawning and rearing requirements. Although careful study of the user's manual could provide each of these disciplines with an idea of the data and analytical requirements, the model reviewers suggest that more detailed and thorough guidance should be provided to each of these disciplines. This is likely available considering the long experience of Enviro Fish being used by experts. Detailed guidance on how to best analyze the data to prepare model inputs would greatly enhance the usability and confidence in Enviro Fish.

3.4.4 Review of Model Assumptions

The assumptions underlying Enviro Fish can be grouped into assumptions about hydrology, fish spawning, and model output post-processing (HSI/HEP) analysis. All models involve assumptions, and that is what makes them approximations of reality. It is very important that the major assumptions be known to model users in order to ensure that the results of Enviro Fish are properly interpreted and correctly implemented. The reviewers are not suggesting that Enviro Fish be changed but rather that the major assumptions should be clearly stated in the user's manual. These assumptions can be addressed quite well in practice, as long as they are explicitly known and a research team comprised of appropriate experts is assembled to implement and interpret Enviro Fish.

Hydrological Assumptions

A major assumption of Enviro Fish is that the definition of a functional floodplain is a valid delineation of the area utilized by fish. The user's manual suggests that the floodplain inundated by the 2-year frequency flood is assumed to be the functional floodplain, although the reviewers are concerned that there may be other considerations. Specifically, if an area of the floodplain is

included that is not accessible by fish or fish can access areas outside of the defined functional floodplain, then predicted changes in suitable habitat will be inaccurate.

The hydrology submodel of Enviro Fish assumes that the water level data and elevation-area relationships for each land use type capture the flooding patterns within the functional floodplain. The accuracy of the water level data is usually sufficient; however, an assessment should be made to determine whether monitored locations are sufficiently representative of the entire floodplain. The accuracy of the derived stage-area relationships can vary significantly as they are dependent on the methods used to estimate the relationships.

Analyses further assume that the historic daily flow and/or stage record can be used directly or modified to project future conditions and that the land use pattern in the functional floodplain will remain the same into the future. The longer the data record, the more likely extreme conditions are captured in the data series. The analyses assume that such water levels observed historically apply in the forward-looking analyses, which can project decades into the future for many projects. Similarly, the analyses assume that the current land use patterns will persist in the future as well. If information is available on how water levels or land use may change, such information should be analyzed as scenarios, with the proper explanation and caveats. The model also assumes that any hydrologic and hydraulic constraints that are not represented in the daily stage record are adequately represented within the definition of functional floodplain. For example, if a fish species spawns in areas with flow velocities less than 1.0 ft/s, then the functional floodplain should exclude areas, regardless of the land use, that have flow velocities greater than 1.0 ft/s.

Biological (fish spawning)Assumptions

Enviro Fish has the advantage of relatively simple biological calculations. While this is one strength of the model, it can erroneously appear to some users that only a few assumptions are needed to conduct the analyses. Enviro Fish makes many assumptions about fish spawning and rearing. A major assumption is that ready-to-spawn fish will respond to rising waters, enter a floodplain, and disperse in the spatial mosaic of multiple habitats according to the quality and quantity of each habitat type. One corollary to this assumption is that the spatial details of the arrangement of the habitat types can be ignored. Other assumptions were already discussed in other sections (3.4.1, Review of Theory, and 3.4.2, Representation of the System). Current fisheries literature suggests that spawning success can also be influenced by habitat size, shape, configuration, proximity, within-habitat heterogeneity at the micro scale, water velocity, and other factors, most of which can be important in different situations but are generally not yet understood well enough to be included in a general model. The representation of fish spawning and rearing in Enviro Fish is reasonable and effective for comparative purposes, but the major biological assumptions underlying the calculations should be clearly stated.

Post-Processing (HSI and HEP Analysis)

Enviro Fish generates output that is then imported into another software package where its output (area as ADFA) is combined with HSI functions to obtain HUs and AAHUs. Enviro Fish uses HSI and the philosophy of HEP, and so carries with it some of the same assumptions that underlie HSI and HEP analyses in general. The validity of HSI and HEP has been discussed in the scientific literature. First, Enviro Fish assumes that a reasonably realistic HSI value can be

determined for the species and system of interest. As discussed in Section 3.4.2, the importance of carefully determining the HSI function is not emphasized enough in the user's manual (FPC #2). As only 20 of the 90 fish species listed in Tables 2.2 and 2.3 in the user's manual have published HSI models, it may be necessary to consult with fishery biologists to develop the HSI models needed for a project.

Second, long-established HEP protocol assumes that an increase in area of any single habitat type with a value greater than zero will linearly increase potential spawning and rearing opportunities (FPC #12). This is generally true of a certain range of habitat areas. When suitable habitat is limiting, then additional habitat will result in a positive response in spawning and rearing. However, it is important to note that spawning can be limited by other factors besides water levels (e.g., egg production, crowding, temperature, substrate type) so eventually more habitat would not result in increased spawning.

Third, even though HEP values are based on *potential* populations, the inference for less informed users may be that more spawning and rearing opportunities will increase spawning and rearing, which would ultimately lead to an increased abundance of the fish species. Enviro Fish only assesses flooding effects on spawning and rearing *opportunities*. Whether increased spawning and rearing opportunities result in more fish over the long term is not determined, as Enviro Fish only quantifies the changes in the amount of suitable habitat available. Increased spawning habitat may have a less than proportional increase in fish because the abundance of fish can be limited by juvenile and adult habitat and by density-dependent responses. For example, more eggs and young can result in crowding of juveniles in their habitat, who then show slowed growth and higher mortality rate that act to negate the increased spawning success.

Fourth, as discussed in Section 3.4.2 (Review of Representation of the System), another assumption of HEP is that a large area of poor habitat is biologically equal to a small area of very good habitat (e.g., a 100 acre area with an HSI of 0.1 results in the same habitat potential for fish as 10 acres with an HSI of 1.0). In reality, small areas of high-quality habitat may outperform a large area of low-quality habitat, even with equal HU values. Because of this assumption, the model may not accurately represent fish spawning and rearing opportunities. Unless model output is carefully reviewed, this assumption has the potential for uniformed users choosing an alternative that provides a lot of cornfield and no bottomland hardwood forest over an alternative where bottomland hardwood forest is present in moderate amounts.

In summary, the assumptions discussed above should be clearly explained in the user's manual to ensure proper implementation of Enviro Fish and proper interpretation of model results. The validity of these assumptions should be assessed on a project-specific basis, keeping in mind that Enviro Fish output is used to make comparisons among scenarios and is not for predicting fish abundances or absolute changes in reproductive success. Enviro Fish is not intended to represent what is actually occurring or could occur within a system, but rather to provide a way to compare flooding effects on habitat suitability among different project alternatives. An enormous amount of responsibility is placed on the model user without much guidance from the model software or user's manual. While a team of appropriate experts would be aware of these assumptions and likely solutions and appropriate caveats, the Enviro Fish model and modeling results are also

meant for a more general audience. These model assumptions should be clearly stated in the user's manual to ensure maximum use of Enviro Fish as a planning tool.

3.4.5 Review of Ability to Evaluate Risk and Uncertainty

Risk and uncertainty have become an important part of USACE analysis and design procedures in recent years, as noted by Moser (1997). Uncertainty is the degree to which responses may deviate from what is projected. The term "risk" is used in many ways to define hazards, losses, and potential problems. Risk is frequently defined as expected losses, generally calculated by combining the probability of system failure with the consequences associated with that failure. This can be computed on a project life or an annual basis. The performance of a project or system is defined as the probability that specific loads will cause the system to fail, and losses are defined as the adverse impacts of that failure if it occurs. In simplified mathematical terms:

Risk = Probability of Failure * Consequences of Failure

Enviro Fish does not appear to have the ability to evaluate any risk or uncertainty associated with the biological assumptions necessary to process the required input data. Because each comparative evaluation is analyzed separately, and multiple simulations are often needed to complete a single scenario, it is impractical to assess risk. If risk and uncertainty are incorporated into the underlying project data, then the model is able to incorporate them, but only with a very large effort and extensive re-running of the model code. Enviro Fish does not seem intended to evaluate risk and uncertainty associated with model outputs.

3.4.6 Review of Ability to Calculate Benefits for Total Project Life

During the project planning phase, USACE is usually required to evaluate the benefits of various project alternatives over the projected life of the project. As the Enviro Fish model does not calculate either HUs or AAHUs, its application as a project planning tool by itself is limited. The model allows a comparison of available fish spawning and rearing habitat between existing conditions and at least two project alternatives; however, relative impacts of project alternatives on fish spawning and rearing habitat are adequately addressed by the Enviro Fish model alone. The model seems capable of evaluating the impacts and benefits of a project, although the output generated requires significant post-processing to calculate HUs and AAHUs, especially if there are time-dependent aspects to the project development and operations (FPC #5).

Relative changes in floodplain habitat quality for fish reproduction are not easily calculated, as there is no convenient way to input any potential changes in either HSI or area values (e.g., from land use changes) that may be predicted over the life of the project. The impacts and benefits can be evaluated to the extent that changes in topography, land use, and daily stage data can be projected over the total project life. Another condition that cannot be predicted for future conditions is water level based on stage record that is developed from historic gage data, which must be addressed on a project by project basis. Although this does not limit the use of Enviro Fish as a planning tool, the model would be more useful for calculating benefits for total project life it is able to directly project changes in the availability of fish reproductive habitat.

3.4.7 Review of Model Calculations/Formulas

The user's manual states (pg. iii) that "Enviro Fish can be used to calculate habitat units for specific floodplain habitats." However, the Enviro Fish model does not calculate HUs. Enviro Fish calculates ADFAs, which is a measure of the area component of HUs. Additionally, Enviro Fish gives only a cursory consideration of HSI determination, providing only a set of "default" HSIs with incomplete documentation of their development. An additional section discussing the development of HSI values for Enviro Fish should be included in the user's manual. This section should not put forward "default" HSI values, but should advise the user to consult with a knowledgeable fishery biologist and recommend the collection of field data on the affected habitats.

ADFAs are calculated for both spawning and rearing habitat. For rearing, land area is included when it is flooded during the season constraint and within the minimum and maximum depth constraints. The same type of calculation is made for spawning, except that an additional constraint is applied such that the water depth constraints must persist for a number of days (i.e., the spawning period). Because the water depth can change over the specified spawning period, the area for spawning can be more limited than for rearing because each spawning event must experience satisfactory conditions over multiple days. Spawning areas (nests) can be lost during the spawning period when water is too shallow (orphaned nests) or too deep (deep nests). The orphaned and deep nests are separate constraints that can be applied independently, together, or not applied.

The model calculations of ADFA were checked using a spread sheet for one daily stage record (Existing Conditions) and one land use (Bottom Land Hardwood – BLH). The ADFAs for spawning, restricted rearing, and unrestricted rearing were checked and the results from the Enviro Fish program were replicated. This test is obviously not exhaustive, but indicates that the calculations of ADFA for spawning and rearing for the sample data can be replicated.
Another test was performed using a set of simple elevation-area curves similar to the BLH data set. The new curves were added to the sample HEC-DSS database using HEC-DSSVue software. Each of the curves included area of 0.0 between elevation 500.0 and 510.0 and increased linearly to an area of 1200.0 at an elevation of 520.0 and remained at 1200.0 for greater elevations. The elevation-area curves differed only in the elevation increment, which included 0.5 ft, 1.0 ft, 2.0 ft and 5.0 ft. The elevation-area curves are shown in the Figure 1 below.

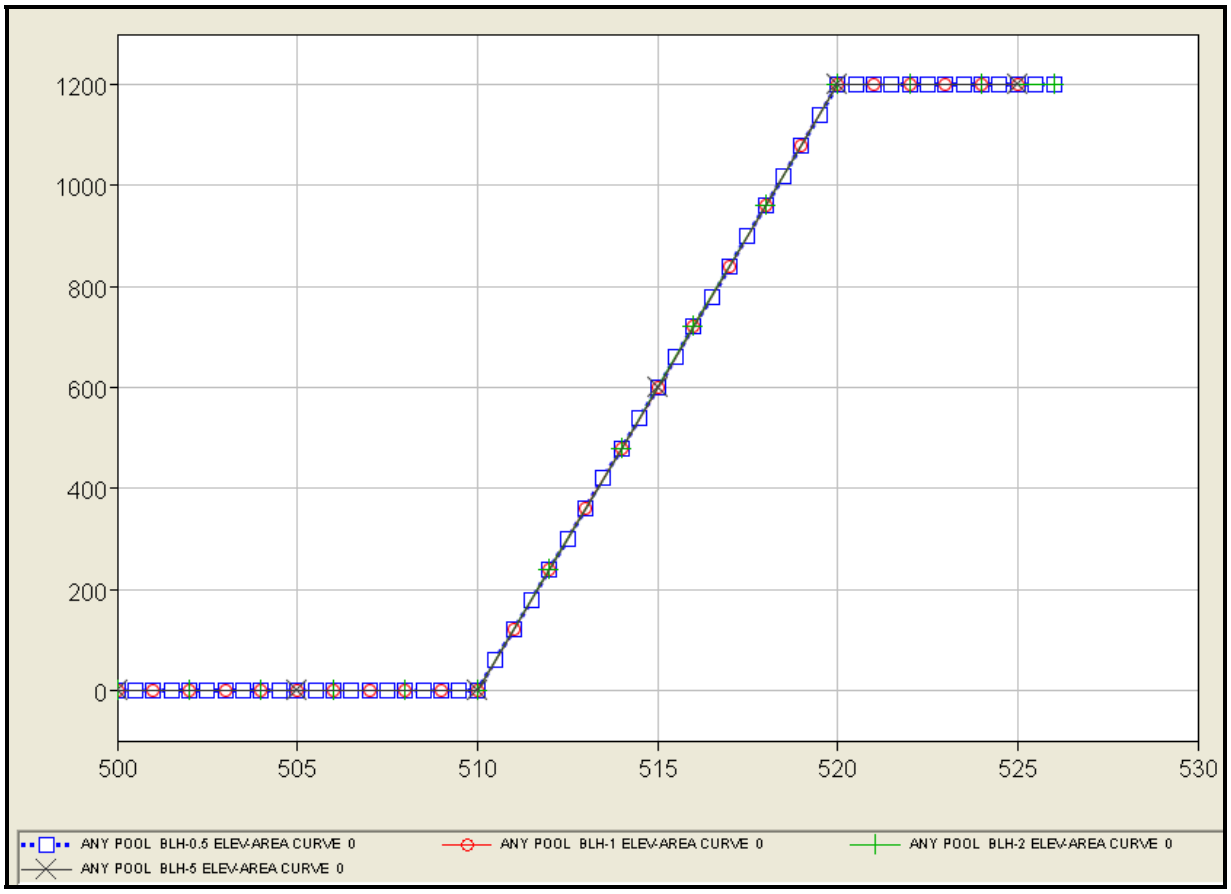

Figure 1. Elevation-Area Curve

Each of the Enviro Fish runs should have produced identical results for these four elevation-area curves. However, different results were generated. The results were checked using the spread sheet and the 1.0 ft increment run was verified as correct. This indicated an interpolation error, which was identified in the Java code (FPC #6) and is discussed in Section 3.5.3.

The calculations and formulas were also tested to determine whether they would use non-sensible data. The software also ran for some non-sensible data. Although the software checked and disallowed minimum depths that were greater than maximum depths, it did not check for negative depths. The software ran for negative depths, which have no physical meaning, and produced results that would be correct if fish were capable of spawning and rearing above the water surface.

Before the model calculations are run, there is one input requirement on the Enviro Fish main screen that is counterintuitive and could lead to incorrectly running and interpreting the model. To apply the orphaned and deep nest constraints, the boxes for these constraints must be left unchecked. A user would have to remember that not applying these constraints requires checking the boxes. Because the area where these boxes resides in the spawning constraints area, users are likely check these boxes when they want to apply the constraints and will produce

ADFAs for the opposite scenario than was intended. The function of checking these boxes should be reversed.

3.5 System Quality

The system quality assessment was based on an assessment of the criteria described in Section 1.2. The assessment was based on a review of the Enviro Fish Version 1.0 User's Manual and software provided by USACE. The results of the model reviewers' assessment of the criteria are summarized in the following sections.

3.5.1 Review of Supporting Software

The model reviewers' broad consensus was that the software supporting the Enviro Fish model produced useful and accurate results with one exception in the interpolation code discussed in Section 3.5.2. However, the model reviewers did find several issues that the model developers should address in terms of making the software more user friendly and adding labels to the model's inputs and outputs (FPC #28, 29, 30, and 31). These include making the software compatible with the current version of the USACE's HEC-DSSVue utility (FPC #22), adding a comprehensive example of software application to the model's documentation, and making the software more flexible to facilitate easy sensitivity analysis of the results.

The Enviro Fish model software uses data stored in the USACE Data Storage System (DSS) format. The USACE's HEC-DSSVue utility is required to edit and manipulate HEC-DSS database files, and Appendix D of the Enviro Fish User's Manual states that "there is not a substitute for using DSSVue in the windows environment." The Enviro Fish software is reportedly incompatible with the current release of HEC-DSSVue, Version 2.0, which was released in August of 2009 (FPC #22). According to the release notes for HEC-DSSVue 2.0, previous installations of HEC-DSSVue are removed by the installer, which makes it difficult for model users to use the new version of HEC-DSSVue and keep a legacy version available for use with the Enviro Fish model. The Enviro Fish User's Manual does not address the version incompatibility, and the older version of HEC-DSSVue is difficult to locate under the "Archived versions" menu on the download page. Updating the Enviro Fish model to be compatible with the current release of HEC-DSSVue would make the using the software more straightforward.

When using the model software, the program saves the path of the last DSS file used using the Java Preferences API. This is a helpful element of the user interface, and the model reviewers recommend that more default values should be made persistent when the model is run (FPC #28 and #29). At a minimum, the output path should not reset to the root directory each time the user saves results. Several model reviewers agreed that the model should also be setup in a way to facilitate a sensitivity analysis of the results. If the model cannot be easily modified to loop over a range of inputs, then having the current inputs made persistent would improve model usability.

The introduction in the Enviro Fish User's Manual would lead most readers to infer that the model calculates habitat units (HUs). The model actually calculates areas and the user is left to use data from the model output and default HSI values to calculate HUs (FPC #1). The important datum (ADFA) for this computation should either be highlighted or extracted and placed in a separate output file. Ideally, developing habitat units should be incorporated into the model so there is direct computation of HEP data for project alternative analysis. The model's

mechanism for exporting data to Excel does not facilitate easy calculation of HUs, and documentation in the user's manual is lacking. The Enviro Fish User's Manual should have an annotated example of how the model should be used in the field. The example should cover all of the steps necessary to use the model effectively, including considerations on the accuracy of the input data, the process of running the software multiple times for different project alternatives, and subsequently analyzing the data and calculating HUs.

The Enviro Fish manual states that "the daily and summary output files can be saved in *.txt, *.csv, and *.xls (Excel) formats." Data can be exported to Excel via the open source Java Excel (JExcel) API. The supported file formats make up the common language for research data, and most analytical software can read at least one of these formats natively. The data load into Excel as expected, but the *.csv files require some manual editing before they can be imported into some statistical packages.

Lastly, the two HEC-DSS data types should be labeled on the user interface for consistency and to clarify the data types to the user (FPC #31). Labels for *HEC-DSS Daily Stage Data* and *HEC-DSS Elevation-Area Curves* should be added to the main form.

Implementing the recommended changes to the software and the accompanying documentation will guide users to employ the software more efficiently and reduce possibilities for user errors. Making the software compatible with the current version of HEC-DSSVue will make the Enviro Fish model more accessible to users. All users would benefit from a comprehensive example of using the software including the post-processing calculation of habitat units.

3.5.2 Review of Programming Accuracy

The model reviewers found several issues in the programming which need to be addressed. Detailed descriptions of the errors are described in FPCs #6 and #7 along with additional suggestions for improving the code throughout the comments.

3.5.2.1 Errors

Dead Stores. One model reviewer replicated the computations for one of the example land uses in a spreadsheet and uncovered an error in the interpolation routine that computes area for a given daily stage. The Enviro Fish software only computes (interpolates) accurate areas when the elevation-area curves are input at 1-ft increments. If a DSS data file contains an elevation-area curve at stage increments other than 1-ft (either smaller or larger) the interpolated values are incorrect. A review of the underlying Java code detected a dead store in the getAreaForStage method which was the source of the problem.
The original source code was:

```
double l = high_stage - low_stage;
double scale = (stage - low_stage) / 1;
```

A new double variable, l, was declared and defined but never used again. The subsequent line defined the scale variable with a division by the number one instead of the just defined l variable. Simplifying the source code as follows eliminated the problem:

```
double scale = (stage - low_stage) / (high_stage - low_stage);
```

There were several other dead stores involving return codes from system operations (e.g., the opening and closing of DSS files or output files). Java was specifically designed so that these types of operations would throw exceptions that the program would have to handle. Unfortunately, the DSS library that the model uses does not appear to throw exceptions, which makes it vital that the program check return values from methods that interact with the system. For example in the following code:

```
// open the interfaces to the dss file
rv = ts.setDSSFileName(lastFile.getAbsolutePath(),true);
rv = pd.setDSSFileName(lastFile.getAbsolutePath(),true);

java.util.Vector paths = new java.util.Vector();

rv = ts.searchDSSCatalog("",paths);
```

The rv variable is set three times in a row and the return values from these methods are never checked. As a result, errors can occur in the program which the user is not informed of. For example, a DSS file can be selected in the file chooser which is not readable by the current user. Selecting the unreadable file triggers an error message from the HEC Data Manager which is echoed to the console and not to the graphical user interface where the user's attention would be. The model should be checking these return values and handling them appropriately.

Incorrect Finalizer. The finalize method defined in MainWindow.java is declared as public. For security reasons the principle is that only the class and derived subclasses should be able to access finalizer methods, thus the method should be declared as protected.

Duplicate code. The runRange method in MainWindow.java has an if-else construct that checks a variable for the same value, negative two, in the if and else statements.

3.5.2.2 Warnings

The source code should be built with the -Xlint command line argument to turn on all recommended warnings. The lint tool will report possible flaws so it might not be necessary to make changes in every instance, but each report should be evaluated and understood to make sure that it is not masking a more serious error. In the Enviro Fish model, the warnings are in a few broad categories:

- Serializeable classes not having a serialVersionUID field
- Potential fall-throughs in switch statements
- Unchecked or unsafe operations

3.5.2.3 Suggested Modifications

The following modifications are suggested to ensure that the software is functioning as intended, to better organize the code for maintenance, and to simplify the code.

Unit Testing. There is no indication that unit testing of the Enviro Fish software code has been performed. If unit tests have not been written for the Enviro Fish model, then this step should be taken. Unit testing involves writing tests for the smallest units of the program, which are classes in Java. Java has mature libraries for writing unit tests; in particular JUnit is an open source industry standard.

Unit testing is considered an essential practice in Java development for several reasons:

- Unit testing ensures that each unit of a program satisfies testing gives increased confidence that the program as a whole is correct.
- Unit testing allows developers to know the anticipated result for a given input. Developers have to work through how their methods will work so that they can make assertions about what the results will be. For example, in order to test a method designed to convert text to upper case the programmer would assert that HELLO would be generated when given hello as an input.
- Unit tests give developers more confidence when modifying their programs. Unit tests provide for what is called regression testing, which ensures that new code generates consistent results.
- Tests are a form of documentation. Unit tests are working and documented examples of how the pieces of a program function.

To facilitate unit testing and improve the overall design of the programming code, the fields and methods related to the model's calculations should be moved into a new class (or several classes) and unit tests should be written for all of the public methods.

Model-View-Controller. Currently, most of the calculations in the Enviro Fish model take place in the MainWindow class which is also responsible for displaying the model's main interface. The model developers should move this logic into its own classes and adopt either a Model-View or Model-View-Controller design which would separate the model's logic from the user interface.

The Model-View-Controller (MVC) design pattern is the dominant methodology for designing programs with user interfaces. The three parts of the design pattern are:

- The Model is part of the program that encapsulates the data and all of the logic (methods, functions) that operates on it.
- The View is the visual representation of the Model which gets input from and delivers output to the user. There can be multiple Views for a particular model. For example, charts and pivot tables can be considered as two different views of a spreadsheet matrix.
- The Controller coordinates exchanges between the Model and the View.

Computational Precision. The computational precision of the model is much greater than the accuracy of the input data (daily stage data or the elevation-area curves). The user's manual should state that the data accuracy should be the same for all alternatives for both land use and stage data. The accuracy of topographic and daily stage data each have similar impact on the accuracy of the results.

There are many places throughout the code where floating-point numbers are divided by integers. It would be preferable to go through the code and ensure that floating-point operations are done consistently on floating-point values. In addition, there should be some checks for the special floating-point values that in Java: NaN (not a number), POSITIVE_INFINITY and NEGATIVE_INFINITY.

Template engine. The Enviro Fish code could be made more compact and flexible by using a template engine to separate the model computations from the format of the output. The logic behind using a template engine is similar to using the MVC design pattern for the graphical user interface; separating the model and view makes each component easier to work with.

The MainWindow class currently has approximately 140 lines of code where output buffers are handled for generating the reports. The majority of this code could be moved out of the Java classes and into template files. There would be two immediate benefits to the separation:

- A change in the structure of the output no longer requires the modification or re-compilation of the code.
- A variety of templates can be generated which present different views of the same data. For example, if the template was marked up with HTML tags then the same program would generate output suitable for the web (or for directly importing into Excel).

Comments. Documentation is a time consuming but essential part of any project. The code does have comments, but adding more documentation to the different methods would be very helpful. Comments should explain what the code is doing it and what the programmer's intentions were. Java has documentation standard called JavaDoc that allows API documentation to be generated automatically from Java source code. Adhering to that standard would allow documentation to be generated in a variety of formats.

Object Orientation. There are several places throughout the program where code is repeated with an identical structure differentiated only in name. For example, the following variables are used by the program to keep track of spawning:

```
private HecDoubleArray yearSpawningArea;
private HecDoubleArray yearMaxSpawningArea;
private HecDoubleArray yearMinSpawningArea;
private HecDoubleArray dailySpawning;
private double sAvg;
private double sMax;
private double sMin;
```

Identical variables are defined for calculating rearing and total habitats, which indicates the

opportunity to simplify the code by creating a new class to encapsulate these fields, and the methods that operate on them. In this instance the class could start with seven fields (yearArea, yearMaxArea, yearMinArea, daily, avg, max and min) and the program could then declare an instance of the class for spawning, rearing and total. Implementing this one class would organize 21 variables into three objects and making the code more concise and maintainable.

There are several other sets of variables that could benefit from being organized into classes including several pairs of minimum/maximum values, and the stageArea and stageData variables.

Idiomatic Java. There are several instances in the model where the code could be simplified by using Java's libraries, using a more object-oriented design, or taking more advantage of the languages control structures.

3.5.3 Review of Model Testing and Validation

Two major aspects of using models such as Enviro Fish is how well has the code been checked to ensure the calculations are done properly (code testing), and how well the model performs in predicting changes in fish reproduction habitat in response to water level fluctuations relative to observed data (model validation). Users and stakeholders often assume the code is correct (i.e., tested) but want to know whether the model has been "validated."

As discussed in the previous section, testing of the model code uncovered several issues. To start, there were few checks on the realism of user-specified inputs. The model will run with non-sensible data inputs, and errors, if generated, are written to the console rather than reported to the user in a file. Input checking should be added to the code to catch unintentional (e.g., typos) and deliberately-incorrect inputs with the intent of minimizing inadvertent user errors. The model reviewers also noted an error in the interpolation scheme, and the non-checking of return codes from system commands (e.g., opening and closing files). As previously mentioned in Section 3.5.2, Review of Programming Accuracy, unit testing should also be implemented to ensure software quality.

The model reviewers did not find any information in the Enviro Fish User's Manual describing validation of the underlying model. If model validation has been performed, then it would be useful to add how the validation was done and provide a summary of the performance of the model (skill assessment). If validation has not been completed then there are two types that could be undertaken:

- Habitat-to-habitat – A comparison of model predictions of changes in habitat area with spatially-referenced field data, or with the output of a more detailed model.

- Habitat versus biology – A comparison of predicted changes in habitat to observed changes in fish reproductive success.

The habitat-to-habitat comparison would involve using data or another model to corroborate the direction and magnitude of predicted changes generated by Enviro Fish. Enviro Fish and a second source of predictions (data or another model) would be run under a known scenario to

determine the degree of agreement in the predicted changes in habitat area. The second source of predictions could be a GIS model that includes hydrology or a hydrodynamics model with bathymetry. Several well-studied locations and species (or guilds) would be identified that had both types of information (i.e., application of Enviro Fish and extensive spatially-detailed data or a spatially-explicit modeling). If the spatially-detailed data were available, then Enviro Fish would need to be set up using these same data to ensure comparability. Similarly, if a spatially-explicit model was available, then Enviro Fish would be configured and inputs estimated using the same data and information that went into the other model. Then several scenarios could be run with both, and their predicted changes in habitat calibrated so that both are predicting the habitat in the same units and at the same temporal and spatial scales (i.e., same level of aggregation).

The habitat versus biology comparison is more difficult to perform than the habitat-to-habitat comparison because the observed biological data includes the effects of many other variables not included in Enviro Fish. High quality biological datasets would need to be identified first, and then Enviro Fish would be applied to those species and locations. Expectations for agreement would be lower for a habitat versus biology comparison than for a habitat-to-habitat comparison because of the effects of environmental variables not considered, and even agreement at the level of direction of change in the habitat versus biology comparisons would be considered as supporting the underlying model of Enviro Fish. Both types of comparisons will greatly enhance the usefulness of Enviro Fish and help in the proper interpretation of its predictions. Although the reviewers believe that Enviro Fish is a reasonable or useful tool for planning purposes, making these comparisons would increase the accuracy of Enviro Fish prediction and users would accept the results with greater confidence.

3.6 Usability

The model usability assessment was based on an assessment of the criteria described in Section 1.2. The assessment was based on a review of the Enviro Fish Version 1.0 User's Manual and software provided by USACE. Model usability was assessed based on data availability, how easily results are interpreted and understood, and how well the model documentation supports and explains the model. The results of the model reviewers' assessment are summarized in the following sections.

3.6.1 Review of Data Availability

There are two types of data that need to be available for the application of Enviro Fish for planning purposes: data for input to the Enviro Fish model to calculate ADFAs and data for calculating HUs and AAHUs for the HEP analysis. The specific analytical requirements are discussed in Section 3.5.3 of this report. Each of these data must be measured, retrieved from other sources, or developed specifically for a project. The section titled "Selecting habitat suitability index values" (beginning on page 2-5 of the Enviro Fish User's Manual) discusses default HSI values and the assumptions on the use of these default values. The constraints for fish spawning and rearing are similar to the HSI data in that the biological requirements, as they relate to flooding depths and durations, must be quantified.

One of the strengths of Enviro Fish is its ability to generate reasonable outputs for a variety of biological organization levels, from entire fish communities (very general outputs) to guilds

(intermediate outputs) to single species(very specific outputs). Appropriate data on spawning and rearing requirements are usually available in the scientific literature for a small subset of species potentially affected by a proposed project. Data for community and guild analyses can be extrapolated from the results obtained for a subset of representative species that are analyzed using Enviro Fish. For example, life history strategies can be used to group similar species, and then the results for a representative species within the group be used to infer how the suite of species might respond. Analyses designed to be truly species-specific should use data unique to that species; rarely are comprehensive data available at the species-level. Basic ecological information for many threatened and endangered fish species is also very limited, and the situation is not much better for invasive species, or even for many recreationally harvested species. Often times extrapolating from "surrogate" species (i.e., closely related species) to the species of interest, for which some data are available, is necessary. The challenge to model users then becomes not necessarily the availability of sufficient biological data to run the model, but rather the quality of the data and how well the species with the data represents the species of interest.

Much of the remaining data, which relates to land use and hydrology, can be developed for the project using standard approaches. Topographic data can be downloaded as DEMs (Digital Elevation Models) from USGS websites; however, the accuracy of USGS DEMs may not be adequate for an Enviro Fish analysis because elevation in USGS DEMs is often accurate only to the nearest meter. More accurate topographic data may be obtained using LIDAR, photogrammetric, and GPS survey techniques because the accuracy is specified as part of the data collection. With each of these methods, within limits, the precision of the extracted data can be specified. Aerial photography for current conditions can be obtained for the project or recent photography can be downloaded from internet sites (e.g., Terra Server, Google Earth). If comparisons need to be made with historic land use conditions, historic aerial photography can be ordered from the USGS Earth Resources Observation and Science (EROS) Center or from the Farm Service Agency. Historic Aerial Photography may also be available within the USACE from the development of river atlases for major waterways.

Hydraulic models will usually need to be developed for the project in order to obtain accurate water surface elevations. The only case when a hydraulic model is not required would be when the project is in the proximity of a USGS gage. The hydraulic models will be needed to determine flooding impacts and benefits of the project and will be well-suited for providing input to the Enviro Fish model. There are often other hydraulic models in existence for other USACE projects or from FEMA flood insurance studies that can be used for an Enviro Fish model.

Depending on the location of the project, hydrologic data may be either readily available or extremely difficult to develop. For large river systems, the daily flow records may be easily downloaded from USGS or USACE gages. These data may be available for a record of many decades. These data will also be available for many smaller river systems. If the project site is very close to a gage, then the daily stage record may be used directly. For other sites the daily flow record will need to be transformed to a daily stage record using a hydraulic model. One difficulty is a project site where no USGS or USACE gage is available and the daily flow record does not exist. In these cases, the daily flow record will need to be generated using gage data from a similar contributing basin and making appropriate adjustments to the data.

A difficulty that applies to all of the data used to derive model input values is adjusting for future conditions. Future conditions may be affected by several factors including changing climate, land-use, topography, and even the land-use quality (as expressed by the HSI value) of an aging land-use type over time. Because the available data for make projections is limited, the future is unknown and unpredictable. Projections are only as good as the data available for making projections. Guidance must be provided in the user's manual on developing future conditions including sensitivity analysis and uncertainty.

A large number of computer runs must be performed for a complete Enviro Fish analysis. This is because the program must be run separately for each alternative daily stage record with each elevation-area curve. This issue is the topic of FPCs #5, 28 and 29. Anything that can be done to make the software more efficient would be welcome to the user, improving the availability of output data to be used for the HEP analysis. Greater efficiency could be achieved by allowing the user to select a flow alternative to be run with a group of area-elevation curves (or an area-elevation curve to be run with a group of flow alternatives).

3.6.2 Review of Results

Enviro Fish is a general model that is appropriate for many situations and generates useful results for evaluating the effects of water level fluctuations on potential fish reproductive success in floodplains. The model is constructed in a very clever way to allow for its applications to many locations and fish species. Enviro Fish is designed to be general so that the user can define the land use types. It also allows for "nests" (i.e., spawning areas) to be evaluated over their natural time duration and permits selection among several options for limiting useable habitat based on water depth constraints. The data needed to estimate model inputs (elevation-area relationships by land use type, time series of water levels) are readily available in many situations. Thus, Enviro Fish was developed so that it could be used to quantify habitat area changes for many situations. Enviro Fish is well-designed in terms of the balance between wide applicability while, at the same time, representing the hydraulics and fish reproduction on reasonably realistic biological, temporal, and spatial scales. Enviro Fish does this and generates useful output variables (i.e., habitat area) for evaluating the effects of water levels on fish reproductive success in floodplains.

Enviro Fish produces output that is well grounded in habitat suitability theory and well-suited for HEP. Both daily and annual values of habitat area are generated for each land use type within each scenario. Such output is easy to explain to people, compact, and therefore easy to interpret and compare among alternative scenarios. Changes in habitat area as a result of different water level scenarios are useful for comparing among alternative projects and for evaluating compensatory mitigation options.

However, there are several aspects of the current version of Enviro Fish related to the generation of results that, if addressed, would increase the model's usefulness. These include more clearly stating the objectives, modifying the existing output files, providing guidance on the development of HSI values, providing simple examples of model calculations to increase transparency, generating additional outputs to allow for better understanding of model results,

providing more guidance on preparing model inputs, and changing the model code to allow for easier sensitivity analyses. Each is discussed in detail below.

First, the objective of the Enviro Fish model should be more clearly stated and expanded in the users' manual. Stating the objective very clearly is important for setting the stage for why the model was constructed and why certain key assumptions were made, and provides context for why the results (outputs) are generated and how to properly interpret them (FPC #13). This is especially important for new users so they use the model appropriately (i.e., as it was intended and designed for), and so that a general audience can best interpret the results.

Second, several modifications to the output files themselves would increase the usability of the results. The output should be labeled with units of measure (FPC #19), and how the user should use the output files to actually compute the final metric of HUs should be clarified (FPC #30). Why Enviro Fish has an HSI function as part of code is not clear, as the HSI is not used; the user applies an HSI as part of post-processing of the output files. However, the results would provide the user with the desired endpoint if the model actually calculated HUs and AAHUs (using the HSI values) rather than simply generating the area values to be used for calculating HUs and AAHUs. Also, the implication that the default HSI values (with vague documentation) should be used to compute HUs (FPC #2) may lead to flawed conclusions as to the overall project impacts.

Third, the usefulness of the model results can be increased by making the model calculations more transparent and by adding a way to partition the relative contributions of the different depth-related constraints to computed areas (FPC #21). The user's manual provides a good description of the model and calculations, but it is unlikely that most users can reproduce the calculations outside of Enviro Fish with the exception of very experienced users or for a few simple cases (part 1 of FPC #21). In general, the more transparent the calculations, the more comfortable users and the general audience are with the generated results. Transparency also results in users and stakeholders properly interpreting model results. Adding an appendix to the user's manual that actually shows the calculations for a limited number of land use types and for a short time period (i.e., a very simplified situation) would increase the transparency of Enviro Fish.

Similarly, understanding why the computed habitat areas differ among scenarios would also lead to increased transparency and better interpretation of model results (part 2 of FPC #21). Presently, Enviro Fish only generates habitat areas in the output files. It is not possible to determine the relative contributions to habitat areas of minimum depth, maximum depth, deep nest option, and shallow nest option based on the output. Knowing which of these is most limiting to habitat can be especially useful when comparing alternative scenarios. It was not obvious to the model reviewers that such calculations are possible in Enviro Fish. If determining the relative contribution of different constraints is possible, then it should be added to the output. If not, and it may well not be possible to do as part of the calculations, then the code should be modified to allow easy sensitivity analysis using multiple runs. Sensitivity analysis can be used to explore how different values of model inputs (e.g., maximum depth; deep nest option on or off) affect the computed habitat areas.

Fourth, model results would be more useful if their uncertainty and sensitivity to the various inputs were easily quantified. Enviro Fish generates point estimates of area (i.e., without any estimate of variability, such as standard errors). The sensitivity of the model results is driven by the precision and accuracy of the input data (FPC #15). This applies to how the floodplain is subdivided; the definitions and identification of land use types; estimation of elevation-area relationships; assumptions about spawning period, development period, and depth constraints; and post-processing of output using HSI relationships. Presently, little guidance is provided in the user's manual on how best to prepare these model inputs to ensure sufficient accuracy and precision so that one knows how to compare the results among scenarios (i.e., what differences in the point estimates are biologically meaningful). In ecological and fishery modeling, the state-of-the-art uses a variety of techniques (e.g., error propagation, Monte Carlo) to assign variability estimates to point predictions. At minimum, sensitivity analysis is practically a requirement. Yet, making multiple runs to explore sensitivity and uncertainty is very cumbersome in Enviro Fish due to the code requiring a run for each land use type within each scenario. This affects the usability of the model, including the results, because it discourages exploratory simulations, and can lead to user error in file management and post-processing of the output files (FPC #10).

Presently, the results of the Enviro Fish model can be understood by a wide range of people; however, the current version of Enviro Fish can only be set-up and run by experts (FPC #14). Balancing a model code to be general and flexible on one hand and user-friendly on the other hand is always a major challenge. Generality and flexibility means much of input preparation is the responsibility of the user, and model runs must be kept simple in scope. The more user-friendly the interface, the easier it is to use the code, but at the cost of generality and flexibility. Interpretation of model results can be enhanced with: (a) more specific statement of objectives in the user's manual, (b) better labeling of output files, (c) increased transparency by adding example calculations to the user's manual and by providing information on which depth constraints cause the changes in computed habitat areas, (d) guidance on preparing model inputs to ensure adequate accuracy and precision of results, and (e) modifications to the code to make sensitivity and uncertainty analyses easier.

3.6.3 Review of Documentation

Documentation for Enviro Fish should involve explanations of the technical aspects for using the computer code, conceptual information on the ecological processes that are relevant to understanding the model, and a brief overview of contemporary theory relevant to the model. Two audiences would then be served:

Users with an understanding of biology, programming, and engineering, which will be applying the model

Users primarily interested in interpreting the output results.

While the user documentation is well written and provides a good general description of Enviro Fish, it is too limited in describing the model and how to use the code. The documentation should include more information on the relevant biology and guidance on how to prepare model hydrologic and hydraulic data inputs and assess the effects of deviations from key model assumptions. It should also explain how Enviro Fish fits into the bigger picture (i.e., contemporary theory) of assessing flow effects on fish reproduction. This is where case studies,

published example applications, an expanded bibliography, and reports of actual assessments that used Enviro Fish would be very helpful.

Changes to the user's manual helpful to a general audience

The model reviewers believe a stronger Introduction to the user's manual is important to overall understanding and, therefore, effective use of the model. The objective of Enviro Fish, as stated in the user's manual (page 1-2), comes across to the reader as a planning tool which models fish spawning and rearing and is available to a wide constituency. The inadequacies of this statement set the stage for confusion on its scope, on why it is useful to the intended user audience, and what the possible products are. Therefore, the objective of Enviro Fish should more clearly and succinctly state why Enviro Fish was developed, and include the purpose, products, and the intended audience. Otherwise, uncertainty exists, especially on the part of the potential users.

The model reviewers suggest a more inclusive and informative objective statement such as: "The objective of Enviro Fish, a modeling approach and computer software, is to facilitate planning for large-river civil projects by predicting changes in the value of spawning and rearing habitat for floodplain fishes from current to projected future conditions for various project alternatives, in a manner understandable to a diverse constituency." An objective statement of this type is needed to more clearly state the intent and usefulness of Enviro Fish by initially addressing several key issues: that the model is a tool for planning, it predicts opportunities for spawning and rearing fishes to compare present conditions and alternative possibilities, and is intended to be used by a diverse constituency of interested parties and decision makers (FPC #13). The model reviewers suggest that it be made very clear throughout the user's manual that actual implementation of Enviro Fish is best done by a team of experts working together. This is stated in some places in the user's manual but is not consistent with the text in the user's manual in other places that implies Enviro Fish can be "used" by a wide audience.

Once the Objective is more clearly stated, other elements of Chapter 1 should be modified. The Background section should provide more information on why the model was developed. As it stands, it provides background of the model development and how it can be used and also contains some misleading statements. For example, the user's manual states that the model can "predict a quantitative response of the fish assemblage." This can be misunderstood by users, especially those not familiar with habitat suitability theory. The Background section might include ecological information on the importance of floodplain habitats to the river system, and if some projects require modification or elimination of these habitats, then Enviro Fish will assist in planning for mitigation or compensation. The Background section should also provide a brief overview of where Enviro Fish fits in terms of available methods (contemporary theory) for assessing water level effects on floodplain fish reproduction. For example, the issues of multiple factors affecting fish reproduction, connectivity, and life-stage specifics versus higher order (population, community) responses provide an important context for properly selecting and interpreting Enviro Fish. The Method section would be more useful if the series of numbered "bullets" were expanded into a narrative, succinctly explaining the function and the integration of biological and physical information – perhaps referring to Figure 2-1. The Scope section should be expanded and should contain information on model usefulness, strengths, limitations, generality, and assumptions

Chapter 2 also offers many possibilities to increase the overall understanding and usability of Enviro Fish. Because the intended audience (at least for the results) is diverse, a more complete description of individual fish species and guild requirements or preferences for particular variables needs to be included or referenced in the user's manual. A compendium in table form for species and guilds (using Tables 2-2 and 2-3 as a basis) that includes land-use habitat preference, preferred spawning substrates, spawning temperatures, depths for eggs, depths for larvae, and egg incubation time would be useful. At minimum, key sources for this type of information need to be listed. Discussion about Enviro Fish and how it should be applied to recreationally important, threatened and endangered, and invasive species is also needed.

Such additions to the user's manual would make model input choices more understandable to users and stakeholders. Choices on representative species should not simply be left to the biologists. Such information would allow model runs that could point out tradeoffs necessary to promote or deter various species.

While user documentation is fairly complete in terms of running the model, it would be easier for some model users to use if the model did not stop where the output had to be transferred to a spreadsheet by the user in order to develop graphs and tables. Because post-processing is required, the user's manual should provide more information on to properly post-process files.

Changes to the user's manual useful to technical users

To summarize what has been discussed in previous sections of this report, the documentation should go into more detail on how the user should develop the necessary topographic, land use, hydrologic, and hydraulic data (FPC #4). GIS technicians, hydrologists, and hydraulics engineers should be able to generate this information, but there needs to be more guidance on how to do this in a way that results in high quality input data going into Enviro Fish.

Several topics should be discussed in greater detail. These include: (a) more clearly defining the Functional Floodplain, (b) guidance on determining the Functional Floodplain, (c) a better description of the purpose for capping the (limiting) Functional Habitat Area, including examples (distance, barriers, etc.), (d) expansion on the importance of Flowlines, including horizontal versus nearly parallel flow lines (FPC #3).

Documentation of analytical requirements of the model is uneven. Chapter 3 provides sufficient descriptions of the land-use, topographic, and daily stage data, and Chapter 4 provides sufficient descriptions about the input decisions related to depth constraints made by the user that controls the runs. It is reasonably clear what the model is computing; however, an example set of calculations (perhaps in an appendix) would be helpful. It is much less clear how to prepare the data for input to the model to ensure useable results with sufficient certainty are generated.

The model and documentation that is presented is reasonable. However, what is missing presents issues. Missing information includes: (a) background information on habitat suitability and contemporary theory, (b) guidance on implementation (including how closely assumptions need to be met), (c) example detailed calculations, (d) examples of applications to provide a

context and a basis for practical guidance, and (e) examples of validation. Of particular importance to the usability and proper interpretation of Enviro Fish is:

The need for more guidance on preparing model inputs

How to assess if major assumptions are sufficiently met

The consequences of different degrees of violation of the assumptions

Documentation of the Code

The introduction of the User Guide states that "Enviro Fish is a Java computer program facilitating the application of the modeling approach," but no rationale is specifically stated for why Java was chosen as the implementation language.

Documentation of a computer code is a time consuming but essential part of any project. The Enviro Fish code would benefit from more comments explaining how the program is structured and how the logic of each section is intended to work (FPC #25). Currently anyone trying to understand the logic of the program has to go line-by-line through the code and infer what the purpose of each section is. For example, this comment was helpful in understanding the purpose of a loop:

```
//DAY_INCREMENT = 3 minutes, so multiply by 480 so that its one day
for(int a = 0; a < (Integer.parseInt(jDurField.getText()) * 480); a++)
  stopTime.add(HecTime.DAY_INCREMENT);
```

In contrast, this comment added very little explanation:

```
//close the file
ts.close();
```

Java has documentation standard called JavaDoc that allows API documentation to be generated automatically from Java source code. Adhering to that standard would allow documentation to be generated in a variety of formats.

3.7 Model Assessment Summary

A review of the technical quality, system quality, and usability of the Enviro Fish model determined that the model and approach are generally appropriate for the intended purpose of evaluating alternatives for planning projects, but some improvements and corrections to the model code and augmented documentation to guide the user in model development and application is needed. In addressing and answering charge questions designed to focus the review of Enviro Fish based on the model assessment criteria in the USACE *Protocols for Certification of Planning Models*, the following underlying issues were identified:

1. Documentation on the Enviro Fish model's intended use, scientific basis, approach, limitations and assumptions, and outputs is limited (FPC #3 - 5 and #12 - 20).
2. A process for the development of HSIs has not been provided (FPC #2).

3. The current software does not directly apply HEP and only models areas (ADFA) that can be used in HEP analysis to determine HUs based on habitat/land use acreage and habitat suitability for fish spawning and rearing in floodplains (FPC #1).
4. It is not clear whether code testing and model validation have been performed (FPC #8 and #9), and errors and issues were identified in the code that need to be addressed (FPC #6 and #7).
5. The current version of the Enviro Fish software is cumbersome to use and could be made more user friendly by adding labels to the model's inputs and outputs, returning to the project directory after each run, making the software compatible with the current version of the USACE's HEC-DSSVue utility, changing how constraints are selected, and making the software more flexible to facilitate accomplishing multiple runs at a time (FPC #10, #11, #22, #28 - 31).
6. The model transparency is reduced because the outputs are not partitioned by the relative contributions of the different limiting factors (minimum and maximum water elevations, deep and shallow nests) to habitat area in the model output, and no examples of model runs are provided in the user's manual (FPC #14 and #21).
7. The model code is unnecessarily complex (FPC #23 – 27).

These issues affect the ability of users to apply the model and the ability of users, reviewers, and readers to fully understand the scientific basis and logic of the model; how model outputs are linked to on-the-ground changes in fish reproductive habitat; the ability of the model to evaluate changes in fish reproductive habitat for project life; and the ability to perform uncertainty and sensitivity analysis associated with each of the alternatives evaluated. The core aspects of the hydrology and biology of Enviro Fish model are sound and defensible for situations when sufficient data and information on land use, water stage, elevation-area relationships, and reproductive biology of representative species and taxa are available. Many of the issues identified by the model reviewers are the direct result of limited documentation to support the method and the model.

4.0 CONCLUSIONS

Overall, the model reviewers agreed that the Enviro Fish model and approach is appropriate for the intended purpose of evaluating alternatives for planning projects that affect fish reproduction on floodplains. However, there were some errors and issues with the software code, issues identified with the model's documentation, potential difficulties in applying HEP to model results, cumbersome user interface, and limited transparency in model results. In order to improve the usability of the Enviro Fish model and, consequently, the ability of the Enviro Fish to meet the model's objective of evaluating changes in floodplain fish reproductive habitat from implementation of various project alternatives, the model review panel recommends the following actions:

1. Provide a clearer explanation of the model objectives (FPC #13 and 14).
2. Provide a brief description in the user's manual of how the Enviro Fish model fits with contemporary theory (FPC #18 and #20).

3. Develop a process that allows repeatable, documented HSI values to be assigned (FPC #2).
4. Provide a more detailed explanation of the model assumptions and limitations (FPC #5, #12).
5. Provide a more clear definition of what constitutes functional floodplain and what biologists should consider when they are delineating these areas (FPC #3).
6. Provide a discussion of code testing and model validation (FPC #8 and #9).
7. Provide guidance on the data requirements, how to prepare the data for input, the required data sensitivity and precision, and the specific roles of the multidisciplinary team (FPC #4, #14, #16, and #17).
8. Provide guidance on how the user could use the output files to actually compute the final metric of HUs (FPC #30) or revise the model to calculate HUs and AAHUs (FPC #1 and #5).
9. Make the software more user friendly by adding labels to the model's inputs and outputs, returning to the project directory, making the software compatible with the current version of the USACE's HEC-DSSVue utility, changing how constraints are applied in the user interface, and making the software more flexible to facilitate accomplishing multiple runs at a time (FPC #10, #11, #14, #15, #19, #21, #22, and #28 - #31).
10. Fix errors and issues in the programming code (FPC #6) and build additional error checks and warning into the model (FPC #7).
11. Improve model transparency by providing additional model outputs that allow the determination of the different limiting factors (minimum and maximum water elevations, deep and shallow nests) to habitat area in the model output and including an example model run in an appendix to the user's manual (FPC #14 and #21).
12. Simplify the code by removing redundancies, better organizing the code and separating it by logic classes, separating computations from the output format, providing additional comments, and using Java's libraries (FPC #23 – 27).

This list of actions summarizes the recommendations for resolution in the FPCs, and more specific detailed recommendations are provided in the FPCs in Appendix B of this report. Failure to address the issues identified may lead to incorrect interpretation or use of Enviro Fish model and outputs. The current version of Enviro Fish can only be set-up and run by experts. The generality and flexibility in the model leave the user responsible for much of the input preparation. Therefore, guidance on the preparation of model input is necessary for its proper use and, ultimately, proper interpretation of the meaning of model outputs by a larger user audience. Interpretation of model results can also be enhanced with: (a) a more specific statement of objectives in the user's manual, (b) better labeling of output files, (c) increased transparency by adding example calculations to the user's manual and by providing information on which depth constraints cause the changes in computed habitat areas, (d) guidance on preparing model inputs to ensure adequate accuracy and precision of results, and (e) modifications to the code to make sensitivity and uncertainty analyses easier.

Many of the issues identified by the model review panel stemmed from limited documentation of the model. The theoretical and scientific bases were not well-documented, and no guidance was provided on how to develop the input data, making a review of the technical quality of the model difficult. The flow of the calculations in the code also was not well-documented, making it difficult to follow the logic of the model code. The model reviewers also strongly suggest simplifying further development of the documentation of the code for easier maintenance of the model software and comprehension of the various functions. Making the recommended revisions will allow better comprehension of the scientific basis and logic behind the model and better comprehension of the model results, promote model transparency, and allow uncertainty and sensitivity analysis to be performed. The model will also be better able to achieve its intended purpose. This is critical for supporting the selection of project alternatives based on model results.

At a minimum, an interpolation error identified in the code needs to be addressed in order for the model software to produce the correct output. The model should not be used until this error is repaired. Once this error in the code is addressed, the model reviewers support immediate conditional use of the model only if the following criteria are met:

1. The HSI values used are defensible and developed specifically to represent the habitats being assessed in the project area.
2. The model developers are the ones who will be running the model.
3. The model users coordinate with the appropriate local experts (biologists and hydraulic engineers).

The model reviewers strongly recommend addressing the remaining review comments before the model is certified for widespread use. The model reviewers concur with some of the USACE model developers responses to the Final Panel Comments that assert some of the issues do not need to be addressed for widespread use of the model, although the model reviewers think adopting the suggested resolutions would be desirable to improve model usability. However, there are other Final Panel Comments that need to be addressed, for example, by adopting the suggested changes to the documentation or model code, before allowing widespread use of the model. The details of USACE responses to the Final Panel Comments and the model reviewers' responses to those comments are provided in a memo submitted with this final report on March 5, 2010. The model reviewers highly recommend the changes recommended in the memo be made as soon as possible in order to allow more widespread use of this useful planning tool.

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Appendix A

Biographic Information for Model Peer Review Panel Experts

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Civil Works Planner/HEP Specialist - Richard Stiehl

Dr. Stiehl earned his Ph.D in environmental science/biology from Portland State University in 1978 and has over 25 years of experience with Habitat Evaluation Procedures (HEP), wildlife biology, avian ecology, and habitat and community modeling. He is currently an independent consultant. He completed his original HEP training in 1981, and the U.S. Fish and Wildlife Service (USFWS_ invited him to write several sections and be the chief editor of the new (and still in use) USFWS HEP Manual. To date, Dr. Stiehl has taught over 30 certified HEP workshops. Other work with USFWS has included revising and/or writing all HEP manuals, rewriting HEP and Habitat Suitability Index (HSI) software, and conducting wildlife research. He has provided HEP expertise to 20 states and many federal agencies, including the USACE, Bureau of Land Management, Natural Resources Conservation Service, and U.S. Environmental Protection Agency, and has led HEP teams on large projects, including HEP analyses for shorebird habitat and the impacts of weapons training for the U.S. Air Force in Utah. After leaving USFWS, he continued his HEP leadership role as a private consultant, constructing community HSI models for riparian, desert, and desert wetland habitats. He has developed software to evaluate long-term impacts to desert ecosystems for the Washington Department of Wildlife and the Columbia Basin Fish and Wildlife Agency. Other high profile HEP projects include consulting with General Electric for Upper Hudson River PCB contamination, New York State for post-9/11 communications network evaluation, and the Theodore Roosevelt Conservation Trust for impacts in central Wyoming gas/oil field development. His experience in the Lower Mississippi River Valley includes his being an assistant and associate professor of biology at Southeast Missouri State University (Cape Girardeau, MO) for ten years and conducting extensive fieldwork in southeastern Missouri on fish and bird populations. Dr. Stiehl also has experience conducting restoration and mitigation analyses for USFWS and tribal lands.

Fishery Biologist - Charles Rabeni

Dr. Rabeni received his Ph.D. in zoology from the University of Maine in 1977 and has over 30 years of professional experience as a fishery biologist. He served as the Leader of the Missouri Cooperative Fish and Wildlife Research Unit from 1985-2008, where he was responsible for administering and conducting research and graduate teaching programs related to natural resource issues involving state and federal stakeholders. Throughout his career, Dr. Rabeni has worked on 50 projects directly related to fishes and their habitats in the lower Missouri/Mississippi River Valley. He has authored or co-authored over 100 papers in peer-reviewed scientific journals, as well as contributing chapters to a number of text books largely focused on fish-habitat relations and habitat analysis. Dr. Rabeni has instructed graduate students on habitat analysis, including HEP and in-stream flow analysis for over 30 years. Dr. Rabeni has had major collaborations with hydrologic and hydraulic modelers, including the development of a hydraulic and process oriented model for classifying aquatic habitat in Ozark streams. Most recently, Dr. Rabeni's research group completed a project, also in collaboration with a USGS hydrologist, to develop a habitat model for spawning river fishes utilizing information on spring flow rates. He has experience in floodplain management demonstrated by his graduate level teaching of watershed management and in some of his written work. He is currently a reviewer of Fish Habitat Evaluation and Habitat Improvement Projects for the Chicago Area Waterways System/Metropolitan Water Reclamation District of Greater Chicago. For the past six years he has served on the national Ecological Processes and Effects Committee

of the EPA's Science Advisory Board charged with evaluating various EPA programs and presenting scientific and technical recommendations directly to the Administrator of the EPA. Dr. Rabeni has worked with the National Park Service (Midwest Region) on numerous issues involving aquatic monitoring and assessment projects, including the Prairie Cluster Park and Heartland Park networks. He served on an expert panel for the USGS's Grand Canyon Monitoring and Research Center to evaluate the existing biological program for the Colorado River. Dr. Rabeni has also been invited to participate in several international joint research efforts and consultations, including as an invited consultant to the China Academy of Sciences to evaluate biological effects of the Three Gorges Dam on the biota of the Yangtze River.

Fishery Biologist - Kenneth Rose

Dr. Rose is the E.L. Abraham Distinguished Professor in Louisiana Environmental Studies at the Department of Oceanography and Coastal Sciences of Louisiana State University. Dr. Rose received his Ph.D. in fisheries science from the University of Washington in 1985, and has been conducting fisheries research at LSU for over 11 years. Dr. Rose has been involved with several projects on the fish and shellfish associated with marsh habitat in the lower part of the Mississippi River Valley. These include modeling the population dynamics of brown shrimp on a 500 x 500 spatial grid configured to represent marsh types. He is currently working on a similar type of model that will represent fish community dynamics (e.g., Gulf killifish, grass shrimp, bay anchovy, silverside, and blue crab) on marshes subjected to fluctuating water levels, as well as a project modeling the responses of the freshwater riverine fish community downstream from the Caernarvon River Diversion in Breton Sound that alters the salinity, water depths, and food productivity. Dr. Rose served as an author on a type of HEP analysis (a summed Habitat Suitability Index approach) used to evaluate how restoration scenarios would affect the habitat for a variety of species endemic to coastal Louisiana. He has been involved with several projects utilizing Habitat Suitability approaches to assess flow fluctuations on fish reproduction, recovery potential of the Moapa dace, and evaluation of large-scale restoration activities for coastal Louisiana. He has regularly collaborated with modelers working to develop 1-D, 2-D, and 3-D hydrodynamics and water quality models, including the Regional Oceanographic Modeling System (ROMS), a widely-used hydrodynamics code, as well as a 3-D water quality model of Chesapeake Bay. He has served as a member of the review panel for the state of California for the Delta Risk Management Study, which focused on events that would cause floodplain flooding due to levee failure. His specific role for that project was to determine how such flooding would affect fish. Dr. Rose currently is a member of the Ecosystem Management Science and Statistical Committee for the Gulf of Mexico Fisheries Management Council. He is a fellow of the American Association for the Advancement of Science and serves as an associate editor for Transactions of the American Fisheries Society, Ecological Applications, Environmetrics, and Canadian Journal of Fisheries and Aquatic Sciences, Marine and Coastal Fisheries, among others.

Hydraulic Engineer - Lyle Zevenbergen

Dr. Zevenbergen earned a Ph.D. in earth science from the University of London in 1989 and has 22 years of experience as a hydraulic engineer. He is a registered professional engineer in six states (AZ, CO, GA, NH, NM, and SC) and is currently the manager of the river engineering department at Ayres Associates, Inc. in Fort Collins, Colorado. While at Ayers, Dr.

Zevenbergen has been responsible for projects requiring computer modeling of hydraulics, hydrology, scour, erosion, and sediment transport. Dr. Zevenbergen combines mathematical modeling and programming skills with in-depth knowledge of fluid mechanics and channel dynamics. His modeling experience includes 1-D and 2-D hydraulic models (WSPRO, HEC-2, HEC-RAS, UNET, FESWMS-2DH, RMA-2V), 1-D and 2-D sediment transport models (HEC-6, HEC2-SR, STUDH), and hydrology models (HEC-1, MULTSED). Dr. Zevenbergen has been involved in numerous floodplain hydrology analyses. For a project with USACE Omaha District, he used the DAMBRK model to simulate a hypothetical failure of Denver's Westerly Creek and Kelly Road dams during a Probable Maximum Flood. Dr. Zevenbergen checked the accuracy of dynamic routing by comparing results of HEC-1 storage routing for a no-failure scenario. The project also required the development of split flow rating curves, use of lateral outflow and inflow options, and utilizing the iterative solution technique. Another project involved Dr. Zevenbergen providing technical oversight of the steady and unsteady hydraulic modeling for the Nassau River Floodplain Study for the USACE Jacksonville District. The project was a floodplain study including data reconnaissance, model development, model calibration, and hydrologic and hydraulic simulation of Nassau River Basin using HEC-HMS, UNET, and HEC-RAS. The Albuquerque Metropolitan Arroyo Flood Control Authority in New Mexico had Dr. Zevenbergen supervising the analysis and design processes related to sediment transport, short-term erosion potential, long-term arroyo shifting, and countermeasure design on the Tijeras Arroyo. This project included an evaluation of arroyo hydrology and hydraulics using HEC-RAS. Dr. Zevenbergen's experience in conducting ecosystem restoration output evaluation has been on projects related to aquatic habitat for endangered species (silvery minnow on the Rio Grande and Colorado pikeminnow on the Yampa River). For these projects, he used 2-D model results to compute the amount of preferred habitat over a range of flows for existing conditions and a number of restoration alternatives.

Java Programming Expert - Robert Burnham

Mr. Burnham earned an M.A. in urban affairs from Boston University in 1990. He has 20 years of professional experience as a programmer working primarily in a research capacity. For the past 10 years he has been a senior research computing associate at the Tuck School of Business at Dartmouth College, where he co-teaches Programming for Decision Support Systems which teaches students to extend spreadsheet models with programming. He has used Java in a professional capacity since the language became commercially available and is the developer of a widely-used toolkit for conducting sensitivity analysis on spreadsheet models. Mr. Burnham has been the principal programmer on dozens of research projects in all areas of finance, economics and decision science and he has proficiency in economic and statistical analysis as well as computer software engineering. He is a frequent presenter and author on topics relating to statistical programming and has extensive experience building solutions for research and consulting clients. Mr. Burnham maintains TuckPERC, the Tuck Platform for Empirical Research Computing, an Open Source web tool for extracting data from large financial databases in C++, Perl, and Java.

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APPENDIX B

Final Panel Comments

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Final Panel Comments

The following forms include the Final Panel Comments from the review of the Enviro Fish model. These comments reflect the key issues identified during the assessment according to the model certification criteria described in the USACE *Protocols for the Certification of Planning Models*. Each form contains a concise statement of the issue (the comment), the basis of the comment, the significance of the comment, and recommendations for resolution. Significance levels are defined as follows:

High: Describes a fundamental problem with the model(s) that could affect the models' ability to serve their intended purpose

Medium: Affects the completeness or understanding of the model(s), model usability, or the level of performance of the model(s)

Low: Affects the technical quality of the model documentation but will not affect the performance of the model(s).

Final Panel Comments are arranged from High to Low significance, but in no other particular order. The Final Panel Comments are:

1. The model output does not directly calculate Habitat Units (HUs) for a project as presented, but provides the area data needed to complete the HU values needed for a Habitat Evaluation Procedures (HEP) analysis.
2. The development of Habitat Suitability Index (HSI) values is not supported in the documentation.
3. The definition of a functional floodplain needs to be clearly stated.
4. The analytical requirements of the model are identified, but guidance needs to be provided on how to prepare the data for input and the roles of the multidisciplinary team.
5. The limitations on the ability of the model to calculate benefits for project life need to be clearly documented.
6. Errors and issues in the programming code were identified and need to be corrected.
7. Additional error checks and warnings need to be built into the program.
8. Unit testing for the model should be performed if it has not been.
9. Testing of the code and validation of the underlying model needs to be documented.
10. The current model is not a stand-alone product and it is tedious to run for individual or multiple scenarios, rendering it error prone and difficult to use for compensatory mitigation.
11. Checking orphaned nests should apply a constraint, rather than remove a constraint.
12. The assumption that an increase in Habitat Units (HUs) will linearly increase spawning and rearing opportunities is incorrect.
13. The Introduction (Chapter 1) to the Enviro Fish User's Manual should be more informative.
14. While the results of the Enviro Fish model can be understood by a wide range of people, those results can only be generated by experts.

15. The sensitivity of the results is driven by the precision and accuracy of the input data. Unless the precision is known, the sensitivity is unknown.
16. The quality and accuracy of the data required by the model needs to be stated.
17. It needs to be clearly stated that similar input data used for the alternatives analysis should be of the same accuracy and precision.
18. The model is based on well-established habitat suitability theory, but not necessarily contemporary theory.
19. Documentation with the output data should include units of measure.
20. Examples in the fisheries section of the documentation should be expanded to inform decision-makers more about the benefits of the project.
21. The model transparency is limited, and it is difficult to understand why different outputs are generated across scenarios, and this limitation needs to be stated in the documentation.
22. Enviro Fish should be able to work with the current version of DSSVue installed.
23. Model calculations should be moved to either a Model-View or Model-View-Controller design which would separate the model's logic from the user interface.
24. The Enviro Fish code could be made more compact and flexible by using a template engine to separate the model computations from the format of the output.
25. Additional comments should be added to the code to explain what the code is doing and what the programmer's intentions were.
26. There are several instances in the model where the code could be simplified by using Java's libraries, using a more object-oriented design, or taking more advantage of the languages control structures.
27. Java is an object-oriented language, and there are opportunities in the code to define classes that would provide more structure to the code.
28. The Output Path "Browse…" option should default to the last directory that was accessed in a previous run.
29. Output files should not return to the "My Documents" root directory each time the user saves, but should default to the "Output Path" directory.
30. The data for calculating HUs does not stand out in the output.
31. Headers for the two DSS file groups, such as "Daily Stage Data" and "Stage – Elevation Curves," should be included in the main program screen.
32. The term "nests" should be replaced.

Comment 1:
The model output does not directly calculate Habitat Units (HUs) for a project as presented, and only provides the area data needed to calculate the HU values needed for a Habitat Evaluation Procedures (HEP) analysis.
Basis for Comment:
The Enviro Fish model is a sufficiently realistic representation of the area of a system being modeled; however, it provides only one of the data sets needed to complete a HEP analysis for a project area. The model accurately calculates changes in the potential fish spawning and rearing areas affected by the proposed project. The model is presented as calculating HUs, but it does not do any HU calculations within the model. All calculations of HUs must be completed as an additional operation after the Enviro Fish model calculations are completed. To complete a HEP analysis, the user is required to transfer selected Enviro Fish output data into a suitable spreadsheet application, enter HSI values, and input the required mathematical operations for each habitat to be included in the analysis to calculate HUs and Average Annual Habitat Units (AAHUs). The limitation is significant, as the current HSI data input presented in Enviro Fish is arbitrary, and final conversion to determine HUs is poorly documented. Furthermore, HEP is based on accurate information concerning both area quantity (which the model does), and habitat quality (which the model suggests as default values). In order to calculate HUs, the user is required to further analyze data from the model output, and enter HSI values to determine Habitat Units. The model suggests default HSI values, which the reviewers were concerned would lead to "default" results. As HEP considers both area and suitability are of equal value, if an analysis uses a "default" area and accurate HSI, it would be just as incorrect as the Enviro Fish model using accurate area and default suitability.
Significance – High:
As Enviro Fish was developed to provide the area data required in a HEP analysis, the tacit implication is that *default* HSI values can provide representative results. Entry errors associated with data transfer and erroneous mathematical entries may further compound the problems associated with requiring additional data manipulation.
Recommendations for Resolution:
To resolve these concerns, an additional capability should be included in Enviro Fish so that with the input of HSI data, no additional computations outside of Enviro Fish are needed to complete a HEP analysis.

Comment 2:
The development of Habitat Suitability Index (HSI) values is not supported in the documentation.
Basis for Comment:
To complete a HEP analysis, the user is required to separately enter HSI values. Table 2-1 provides "default" HSI values for five habitats common in the Lower Mississippi River Valley. These "default" HSI values were obtained primarily using the Delphi Technique, where subjective judgments of fair, good, very good, etc., were translated into scores from 0 to 1.0 in 0.1 intervals. Additionally, the fisheries literature and professional judgment were used to establish the "default" HSIs. As judgment cannot be quantified precisely, published references comprise the only objective input into the development of the HSIs. This potential subjectivity of HSI values is problematic as the subjective selection of habitat suitability values affects any conclusion that might be drawn from the output data provided by the Enviro Fish Model. The HSI's developed from expert opinion were always considered by the original USFWS developers as interim measures, even while they promoted the Delphi technique. The HSI's developed from expert opinion require field sampling, preferably at the location of the project. An accurate HSI is truly valuable, and should be developed on a project-specific basis. The importance of accurate HSI values is underestimated, as the model suggests a suite of default HSI values. The use of default values undermines the evaluation process demanded by HEP. There is scant documentation concerning the development of the values presented in Table 2-1 (pg. 2-5). The model would benefit from using HSIs based on actual biological and habitat data, instead of just estimating habitat potential, assigning meaning to the real differences between HSI values (i.e., what an HSI of 0.1 means for fish habitat versus and HSI of 0.5), especially for large projects.
Significance – High:
Because users will apply default HSI values without field verification, the ability of the model to yield accurate comparable HEP results is diminished.
Recommendations for Resolution:
Develop a process that allows repeatable, documented HSI values to be assigned. Additionally, another step in the program should be developed that allows direct input of HSI data, allowing model results to converted to HUs within the Enviro Fish code.

Comment 3:
The definition of a functional floodplain needs to be more clearly stated.
Basis for Comment:
In the Enviro Fish User's Manual page 2-3, Section "Delineating the boundaries of the functional floodplain," the only definition for functional floodplain is: "In an EnviroFish analysis, functional floodplain refers to inundated areas available for fishes to use in spawning and rearing." Another suggestion contained in this section is: "At this time, the elevation-area table in DSS must be revised to cap the functional habitat area." Delineating functional floodplain is at the core of the Enviro Fish method. Therefore, the user's manual should provide more complete discussion on what constitutes functional floodplain and what biologists should consider when they are delineating these areas. Without clear direction, a hydrologist or hydraulic engineer may apply a very different definition of functional floodplain than the biologist. Similarly, a biologists needs input from the hydrologists to properly define a functional floodplain. From the discussion, it appears that the starting point may be the 2-year floodplain, although there could be many other factors that limit the functional floodplain. These include barriers, proximity to the river (even the 2-year flood may inundate areas remote from the river), flow velocity (some floodplain areas may convey water at velocities too high for spawning). There may be other considerations, as well. The topic of "capping the functional habitat area" also factors into this discussion. Presumably, an area of bottomland hardwood that is outside the 2-year floodplain would not be included and only the area within the 2-year floodplain would count. For example, at elevation X (corresponding to the 2-year water surface) there is an area of Y. At elevation X+1 the actual area would increase, but the elevation-area table is "capped," or limited, to the value of Y.
Significance – High:
The concept of "Functional Floodplain" is crucial to obtaining correct input data and computing meaningful results from an Enviro Fish analysis. Without a detailed understanding of this fundamental concept, users may not obtain correct results for the intended use.
Recommendations for Resolution:
To resolve these concerns: ▪ Describe the factors that would be considered when delineating functional floodplain areas. ▪ Describe the methods for determining whether an area is functional floodplain. ▪ Include an example of a moderately complex situation where functional floodplain could have been incorrectly delineated. ▪ Provide an example of "capping" the area.

Comment 4:
The analytical requirements of the model are identified, but guidance needs to be provided on how to prepare the data for input and the roles of the multidisciplinary team.
Basis for Comment:
In order to complete the Habitat Evaluation Procedures (HEP) analysis for fish reproduction in floodplains, the multidisciplinary team should include: HEP specialists, fishery biologists, riparian ecologists, hydrologists, hydraulic engineers, and GIS specialists. The Enviro Fish User's Manual does not discuss the roles of these individuals nor provide guidance on developing the input data. The HEP specialist or fishery biologist would lead the team and define the data needs and constraints, but each team member would need to perform their duties based on the system hydrology, geography, ecology, and fish biology. Although there does not need to be guidance on creating a HEC-DSS file per se, there should be more guidance on developing the data from the standpoint of hydrology, hydraulics, and land use as it pertains to the HEP process. The daily flow record must be analyzed for suitability for future conditions. The flow record would then be transformed into a daily stage record using a hydraulic model, and the land use must be evaluated for habitat suitability. Each step must consider future conditions. A complete HEP analysis requires data acquisition (including topography, land use and hydrology), preliminary analysis (assigning Habitat Suitability Index (HSI) values, and performing hydraulic and hydrologic analyses), and final analysis (computing Average Daily Flooded Area [ADFAs] and Habitat Units [HUs]). If these steps are performed without the expertise of each of the disciplines, erroneous results are likely.
Significance – High:
If the complete HEP analysis is not led by the proper individual and with the support of several specialized disciplines, the results may be meaningless and the model will fall short of its intended purpose.
Recommendations for Resolution:
To resolve these concerns: ▪ Clearly define the roles of the members of the multidisciplinary team required for an Enviro Fish analysis. ▪ Include sections in the user's manual describing how each discipline would conduct their portion of the analysis.

Comment 5:

The assumptions and limitations on the ability of the model to calculate benefits for project life need to be clearly documented.

Basis for Comment:

The reviewers recognize that current and historic data must be the basis for developing model input to represent conditions over the project life. This is both an assumption and a limitation of Enviro Fish that needs to be documented. Guidance needs to be provided to assess the suitability of current and historic data for this purpose.

- There is an assumption that realistic hydrology, particularly daily flow and stage data, can be developed for future conditions over the life of the project.
    - It appears that historic gage data are applied as the existing condition.
    - It appears that the historic gage data are then manipulated to create future alternative hydrology.
    - A limitation of this approach is the suitability of the historic gage data. For example, if a 50-year project life is required but there are only 10 years of gage data, the gage data must be used to represent the longer period or manipulated to generate a longer time series. If the gage data are from a time period that is wetter or drier than the long-term average, then the results can be misleading, even for a relative comparison of alternatives.
- There is an assumption that land use and topography are either constant through time or that future conditions can be projected over the life of the project. This is a limitation because the quantity and quality (Habitat Suitability Index [HSI]) of a particular land use type can change over the relatively long life of a project.
- The model has a usability limitation because it is designed to run only one daily stage record with one elevation-area curve at a time (rather than combining multiple data sets). It would, therefore, be very cumbersome to perform the number of program runs required to evaluate alternative future scenarios.

Significance – High:

Failure to understand the model assumptions could result in misinterpretation of model results and incorrect application of the model.

Recommendations for Resolution:

To resolve these concerns:

- Provide discussion related to the limitations of a typical Enviro Fish analysis. The limitations include use of historic gage data (especially short term records) and accounting for changing future conditions (including HSI, land use, topography, hydrology, and hydraulics).
- Provide guidance in the user's manual for developing the hydrologic and land use data that are representative of future conditions. These methods could include sensitivity analysis, Monte Carlo simulation, review of historic aerial photography, comparisons with other long-term flow gages, etc.
- Modify the software to loop through selected flow alternatives with selected land use alternatives and generate easily understood summary output.
- Modify the model be able to generate output by looping through the values of Parameter X and generating labeled output so that it is easier to perform a sensitivity analysis.

Comment 6:

Errors and issues in the programming code were identified and need to be corrected.

Basis for Comment:

One error was located which lead to incorrect results from the model. Several other issues should also be corrected in order to ensure that erroneous results are not generated inadvertently.

Dead stores to variables. Values are being assigned to variables and then not referenced by the program. While these errors are bad style on their own, they are often helpful in diagnosing more serious errors. The Enviro Fish model has several of these that need to be addressed.

- The getAreaForStage method defined in MainWindow.java has the following code which generates incorrect results when interpolating stages:

```
double l = high_stage - low_stage;
double scale = (stage - low_stage) / 1;
```

  The intent of the programmer was most likely to divide by the variable l, but the code divided by 1 (one) instead. In this case it makes more sense to forgo creating a local variable to use once and simplify the code to:

```
double scale = (stage - low_stage) / (high_stage - low_stage);
```

- In the loadDSSFile method defined in MainWindow.java there are several calls to methods that store return values from methods that interact with the system in a variable named `rv`. Those return values are never checked for errors, which violates an important rule of software engineering: System calls should have their return status checked.

  There is another instance of this bug in ReportDiplay.java. The method createNewFile is called twice without checking the method's return status.

- Neither loadDSSFile nor closeDSSFile return values (they are of type void) so the program does not check whether these methods completed successfully. These methods should either throw an exception or return a value that indicates whether they were successful in opening or closing the DSS files.

- In the jTextArea1KeyReleased method defined in ReportDisplay.java, the String variable msg is defined and initialized but not referenced again.

Incorrect finalizer. The finalize method defined in MainWindow.java is declared as public. For security reasons the principle is that only the class and derived subclasses should be able to access finalizer methods, thus the method should be declared as protected.

Stream not closed. The loadFile method defined in CategoryWindow.java opens a stream that is never closed.

Duplicate code. The runRange method in MainWindow.java has the following return status checks near the beginning of the method:

```
if ( rv == -2)
{
  javax.swing.JOptionPane.showMessageDialog(this,
```

```
            "No data found in Stage Area Curve",
            "Missing Data",
            javax.swing.JOptionPane.ERROR_MESSAGE);
        }
        else if ( rv == - 2)
        {
          javax.swing.JOptionPane.showMessageDialog(this,
            "Could not read Stage Area Curve",
            "Corrupt DSS File",
            javax.swing.JOptionPane.ERROR_MESSAGE);
        }
```

In this case the "else" clause is testing for the same value as the "if" clause (negative two) so the "else" code will never be executed.

Error Checking. There are some checks built-in, e.g., the program checks that the min depth must be less than the max depth for both spawning and season constraints. There are additional tests that need to be included:

- No checking is done on where the DSS files are opened successfully. When a DSS file is selected in the file chooser, there is no check to see if the file is readable by the current user. Selecting an unreadable file does trigger error messages from the HEC Data Manager which are echoed to the console and not to the GUI where the user's attention would be.
- It is acceptable to enter a negative number of days as an input. This throws a Java ArrayIndexOutOfBounds exception.
- Negative depths can be entered for both spawning and season constraints.
- Entering an extremely small negative year as a period throws a NullPointerException.
- Entering a year such as 1000 as a starting period triggers an OutOfMemory error.
- If the end year is before the start year then a NegativeArraySizeException is generated.
- If the model needs data for a time period that is missing then a warning message is written to the log saying "Data block not found in file" but no messages are displayed to the user.

Significance – High:

The error in the interpolation code leads to incorrect results. The remaining errors can also lead to incorrect results and violate important principles for developing software.

Recommendations for Resolution:

To resolve these concerns:

- Fix the issues in the code specified.
- Implement unit testing (detailed in Comment #9).
- Consider using a code analysis tool. There are several Open Source tools that work with Java including PMD and FindBugs.
- Test the user interface often to enter unexpected data and try and break the model. Check that the software is verifying inputs and informing the user of any unexpected conditions (such as Out of Memory errors) that occur during processing.

Comment 7:

Additional error checks and warnings need to be built into the program.

Basis for Comment:

The source code should be built with the –Xlint flag to turn on all recommended warnings. The warnings generated by the Enviro Fish code include:

- **Warnings about serializeable classes not having a serialVersionUID field.** The Java documentation states: "The serialization runtime associates with each serializable class a version number, called a serialVersionUID, which is used during deserialization to verify that the sender and receiver of a serialized object have loaded classes for that object that are compatible with respect to serialization." The majority of these warnings can be taken care of by running the JDK's *serialver* utility on the classes and adding the generated field code to the source. The form editor that was used to build the model's graphical user interface generated many of the impacted classes.

- **Potential fall throughs in switch statements.** On line 104 of EvfCatagory.java there is a switch statement where the last case before the default does not have a break statement. While this is not an error in this case, it is preferable to code defensively and make sure that each case does have a break statement. It would also be preferable if the class was renamed EvfCategory so that the spelling was correct and consistent with the rest of the code in the project.

  The switch statement starting on line 141 of ReportDisplay.java has only one case before the default statement; however, this should also end with a break statement as good style.

- **Unchecked or unsafe operations.** In MainWindow.java there are several instances where code is similar to the following:

  ```
  java.util.Vector paths = new java.util.Vector();
  ```

  Since generics were introduced in Java 1.5, this code has produced a warning. This vector is intended to hold strings, so the preferred way to declare the vector is as follows:

  ```
  java.util.Vector<String> paths = new java.util.Vector<String>();
  ```

Significance – High:

Building the code without enabling all warnings and addressing sections of the code tagged as problematic leads to errors in the model output.

Recommendations for Resolution:

To resolve these concerns:

- Always compile the Java code with the –Xlint compiler flag and understand and address warnings as needed.
- A combination of techniques including the lint compiler argument, unit testing and static code analysis tools will improve the quality of the code.

Comment 8:

Unit testing for the model should be performed if it has not been.

Basis for Comment:

One of the strengths of Java is that it has mature libraries for writing unit tests; in particular JUnit is an open source industry standard. Unit testing involves writing tests for the smallest units of the program, which are classes in Java.

Unit testing is considered an essential practice in Java development for several reasons:

- Knowing that each unit of a program satisfies testing gives increased confidence that the program as a whole is correct.
- Unit tests force developers to know the anticipated result for a given input. Developers have to work through how their methods will work so that they can make assertions about what the results will be. For example, in order to test a method designed to convert text to upper case, the programmer would assert that *HELLO* would be generated when given *hello* as an input.
- Unit tests give developers more confidence when modifying their programs. Unit tests provide for what is called regression testing, which ensures that new code generates consistent results.
- Tests are a form of documentation. Unit tests are working and documented examples of how the pieces of a program function.

The simplest example for the Enviro Fish model would be the code currently in the MainWindow class. The getMonthName method returns the abbreviation of a month given the month's number in the calendar; so we would expect getMonthName(1) to return JAN. Unit testing is normally done on the accessible member of a class so for purposes of this example assume that getMonthName is declared as protected rather than private. A sample test case might look like this:

```
import junit.framework.TestCase;

public class MainWindowTest extends TestCase {
    private MainWindow window;
    public void testGetMonthName() {
        assertEquals("JAN", window.getMonthName(1));
    }
}
```

A sample run would look like this:

```
> java junit.textui.TestRunner MainWindowTest
.
Time: 0.005
OK (1 test)
```

Significance – High:

The lack of unit testing increases the likelihood that code bugs will be missed and that further development of the program will inadvertently introduce new errors.

Recommendations for Resolution:

To resolve these concerns:

- Implement unit testing using JUnit, TestNG, or another unit testing framework.

Comment 9:

Testing of the code and validation of the underlying model needs to be documented.

Basis for Comment:

The model reviewers did not find any information in the Enviro Fish User's Manual describing testing of the code or validation of the underlying model.

Code testing. The output of the computer program should be compared to results that are obtained by performing the same calculations as in the code but in another manner (e.g., through a spreadsheet). Both USACE and the rest of the user community would benefit from having these benchmark results presented in the documentation along with all of the parameters necessary to duplicate them using the program. Users would benefit from annotated results explaining how the model was applied, and USACE would have verified results to check against when modifications are made to the code.

Model validation. If validation of Enviro Fish, or any comparisons to other models or data, has been performed, it would be useful to add how the validation was done and a summary of the performance of the model (skill assessment). If model validation has not been completed, then there are two types of validation that could be undertaken:

- Habitat-to-habitat – A comparison of model predictions of changes in habitat area with spatially-referenced field data or with the output of a more detailed model.

- Habitat versus biology – A comparison of predicted changes in habitat to observed changes in fish reproductive success.

The habitat-to-habitat comparison is more straightforward and could be done for several well-studied projects that also have more detailed models already developed. The habitat versus biology comparison is more difficult because biological data reflect the effects of many other factors not included in Enviro Fish. Exact agreement is not expected in either situation, but similar direction of responses would further people's confidence in Enviro Fish.

Significance – High:

The code needs to generate correct results, and the underlying biological realism of the model should be established. USACE needs to reference results that are confirmed correct for code testing purposes. The user community will benefit from understanding how the underlying biological model was evaluated against empirical data or the predictions from other models.

Recommendations for Resolution:

To resolve these concerns:

- Provide information in the user's manual on code testing that has been completed. If no testing has been completed then this needs to be done.
- Provide information in the user's manual on any model validation that has been performed. Consideration should be given to using existing applications of Enviro Fish as a basis for performing model validation comparisons.

Comment 10:

The current model is not a stand-alone product and it is tedious to run for individual or multiple scenarios, rendering it error prone and difficult to use for compensatory mitigation.

Basis for Comment:

The model requires a separate run for each land use type within each flow scenario. This will result in many individual runs for a single flow scenario, and even more runs when alternative scenarios are analyzed. The possibility of the user making a mistake increases with the more individual runs that are required. One advantage of using a model like Enviro Fish is that it formalizes the assumptions and enables quantitative comparison of alternative scenarios and alternative assumptions (e.g., different minimum and maximum depths within each scenario). The current structure of the Enviro Fish model does not enable easy exploration of scenarios and assumptions because the model requires a run for each land use type within each scenario. Many projects will involve multiple land types, and for each type, multiple alternative assumptions are nested within multiple scenarios. Keeping track of inputs and output files in such situations can lead to errors in file naming and errors in importing the many output files into other software (e.g., Excel) for post-run comparisons. Furthermore, Enviro Fish generates point predictions, and the current structure prevents easy sensitivity and uncertainty analysis.

Significance – High:

Making runs in Enviro Fish is cumbersome, which can result in errors and limits the user's ability to fully explore multiple scenarios and alternative assumptions. This is considered "high significance" because one of the major purposes and advantages of models like Enviro Fish is to allow exploration of alternatives.

Recommendations for Resolution:

To resolve these concerns:

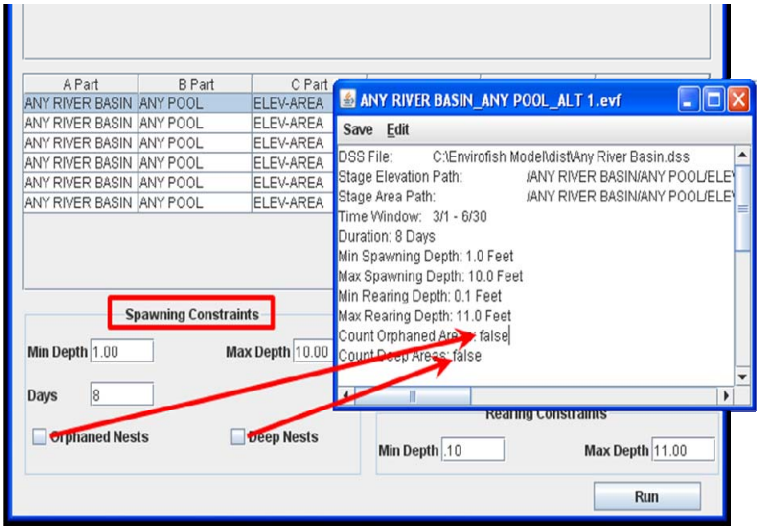
- At minimum, the user interface to Enviro Fish should be expanded to allow multiple land uses to be simulated with one run (i.e., one run per scenario). The output files would also need to be expanded and the current easy importing into other software should be maintained with the expanded output files.
- Optionally, the user interface could be expanded even further to allow multiple scenarios to be run in an easy manner, and the outputs sent to files with names defined by the user. Ideally, the Enviro Fish interface would generate some simple plots and tables for easy comparison among scenarios.

Comment 11:

Checking "Orphaned Nests" and "Deep Nests" should apply a constraint, rather than remove a constraint.

Basis for Comment:

Orphaned nests and deep nests are areas that may be abandoned or lost when the water depth changes after a nest is established and spawning occurs. Because these lost nests reduce the amount of spawning habitat, not counting them is applying a constraint. The other items in the "Spawning Constraints" (Min Depth, Max Depth and Days) are all truly constraints. However, when running Enviro Fish, not checking these boxes applies a constraint. This is evident in the output file indicated by a value of "false" for "Count Orphaned Areas" and "Count Deep Areas" when the boxes are not checked. Checking these boxes actually removes the constraints. This is counter-intuitive and could result in some users producing results opposite to their intention.



Significance – High:

The importance is high because it would be easy for a user to obtain the opposite results from the model than their intended purpose.

Recommendations for Resolution:

To resolve these concerns:

- Reverse the result of checking either of these options so the constraint is applied when the box is checked. The caption should also be made clearer by revising to "Apply Orphaned Nest Constraint" and "Apply Deep Nest Constraint."
- Alternatively, replace "Orphaned Nests" with "Checking Removes the Orphaned Nest Constraint" and similar revision for "Deep Nests."

Comment 12:
The assumption that an increase in Habitat Units (HUs) will linearly increase spawning and rearing opportunities is incorrect.
Basis for Comment:
The foundation of the Habitat Evaluation Procedures (HEP) process is the calculation of HUs at incremental surface elevations and the assumption of a positive linear relation between HU area and fish spawning and rearing. While it is technically correct that the relation might exist between HUs and "opportunities for spawning and rearing," it is biologically misleading to assume that more HUs, after a point, produce more young fish. The fisheries literature does not support this.
Significance –Medium:
Not addressing this important assumption could lead some readers to develop unrealistic expectations for projects.
Recommendations for Resolution:
The user's manual could increase transparency by providing a more detailed explanation of the HEP process and assumptions as they apply to aquatic systems. This, along with a clearer explanation of the biological objectives of the model (see Comment #13), will give users a more complete and realistic understanding of model outputs.

Comment 13:

The Introduction (Chapter 1) to the Enviro Fish User's Manual should be more informative.

Basis for Comment:

The Introduction chapter of the Enviro Fish User's Manual incompletely informs the reader on three important issues: the model's intended use, its approach, and possible products. Because the Introduction of any document is usually one of the first sections read for guidance, a clearer and more complete statement on the above issues would allow potential users to better estimate how the model might fit with their expectations and needs.

The Background section does not clearly explain why the model was developed. As it stands, it is more of a background of the model development and how it can be used and includes misleading statements such as, "…predict a quantitative response of the fish assemblage."

Significance – Medium:

The Introduction sets the stage for a clear explanation of the scope, importance and usefulness of the model. An incomplete Introduction hinders understanding of the full utility of Enviro Fish, and makes it less likely that stakeholders and other interested parties will become full participants in the overall project.

Recommendations for Resolution:

The model reviewers believe a stronger Introduction in the user's manual is essential to the overall understanding and therefore efficient use of the model. There is a need for a more inclusive and informative objective statement such as, "The objective of Enviro Fish, a modeling approach and computer software, is to facilitate planning for large-river civil projects by predicting the value of spawning and rearing habitat for floodplain fishes in extant versus project alternatives, in a manner understandable to a diverse constituency."

An objective statement of this type is needed to more clearly state its intent and usefulness by initially addressing such questions as:

a) What is it? A tool useful for planning.
b) What is it capable of doing? It predicts opportunities for spawning and rearing fishes in present conditions and alternative possibilities.
c) For whom is it intended? Users are a diverse constituency of interested parties and decision makers.

Other elements of Chapter 1 should be modified, as well. The Background section should include information of value to a variety of users, including ecological information on the importance of floodplain habitats to the river system and a general description of the fish community. An explanation of why some projects require modification or elimination of certain floodplain habitats, and how Enviro Fish will assist in planning for mitigation or compensation would be very useful to the overall understanding by the average reader.

The Method section of the Introduction (pg. 1-2) would be more useful if the series of numbered statements was expanded into a narrative succinctly explaining the function and the integration of biological and physical information, perhaps referring to Figure 2-1.

The Scope section should be expanded to contain information on model usefulness, strengths, limitations, geographic and temporal generality, and assumptions.

Comment 14:
While the results of the Enviro Fish model can be understood by a wide range of people, those results can only be generated by experts.
Basis for Comment:
Enviro Fish was developed for planning purposes for comparatively large civil projects with involvement of a large number of decision makers, stakeholders, and other interested organizations and individuals. The model is intended to explain likely outcomes of various alternatives that are understandable by all participants. Enviro Fish has the stated objective that includes providing a modeling tool to "government, academia, environmental organizations, and communities..." The model meets this objective, but only when used by experts. Even experts would likely need guidance from the model developers or a greatly expanded, more informative user's manual to apply the model to new situations. A significantly complex data set, comprised of geomorphological, hydrological, and biological input is required to complete an accurate assessment. The current model stops just before the final computation of HUs, but does provide the area data needed to compute it.
Significance – Medium:
Lack of proper guidance as to the complexity of Enviro Fish input requirements increases the possibility of improper model implementation, erroneous interpretation of model results, and misleading conclusions being drawn.
Recommendations for Resolution:
To resolve these concerns, provide expanded guidance in the user's manual that fully informs potential users of the expertise and the complex data set required to produce comprehensive results.

Comment 15:

The sensitivity of the results is driven by the precision and accuracy of the input data. Unless the precision is known, the sensitivity is unknown.

Basis for Comment:

1. The Habitat Suitability Index (HSI) values given to the various land types, which are then multiplied by available acreage to obtain spatially explicit Habitat Units (HUs), were obtained primarily from the fisheries literature and professional judgment – the Delphi Technique. The subjective judgments of fair, good, very good, etc. were translated into a score from 0 to 1.0 in 0.1 intervals. If empirical evidence is unavailable, the designation of, for instance, 0.3 might just as well have been a 0.2 or a 0.4 because professional judgment cannot be quantified that precisely. As an example of results from a small difference in HSI values: 0.2 HSI X 100 acres = 20 HU, and 0.3 HSI X 100 acres = 30 HU. A 0.1 increase results in a 50% difference, and some might conclude this represents a 50% "better" habitat.

   This potential subjectivity of HSI values would be problematic if the model were actually used, as stated on page 1-1, to "estimate the value of floodplain habitat" instead of more appropriately, as stated in other places in the user's manual, for "comparing alternatives" of available floodplain habitat. A test of model outputs using the example provided in Chapter 4 for comparing outputs when HSI values were changed in various combinations indicated very little difference in the **ratio** of existing HUs to alternative HUs. Therefore, it seems that the perceived "weakness" of using non-empirically determined HSI values (primarily from literature and professional judgment) likely does not negate their value in this case when average fish community values are used and the outcomes are comparisons between existing conditions and project alternatives.

   However, increasing accuracy is never a bad thing. As the USFWS recognized over 30 years ago, HSIs can be developed three ways: expert opinion, with use criteria, or with preference criteria. The most accurate method, using preference criteria (more appropriately named "selection" criteria) requires field sampling, preferably at the location of the project. HSIs developed from expert opinion were always considered by the original USFWS developers as interim measures, even while they promoted the Delphi Technique.

   If accurate HSI's are truly valuable, they would be developed for specific projects. A large enough project – such as the one mentioned in the Enviro Fish User's Manual would justify the relatively small costs to provide the best biological data. If there are ongoing USACE, USFWS, or state assessment programs of floodplain fisheries, it would be simple to organize sampling in a manner to sample replicates of flooded land types over a restricted period using the same gear and methodologies to obtain representative samples so that spawning and rearing use (instead of just assumed potential) of different habitats could be compared to each other on a relative basis. Only then could we get a realistic idea of what an HSI of, for example, 0.5 really means as compared to an HSI of 1.0.

2. A central Habitat Evaluation Procedures (HEP) assumption states that a large area of poor habitat is biologically equal to a small area of very good habitat. An HSI of 0.1 with 100 acres results in the same potential for fish as 10 acres with a HSI of 1.0. This has never been shown in the peer-reviewed fisheries literature. One HU should not be equal to another in habitat value unless the habitats are exactly the same. In reality, a low area of high-quality habitat is likely to outperform a high number of low-quality habitat areas even if they both have equal HU values. This assumption creates the potential for choosing an alternative that provides a lot of cornfield, and no bottomland hardwood forest over one where bottomland hardwood forest is present in moderate amounts. This assumption precludes the model from organizing the output to maximize the highest quality habitat type.

Significance – Medium:
While some lack of sensitivity and precision are inherent in the HEP process, a better explanation of limitations of the model and expected variance allows the reader to better evaluate the value of model outputs.
Recommendations for Resolution:
To resolve these concerns: ▪ Be very specific in the user's manual that the most accurate outputs of the model are those comparing the relative difference between existing and future conditions. ▪ Present options for determining final habitat areas. While experienced biologists may not always agree on a quantification of habitat, they likely agree on what is good habitat versus what is poor habitat. In this user's manual's example, cropland land use is considered poor quality, but how poor is not defined. Carp will do well spawning in cornfield stubble, but maybe not many other species will. The opportunity exists to greatly increase the area of lower quality habitat for an alternative or future condition without regard for the absolute acreage of high quality habitat. It might be more appropriate to develop HSI's for all habitat types but then ignore any habitats that are, for example, <0.4 in the calculation of HUs. Then the trade off would be for what is known to be good habitat for other good habitat. The value of HUs would be much more comparable.

Comment 16:
The quality and accuracy of the data required by the model needs to be stated.
Basis for Comment:
The Enviro Fish model is based on several major simplifying assumptions which, when satisfactorily met, will result in reasonable predictions of flooding effects on fish reproductive success. However, no guidance is provided regarding how close the assumptions (i.e., quality of the input data) need to be met to ensure the model predictions are of sufficient confidence. For example, no specific guidance is provided on how finely to subdivide the floodplain so that the stage-area relationship can be best estimated for each unit, and the tradeoffs of dividing the floodplain into increasingly finer subareas are not explained. There are also no recommendations on the required accuracy of the topographic data or on the desired quality of the hydraulic analysis. Some guidance is provided regarding defining land use types, but even that is minimal. Enviro Fish has the advantage of having been used for many years, so there is an accumulated knowledge base that can be used to provide a new user with guidance and tips on how to prepare the inputs required by the model. This will help users and the audience for model results by providing them with information on the appropriate level of confidence to associate with model results.
Significance – Medium:
Lack of guidance on the quality and accuracy of data required by the model does not prevent the model from being used appropriately, but does allow for the possibility of unnecessary uncertainty in model predictions in some situations when the user could have made better decisions for preparing the model inputs. Some guidance would enable more efficient use of Enviro Fish, especially by inexperienced users, and maybe more accurate model predictions when alternative decisions about input preparation are available.
Recommendations for Resolution:
To resolve these concerns: ▪ The user's manual should be expanded (perhaps an Appendix) to include guidance for preparing model inputs. ▪ Examples of how decisions were made in previous applications of Enviro Fish should either be summarized in the user's manual or referenced.

Comment 17:
It needs to be clearly stated that similar input data used for the alternatives analysis should be of the same accuracy and precision.
Basis for Comment:
Alternative scenarios can involve preparation of a new set of inputs. For example, mitigation may involve a different area of the floodplain than was analyzed in the primary (baseline) analysis. In order to allow for direct comparison among such scenarios, the accuracy, precision, and temporal and spatial resolution of the different sets of inputs should be very similar. Otherwise, differences in model predictions between the alternatives become confounded with differences in the quality or timing of the inputs. With inputs of differing quality or temporal coverage, it becomes difficult to compare the effects of alternative scenarios on fish reproduction habitat. This is because a user may incorrectly attribute either similarities or differences between alternatives to other properties when they are actually caused by differences in data quality.
Significance – Medium:
Although lack of guidance for using input data of the same accuracy and precision does not prevent Enviro Fish from being used, such information would increase the completeness of the documentation and assure that model results are comparable among all alternative scenarios.
Recommendations for Resolution:
To resolve these concerns: ▪ The user's manual should be expanded to include a discussion of how input data should be of similar quality and temporal and spatial resolution when scenarios involve different sets of input values. ▪ More extensive examples and summaries of how previous applications dealt with differing input sets should be added to the user's manual.

Comment 18:

The model is based on well-established habitat suitability theory, but not necessarily contemporary theory.

Basis for Comment:

The Enviro Fish model is based on well-established theory of habitat suitability, which has a long history, and appropriately accommodates the systems theory ideas that evaluation of fish reproduction involves the explicit linkage between the river and its associated floodplain (i.e., watershed thinking). The use of habitat suitability is appropriate because it reflects the typical data and information available for many projects, and generates results in a form that is useful for decision-making. People have recognized the distinction between habitat and population abundance, so with proper caveats and in the correct situations, habitat suitability is the best available approach. The explicit treatment of rivers connected to floodplains is also appropriate.

Whether the model is based on "contemporary" theory requires more discussion. Four aspects of contemporary theory not directly addressed by Enviro Fish are multi-factor interactions, spatially-explicit modeling, full life cycle effects, and species interactions. As the authors state, the basis of Enviro Fish goes back to the early 1990s. Enviro Fish appropriately focuses on water depths (i.e., single factor analysis), but has little discussion about how other environmental variables (e.g., temperature) may be important in some situations. We now recognize that fish reproduction can be influenced by multiple factors, which can vary in time and space as to their influence and can have interactive effects on reproductive success. Second, our ability for mapping bathymetry and handling spatial-resolved data, modeling hydraulics and hydrodynamics, and tagging and following fish on fine spatial and temporal scales has greatly increased in the past decade. In some situations of well-studied systems or controversial decisions, a spatially-explicit approach, in addition to Enviro Fish, should be considered. A spatially-explicit approach allows for the connectance among land use types and their spatial arrangement relative to each other to the river to be explicitly considered in the analysis.

Similarly, contemporary theory has moved from single life stage analyses and single-species approaches to more explicit consideration of population level responses and community and food web dynamics. Enviro Fish is very much a single species (or guild) approach, and is even further limited to certain life stages. It is not being suggested that Enviro Fish add additional environmental factors beyond water depth or become a population or multi-species model. The water depth and life stage foci are reasonable because water depth is a fundamental variable and modeling multiple factors or population dynamics (full life cycle) is not possible within an off-the-shelf model. Dealing with species interactions within the life stage of interest is also difficult because our knowledge about predation and competition is also lacking. But these issues should be discussed so that the user has a clear idea of the benefits and limitations of using habitat suitability and where Enviro Fish fits in within contemporary theory. A user can erroneously assume Enviro Fish is state-of-the-art, which it is not; but Enviro Fish is very flexible and can be applied to many situations because it uses readily-available data. However, there are important assumptions underlying habitat suitability, and there other approaches that may be more reflective of contemporary theory that should be discussed.

Significance – Medium:

This is a documentation issue related to completeness and does not hinder the use of Enviro Fish. Additional information on the appropriate interpretation of habitat suitability and how Enviro Fish fits in with contemporary theory would make for a more informed user by helping the user understand the limitations of Enviro Fish and under what conditions Enviro Fish is best applied.

Recommendations for Resolution:

To resolve these concerns:

- Enviro Fish should not be modified or expanded to incorporate the aspects of contemporary theory discussed.

- The user documentation should better explain the assumptions of habitat suitability and the limitations of the approach used by Enviro Fish, and should briefly describe the alternative approaches to Enviro Fish that are available.

Comment 19:
Documentation with the output data should include units of measure.
Basis for Comment:
Although Enviro Fish output provides an array of data for each user-requested year, the program output data do not have any units of measure assigned. The user is left to interpret the appropriate units of measure for each data category. Although the basic unit of measure is incorporated into the header (e.g., Duration in days, Depths in feet), the data table could be improved by including the units of measure for each of the data categories (e.g., Avg Stage, Max Total Rearing), all of the Average Season data, and all of the Period Averages data.
Significance – Medium:
Without explicit units of measures, mathematical errors based on assumptions of measure may occur.
Recommendations for Resolution:
To resolve these concerns, incorporate "Units of measure" (e.g., "in feet") in the header section of the model output or as a legend with each output page.

Comment 20:

Examples in the fisheries section of the documentation should be expanded to inform decision-makers more about the possible benefits of the project.

Basis for Comment:

Enviro Fish is highly usable, but the model documentation could be improved by expanding the Biological section with some additional information on elementary fish ecology. Additional information on ecological requirements of spawning fishes would be very helpful. Because the intended audience is diverse (pg 1-2 paragraph 1), a more complete description of potential outcomes for the project is warranted. Information on individual fish species and guild requirements or preferences for particular variables needs to be included or referenced in the user's manual. Special emphasis should be given recreationally important and threatened and endangered species. Invasive species (e.g., Asian carp) are a major concern for our great rivers, not only for the rivers themselves, but also as conduits into reservoirs and tributaries and for the Mississippi River and the Great Lakes. Project alternatives should explain the potential effect of floodplain changes or alterations on these and other species.

Such additions to the user's manual would make model input choices more understandable to project participants. Increasing the knowledge base among stakeholders should increase their active participation in the process, which in turn increases chances of a satisfactory outcome for the most people.

Significance – Medium:

The suggested changes would make the user's manual more informative and useful to a diverse audience. Involved, committed stakeholders are important to a successful project outcome. Without the changes, stakeholders will have less understanding of the ecological processes that are involved and may be less likely to feel they are full participants in the process.

Recommendations for Resolution:

A compendium in table form for species and guilds (using Tables 2-2 and 2-3 as a basis) that includes land-use habitat preference, preferred spawning substrates, spawning temperatures, depths for eggs, depths for larvae, and egg incubation time should be added for reference by project participants to facilitate discussions with project biologists.

Comment 21:

The model is moderately transparent, and it is difficult to fully interpret the different outputs generated across scenarios.

Basis for Comment:

The model has an intermediate level of transparency in terms of the user having detailed knowledge of the calculations and in terms of the user being able to understand why certain results are generated. The user's manual provides a good description of the model and calculations, but it is unlikely that most users can reproduce the calculations outside of Enviro Fish except for very simple cases. Also, because of the nature of the calculations, the model reviewers believe it is difficult to tease apart the model predictions to understand why the results occurred. For example, within a scenario, it is not presently possible to determine the relative contributions to habitat area of the minimum depth constraint, maximum depth constraint, the deep nest option, and the shallow nest option. Knowing which of these is most limiting to habitat can also be especially useful when comparing alternative scenarios. The inability to easily perform sensitivity analysis further contributes to a lack of complete transparency because the approach of making many multiple runs to better understand model results is cumbersome.

Significance – Medium:

Reduced transparency limits the user in fully understanding model predictions.

Recommendations for Resolution:

To resolve these concerns:

- Expand the model user interface to allow for easy generation of multiple runs, allowing the user to more easily explore alternative assumptions.
- Add as an appendix to the user's manual a detailed set of example calculations for a simple case (e.g., one land use type for a few time steps).
- Partition the relative contributions to habitat area of the different limiting factors. Given the time constraints, how to do this was not obvious to the model reviewers. If such information is not possible to generate, then suggestions on a sensitivity analysis approach to better understanding the model predictions could be added to the user's manual.
- If feasible, change the program to automatically calculate areas for one-foot depth increments on a daily and yearly basis so that the user can better determine the range of depths that are controlling the results. For example, for an average annual spawning of 275 acres produced by a 1.0 to 10.0 ft depth range, a table of areas could be produced similar to the following:

Depth Range (ft)	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	1-10 (total)
Area (acres)	90	70	30	20	18	17	15	10	5	275

This shows that the greater depths are not contributing significantly to habitat.

- Change the program to automatically run with and without the deep and shallow nest options rather than requiring the user to select this as an option and make multiple runs.

Comment 22:

Enviro Fish should be able to work with the current version of DSSVue installed.

Basis for Comment:

The Enviro Fish software requires the use of HEC-DSS data storage system for the Daily Water Surface Elevation (Daily Stage) data and for the Elevation-Area curves. HEC-DSS is an excellent choice for storing and retrieving data for Enviro Fish. When the Enviro Fish software was first distributed to the reviewers, it was not clear that DSSVue needed to be installed, nor was it clear that only a previous version of DSSVue (Version 1.2) was compatible with Enviro Fish. Many users will have the most recent version of DSSVue (currently Version 2.0) installed on their computer. If Enviro Fish is not compatible with the most recent version of DSSVue, it will not be contemporary with other USACE software.

Because the USACE - HEC Center makes archived versions of their software available for download, this does not significantly impact the use of Enviro Fish. However, a user cannot have more than one version of DSSVue on a computer, so this could significantly impact the ease of use by some users who would want (or need) the most recent version of DSSVue installed on their computer.

Significance – Medium:

Although it does not affect the results of the model, the significance is medium because it could significantly impact the usability of the model by some users.

Recommendations for Resolution:

To resolve these concerns:

- Investigate and correct this compatibility issue.
- Once the issue is resolved, test Enviro Fish with benchmark data to ensure that correct results are generated.

Comment 23:

Model calculations should be moved to either a Model-View or Model-View-Controller design which would separate the model's logic from the user interface.

Basis for Comment:

Currently, most of the calculations in the Enivro Fish model take place in the MainWindow class which is also responsible for displaying the model's main interface. The model reviewers strongly recommend that the model developers move this logic into separate classes and adopt either a Model-View or Model-View-Controller design that would separate the model's logic from the user interface.

The Model-View-Controller (MVC) design pattern is the dominant methodology for designing programs with user interfaces. The three parts of the design pattern are:

1. The *Model* is part of the program that encapsulates the data and all of the logic (methods, functions) that operate on it.

2. The *View* is the visual representation of the Model which gets input from and delivers output to the user. There can be multiple Views for a particular model. For example, charts and pivot tables can be considered as two different views of a spreadsheet matrix.

3. The *Controller* coordinates exchanges between the Model and the View.

Separating the model's logic and interface will facilitate two immediate improvements:

- The model code, separated from the verbose GUI, will be easier for the developers to develop and test.

- The individual components become more reusable. For example, it becomes much easier to integrate the model code into a command line or web based architecture. Alternatively, the view code could be re-used with a different model that calculates things in a different manner.

Significance – Low:

Switching to an MVC design would make the program more flexible and easier to maintain but is not essential.

Recommendations for Resolution:

To resolve these concerns, refactor the Java code to use a Model View Controller (MVC) paradigm. An example structure would include the following classes:

- Enviro FishModel: The fields and methods currently in MainWindow.java that comprise the project's logic (e.g. maxDepth, dailyStage, getMaxRearingStage). This class would be independent of the program's user interface.

- MainWindow: The remaining code in MainWindow.java (mostly generated by the Netbeans IDE) would consist of the code that lays out the window's components (text boxes, buttons, etc.). This would be the project's principal view

- EnviroFishController: The controller would connect the model and view. It would provide listeners to the view's interface widgets that would respond to events (such as the Run button being pressed) by passing user input from the view to the model and then calling the appropriate methods to calculate the model's outputs.

- Main: The Main class would create instances of the model, view and controller and make the main window visible to the user.

Comment 24:

The Enviro Fish code could be made more compact and flexible by using a template engine to separate the model computations from the format of the output.

Basis for Comment:

The logic behind using a template engine is similar to using the MVC design pattern for the graphical user interface; separating the model and view makes each component easier to work with.

The MainWindow class currently has approximately 140 lines of code where output buffers are handled for generating the reports. The majority of the code looks something like this:

```
dBuffer.append("Time Window:\t");
dBuffer.append(jSeasonField.getText() + "\n");
dBuffer.append("Duration: " + periodDays + " Days\n");
dBuffer.append("Min Spawning Depth: " + minDepth + " Feet\n");
```

As an example, using the open source StringTemplate engine, the code might be separated like this:

Java:

```
public class Example {
  public static void main(String[] args) {
    StringTemplateGroup templates =
      new StringTemplateGroup("example", "templates");
    StringTemplate tmpl = templates.getInstanceOf("envirofish");
    Model model = new Model();
    tmpl.setAttribute("season", model.getSeason());
    tmpl.setAttribute("period", model.getPeriodDays());
    tmpl.setAttribute("min_depth", model.getMinDepth());
    System.out.println(tmpl.toString());
  }
}
```

Template:

```
Time Window: $season$
Duration: $period$ Days
Min Spawning Depth: $min_depth$ Feet
```

There are two immediate benefits to the separation:

1. A change in the structure of the output no longer requires the modification or re-compilation of the code.

2. A variety of templates can be generated which present different views of the same data. For example, if the template is marked up with HTML tags then the same program could generate output suitable for the web (or for directly importing into Excel).

Significance – Low:

Using a template engine would make the code more flexible and succinct but is not essential.

Recommendations for Resolution:

To resolve these concerns, consider using a string template engine to simplify the Java code and separate out the calculations from the format of the output.

Comment 25:

Additional comments should be added to the code to explain what the code is doing and what the programmer's intentions were.

Basis for Comment:

Documentation is a time consuming but essential part of any project. There should be more comments explaining how the code is supposed to work. Anyone trying to understand the logic of the program would have to go line by line through the code trying to infer what sections of code do.

Comments should document the purpose of the code and explain the programmer's logic. For example, this comment was helpful in understanding the purpose of a loop:

```
//DAY_INCREMENT = 3 minutes, so multiply by 480 so that its one day
for(int a = 0; a < (Integer.parseInt(jDurField.getText()) * 480); a++)
  stopTime.add(HecTime.DAY_INCREMENT);
```

In contrast, this comment added very little explanation:

```
//close the file
ts.close();
```

Java has documentation standard called JavaDoc that allows API documentation to be generated automatically from Java source code. Adhering to that standard would allow documentation to be generated in a variety of formats.

Significance – Low:

Documentation makes code easier to maintain and reuse in other projects.

Recommendations for Resolution:

To resolve these concerns:

- Search the code looking for instances where additional comments would document how the program works and why certain things were done. For example, inserting comments along the lines of, "Parse the third component of the DSS path and increment the date." would have instantly made everything clearer.
- Comment using the JavaDoc standard, generate the documentation, and keep it up to date as and integral part of the project.

Comment 26:

There are several instances in the model where the code could be simplified by using Java's libraries, using a more object-oriented design, or taking more advantage of the languages control structures.

Basis for Comment:

Here are some examples of where the use of more idiomatic Java could simplify the code and make it easier to adapt and maintain.

- The getMonthName method in MainWindow.java is currently implemented in a switch statement with a different case for each month:

```
private String getMonthName(int m) {
  switch(m) {
    case 1:
      return "JAN";
    ...
       case 12:
      return "DEC";
        default:
      return "JAN";
  }
}
```

Since Java already has a library with the names of the months, it would be more concise to say:

```
private String getMonthName(int m) {
  if ((m < 1) || (m > 12)) { m = 1; }
  String month = new
    DateFormatSymbols(new Locale("en","US")).getMonths()[m-1];
  return month.substring(0,3).toUpperCase();
}
```

An implementation closer to the original programming would be:

```
private String getMonthName(int m) {
    if ((m < 1) || (m > 12)) { m = 1; }
    String months[] = { "JAN","FEB","MAR","APR","MAY","JUN",
                        "JUL","AUG","SEP","OCT","NOV","DEC" };
    return months[m-1];
}
```

- In the loadDSSFile method defined in MainWindow.java there is code that adds each element of a string array to a vector, one at a time like this:

```
java.util.Vector path = new java.util.Vector();
path.add(selectedParts[0]);
path.add(selectedParts[1]);
path.add(selectedParts[2]);
path.add(selectedParts[3] + " - " + currentParts[3]);
```

It would be more concise to initialize the vector with the array in the constructor such as:

```
java.util.Vector<String> path = new
  java.util.Vector<String>(java.util.Arrays.asList(selectedParts));
path.set(3, path.elementAt(3) + " - " + currentParts[3]);
```

- In the runRange method defined in MainWindow.java there is some code that counts the instances of the path separator to find the position of a string to be replaced:

```
pos1 = buffer.indexOf("/",1);      // 2nd /
pos1 = buffer.indexOf("/",pos1+1); // 3rd /
pos1 = buffer.indexOf("/",pos1+1); // 4th /
pos2 = buffer.indexOf("/",pos1+1); // 5th /

// make the path for the current year
buffer.replace(pos1+1, pos2, tmp);
```

In this case the path could be transformed in a function in a more straight forward fashion:

```
private StringBuffer incrementDatePath(StringBuffer b, String dateStr) {
  // split the buffer and replace one segment with a new date

  StringBuffer result = new StringBuffer();
  String pathBuffer[] = b.toString().split("/");
  pathBuffer[4] = dateStr;
  for(int i = 0; i < pathBuffer.length; i++) {
    result.append(pathBuffer[i] + "/");
  }
  return result;
}
```

- There are several instances where the String(String) constructor is used. For example:

```
return new String("DSS File filter");
```

This code can be simplified to:

```
return "DSS File filter";
```

- In the loadDSSFile method in MainWindow.java is a while statement that looks like this:

```
while ( selectedParts[0].equals(currentParts[0]) &&
        selectedParts[1].equals(currentParts[1]) &&
        selectedParts[2].equals(currentParts[2]) &&
        selectedParts[4].equals(currentParts[4]) &&
        selectedParts[5].equals(currentParts[5]) &&
        ++i < paths.size() );
```

When you have code that looks like this, it is almost always preferable to use a loop rather than hard code each value:

```
private boolean pathsAreEqual(String[] current, String[] selected) {
  int i;
  for(i = 0; i <= 5; i++) {
    if(i == 3) { continue; }
    if(!current[i].equals(selected[i])) {
      return false;
    }
  }
  return true;
}
```

Significance – Low:

The suggested changes will not change the results or performance of the model noticeably. However, these modifications, in concert with the other suggested code changes, will make the model much easier to maintain over time.

Recommendations for Resolution:

To resolve these concerns:

- Implement the changes noted and look for other instances in the code where things can be simplified.
- Considering the amount of code dedicated to working with the DSS paths and files, it might make sense to develop a class to encapsulate that level of functionality.

Comment 27:

Java is an object-oriented language, and there are opportunities in the code to define classes that would provide more structure to the code.

Basis for Comment:

There are several places throughout the program where code is repeated with an identical structure differentiated only in name. For example, the following variables are used by the program to keep track of spawning:

```
private HecDoubleArray yearSpawningArea;

private HecDoubleArray yearMaxSpawningArea;

private HecDoubleArray yearMinSpawningArea;

private HecDoubleArray dailySpawning;

private double sAvg;

private double sMax;

private double sMin;
```

Identical variables are defined for calculating rearing and total habitats, which indicates the opportunity to simplify the code by creating a new class to encapsulate these fields and the methods that operate on them. In this instance the class could start with seven fields (yearArea, yearMaxArea, yearMinArea, daily, avg, max and min) and the program could then declare an instance of the class for spawning, rearing and total. Implementing this one class would organize 21 variables into three objects and making the code more concise and maintainable.

There are several other sets of variables that could benefit from being organized into classes including several pairs of minimum/maximum values, and the stageArea and stageData variables.

Significance – Low:

The current structure of the code does not impact the results or performance of the model, but it does make the code unnecessarily verbose and complex.

Recommendations for Resolution:

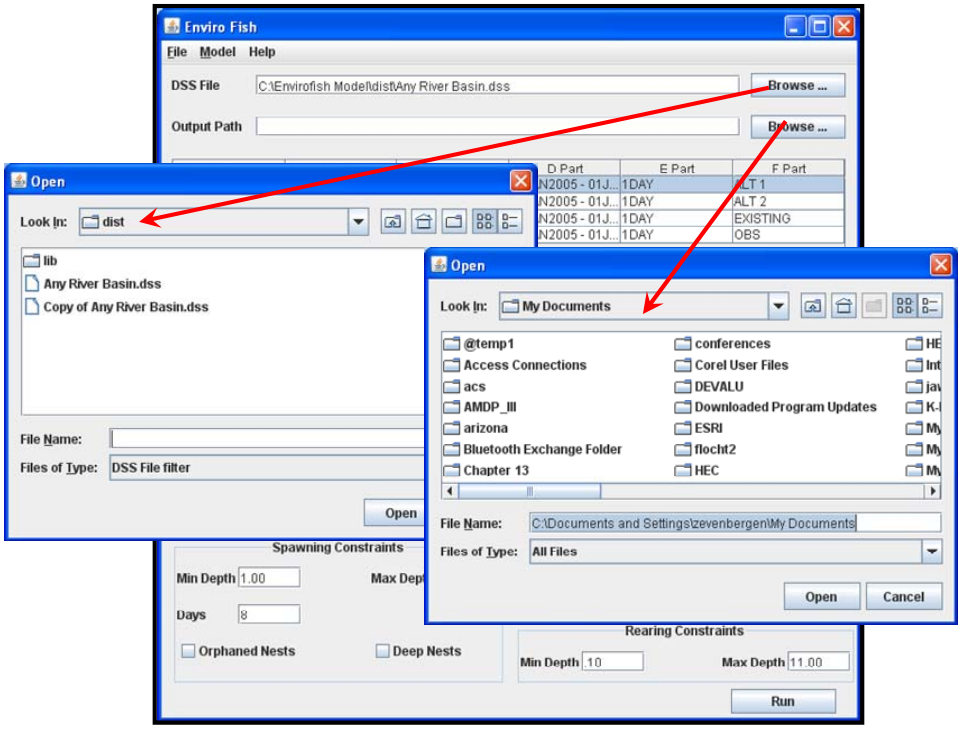
To resolve these concerns, refactor the code to simplify the code by organizing repetitive data structures into new Java classes.

Comment 28:

The "Output Path" "Browse…" option should default to the last directory that was accessed in a previous run.

Basis for Comment:

The "Browse…" option for the "DSS File" does default to the directory that was last accessed in the previous Enviro Fish run. This is not the case for the "Browse…" option for the "Output Path", as it always defaults to the "My Documents" directory. The software has the functionality to perform this task so it should be included for the "Output Path" for consistency and user friendliness.



Significance – Low:

This does not affect the results of the analysis but would improve user friendliness.

Recommendations for Resolution:

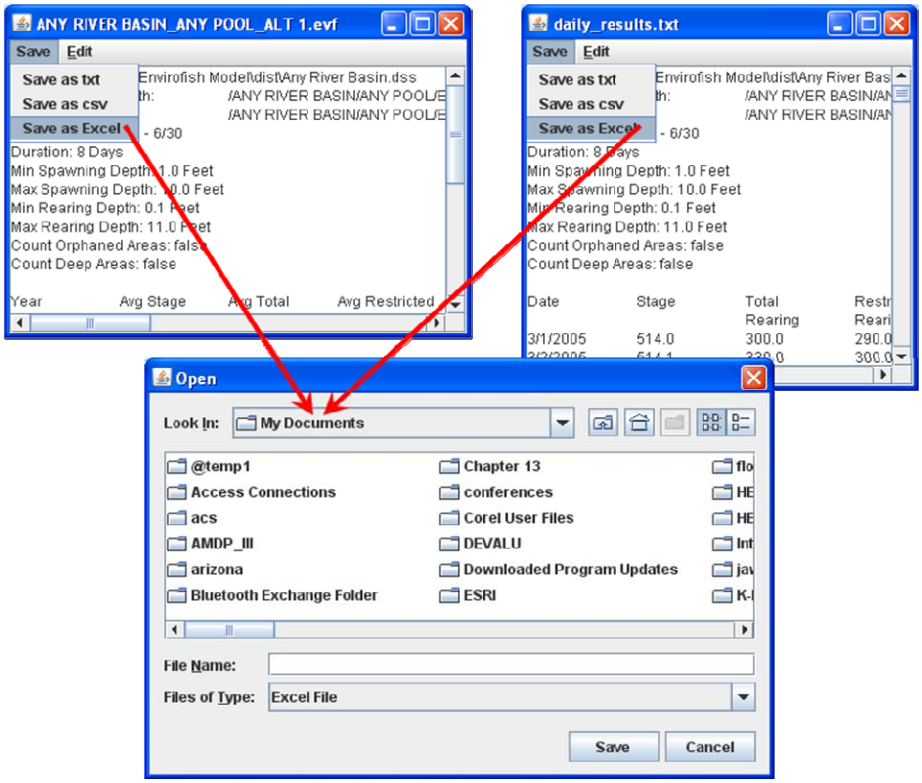
To resolve these concerns, incorporate the same functionality of the "DSS File" "Browse…" button for the "Output Path" "Browse…" button.

Comment 29:

Output files should not return to the "My Documents" root directory each time the user saves, but should default to the "Output Path" directory.

Basis for Comment:

The Enviro Fish program is designed to run each flow alternative with each land use type, resulting in a large number of individual output files. Each run may generate two output files: "daily_result.txt" and an ".evf" file, and each file may be saved in three different formats (txt, csv and Excel). Each time the user saves any of these files, the software defaults to the "My Documents" directory and then the user must navigate to the desired directory, which really should be the "Output Path" directory.



Significance – Low:

This is low significance because it does not affect the model results. However, it is significant for program usability.

Recommendations for Resolution:

To resolve these concerns, default to the "Output Path" directory.

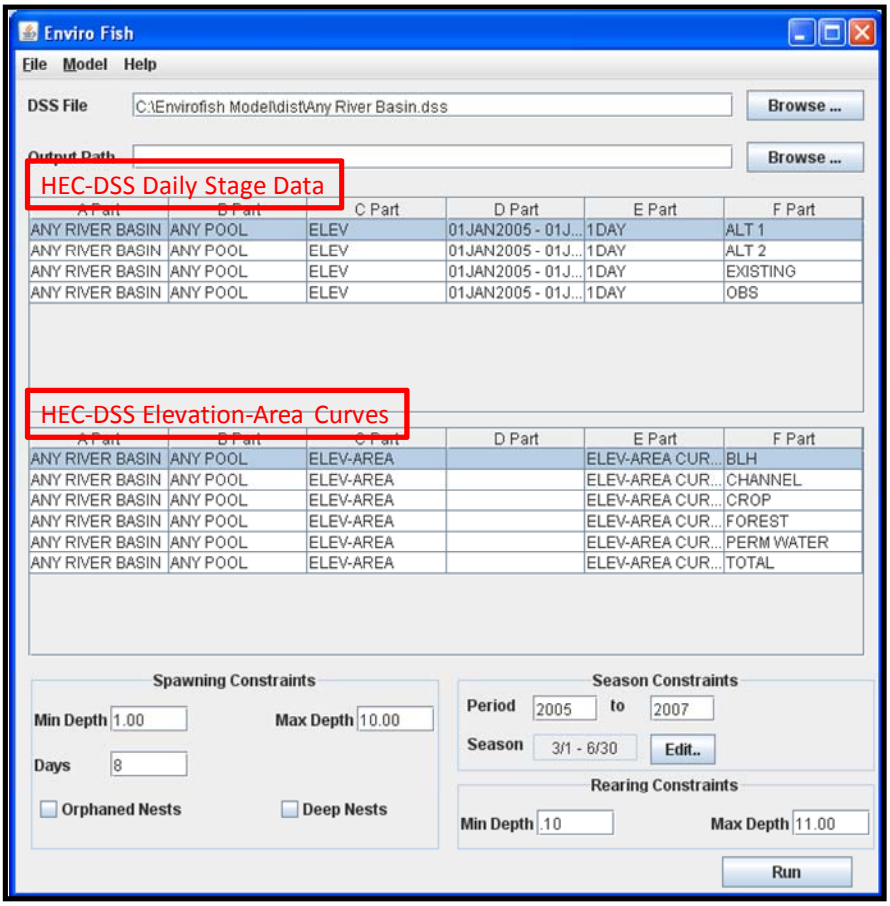
Comment 30:
The data for calculating HUs does not stand out in the output.
Basis for Comment:
The Enviro Fish model output provides a large array of data. The data needed for a HEP application is presented in the lower portion of the data table in the *Period Averages* section. If Enviro Fish is not expanded to incorporate a HEP analysis, these HEP-required data should be highlighted to allow the user to more easily locate the information necessary for a HEP analysis.
Significance – Low:
Highlighting allows a straightforward method to efficiently locate the area data needed to complete a HEP analysis after Enviro Fish calculates the area.
Recommendations for Resolution:
To resolve these concerns, highlight the cells needed for HEP analysis in the Enviro Fish output.

Comment 31:

Headers for the two DSS file groups, such as "Daily Stage Data" and "Stage – Elevation Curves," should be included in the main program screen.

Basis for Comment:

Each of the Enviro Fish user interface components (e.g., "DSS File", "Spawning Constraints", etc.) is identified with a header except for the two HEC-DSS data types. These should be included for consistency and to clarify the data types for the user.



Significance – Low:

This does not affect the model results, but would slightly improve user friendliness.

Recommendations for Resolution:

To resolve these concerns, include headers similar to those shown in red in the Basis for Comment section.

Comment 32:
The term "nests" should be replaced.
Basis for Comment:
The term "nest" is used many times in the narrative and as a variable for input for the model (e.g., page3-4, second sentence under Spawning). This is after Chapter 2 details the diversity of spawning strategies – including preferred substrates. The term "nests" generally refers to a structure or area for the deposition of eggs. The majority of floodplain spawners do not have this reproductive strategy.
Significance – Low:
Changing this term would help avoid potential confusion and make the model more accurate.
Recommendations for Resolution:
To resolve these concerns, substitute the term "nest" in the document narrative and in the model input with a more appropriate descriptor suitable for all floodplain species, such as "shallow allowable spawning area," and "deep allowable spawning area."

ATTACHMENT A

Work Plan

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REVISED FINAL WORK PLAN

INDEPENDENT EXTERNAL PEER REVIEW

for

Certification of Four Ecological Models: EnviroFish, Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, Waterfowl Assessment Methodology (WAM), and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook

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Prepared for
U.S. Army Corps of Engineers
Ecosystem Planning Center of Expertise

Contract No. W911NF-07-D-0001
Task Control Number: 09-210
Delivery Order Number: 0799

October 8, 2009

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Prepared by:

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Independent External Peer Review
for
Certification of Four Ecological Models:
EnviroFish, Waterfowl Assessment Methodology (WAM), Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook

General Project Information

- Project Title: Independent External Peer Review (IEPR) for Model Certification for Four Ecological Models: EnviroFish, Waterfowl Assessment Methodology (WAM), Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook (Four Ecological Models Review).
- Project Number: TG/G898592
- Client: U.S. Army Corps of Engineers, Ecosystem Planning Center of Expertise
- Effective Date of Work Plan: September 8, 2009
- Version Number: 1
- Project Manager: Karen Johnson-Young
- Deputy Project Manager: Amanda Maxemchuk
- Deliverable Due Dates: Draft Work Plan: October 1, 2009; Final Work Plan: October 8, 2009; Draft Charge: October 1, 2009; Final Charge: October 8, 2009; List of Peer Reviewers: October 16, 2009; Draft Model Review Reports: (A) January 5, 2009, (B) March 1, 2010; (C) February 3, 2010; (D) February 3, 2010; Final Model Review Reports: (A) January 22, 2010; (B) March 17, 2010; (C) February 22, 2010; (D) February 22, 2010
- Period of Performance: September 8, 2009 – April 30, 2010

1.0 Background, Objectives, and Scope of Work

1.1 Background

Planning models are defined as any models and analytical tools that planners use to define water resources management problems and opportunities, formulate potential alternatives to address the problems and take advantage of the opportunities, and evaluate potential effects of alternatives and to support decision-making. The United States Army Corps of Engineers (USACE) Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of planning models in the USACE and to make recommendations to assure that high quality methods and tools are available to enable informed decisions on investments in the Nation's water resources infrastructure and natural environment. The main objective of the PMIP is to carry out a process to review, improve and validate analytical tools and models for USACE Civil Works business programs. The PMIP Task Force collected the views of USACE leaders and recognized technical experts, and conducted investigations and numerous discussions and

debates on issues related to planning models. This task force identified an array of model-related problems, conducted a survey of planning models, prepared papers on model-related issues, analyzed numerous options for addressing these issues, and formulated recommendations.

Use of certified models for all USACE planning activities is mandatory. This policy is applicable to all planning models currently in use by USACE, as well as models under development and new models. District Commanders are responsible for providing high quality, objective, defensible, and consistent planning products. Development of these products requires the use of tested and defensible models. National certification of planning models will result in significant efficiencies in the conduct of planning studies and enhance the capability to produce high quality products. The appropriate USACE Planning Center of Expertise (PCX) will be responsible for model certification. The goal of certification is to establish that USACE planning products are theoretically sound, compliant with USACE policy, computationally accurate, based on reasonable assumptions, and are in compliance with the requirements of the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* (Federal Register Vol. 70, No. 10, January 14 2005, pp 2664-2677). The use of a certified model does not constitute technical review of the planning product. Independent technical review of the selection and application of the model and the input data is still the responsibility of the users. Once a model is certified, the PCXs will work with model developers and managers to ensure that documentation and training in model use are available and that model updates comply with certification requirements.

The primary criterion identified for model certification is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of the theory, the certified model should: 1) be based on validated and accepted "state of the art" theory; 2) incorporate USACE policies and requirements; 3) properly incorporate the conceptual theory into the software code; and, 4) clearly define the assumptions inherent in the model. In terms of computational correctness, the certified model should: 1) employ proper functions and mathematics to estimate functions and processes represented; and, 2) properly estimate and forecast the actual parameters it is intended to estimate and forecast. Other criteria for certification are efficiency, effectiveness, usability, and clarity in presentation of results. A certified model will stand the tests of technical soundness based on theory and computational correctness, efficiency, effectiveness, usability and clarity in presentation of results.

1.2 Objectives

The objectives of this work are to conduct a review for the USACE Ecosystem Planning Center of Expertise (ECO-PCX) to evaluate the technical quality, system quality, and usability of the following models in accordance with *Planning Models Improvement Program: Model Certification* (EC 1105-2-407, dated May 31, 2005) and the *Protocols for Certification of Planning Models* (July 2007), with the goal of certifying each model for use within the geographic area specified in the model documentation.

Model A EnviroFish Functional Reproductive Habitat Model

Model B Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley
Model C Waterfowl Assessment Methodology (WAM)
Model D Delta Region of Arkansas Regional HGM Guidebook

The review will not include a technical evaluation of the application of these models on a specific project. However, sample documentation of model application may be provided for informational purposes.

The general objectives of this work are to: a) prepare a work plan that will describe the process for conducting the model certification reviews of the four ecological models, b) identify potential panel members for the external peer review panel, and c) execute the work plan to conduct the model certification review.

1.3 Scope of Work

As a 501(c)(3) nonprofit science and technology organization with experience in establishing and administering peer review panels for USACE, Battelle was engaged to conduct the Model Review of the Four Ecological Models. Independent review ensures the quality and credibility of USACE planning tools. The Model Certification Review will follow the procedures described in the Department of the Army, USACE guidance entitled *Planning Models Improvement Program: Model Certification* (EC 1105-2-407), dated May 31, 2005, and the PMIP document entitled *Protocols for the Certification of Planning Models*, dated July 2007.

To accomplish the model certification review, subject matter experts will be recruited to participate on the peer review panel. Potential candidates for the peer review panel will be screened for availability, interest, and technical experience in defined areas of expertise and any actual or perceived conflicts of interest (COIs) will be determined. Ultimately, no more than 12 total panel members will be selected for the model certification review panels using predetermined criteria related to technical expertise and credentials in the subject matters related to the documents and materials to be reviewed. The following is a list of documents and reference materials that will be provided to the panel members for the review.

1. EnviroFish User Manual
2. EnviroFish Software
3. EnviroFish model code
4. Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley documentation
5. Habitat Model for Migrating Shorebirds communications
6. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley, including HGM spreadsheets (Appendix D) and spatial data (Appendix E)
7. Waterfowl Assessment Methodology (WAM), also called the Duck-use-day Model

2.0 **Methods and Technical Approach**

One of the initial steps in the review process is to prepare a detailed work plan (this document) under Task 2. Additional tasks are detailed below in Section 2.0 (this section). The tasks described are based on the key tasks defined and described in detail in the USACE Model Certification For Four Ecological Models: Envirofish, Waterfowl Assessment Methodology (WAM), Migrating Shorebird Habitat Suitability Index Model, and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook Statement of Work (SOW). All tasks for the reviews shall be performed independent of government supervision, direction, or control.

Task 1: Kick-off Meeting.
Battelle will hold a kick-off teleconference with the PMIP team and representatives from the ECO-PCX. The purpose of the kick-off is to review the schedule, discuss the model review process, and address any questions regarding the scope, review documents, or required panel member expertise. Battelle will review the model documentation provided with the SOW and, based on a comparison with Table 2 of the USACE *Protocols for the Certification of Planning Models*, determine if additional information will be required to conduct the model reviews. A plan for the ECO-PCX providing the additional information required will be developed at this kick-off meeting.

Task 2: Work Plan.
Battelle will prepare a draft and final work plan (this document) that describes the process for conducting four separate and consecutive model reviews, including the screening criteria and process for selecting model review panel members, the schedule, charges to model review panel members (including charge questions), the process for conducting the reviews and drafting and finalizing four reports that summarize the results of each model review, communication and meetings with the USACE project team, and quality control. Battelle will also conduct a cursory review of each model to determine the level of effort required for panel members to conduct their reviews.

USACE has provided comments on the draft work plan and draft charge questions. Battelle has consolidated and address all comments in this final work plan, which was submitted within three (3) working days of the receipt of comments.

Task 3: Prepare and Finalize Charge to Reviewers.
Battelle will prepare and finalize the charge to each model review panel based on technical direction received from USACE and guidance provided in Department of the Army, U.S. Army Corps of Engineers EC No. 1105-2-407, *Planning Models Improvement Program: Model Certification*, dated 31 May 2005, and *Protocols for the Certification of Planning Models*, dated July 2007.

The process and evaluation criteria for the review, as outlined in the *Protocols for Certification of Planning Models* (July 2007), may include any or all of the following steps:

1. Panel members determine whether project needs/objectives are clearly identified and whether the model described is meeting those needs/objectives.

2. Panel members evaluate the technical quality of the models (review of model documentation).
    a. Model is based on well-established contemporary theory.
    b. Model is a realistic representation of the actual system.
    c. Analytical requirements of the model are properly identified and the model addresses and properly incorporates the analytical requirements.
    d. Assumptions are clearly identified, valid, and support the analytical requirements.
    e. USACE policies and procedures related to the model are clearly identified, and the model properly incorporates USACE policies and accepted procedures.
    f. Formulas used in the model are correct and model computations are appropriate and done correctly.
3. Panel members evaluate system quality (review by running test data sets or reviewing the results of beta tests).
    a. Rationale for selection of supporting software tool/programming language and hardware platform is adequately described, and supporting software tool/programming language is appropriate for the model.
    b. Supporting software and hardware is readily available.
    c. Programming was done correctly.
    d. Model has been tested and validated, and all critical errors have been corrected.
    e. Data can be readily imported from/into other software analysis tools, if applicable.
4. Panel members evaluate the usability of the model.
    a. Examine the data required by the model and the availability of the required data.
    b. Examine how easily model results are understood.
    c. Evaluate how useful the information in the results is for supporting project objectives.
    d. Evaluate the ability to export results into project reports.
    e. Training is readily available.
    f. User documentation is available, user friendly and complete.
    g. Adequate technical support is available for the model.
    h. Software/hardware platform is available to all or most users.
    i. Model is easily accessible.
    j. Model is transparent and allows for easy verification of calculations and outputs.

Each model review panel member will be provided with a charge that will guide their review of any model documentation, software, and code provided. The charge will include an assessment of the criteria listed above which are relevant to each review and ask panel members to respond to specific charge questions or directives regarding individual sections of the model document, as appropriate.

Battelle prepared a generic draft charge to the model review panels. The draft charge has been finalized based on technical direction received from USACE. The final charge is being submitted to USACE (Appendix A of this document) for final approval and distribution to the model review panel members.

Task 4: Identify Candidate Reviewers.

Screen Candidate Reviewers

Battelle will develop criteria for selecting the candidate reviewers; contact potential reviewers to evaluate technical skills, potential COIs, availability, and hourly rates; and identify up to 24 (12 primary and 12 backup) available potential experts to serve on the model review panels. The selection criteria used to identify candidate reviewers are provided in Appendix B to this work plan. Battelle will also develop a detailed COI screening questionnaire to be included in recruiting communications (Appendix C of this document). USACE will review the questionnaire, suggest changes (if needed), and approve this COI list prior to any potential reviewer receiving it.

To identify potential reviewers, Battelle will review candidates in Battelle's database of peer reviewers, seek recommendations from colleagues, contact former panel members, and conduct targeted internet searches. Preliminary information about the up to 24 potential reviewers, including brief biographical information and their responses to the COI questionnaire, will be provided to USACE as early as possible.

Specifically, the final model review panels will include members with the expertise described in Table 1 below.

Table 1. Number of Required Panel Members

Panel Member Expertise	A. EnviroFish Model	B. Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley	C. Waterfowl Assessment Model	D. HGM Guidebook
Civil Works Planner/Habitat Evaluation Procedures (HEP) Specialist	1	1	1	
Civil Works Planner/HGM Specialist				1
Programming/Spreadsheet Auditor	1			1
Fisheries Biologist	2			
Hydraulic Engineer	1			
Avian Biologist		2		
Waterfowl Biologist			2	
Wetland Ecologist				1
Forester				1
Total Number of Reviewers	**5**	**3**	**3**	**4**

Greater detail on the desired expertise for each of the panel members is presented in Appendix B of this work plan, along with the selection criteria. Each panel member will review one model, with the exception of the civil works planner/HEP specialist (who will review three models) and the programmer/spreadsheet auditor (who will review two models).

Finalize Contracts with Peer Reviewers

Battelle will identify up to 24 potential panel members and select no more than 12 final panel members according to the selection criteria. For each reviewer, Battelle will prepare a tailored scope of work that describes required panel member activities for this project. This scope of work description, along with a request for quotation and a COI inquiry form (Appendix C) will be sent to each selected peer reviewer. Upon receipt of the reviewers' written quotations indicating willingness to participate and the absence of a COI, Battelle will establish contracts with the panel members at agreed-upon rates and hours to ensure/secure participation. Each contract established also includes a non-disclosure statement.

The scope of work for each peer reviewer will consist of:

- Participation in a Battelle kick-off meeting (via teleconference)
- Participation in a USACE kick-off meeting (via teleconference) with the PDT and Battelle
- Participation in a Habitat Evaluation Procedures (HEP) training teleconference (8 panel members)
- Review and assessment of the technical quality, system quality, and usability of the Four Ecological Models and preparation of individual written comments
- Participation in a panel review teleconference to discuss findings and agree on a list of key topics/issues that will be presented in the Draft Model Certification Review Report and form the basis for the model certification review Final Panel Comments
- Preparation of the model certification review Final Panel Comments
- Review of the Draft Model Certification Review Report before it is submitted to USACE
- Review of USACE comments on the Draft Model Certification Review Report and Final Panel Comments
- Participation in a teleconference with USACE to discuss USACE's comments on the Draft Model Certification Review Report and Final Panel Comments
- Revision of the Draft Model Certification Review Report and Final Panel Comments in response to USACE comments
- Review of the Final Model Certification Review Report before it is submitted to USACE
- Provide additional technical support as directed.

Battelle has estimated the level-of-effort required for each panel member for the reviews in Table 2.

Table 2. Estimated Levels-of-Effort (hours) for Panel Members

	Kickoff Meeting	HEP short-course	A. EnviroFish Model	B. Shorebird Model	C. Waterfowl Model	D. HGM Guidebook	Total Hours
CWP/HEP Specialist	3	15	74	29	74		195

	Kickoff Meeting	HEP short-course	A. EnviroFish Model	B. Shorebird Model	C. Waterfowl Model	D. HGM Guidebook	Total Hours
Fisheries Biologists	3	3	74				80
Hydraulic Engineer	3	3	74				80
Spreadsheet Auditor	3		74			74	151
Avian Biologists	3	3		29			35
Waterfowl Biologists	3	3			74		80
CWP/HGM Specialist	3					74	77
Wetland Ecologist	3					74	77
Forester	3					74	77

Note: CWP = Civil Works Planner; HEP = Habitat Evaluation Procedures

The estimated hours listed above include time for the model review and charge question response, teleconferences, preparation of final comments and Draft Model Certification Review Report, report review, responding to USACE comments on the draft report, Final Model Certification Review Report review, and support-related activities.

Task 5 A-D: Conduct Assessment of Model.
A kick-off meeting with Battelle, the model review panel members, representatives from the USACE ECO-PCX, and Model Proponents will be held via teleconference to discuss the model certification requirements and expectations and to facilitate information exchange for each of the model reviews. One kick-off meeting will be conducted and it will cover all four model certification reviews for models A through D.

The description of the model review process in the following paragraphs applies to each of the four models being reviewed. Battelle will provide the panel members with electronic copies of the documentation for the model, software, and model code; *Protocols for Certification of Planning Models;* EC 1105-2-407, *Planning Models Improvement Program: Model Certification*; and other supporting documentation. USACE will provide these documents to Battelle via its FTP site. Battelle will prepare and deliver a memorandum instructing the panel members to undertake the review and outlining the steps and deadlines. Working with USACE, Battelle will respond to any panel member questions or information requests during the review process.

The panel members will complete their review and provide comments to Battelle. After receipt of all individual panel member comments, Battelle will merge all comments into one document and share the document with the panel members. In addition, Battelle will carefully review the comments and identify key issues/topics related to the technical quality, system quality, and usability of the model, as well as the model description and model testing. These key

issues/topics identified in the merged individual comments will be distributed to the panel members.

A panel review teleconference will be convened to ensure the exchange of technical information among the panel members, many of whom will be from diverse scientific backgrounds, and to identify key issues/topics specifically associated with the technical quality, system quality, and usability of the model. The result of the teleconference will be a list of key issues/topics (i.e., findings) that the panel members agree should be presented to USACE in the Draft Model Certification Review Report (Task 7) and as final panel comments. During the teleconference, the specific wording for the final panel comment statement will be agreed upon by all panel members, and final panel comments will be assigned "high," medium," or "low" significance based on the following definitions:

- High: Describes a fundamental problem with the model that could affect the model's ability to serve the intended purpose.
- Medium: Affects the completeness or understanding of the model, model usability, or the level of performance of the model.
- Low: Affects the technical quality of the model documentation but will not affect the performance of the model.

At the end of the teleconference, Battelle will prepare a memorandum to the panel members directing them to prepare specific sections of the Draft Model Certification Review Report (Task 6) based on the findings discussion and the technical quality, system quality, and usability criteria outlined in the *Protocols for Certification of Planning Models*, July 2007. The panel members will also be directed to prepare final panel comments, each of which will include the following four parts: (1) a clear statement of the comment; (2) the basis for the comment; (3) the significance of the comment (high, medium, or low); and (4) recommendations to resolve the comment (including additional research or analysis that may influence the conclusions). The individual comments in response to the charge and the panel review teleconference notes will be used as background information to prepare the final panel comments and the Model Certification Review Report.

Task 6 A-D: Prepare Draft Certification Report.
Four separate Draft Model Certification Review Reports for models A through D will be prepared and submitted. Battelle will prepare each Draft Model Certification Review Report and submit it to USACE for review. The report will assess the degree to which the model meets the technical quality, system quality, and usability criteria outlined in the *Protocols for Certification of Planning Models*, July 2007.

The report will follow the general outline below:

1.0 Introduction

1.1. Model Purpose

1.2. Model Assessment

1.3. Contribution to Planning Effort

1.4. Report Organization

2.0 Model Description

2.1. Model Applicability

2.2. Model Summary

2.3. Model Components

3.0 Model Evaluation

3.1. Assessment Criteria

3.1.1.Technical Quality

3.1.2.System Quality

3.1.3.Usability

3.2. Approach to Model Testing

3.3. Technical Quality Assessment

3.3.1.Review of Theory and External Model Components

3.3.2.Review of Representation of the System

3.3.3.Review of Analytical Requirement

3.3.4.Review of Model Assumptions

3.3.5.Review Ability to Evaluate Risk and Uncertainty

3.3.6.Review Ability to Calculate Benefits for Total Project Life

3.3.7.Review of Model Calculations/Formulas

3.4. System Quality

3.4.1.Review of Supporting Software

3.4.2.Review of Programming Accuracy

3.4.3.Review of Model Testing and Validation

3.5. Usability

3.5.1.Review of Data Availability

3.5.2.Review of Results

3.5.3.Review of Model Documentation

3.6. Model Assessment Summary

4.0 Conclusions

5.0 References

The final panel comments will be included as an appendix to the Draft Model Certification Review Reports. Individual comments will not be included in the Draft Model Certification Review Reports.

The Draft Model Certification Review Reports will be submitted electronically to USACE for review. The ECO-PCX and PMIP will review the Reports and provide comments back to Battelle.

Task 7 A-D: Meeting to Discuss Findings.

As necessary, for each model review (A – D), Battelle and the panel members will meet via teleconference with USACE's Technical Point of Contact, representatives from the ECO-PCX

and CECW-P, and Model Proponents to discuss their initial findings and ask clarifying questions that will aid in determining the information to be included in each of the Model Certification Review Reports.

Task 8 A-D: Prepare Final Certification Report.
For each model review (A – D), Battelle will prepare a Final Model Certification Review Report including a description of the process used to assess the model, assessment of the model based on the criteria outlined in Section 3.a. of *Protocols for Certification of Planning Models* (July 2007) and issues related to model recommendation.

3.0 Quality Control and Quality Assurance

During the review of the Four Ecological Models, there are numerous instances when quality assurance and/or quality control (QA/QC) practices will be implemented to ensure products of the highest quality are being provided to USACE. These QA/QC practices are described below.

Deliverable Review
It is Battelle policy that every deliverable be independently reviewed to ensure that it is accurate, technically sound, has objective interpretation, solid conclusions, satisfying presentation, and meets or exceeds client expectations. The deliverables for this project are listed in Section 4.0 of this work plan. The review may include a technical, editorial, and/or quality assurance component, depending on the document and project requirements. The Project Manager (PM) will determine the type(s) of review appropriate for each deliverable. In addition, per Battelle policy, all deliverables must have a one-over-one review and approval by the appropriate Battelle Manager prior to external distribution.

In addition to general technical, editorial, and/or QA reviews, Battelle will assign at least two people familiar with the project to review the panel members' responses to the charge questions. Because the charge question responses are used to develop the key themes of the panel members' findings, it is important that the responses be reviewed by a second person to ensure that the key themes have been appropriately captured. In addition to the charge question responses, each final panel comment is carefully reviewed by both the PM and the Deputy Project Manager (DPM) to ensure accuracy and thoroughness.

Peer Review Panel Recruitment
As an unbiased panel is critical to the successful completion of the Model Certification Review process, Battelle conducts a thorough peer review panel recruitment process. The first step in this process is the preparation of a COI questionnaire. Each potential panel member must fully complete the COI (see Appendix C for the COI issues identified for the Four Ecological Models reviews). In addition, USACE will provide information on more general COI issues that have been identified by USACE. USACE must approve the final list of potential COI issues before the questionnaire is distributed to potential panel members.

A detailed review is conducted for each candidate panel member. The Battelle recruitment team will present each candidate panel member's technical qualifications and COI screening responses to the Battelle PM and DPM. The candidate's qualifications are compared to the scope of work

and to the pool of potential candidates. If there are any outstanding questions regarding the candidates' responses to the COI screening, the candidate is contacted and the questions resolved prior to submitting the candidate's name to USACE.

Teleconferences

Teleconferences are an important component of conducting a Model Certification Review. They are critical to developing the final panel comments and discussing the final panel comments with USACE. Thus, accurate recording of action items, resolutions, and other information discussed during these teleconferences is critical to the process. To ensure that important information is not missed, Battelle provides at least two note-takers for all teleconferences and kick-off meetings with USACE and/or the panel members. All sets of notes taken by Battelle staff are compared and consolidated after each teleconference to provide one set of official notes. These notes are retained in the project files.

Development of Talking Points for Panel Review Teleconference

After reviewing all the panel members' comments in response to charge questions on the review documents, a talking points memorandum is developed by the DPM prior to the panel review teleconference. This document guides the teleconference and includes the key themes identified from the panel's comments, in addition to specific issues where the reviewers may have disagreed with one another. After drafting the talking points memo, the DPM sends it to at least one member of the Battelle project team to ensure that no important issues were omitted. The talking points are also provided to the panel members prior to the teleconference for review.

4.0 **Reporting**

Deliverables for the Certification of Four Ecological Models project include the following:

- Draft and final version of the work plan and Model Certification Review Charges
- Final list of up to 24 (primary and backup) selected model review panel members
- Draft and final Model Certification Review Report – EnviroFish Model
- Draft and final Model Certification Review Report – Shorebird Model
- Draft and final Model Certification Review Report – Waterfowl Model
- Draft and final Model Certification Review Report – HGM Guidebook

All draft and final deliverables will be provided to USACE electronically only and in PDF format, with the exception of each Final Model Certification Review Report, which will be sent to the USACE Technical Representative in hard copy (in addition to electronically). The draft work plan and charges were also provided to the USACE in Microsoft Word 2003 format to facilitate their review and allow comments and suggested revisions to be made in track changes.

There are no monthly report requirements for this project.

5.0 **Schedule**

The due dates for milestones and deliverables in Table 3 below are based on the date Battelle was supplied the final decision regarding the process to follow for conducting these four reviews (September 22, 2009). The asterisks indicate deliverables. All changes to the schedule will be documented and a revised schedule will be submitted to the USACE for approval.

Table 3. Four Ecological Models Certification Review Milestones and Deliverables

TASK	ACTION	DUE DATE
	Receipt of final decision on review process	**9/22/09**
	Review documents available	various
1	USACE/Battelle Kick-off Meeting	09/17/09
	USACE/Battelle/Panel Kick-off Meeting with all panel members	10/28/09
2	*Battelle submits Draft Work Plan to USACE	10/1/09
	USACE provides comments on Draft Work Plan	10/5/09
	Conference Call (if necessary)	TBD
	*Battelle submits Final Work Plan to USACE	10/8/09
3	*Battelle submits Draft Charge (combined with Draft Work Plan – Task 1) to USACE	10/1/09
	USACE provides comments on draft charge	10/5/09
	*Battelle submits Final Charge (combined with Final Work Plan – Task 1) to USACE	10/8/09
	USACE approves Final Charge	10/13/09
4	Battelle provides USACE with conflict of interest (COI) statements for review	9/14/09
	Battelle recruits and screens up to **24** candidate panel members	10/16/09
	*Battelle submits list and summary information of candidate panel members	10/16/09
	USACE provides comments on candidate panel members	10/21/09
	Battelle completes subcontracts for panel members	10/30/09
5A	Battelle provides review documents to panel members	11/2/09
	Panel **A** completes its review	11/20/09
	Battelle collates comments from panel **A**	11/24/09
	Battelle convenes panel review teleconference for panel **A**	12/01/09
	Panel **A** provides final panel comments and report section writing assignments to Battelle	12/11/09
6A	Battelle convenes teleconference with USACE to ask clarifying questions	As needed
7A	*Battelle submits Draft Model Certification Review Report **A** to USACE for review	1/5/10
	USACE provides comments on Draft Model Certification Review Report **A**	1/11/10
	Battelle convenes teleconference to discuss USACE comments on Draft Model Certification Review Report **A**	1/14/10
8A	*Battelle submits Final Model Certification Review Report **A** to USACE	1/22/10
5B	Battelle provides review documents to panel members	11/2/09
	Panel **B** completes its review	1/29/10
	Battelle collates comments from panel **B**	2/2/10

TASK	ACTION	DUE DATE
	Battelle convenes panel review teleconference for panel **B**	2/3/10
	Panel **B** provides final panel comments and report section writing assignments to Battelle	2/15/10
6B	Battelle convenes teleconference with USACE to ask clarifying questions	As needed
7B	*Battelle submits Draft Model Certification Review Report **B** to USACE for review	3/1/10
	USACE provides comments on Draft Model Certification Review Report **B**	3/8/10
	Battelle convenes teleconference to discuss USACE comments on Draft Model Certification Review Report **B**	3/10/10
8B	*Battelle submits Final Model Certification Review Report **B** to USACE	03/17/10
5C	Battelle provides review documents to panel members	11/2/09
	Panel **C** completes its review	1/7/09
	Battelle collates comments from panel **C**	1/11/09
	Battelle convenes panel review teleconference for panel **C**	1/12/09
	Panel **C** provides final panel comments and report section writing assignments to Battelle	1/20/10
6C	Battelle convenes teleconference with USACE to ask clarifying questions	As needed
7C	*Battelle submits Draft Model Certification Review Report **C** to USACE for review	2/3/10
	USACE provides comments on Draft Model Certification Review Report **C**	2/10/10
	Battelle convenes teleconference to discuss USACE comments on Draft Model Certification Review Report **C**	2/15/10
8C	*Battelle submits Final Model Certification Review Report **C** to USACE	2/22/10
5D	Battelle provides review documents to panel members	11/2/09
	Panel **D** completes its review	1/7/09
	Battelle collates comments from panel **D**	1/11/09
	Battelle convenes panel review teleconference for panel **D**	1/12/09
	Panel **D** provides final panel comments and report section writing assignments to Battelle	1/20/10
6D	Battelle convenes teleconference with USACE to ask clarifying questions	As needed
7D	*Battelle submits Draft Model Certification Review Report **D** to USACE for review	2/3/10
	USACE provides comments on Draft Model Certification Review Report **D**	2/10/10
	Battelle convenes teleconference to discuss USACE comments on Draft Model Certification Review Report **D**	2/15/10
8D	*Battelle submits Final Model Certification Review Report **D** to USACE	2/22/10
	Project Closeout	4/30/2010

Note: A indicates tasks for the review of the EnviroFish model, B indicates tasks for the review of the Habitat Model for Migrating Shorebirds in the Upper Mississippi Aluvial Valley, C indicates tasks for the review of the Waterfowl Assessment Methodology, and D indicates tasks for the review of the Delta Region of Arkansas Hydrogeomorphic Methodology Guidebook.
* = deliverable

6.0 **Project Organization and Communication**

Role and contact information for the key persons who will be working on the Four Ecological Models Review are presented in Table 4 (Battelle staff members), and Table 5 (USACE Project Delivery Team).

Table 4. Battelle Staff for the Four Ecological Models Project IEPR

Name	Project Role	Phone	E-mail
Karen Johnson-Young	Project Manager	(561) 656-6304	johnson-youngk@battelle.org
Amanda Maxemchuk	Deputy Project Manager	(781) 952-5384	maxemchuka@battelle.org
Rachel Sell; Corey Wisneski	Recruiting	(614) 424-3579; (781) 952-5296	sellr@battelle.org; wisneskic@battelle.org
Anne Gregg	Subcontracting Lead	(614) 424-7419	gregga@battelle.org

Table 5. USACE Staff for the Four Ecological Models Project

Name	Project Role	Phone	E-mail
Charles Theiling	Technical Representative/Point of Contact (Rock Island District)	(309) 794-5636	charles.h.theiling@usace.army.mil
Jodi K. Staebell	Alternate Technical Representative/Alternate Point of Contact (Mississippi Valley Division)	(309) 794-5448	jodi.k.staebell@usace.army.mil
Daniel Ward	Alternate Technical Representative/Alternate Point of Contact PDT (Memphis District)	(901) 544-0709	daniel.d.ward@usace.army.mil
Kelly Baerwaldt	Contracting Officer's Representative (Rock Island District)	(309) 794-5285	kelly.l.baerwaldt@usace.army.mil

Communication with USACE

Battelle's Point of Contact (POC) is the Technical Representative for the ECO-PCX. The alternate POC will be copied on all emails to the POC. If the POC is not available (e.g., on vacation), Battelle will contact the alternate POC directly. Communications may include status reports, questions, and/or requests for additional information from the panel.

Communication with the Model Review Panel

Battelle will be the main POC between USACE and model review panel members. Direct contact between the USACE and model review panel members will only occur during teleconferences with a Battelle representative present. All other communications will be directed through Battelle's Project Manager and Deputy Project Manager. The panel will be briefed that they are to have no direct communication with USACE and if they are contacted by USACE, they are to immediately inform Battelle.

7.0 **Budget**

The approved budget for this project is $392,531.

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APPENDIX A

Final Charge Guidance and Questions to the Peer Reviewers for the Model Certification Review of *Model Name*[1]

BACKGROUND
Model-specific background will be added.

OBJECTIVE

The objective of this effort is to conduct a review to evaluate the technical approach, system quality, and usability of the ***Model Name***. The ***Model Name*** will be evaluated in accordance with EC 1105-2-407, *Planning Models Improvement Program: Model Certification* (May 2005) and the *Protocols for Certification of Planning Models* (July 2007).

The U.S. Army Corps of Engineers Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of planning tools and models in the U.S. Army Corps of Engineers (USACE) and to make recommendations to assure that high quality methods and tools are available to enable informed decisions on investments in the Nation's water resources infrastructure and natural environment. The main objective of the PMIP is to carry out "a process to review, improve and validate analytical tools and models for USACE Civil Works business programs." The model review for the ***Model Name*** will follow the guidance described in the Department of the Army, U.S. Army Corps of Engineers document entitled *Planning Models Improvement Program: Model Certification* (EC 1105-2-407), dated May 31, 2005, and the Planning Models Improvement Programs document entitled *Protocols for the Certification of Planning Models*, dated July 2007.

MODEL REVIEW

The following outlines the basic steps for the USACE model certification process. These steps are designed to guide the review of models being certified for widespread use and are also used to assess the technical quality and applicability of project-specific models. Model development is a multi-step, iterative process, with the number of steps and iterations being dependent upon the complexity of the model. In general, these steps occur in four fundamental stages.

- Stage 1 (Requirements Stage) involves identifying the need for a specific analytical capability and the options for tools to meet the need.
- Stage 2 (Development Stage) involves the development of software programming code or a spreadsheet and testing by the model developer.
- Stage 3 (Model Testing Stage) involves a beta test of the model by selected users whose objective is to validate the model and ensure that it is usable in real world applications.
- Stage 4 (Implementation Stage) involves providing training, user support, maintenance and continuous evaluation of the model.

[1] Note that all highlighted items in this draft charge will be changed to be specific for the model under review

The certification procedure depends on the stage of model development. The process may include the following steps.

1. Panel members determine whether project needs/objectives are clearly identified and whether the model described is meeting those needs/objectives.
2. Panel members evaluate the technical quality of the models (review of model documentation).
    a. Model is based on well-established contemporary theory.
    b. Model is a realistic representation of the actual system.
    c. Analytical requirement of the model are properly identified and the model addresses and properly incorporates the analytical requirements.
    d. Assumptions are clearly identified, valid, and support the analytical requirements.
    e. USACE policies and procedures related to the model are clearly identified, and the model properly incorporates USACE policies and accepted procedures.
    f. Formulas used in the model are correct and model computations are appropriate and done correctly.
3. Panel members evaluate system quality (review by running test data sets or reviewing the results of beta tests).
    g. Rationale for selection of supporting software tool/programming language and hardware platform is adequately described, and supporting software tool/programming language is appropriate for the model.
    h. Supporting software and hardware is readily available.
    i. Programming was done correctly.
    j. Model has been tested and validated, and all critical errors have been corrected.
    k. Data can be readily imported from/into other software analysis tools, if applicable.
4. Panel members evaluate the usability of the model.
    l. Examine the data required by the model and the availability of the required data.
    m. Examine how easily model results are understood.
    n. Evaluate how useful the information in the results is for supporting project objectives.
    o. Evaluate the ability to export results into project reports.
    p. Training is readily available.
    q. User documentation is available, user friendly and complete.
    r. Adequate technical support is available for the model.
    s. Software/hardware platform is available to all or most users.
    t. Model is easily accessible.
    u. Model is transparent and allows for easy verification of calculations and outputs.

The final deliverable for this effort will be a Model Certification Review Report that Battelle will deliver to USACE. The model review panel members will contribute to the preparation of the draft and final reports, as well as participate in two teleconferences with USACE and the Model Proponents to discuss review panel comments on the method (first teleconference) and USACE comments on the Draft Model Certification Review Report (second teleconference). The general outline for the report will be:

1.0 Introduction

1.1. Model Purpose

1.2. Model Assessment

1.3. Contribution to Planning Effort

1.4. Report Organization

2.0 Model Description

2.1. Model Applicability

2.2. Model Summary

2.3. Model Components

3.0 Model Evaluation

3.1. Assessment Criteria

3.1.1. Technical Quality

3.1.2. System Quality

3.1.3. Usability

3.2. Approach to Model Testing

3.3. Technical Quality Assessment

3.3.1. Review of Theory and External Model Components

3.3.2. Review of Representation of the System

3.3.3. Review of Analytical Requirement

3.3.4. Review of Model Assumptions

3.3.5. Review Ability to Evaluate Risk and Uncertainty

3.3.6. Review Ability to Calculate Benefits for Total Project Life

3.3.7. Review of Model Calculations/Formulas

3.4. System Quality

3.4.1. Review of Supporting Software

3.4.2. Review of Programming Accuracy

3.4.3. Review of Model Testing and Validation

3.5. Usability

3.5.1. Review of Data Availability

3.5.2. Review of Results

3.5.3. Review of Model Documentation

3.6. Model Assessment Summary

4.0 Conclusions

5.0 References

DOCUMENTS PROVIDED

The following is a list of documents and reference materials that will be provided for the review. **The documents and files presented in bold font are those which are to be reviewed.** All other documents are provided for reference.

- **Model Documentation**
- **Software**
- **Model Code**
- Department of the Army, U.S. Army Corps of Engineers *Planning Models Improvement Program: Model Certification* (EC 1105-2-407), dated May 31, 2005
- USACE Planning Models Improvement Programs document entitled: *Protocols for the Certification of Planning Models*, dated July 2007

SCHEDULE

Task	Activity	Due Date	Projected Date
5	*Conduct kick-off conference call with panel members and Model Proponents	Within 3 days of completing contracts	October 28, 2009
	Model review panel members submit comments to Battelle	Within 12 days of kick-off conference call with panel members	*Date*
	Contractor convenes meeting with panel members to discuss initial findings	Within 3 days of receipt of model team comments	*Date*
6	*Convene teleconference with USACE to ask clarifying questions on initial findings	Within 5 days of receipt of model team comments	As needed
	*Submit Draft Model Review Report to USACE for review	Within 14 days of receiving final panel comments and writing assignment from panel members	*Date*
	USACE provide comments on Draft Model Review Report	Within 5 days of receipt of draft report	*Date*
7	Convene a teleconference with USACE to discuss the Draft Review Report	Within 2 days of receipt of USACE comments	*Date*
8	*Submit the Final Model Review Report to the USACE	Within 5 days of review conference call on USACE draft report comments	*Date*

* denotes a deliverable

CHARGE FOR PEER REVIEW

The charge questions and guidelines are based on the model certification criteria discussed in the guidance document *Protocols for Certification of Planning Models* (July 2007) from the USACE

Planning Models Improvement Program. The intent of these questions is to focus your thinking, not to suggest or dictate your answers. We want you to consider several aspects of models during your review, from the inputs to the outputs to the underlying structure of the method.

General Charge Guidance

1. Please answer the scientific and technical questions listed below and conduct a broad overview of the model. Please focus on your areas of expertise and technical knowledge.
2. Evaluate the soundness of model as applicable and relevant to your area of expertise. Comment on whether model explains past events and how model will be validated.
3. Please focus the review on scientific information, including factual inputs, data, the use and soundness of model calculations, assumptions, and results that inform decision makers.
4. Offer opinions as to whether the model parameters and formulas are sufficient to quantify ecosystem function.
5. Panel members may contact each other. However, panel members **should not** contact anyone who is or was involved in the project, prepared the subject documents, developed the model, or was part of the USACE Independent Technical Review.
6. Please contact the Battelle Deputy Project Manager, Amanda Maxemchuk (maxemchuka@battelle.org) and cc: Karen Johnson-Young (johnson-youngk@battelle.org) if you have questions for Battelle or the USACE or need additional information.
7. In case of media contact, notify the Battelle project manager immediately.

Your name will appear as one of the panelists in the peer review. Your comments will be included in the Final Model Certification Review Report, but will remain unattributed. The Final Model Certification Review Report is expected to be released to the public by the USACE at some time in the future.

Please submit your comments in electronic form to Amanda Maxemchuk (maxemchuka@battelle.org) no later than *Date*.

MODEL ASSESSMENT CRITERIA

General Questions

1. Are the project needs/objectives clearly identified?

2. Does the model described meet those needs/objectives?

Technical Quality

3. Comment on the overall technical quality of the model.

4. Comment on the temporal and spatial resolution of the model.

5. Is it clear where the model's geographic boundaries fall?

6. Are the limitations of the model clearly defined?
   a. How do the limitations impact the ability of the model to evaluate ecological benefits?
   b. What are the potential impacts to the project?
   c. How can those limitations be overcome?

7. Is the model based on well-established contemporary theory?

8. Is the model a realistic representation of the actual ecosystem?

9. Does the model effectively capture the variables that are most important for the intended use of the model?

10. Comment on the precision and accuracy of the model for evaluating potential outcomes of project alternatives. What factors/variables provide the greatest impact on precision and accuracy?

11. Comment on the sensitivity of the model.

12. Are the analytical requirements of the model properly identified?

13. Does the model address and properly incorporate the analytical requirements?

14. Are the assumptions clearly identified, valid, and do they support the analytical requirements?

15. Comment on the ability of the model to evaluate risk and uncertainty.

16. Comment on the ability of the model to evaluate impacts and benefits for total project life.

17. Comment on the ability of the model to determine adequate compensatory mitigation.

18. Are the formulas used in the models correct and are the model macros and computations appropriate and done correctly?

19. Are USACE policies and procedures related to the model clearly identified, and does the model properly incorporate USACE policies and accepted procedures?

20. Do the models allow the user(s) to make assumptions regarding future global events such as, but not limited to, global climate change and changes to sea level.

System Quality

21. Is the rationale for the selection of the supporting software tool/programming language and hardware platform adequately described?

22. Is the supporting software tool/programming language is appropriate for the model?

23. Was the programming done correctly?

24. Can data be readily imported from/into other software analysis tools?

25. Has the model been sufficiently tested and validated, and have all critical errors been corrected?

26. Are error checks built into the models?

27. Do the models work using both sensible and non-sensible data?

Usability

28. Comment on the model usability.

29. Comment on the availability of the data required by the model.

30. How easily are model results understood?

31. Comment on how useful the information in the results is for supporting project objectives.

32. Comment on the usability of the model for selecting the best project alternative.

33. Is user documentation user friendly, and complete?

34. Are the models transparent and do they allow for easy verification of calculations and outputs?

APPENDIX B

Four Ecological Models Model Certification Review Panels Considerations and Proposed Selection/Exclusion Criteria

According to the documents for the Certification of Four Ecological Models, the overall model review scope includes:

- Two avian biologists (Migrating Shorebird Habitat Suitability Index Model)
- One civil works planner/HEP specialist (EnviroFish, Migrating Shorebird Habitat Suitability Index Model, Waterfowl Assessment Method)
- One civil works planner/HGM specialist (Delta Region of Arkansas HGM Guidebook)
- Two fisheries biologists (EnviroFish)
- One forester (Delta Region of Arkansas HGM Guidebook)
- One hydraulic engineer (EnviroFish)
- One programmer/spreadsheet auditor (EnviroFish, Delta Region of Arkansas HGM Guidebook)
- Two waterfowl biologists (Waterfowl Assessment Method)
- One wetland ecologist (Delta Region of Arkansas HGM Guidebook)

Technical Criteria /Areas of Expertise for Potential Independent External Peer Reviewers

All panel members should have at least 5-10 years of experience and have familiarity with large, complex civil works projects with high public and interagency interests. The panel members should at least have M.S. degrees, although Ph.Ds are preferred.

Technical areas related to **avian biology** (2 experts; Migrating Shorebird Habitat Suitability Index Model):

- Familiarity with methods for evaluating bird habitat suitability and have knowledge of the Lower Mississippi River Valley bird populations, specifically shorebirds.

Technical areas related to **civil works planning and Habitat Evaluation Procedures** (1 expert; EnviroFish, Migrating Shorebird Habitat Suitability Index Model, and Waterfowl Assessment Method reviews):

- Experience in the area of floodplain management including ecosystem restoration, impact analysis, compensatory mitigation and knowledge of Lower Mississippi River Valley ecosystems.
- Experience in the use of HEP.

Technical areas related to **civil works planning and Hydrogeomorphic Models** (1 expert; Delta Region of Arkansas HGM Guidebook):

- Experience in the area of floodplain management including ecosystem restoration, impact analysis, compensatory mitigation and knowledge of Lower Mississippi River Valley ecosystems.
- Experience in the use of Hydrogeomorphic approach for assessing wetland functions.

Technical areas related to **fisheries biology** (2 experts, EnviroFish):

- Familiarity with the methods for evaluating fish habitat suitability and have knowledge of the Lower Mississippi River Valley fisheries.
- Experience working with hydrologic and hydraulic modelers to evaluate floodplain hydraulics is desirable.

Technical areas related to **forestry** (1 expert, Delta Region of Arkansas HGM Guidebook):

- Experience in riverine forest ecology, experience in bottomland hardwood community structure and dynamics within the Lower Mississippi River Valley.
- Familiarity with ecosystem output evaluation, particularly the hydrogeomorphic approach to assessing wetland function, is essential.

Technical areas related to **hydraulic engineering** (1 expert, EnviroFish):

- Experience in estimating the effects of flood protection on floodplain hydrology using the HEC-RAS 1-D Flow and associated DSS (direct storage system) files and conducting ecosystem restoration output evaluations.

Technical areas related to **programmer/spreadsheet auditing** (1 expert, EnviroFish and Delta Region of Arkansas HGM Guidebook):

- Experience testing, debugging and auditing computer programs/spreadsheets to check for accuracy of formulas, cell references, and computer code.
- Must have experience with Java programming language.

Technical areas related to **waterfowl biology** (2 experts, Waterfowl Assessment Method):

- Familiarity with methods for evaluating waterfowl habitat suitability and have knowledge of the Mississippi River Valley migratory waterfowl.

Technical areas related to **wetland ecology** (1 expert, Delta Region of Arkansas HGM Guidebook):

- Experience in wetland ecology of large floodplain rivers, preferably experience in southern bottomland wetlands.
- Familiarity with ecosystem output evaluation, particularly the Hydrogeomorphic approach to assessing wetland function, is essential.

Other considerations:

- Participation in previous USACE technical review panels
- Other technical review panel experience

Reviewer Categories [candidate may fit into more than one category]

- Academic
- Consultant (company-affiliated, *e.g.*, architect-engineer or consulting firm)
- Consultant (independent)
- Non-governmental organization (*e.g.*, public agency)

Potential Exclusion Criteria/Conflicts of Interest

- Involvement by you or your firm[1] in any part of the development, assessment, or review of the following models:
    - EnviroFish Functional Reproductive Habitat Model
    - Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley/Migrating Shorebird Model
    - Waterfowl Assessment Methodology/ Duck Use Days Model
    - A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley
- Involvement by your firm[1] in any part of the St. Johns Bayou and New Madrid Floodway Environmental Impact Statement process, including:
    - Final Environmental Impact Statement entitled Mississippi River and Tributaries, Mississippi River Levees (MRL) and Channel Improvement (1976);
    - Final EIS entitled St. Johns Bayou/New Madrid Floodway Project Final EIS (1982);
    - 1998 Mississippi River Mainline Levees Enlargement and Seepage Control EIS
    - Draft Supplemental EIS (1999)
    - Final Supplemental EIS (2000)
    - Revised Supplemental EIS (2002); or,
    - Second Revised Supplemental EIS (2006).
- Any involvement by you or your firm[1] in the conceptual or actual design, construction, or O&M of the St. Johns Bayou and New Madrid Floodway, MO project or the Mississippi River and Tributaries Project.
- Involvement as an expert or provided testimony for the civil action (04-1575) Environmental Defense, et al. v. U.S. Army Corps of Engineers (USACE) et al.
- Involvement as an expert or provided testimony for Water Quality Certification for the St. Johns Bayou and New Madrid Floodway Project (06-0421) Missouri Coalition for the Environment, et al. v. Missouri Department of Natural Resources *et al*.
- Any involvement by you or your firm[1] in any litigation involving the United States of America and the U.S. Army Corps of Engineers in particular
- Any application by you or your firm[1] for a USACE permit of any nature or representation for a client that applied for a USACE permit of any nature within the boundaries of the Memphis or Vicksburg Districts.
- Current employment by the USACE.
- Current or previous employee or affiliation with the interagency mitigation team or the local sponsor, the U.S. Fish and Wildlife Service, Environmental Protection Agency, Missouri Department of Conservation, Missouri Department of Natural Resources, and the St. Johns Levee and Drainage District.
- Any employment as an individual or contractually by a State agency, levee or drainage district, or a city or municipality that had committed to serve as a local sponsor for a USACE project within the boundaries of the Memphis, or Vicksburg Districts.
- Current or previous employment or affiliation with Environmental Defense, National Wildlife Federation, or Missouri Coalition for the Environment (for pay or pro bono).

- Any voluntary service by you or your firm[1] to provide expert opinions or testimony in connection for any party in connection with a federal project.
- Current or future interests in the St. Johns Bayou and New Madrid Floodway Project.
- Involvement with paid or unpaid expert testimony related to the models or document listed above in numbers 1 and 2.
- Current personal involvement with other USACE projects, including whether involvement was to author any manuals or guidance documents for USACE. If yes, provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please highlight and discuss in greater detail any projects that are specifically with the Vicksburg District or the Memphis District.
- Current firm[1] involvement with other USACE projects, specifically those projects/contracts that are with the Vicksburg District or the Memphis District. If yes, provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role.
- Previous employment by USACE as a direct employee or contractor (either as an individual or through your firm[1]) within the last 10 years, notably if those projects/contracts are with the Vicksburg District or the Memphis District. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
- Other USACE affiliation [e.g., scientist employed by USACE (except as described in NAS criteria, see EC 1105-2-410 section 8d)].
- Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning flood risk management projects, and include the client/agency and duration of review (approximate dates).
- A significant portion (i.e., greater than 50%) of personal or firm[1] revenues within the last 3 years came from USACE contracts.
- A significant portion (i.e., greater than 50%) of personal or firm[1] revenues within the last 3 years came from U.S. Fish and Wildlife Service contracts.
- Any publicly documented statement (including, for example, advocating for or discouraging against) related to the models or document listed above in numbers 1 and 2.
- Any publically documented statement advocating for or against the Mississippi River and Tributaries Project, including the St. Johns Bayou and New Madrid Floodway Project.
- Is there any past, present or future activity, relationship or interest (financial or otherwise) that could make it appear that you would be unable to provide unbiased services on this project? If so, please describe:
- Any other perceived COI not listed, such as:
    - Repeatedly served as USACE technical reviewer
    - Paid or unpaid participation in litigation related to the work of the USACE.
    - Prior repeated service as technical advisor to, or expert witness for, Environmental Defense, National Wildlife Federation, the Missouri Coalition for the Environment, or any other interest group that opposed a USACE Project.
    - Any other perceived COI not listed.

[1] Note: Includes any joint ventures in which your firm is involved.

APPENDIX C

Peer Review Conflict of Interest Inquiry

Dear (Peer Reviewer -- insert name):

You have been requested by the U.S. Army Corps of Engineers (USACE) to serve as an external peer reviewer for the Independent External Peer Review of the Model Certification for Four Ecological Models: EnviroFish, Waterfowl Assessment Methodology (WAM), Migrating Shorebird Habitat Suitability Index Model, and the Delta Region of Arkansas Hydrogeomorphic Methodology. Your participation in this review will be greatly appreciated. However, it is possible that your personal affiliations and involvement in particular activities could pose a conflict of interest or create the appearance that you lack impartiality in your involvement for this peer review. Although your involvement in these activities is not necessarily grounds for exclusion from the peer review, you should consult the contact named below or other appropriate official to discuss these matters. Affiliations or activities that could potentially lead to conflicts of interest might include:

a) current work or arrangements concerning future work in support of industries or other parties that could potentially be affected by developments or other actions based on material presented in the document (or review materials) that you have been asked to review;
b) your personal benefit (or benefit of your employer, spouse or dependent child) from the developments or other actions based on the document (or review materials) you have been asked to review;
c) any previous involvement you have had with the development of the document (or review materials) you have been asked to review;
d) any financial interest held by you (or your employer, spouse or dependent child) that could be affected by your participation in this matter;
e) any financial relationship you have or have had with USACE such as employment, research grants, or cooperative agreements;
f) significant portion (i.e., greater than 50%) of your personal or firm's revenues within the last 3 years came from USACE contracts;
g) you or your firm made a publicly documented statement advocating for or against the subject project;
h) litigation associated with USACE; and
i) past, present or future activity, relationship or interest (financial or otherwise) that could potentially be perceived by a third party, or give the appearance that you would be unable to provide independent unbiased subject matter knowledge, expertise, and/or services on this project.

[1] Note: Includes any joint ventures in which your firm is involved

If you have any concerns over a potential conflict of interest, please contact Mr. Mike Genovese, Battelle (GenoveseM@Battelle.org, (614) 424-4007) to discuss any potential conflict of interest

issues at your earliest convenience, but no later than two (2) days after receiving this request.

If you agree to be on this peer review panel, please check one of the following boxes, sign this form, and fax to Mr. Mike Genovese, Battelle, at (614) 458-4007 no later than two (2) days after receiving this request.

This form does not constitute an authorization to participate in this review; authorization for performance will come from Battelle's Government Subcontracts office.

[ ] I have no known existing or potential conflicts of interest associated with this task.

[ ] I have identified and disclosed in writing all known existing or potential conflicts of interest associated with this task.

_____ _____

Signature *Date* *Printed Name*