FISH PASSAGE AT LITTLE GOOSE DAM

Research Summary SPE-W-04-02

Preliminary Technical Proposal

August 2006

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Prepared for

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August 2006

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1.0 INTRODUCTION/BASIC INFORMATION

Normandeau Associates, Inc. is pleased to submit this preliminary proposal in response to the Research Summaries issued by the U.S. Army Corps of Engineers (USACE), on 24 July, 2006. Normandeau Associates will undertake and complete the objectives of evaluating fish passage and vertical distribution (objectives 1, 4, and 5) with hydroacoustic technology at Little Goose Dam (SPE-W-04-02).

Normandeau Associates understands that the work for 2007 will be to collect critical information at the USACE's Little Goose Dam for its surface bypass and spill passage programs. Our response seeks to address the objectives 1, 4, and 5 identified in the Research Summary for the study period of Spring/Summer, 2007. Additionally, we introduce other related measurement tasks not requested in the Research Summary.

A. TITLE OF PROJECT

Fish passage at Little Goose Dam.

B. PROJECT LEADERS

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1.1 C. STUDY CODES

SPE-W-04-02

1.2 D. DURATION

1 January 2007 – 31 December 2007

1.3 E. DATE OF SUBMISSION

August 2006

2.0 RESEARCH PROJECT SUMMARY

In the 2004 Revised Biological Opinion (2004 BiOp) NOAA Fisheries approved the *Final Updated Proposed Action for the FCRPS Biological Opinion Remand* (UPA). The UPA describes the actions and goals of the agencies over the duration of the 2004 BiOp. Included in these goals and actions is the continued commitment of the USACE to configure dam facilities to improve juvenile and adult fish passage survival and reduce reservoir residency time of smolts. Among the alternatives to be addressed and evaluated are surface collection techniques such as a Removable Spillway Weir (RSW).

The installation of a RSW is planned for the near future at Little Goose Dam. The purpose of the 2007 study is to obtain pre-construction baseline information regarding juvenile salmon distribution, passage, and behavior at Little Goose Dam and provide passage metrics for comparison with those to be collected after the installation of an RSW, or other future construction or operational changes at Little Goose Dam.

Goals of the 2007 study addressed in this document include:

- Estimate fish guidance efficiency (FGE) for yearling Chinook, steelhead, and sub-yearling Chinook at a precision (ε) level $\leq \pm 5\%$, $\alpha=0.05$;
- Collect vertical distribution of spring and summer migrants passing over the spill bays; and
- Estimate fish passage efficiency (FPE) for yearling Chinook, steelhead, and sub-yearling Chinook using two test operations, evaluating at a precision (ε) level $\leq \pm 5\%$, $\alpha=0.10$.

Other goals of the 2007 study that are not addressed in this document include:

- Estimate dam, reservoir, and route-specific survival for yearling Chinook, steelhead, and sub-yearling Chinook using two test operations at a precision (ε) level $\leq \pm 3\%$, $\alpha=0.10$;
- Determine forebay behavior patterns and residence time for yearling Chinook, steelhead, and sub-yearling Chinook to aid in locating an RSW;
- Estimate direct injury and survival of fish passing the spillways;
- Estimate tailrace egress for all passage routes, including passage time and route, for spring and summer test operations; and

Optional Drought Objective: if there are no spill operations at Little Goose Dam as a result of drought conditions, continue the research on objectives that are not dependent on spill.

Our study plan proposes use of a block design in which fish passage is compared between two different spill patterns. We will test the hypothesis that there is a significant difference in spill efficiency and effectiveness measurements depending on the operation of the spillway and will we will test for significant differences between the two 2007 treatments. The statistical approach to achieve adequate statistical power will be designed by the project statistician prior to installation of the acoustic systems.

Our proposed methodology uses focused acoustic transducers with low side lobes. To estimate turbine passage, paired transducers will be mounted on the trash racks, one aimed upward and normal to the intake ceiling and the other aimed downward. These transducers will be used to estimate guided and unguided, respectively, fish passage into the turbine intakes. To estimate fish passage in the spillway, transducers aimed downward from just below the water surface will be used to estimate fish passage through deep spill gates. Sequencing of samples will be designed to achieve adequate statistical power.

3.0 PROJECT DESCRIPTION

3.1 Introduction/Background

Little Goose Dam is located on the Snake River at river mile 70, or 394 miles from the ocean. It has 6 generating units with 3 intakes each and is capable of generating 810 MW and 8 spill bays equipped with tainter gates. The USACE is committed to increasing survival rates for fish passing this project. To assist them in achieving this goal, a study of fish passage is proposed for 2007 including those objectives listed in this document. The RSW concept may be implemented at Little Goose Dam in 2008.

Research focusing on fish passage and protection at hydroelectric facilities has led to the development of surface passage routes as relatively efficient and safe passage routes for juvenile salmonids. The use of ice-trash sluiceways and the construction of surface collection structures are attempts to take advantage of the fact that smolts tend to stay in the upper 10 to 20 feet of the water column during their downstream migration. Surface passage routes have been shown to be highly effective means of moving large numbers of smolts past dams in relatively small amounts of water (Johnson et al. 2005; Iverson et al. 1999). High volumes of spill have also been successful in moving large percentages of smolts past dams, but this has often been at the expense of potential power generation and may expose smolts to injurious concentrations of dissolved gas (Ferguson et al. 2005). The development of effective and safe fish passage at spillways is a critical need, especially during drought years, and the development of the RSW is an attempt to meet that need.

Spillway gates at many of the USACE's Columbia and Snake River dams open 50 feet below the water surface. The RSW redirects the flow produced by the lifting of a tainter gate from the deep spill location to the near-surface region and thereby provides surface passage at the spillway for juvenile salmon and steelhead. In addition to providing an effective means of passing fish, RSW's are designed to benefit survival. As migrating smolts are entrained downward in the water column to the spillway openings they are subjected to high pressure and velocity (Normandeau Associates 2005). By reducing the pressure and velocity changes smolts encounter, the RSW may provide a less physically stressful passage route than deep spill. Further, the RSW is designed to reduce forebay delay by enabling the surface-oriented smolts to locate downstream flow more easily.

The USACE has installed RSW's at Lower Granite and Ice Harbor dams, is currently installing an RSW at Lower Monumental Dam, and may install an RSW at Little Goose Dam in the future. Radio telemetry studies at both of the currently installed RSWs have verified passage effectiveness benefits with RSW operation, but have had conflicting results regarding forebay residence times. At Lower Granite, the RSW operating with training spill passed comparable percentages of fish with much less water than did bulk spill alone, and forebay residence times decreased during RSW operation (Plumb et al., 2003). At Ice Harbor in 2005, effectiveness (fish per volume water) for the spillway was higher while the RSW was operating, although project fish passage efficiency (FPE) was slightly lower (Axel, et al. and Ogden et al. from 2005 AFEP). Forebay residence times were higher during RSW operation at Ice Harbor.

Studies using hydroacoustics have confirmed the benefits of RSWs to fish passage and have provided additional information useful to fisheries managers. At Lower Granite Dam in 2002, Anglea et al. found the highest combined spill efficiency occurred when the RSW was operating, and combined spill effectiveness with the RSW operating was inversely related to spill discharge.

Survival estimates of smolts at spillways and RSW's vary in part due to the spatial distribution of fish passing these structures and are site specific. At Ice Harbor, Normandeau Associates (2005) found that deep-released fish at both the RSW and Spillway 3 had higher injury rates and lower survival than mid-released fish. No differences in survival probability or injury rate between deep and mid-depth releases were found at two spillways at Lower Monumental Dam (Normandeau Associates 2006). The varying injury patterns may be influenced by differences in the angle that spill discharge impacts the flow deflectors at Ice Harbor Dam (55 degrees) and Lower Monumental Dam (45 degrees) and by the vertical distribution of passing fish (Normandeau Associates 2006). Fish that pass very close to the crest of spillways and RSW's may be more likely to collide with flow deflectors, particularly high-angle ones like those at Ice Harbor (Normandeau Associates 2006).

Lateral distribution within and between structures may also influence survival. Normandeau Associates (2002) found lower survival for balloon-tagged fish released near the edge of the RSW at Lower Granite (96.9%) than for fish released in the center (99.2%). Normandeau Associates (2006) also found higher injury rates at Spillbay 7 of Lower Monumental than at Spillbay 8. Factors that may have contributed to the difference at Lower Monumental Dam include possible increased predation at Spillbay 7 due to tailrace egress conditions, or increased contact with the flow deflector at Spillbay 7, which is two feet higher in elevation than the deflector at Spillbay 8.

At Little Goose Dam, the Corps of Engineers is in need of baseline data to guide them in their decision making process regarding installation of an RSW at Little Goose Dam. The specific objectives to be addressed are included in the following section.

3.1.1 SPECIFIC OBJECTIVES

Objectives of the hydro-acoustic monitoring of fish passage at Little Goose Dam will be to:

- Estimate the efficiency (percent passage) and effectiveness (percent passage of fish relative to percent of project discharge) of conventional spillbays and the powerhouse during two different spill patterns. *Efficiency and effectiveness measurements from hydroacoustics are used to summarize fish passage for the run-at-large during the spring and summer migration seasons. Comparison of metrics between spill treatments will help determine the spill pattern that maximizes spill passage. Because similar methods will likely be applied at Little Goose*

Dam after installation of the RSW, the metrics obtained in the 2007 study can be compared to future years results.

- Determine Fish Passage Efficiency (FPE) for the project as a whole during two different spill patterns. FPE is defined as the percentage of fish that pass the dam by routes other than turbine passage (spill and screen bypass system)
- Estimate diel, vertical, and horizontal fish distribution at the powerhouse and spillway. *Spatial and temporal distribution data are essential for the design and evaluation of project operations and structures intended to increase smolt survival.*

3.2 SPECIFIC METHODOLOGY

3.2.1 Transducer Deployment

Powerhouse Measurements. We will estimate fish passage through turbine intakes using paired 6-degree low side lobe transducer installed on mounts attached to the trash racks. Specific aiming angles will be determined based on dam schematics and previous studies, and will be checked during installation by observing interference patterns. The mounts will require installation by divers. The transducer cables will be run through a conduit for protection and routed to the echo sounder unit. For normal study design requirements, one intake slot of each turbine will be instrumented; we would propose to monitor each intake slot of one of the turbines to provide improved resolution and address the potential that passage varies between intake slots. Slot selection will either be randomized or systematic, based on conversation with the USACE and the project statistician.

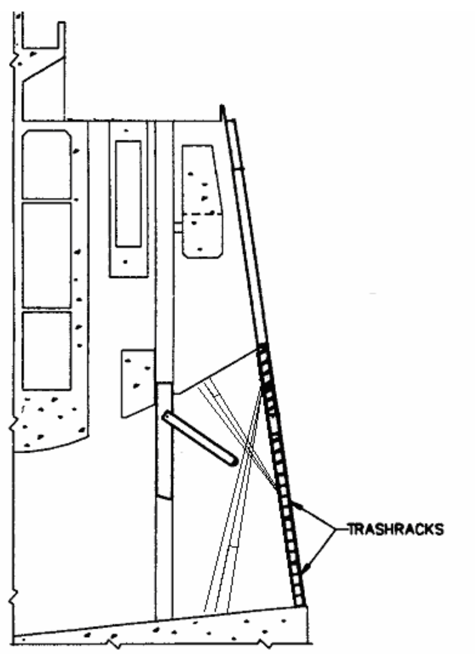

Figure 1 - Representative transducer deployment at turbine intake equipped with submerged traveling screens.

Spill bay Measurements. A ten-degree transducer will be mounted on a pole mount attached to the dam structure at the center of each functioning spill bay at Little Goose Dam. Transducers will be aimed down vertically, and at an angle to minimize any masked zones produced by the sloping ogee face and to maximize the detection of fish actively entrained by spill flow. Specific aiming angles will be determined based on dam schematics and previous studies, and will be checked during installation by observing interference patterns.

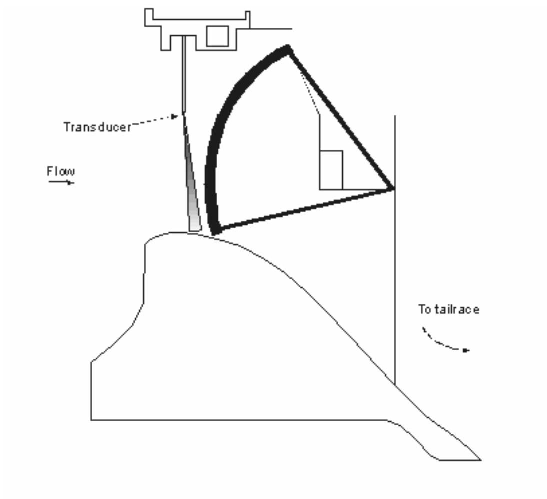

Figure 2 – Representative transducer deployment at a tainter gate equipped spillway.

Acoustic Methodology. We propose to maximize the numbers of samples per location, as recommended by Skalski et al. (1993). In order to maximize pulse repetition rate we will "slow multiplex" (sample one transducer at a time per system). This will enable us to maximize detectability.

Acoustic data will be stored in files, allowing any type of analysis to be completed. In 2005 studies at Lower Granite Dam, a new data file was started each 1.5 minutes, while collecting data continuously throughout the study period except for periods of system maintenance and data archiving. We propose to follow a similar protocol in 2007. All acoustic data will be time-coded by the echo sounder. PC system times will be continuously synchronized over the network, and set by interrogating a GPS time source from the Master Control Computer (as used at Lower Granite Dam in 2005).

3.2.2 Statistical Approach

Previous studies have used a relatively low number of echo sounders to sample a large number of transducers. The consequence of this approach is to reduce sample time at individual locations. We propose to use a minimum sample time at any location of 25%. Increased sample time produces increased sample size, reducing error bounds about passage estimates.

Based on consultation in 2005 with the project statistician, Dr. John Skalski, a sample plan for Lower Granite Dam was devised that called for ten 1.5-minute replicates for each transducer per hour. In 2007, we anticipate that a block design will be incorporated for the comparison of spill pattern on RSW performance. Details of the statistical design will be developed with the project statistician during preparation of the final proposal. Sub-blocks may be incorporated that implement changes in project operations or link to concurrent studies at other dams.

3.2.3 Data Analysis

All data files will be played through a trace formation program. All single-beam data will be processed with a 2-dimensional (time/range) process; we will evaluate whether this 2-dimensional model or a 4-dimensional (XYZ/Time) tracking model will perform best on the split-beam data. Tracking parameters used by the automated program will be verified in part by manual analysis with a visual trace formation program. The date/time, mean range, echo level, and slope of each target detected by the single-beam systems will be written to file, along with a host of other descriptive measurements; mean Target Strength (TS), direction of travel, and fish velocity will be provided by split-beam systems. Fish direction will be expressed in the XY plane, represents a plane parallel to the reservoir surface. The YZ plane corresponds to a cross-sectional plane, while the XZ plane is vertical and parallel to the dam axis: both data sets are available if required. XY trajectories describe movement toward, along, or away from the structure in a plan view, while the YZ path provides an indication of the fish trajectory in a cross-sectional plane. Direction of travel in the XY direction will be calculated for each detected fish; XZ and YZ data will be available if requested.

Area expansion will be based on a per-fish weighting factor, calculated from echo sounder ping rate, number of echoes, specific trajectory parameters, and other values that affect detectability. Total passage for a sample period is the sum of these weighting factors. The use of *in-situ* based detectability parameters will minimize or eliminate biases that might corrupt any ratio-based estimator.

3.2.4 Treatments

We will examine the effects of differing spill strategies on fish passage metrics and fish distributions. The exact spill configurations are still to be decided. Ideally, we will have discrete and sustainable discharge levels during the smolt migration. However, if necessary, data will be collected over the specified period and grouped posteriori into different discharge levels.

3.2.5 Limitations of Proposed Methodology and Expected difficulties

While not providing species specific passage information, hydroacoustics is unique in its ability to provide robust sampling of passage at specific routes as well as temporal and spatial passage distributions. A potential exists for interference with instruments and cable routing related to other experiments but these conflicts have been easily resolved in past years. Overall, we expect few difficulties with completing the planned objectives. However, clear and timely communication between Normandeau Associates and the USACE will be essential during installation of equipment and throughout the evaluation. We have successfully worked with USACE personnel at mainstem hydroelectric projects throughout the Columbia River Basin and do not expect any problems with communications.

3.2.6 Expected Results and Applicability

The results from this study and others will provide the region with information to make decisions regarding long-term smolt protection measures at Little Goose Dam. Currently, spillway survival and passage effectiveness improvements are the top priority. As this work progresses, information on fish passage project-wide can be used to understand the proportion of fish affected by the spillway improvements, and be incorporated into total project survival estimates accordingly.

3.2.7 Schedule

The schedule for the Little Goose Dam deployment, data collection, and reporting will be established in consultation with Corp biologists and project personnel. Prior to commencement of the project, a planning meeting will be held with USACE personnel. Preparation and system calibration will take place immediately prior to delivery to the site.

Once calibrated the hydroacoustic equipment will be delivered on-site. It is anticipated that approximately 2-3 weeks will be required for deployment and optimization of aiming angles and system parameters. We propose to install the acoustic systems several weeks before the proposed start date. This advanced schedule allows us to complete testing of the systems, and minimizes any adverse interactions with other researchers that plan to install their equipment in the week or two preceding the project start date.

We anticipate that the following schedule will be used at Little Goose Dam. Data collection will occur 24 hours per day, 7 d/wk, from approximately 15 April through 15 July. All equipment will be calibrated, installed, and tested prior to 15 April and removed after 15 July. Daily sampling will initiate at 0500 hr and conclude at 0500 hr the next day. Upon completion of data collection, approximately 2 weeks will be required for equipment removal, packing, and shipping; acoustic equipment will be recalibrated.

Data processing will be accomplished in the field, and verification of analysis, results summarization, and report writing will be conducted at Normandeau Associates offices. All methods and results will be incorporated into a comprehensive report relaying study methods, results, and conclusions. Reports and presentations will be delivered according to the schedule detailed in the USACE Scope of Work. If desired, weekly data reports can be furnished from the near real-time analysis procedures.

3.2.8 Quality Control

Normandeau Associates prides itself on its quality control measures and reliability of data collection and analysis procedures, as well as those of its subcontractors. We maintain rigorous quality assurance programs during all aspects of operations in the field, especially during data collection and analysis. All personnel are rigorously trained in the operation of the systems for which they retain responsibility. Quality control measures will include:

- Calibrate all acoustic systems before installation.
- Develop a hardcopy of visual acoustic patterns for each transducer, display at the site of the remote access portal for comparison purposes.
- Determine the magnitude of observed deviations that will indicate changes in aim or calibration.
- Document all procedures for data collection, short/long term archiving.
- Document all analytical steps: thresholding, echo formation, trace formation, filtering, area and time weighting.
- Data sets from each transducer shall be analyzed within the first few days of data collection and weekly thereafter to insure accuracy of data collection and analysis parameters.
- Spare transducers and cables will be stored on site during the study to insure timely replacement of failed components. A spare computer will be stored on site during the study.
- A field log shall be maintained at the remote access portal site for each system.

- We will endeavor to maintain continuity in all project personnel and all remote access procedures.

3.3 Facilities and Support Required

For the study at Little Goose Dam, the USACE will provide (from previous studies or newly fabricated) acceptable transducer mounts. If needed, Normandeau Associates will provide any additional required transducer mounts. Also, we will lease or supply all networking components, the Project Master Control computer, and any other needed equipment.

During installation of equipment, we will require the use of divers to install the transducers in the powerhouse turbine intakes. We will require the use of a large crane during this installation. In the spill region, we will require the use of a large crane to remove and reinstall the deck covers, and to lower the spill mounts into place.

Normandeau Associates will require the use of deck space to position a mobile office trailer, as well as power for the trailer. Alternatively, we would require shelf space in a room inside or on top of the dam. We will also require either two phone lines, or a single phone line and a high-speed internet connection. If the Internet connection cannot be provided, we will install a satellite-based internet access point. We will require 15-amp 120 Volt AC power outlets at selected locations on the upstream side of the powerhouse roadway deck, as well as at selected locations on the downstream side of the spill bay roadway deck.

We will require access to the project operations data. In the 2005 acoustic study at Lower Granite Dam, we received these reports daily via email. After the season was over, we received high-resolution operational data on a CD. These methods are satisfactory, however if real time access to operational data is possible, we would use it to compute various fish passage values.

If available for this project, the USACE will provide Precision Acoustic Systems (PAS) scientific sounders, multiplexers, and transducers as well as transducer cables, communication cables, and data acquisition computers. If USACE owned acoustic gear is not available at the time of this project, Normandeau Associates will lease or otherwise procure the necessary acoustic gear, at the request and approval of the USACE.

3.4 Impacts on Project Operation and on Other Research

3.4.1 Other Research

We plan to coordinate closely with other researchers and USACE personnel to assure that sampling efforts are complementary with any other research conducted at Little Goose Dam in 2007.

3.4.2 Installation of Equipment

Cables from the acoustic transducers must be routed from the transducer location to the environmental case containing the digital echo sounder. In the powerhouse region, these cables extend from the top of the trash rack to the railing on the upstream side of the road deck. These cables may be routed some distance from the location where the transducer is located. A potential exists for interference with instruments and cable routing related to other experiments. These conflicts have been easily resolved in past years.

Transducers installed in the region of the powerhouse will require the use of divers. This activity requires the lockout of the turbine at the specific location, as well as those turbines located on either side. These activities seriously impact project operations, and must be scheduled well in advance with project personnel and system dispatchers. The use of a large crane to remove deck covers and install the transducer mounts in the spillway will also impacts project operations, and must be carefully scheduled and orchestrated.

The methodologies proposed for 2007 may include remote access to the acoustic systems. This capability will require that the overflow room have either 1 phone line and high speed internet access, or two phone lines. Installation of these capabilities may cause minor impacts to project personnel as they review, revise, or implement these capabilities. The operation of electronics inside the instrumentation room would benefit by incorporation of some type of air conditioning during the summer portions of the studies. An alternative to providing air conditioning for the entire room is to build an environment enclosure inside the room that has some form of air conditioning supplied to it.

3.5 Project Data Collection

Previous studies have required that Project Operations data be provided. This has been accomplished by daily emails containing operations files attached and sent by the operators. If access to the automated operations system can be provided, we can automate the collection of the operational data.

3.6 Collaborative Arrangements

The project team draws upon the expertise of a statistical consultant for design and review of the statistical aspects of the proposed studies. We anticipate using the same consultant (Dr. John Skalski) as in previous years. In addition, we may arrange to team with other firms with hydroacoustic expertise such as Hydroacoustic Technology, Inc. or Biosonics, Inc. These details will be arranged during preparation of the final proposal.

4.0 LIST OF KEY PERSONNEL AND PROJECT DUTIES

Dilip Mathur, Ph.D. is the overall program manager for the ID/IQ professional services contract with the Walla Walla District. He is well acquainted with the Corps biological goals and has a thorough understanding of the issues in the Columbia and Snake River Basins. Dr. Mathur brings over 35 years of experience in managing multidisciplinary research and environmental projects for both public and private sector clients. He has worked with the Corps over the last 10 years completing various task orders under existing contracts. His expertise lies in the fields of thermal discharges, anadromous fish passage and restoration, fish behavior, integration of fish data with power plant operations, turbine and non-turbine passage survival of fishes, turbine and spillway rehabilitation relative to friendlier fish passage, delineation of effects of power plants on aquatic ecosystems, fisheries biology, data analysis and population dynamics.

Mr. Michael Hanks will serve as the project manager for this task order and will be the principal investigator. Mr. Hanks has over twelve years experience in the planning and management of large and small studies that used acoustic methods to sample fish presence and behavior, and to measure water velocity and flow discharge. He has been a key contributor to large-scale fixed-aspect hydroacoustic studies at mainstem Columbia River dams as well as smaller studies that linked fish behavior with hydraulic components in the forebays of dams and at surface collection entrances. Normandeau Associates will provide Technical support, administration/management and oversight for this project, and report review.

Mr. Robert McDonald will assist the project manager for this task order. Mr. McDonald has over 15 years of experience conducting biological evaluations at hydroelectric projects. He has overseen, as project manager, large hydroacoustic and acoustic telemetry projects conducted at Rock Island Dam and elsewhere. He has extensive experience budgeting and meeting the logistical demands of large biological and hydroacoustic studies. He will assist the project manager in all aspects of the planning and conduct of the proposed evaluation.

Mr. George Nardacci will assist with project administration and interactions with USACE contract and purchasing personnel. Mr. Nardacci has 10 years experience in working closely with USACE staff to successfully administer numerous and complex projects over a broad range of study areas.

5.0 TECHNOLOGY TRANSFER

Information acquired during the proposed work will be transferred in the form of written and oral research reports. A draft report will be submitted on October 31, 2007. A presentation will be made at the USACE annual Anadromous Fish Evaluation Program Review in November 2007. A draft final report will be provided to the USACE by December 31, 2007, and the final report will be completed 30 days after review comments are received. Technology transfer activities may also include presentation of research results at regional or national fisheries symposia and publication of results in scientific journals.

6.0 REFERENCES

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