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A4.06
PR

December 19, 2005

Dr. Chuck Carr Brown
Assistant Secretary
Office of Environmental Services
Louisiana Department of Environmental Quality
P.O. Box 4313
Baton Rouge, Louisiana 70821-3181

Reference: Waterford Steam Electric Station - Unit Number 3
Agency Interest Number 35260
LPDES Permit Number LA0007374

Subject: 316(b) Proposal for Information Collection (PIC)

Dear Dr. Brown:

Entergy Operations, Inc. hereby submits three copies of its Proposal for Information Collection (PIC) for review by the Department pertaining to the referenced facility. Please provide comments as soon as possible so that Entergy can update information-gathering activities in a timely manner. As described under 40 CFR 125.98(a)(1) the LDEQ must review and comment on the PIC submitted by applicants in accordance with 125.95(a)(1).

As required by Part II.X of Waterford 3's LPDES permit, the permittee shall initiate compliance with Section 316(b) Phase II Rule and applicable state regulations for cooling water intake structures, as required, per the schedule specified in the Final Rule. This shall include, but not be limited to the submission of the comprehensive demonstration study and other information required by 40 CFR 125.95 as expeditiously as practicable but no later than January 7, 2008

Under the Rule, a Comprehensive Demonstration Study (CDS) is ideally supposed to accompany the permit renewal application and must reflect output from the reviewed PIC. Given Entergy's proposed compliance approach, completing the CDS by that date should be achievable.

The focus of the Rule is to minimize impingement and entrainment of fish and shellfish at power plant cooling water intake structures. Under the Rule, certain facility applicants are required to perform and submit to the LDEQ all applicable components of a CDS. The seven basic components include: (1) a proposal for information collection; (2) source waterbody flow information; (3) impingement mortality and entrainment characterization study; (4) technology and compliance assessment information (5) restoration plan; (6) information to support site-specific determination of best technology available for minimizing adverse environmental impact; and (7) verification monitoring plan.

EPA, in the preamble to the Rule, recognized that it takes a significant amount of time to prepare a CDS, particularly in light of the need to gather meaningful data to characterize the aquatic community in the vicinity of a cooling water intake structure and to document current impingement mortality and/or entrainment data.

The Rule is designed for implementation through the next round of LPDES permit renewals. Entergy recognizes that there is some uncertainty around LDEQ adoption of the Rule through the Louisiana-delegated NPDES program. To the extent that LDEQ may choose an approach that is different from the process identified by the Rule, Entergy must make appropriate adjustments.
Should you have any questions or comments, please contact Mr. Mark J. Louque at (504) 464-3267.

Sincerely,

Joe Venable

Joseph E Venable
Vice President, Operations
Waterford 3

JEV/MJL/mjl
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PROPOSAL FOR INFORMATION COLLECTION

Entergy Operations, Inc.
Waterford 3 Plant

Prepared by:

ENSR International
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EXECUTIVE SUMMARY

This Proposal for Information Collection (PIC) for the Entergy Operations, Inc. – Waterford 3 Plant is developed as part of Entergy's obligations under the Section 316(b) Phase II Rule (Rule). Due to the proportion of the average river flow used by the cooling water intake structure (CWIS), the Waterford 3 Plant is subject to only the impingement mortality goals under the rule.

The Waterford 3 Plant is a nuclear generating facility which employs open cycle cooling. The plant obtains water directly from the non-tidal portion of the Mississippi River. The cooling water intake structure (CWIS) canal extends approximately 162 feet offshore into deep, fast-moving water.

The CWIS is equipped with eight traveling water screens with 1/4" mesh. Approximately 10% of the screen panels have been replaced with 3/8" mesh. The traveling water screens (dual- speed) are each equipped with high pressure wash systems on the front side of the screens. Debris is returned via a combined concrete trough system which discharges into the Mississippi River. The debris is returned away from the influence of the intake canal and cooling water discharge zone. Screen wash and rotation is initiated manually and operational frequency varies with seasonal debris loading.

Rates of impingement have not been evaluated at Waterford 3 but have been evaluated at the Entergy Waterford 1 & 2 Plant, located 2,100 feet upstream, and at other similar plants on the Mississippi River, including the Entergy Willow Glen and Baxter Wilson plants (also located upstream) and the Entergy Michoud and A. B. Paterson plants (located further south in tidally influenced waters adjacent to the river). The Waterford 1 & 2 impingement study indicated that the rates of impingement are relatively low. Using the data sets available, annual impingement was estimated to be 336,500 fish and shellfish per year for both units combined (see Appendix B). Impingement was represented by several species, primarily juveniles, including blue catfish, anchovy, threadfin shad, freshwater drum, striped mullet, skipjack herring, river shrimp, and blue crab. This information generally is consistent with the 316(b) demonstration completed for Waterford 3 in 1979, which supported a finding that the current configuration was Best Technology Available for the facility (EPA Region 6 NPDES permit, 1991).

Documented impingement at Entergy's freshwater Mississippi River plants were dominated by a relatively small number of species, primarily juveniles, including freshwater drum, gizzard and threadfin shad, carp, white and black crappie, skipjack herring, and blue catfish, as well as freshwater shrimp and crayfish. Based on the literature, the current patterns of impingement (i.e., rates and species) at the Waterford 3 Plant are likely to be similar to those observed historically at the other stations.

The operation and design of the Waterford 3 Plant cooling water system suggests that potential rates of impingement mortality are considerably less than the Calculation Baseline condition. Based on an informal review of the available information, the submerged (due to the skimmer wall) location of the CWIS 162 feet offshore (sheet piling canal) in the main river channel appears to allow the CWIS to meet the relevant performance goals for impingement imposed by the Phase II Rule.

Future plans are to maintain the plant at current operating levels, which are above a 15% capacity factor. Entergy cannot commit to the maintenance of any reduced capacity factor at this time and, therefore, does not credit that toward the performance goal.

In assessing the potential costs of the Phase II Rule, US EPA estimated capital costs and total annualized costs for Waterford 3 to be $27.4M and $7.3M, respectively based on the "addition of a passive fine-mesh screen system (cylindrical wedgewire) near shoreline with mesh width of 1.75 mm." These costs inappropriately cover compliance with both impingement mortality and entrainment performance standards. Adjusted costs to address only the impingement performance standard, using procedures set out in the rule, are $12.4M and $3.4M respectively for capital and annualized costs. This cost serves as the basis of the Cost-cost test that may be pursued under the Site-Specific Best Technology Available (BTA) compliance approach provided for by the Rule. An alternative approach to the Site-Specific BTA is the demonstration that the costs of compliance are significantly greater than the monetized benefits of compliance, the so-called Cost-benefit test.

This PIC provides a focused review of available mitigation technologies and concludes that no reasonable, cost-effective measure exists to mitigate impingement mortality beyond that provided by the current configuration. In particular, each technology is found to be of limited feasibility and effectiveness or of "significantly greater" cost than the benefits gained from meeting the performance standards. The importance of an uninterrupted cooling water supply for nuclear power stations under Nuclear Regulatory Commission (NRC) rules is recognized by the Phase II rule (see 40 CFR 125.94(f)) and is important to consider when evaluating several technologies that involve screening of the cooling water with attending fouling issues. Restoration measures may be retained for further evaluation as "cost-effective measures" potentially to be implemented to supplement the Site-specific BTA.

Entergy proposes to pursue simultaneously the Rule's Compliance Alternative 2 (existing plant currently meets the performance standard), based on the current performance of the CWIS, and Compliance Alternative 5 based on the Cost-cost and/or Cost-benefit tests. Entergy proposes to use existing data collected at the Waterford 1 & 2 Plant and other data from the Mississippi River to support the Comprehensive Demonstration Study (CDS) including the Impingement Mortality and Entrainment Characterization Study (IMECS). Entergy, therefore, proposes to collect no additional field data to support the CDS. We believe that the available data can support the requirements of the CDS. Notably, the attributes of the CWIS (especially its location in the main

river channel) strongly support that it meets the Rule's performance goal. As importantly, additional data on the relative density of fish at the off-shore location of the CWIS will be very expensive and potentially hazardous to obtain. Finally, Entergy also believes that the parallel application of the Cost-cost and/or Cost-benefit test will lessen the need for further consideration of certain alternatives. Importantly, Entergy believes that existing rates of impingement from nearby stations allow for reasonable estimates of the rates of impingement at Waterford 3, including the species and age of fish. These data can be used to support the estimate of monetized benefits to support the Site-specific BTA. Consideration of both Compliance Alternatives will allow for a "weight-of-evidence" to support the finding that the CWIS at the Waterford 3 Plant meets the BTA requirements of the Phase II Rule.

The proposed component elements of the CDS are listed and a tentative schedule for the CDS completion, consistent with the Louisiana Pollutant Discharge Elimination System (LPDES) permit renewal, is defined within this PIC for the Waterford 3 Plant.

1.0 INTRODUCTION

The Entergy Operations, Inc. (Entergy's) Waterford 3 Plant is located on the west (right descending) side of the Mississippi River in Killona, Louisiana, approximately 25 miles upstream from New Orleans. The plant consists of a nuclear reactor with a net plant output of 1,165 MW. Because the plant uses cooling water from the Mississippi River in excess of 50 million gallons per day (MGD), the plant is regulated by the recently-finalized Phase II Rule developed under the Clean Water Act's Section 316(b). Because the facility's design intake flow is less than 5 percent of the mean annual flow of the Mississippi River, a freshwater river, the Waterford 3 Plant is only subject to the Rule's performance goals for impingement mortality.

The goals of this Proposal for Information Collection (PIC) for the Waterford 3 Plant include the following:

- Address the requirements of the Code of Federal Regulations (CFR), Title 40, Section 125.95(b)(1); and
- Facilitate the compliance process by explaining Entergy's proposed approach.

40 CFR Section 125.95(b)(1) describes the PIC requirements as follows:

> "You must submit to the Director for review and comment a description of the information you will use to support your Study. The Proposal for Information must be submitted prior to the start of information collection activities, but you may initiate such activities prior to receiving comment from the Director. The proposal must include:
>
> (i) A description of the proposed and/or implemented technologies, operational measures, and/or restoration measures to be evaluated in the Study;
>
> (ii) A list and description of any historical studies characterizing impingement mortality and entrainment and/or physical and biological conditions in the vicinity of the cooling water intake structures and their relevance to this proposed Study. If you propose to use existing data, you must demonstrate the extent to which the data are representative of current conditions and that the data were collected using appropriate quality assurance/quality control procedures;
>
> (iii) A summary of any past or ongoing consultations with appropriate Federal, State, and Tribal fish and wildlife agencies that are relevant to this Study and a copy of written comments received as a result of such consultations; and
>
> (iv) A sampling plan for any new field studies you propose to conduct in order to ensure that you have sufficient data to develop a scientifically valid estimate of impingement mortality and entrainment at your site. The sampling plan must document all methods and

quality assurance/quality control procedures for sampling and data analysis. The sampling and data analysis methods you propose must be appropriate for a quantitative survey and include consideration of the methods used in other studies performed in the source waterbody. The sampling plan must include a description of the study area (including the area of influence of the cooling water intake structure(s)), and provide a taxonomic identification of the sampled or evaluated biological assemblages (including all life stages of fish and shellfish)."

The following tabulation provides the section of the PIC where each of the above mentioned regulatory requirements are presented.

Regulatory Requirement	PIC Section
§ 125.95(b)(1)(i) – Review of Measures and Technologies	3.0
§125.95(b)(1)(ii) – Historical Studies	4.0
§ 125.95(b)(1)(iii) – Agency Consultations	5.0
§ 125.95(b)(1)(iv) – Proposed Sampling Plan	7.0

The Phase II Rule allows for significant discretion by the Secretary of the Louisiana Department of Environmental Quality (LDEQ) during the implementation process. In fact, the Rule allows for flexibility in the compliance approach taken at a plant by including several specific criteria associated with assessing compliance, including:

- On which species and life stages to base the compliance assessment;
- Whether to base the assessment on numbers of individuals or biomass;
- The specifics of estimating the Calculation Baseline condition;
- The averaging period to use in estimating the Calculation Baseline or assessing compliance;
- The ability to discount "unavoidable, episodic impingement or entrainment events" in the assessment of performance;
- The specific design parameters (e.g., slot size) for the cooling water intake structure (CWIS);

- The need for, and nature of, peer review for assessment of restoration and/or monetized benefits;
- The need for additional information collection to support the Comprehensive Demonstration Study (CDS);
- The nature of the Technology Installation and Operation Plan (TIOP);
- The nature of Approved Technology (i.e., Compliance Alternative 4);
- The definition of "significantly greater" under site-specific Best Technology Available (BTA) (Compliance Alternative 5); and
- The timing of the component reports of the CDS.

Entergy believes that this level of discretion allows LDEQ to oversee a focused and efficient compliance program to:

- Assess the current performance of the CWIS and operation/restoration measures;
- Review the alternative measures to determine those that are feasible and cost effective;
- If appropriate, implement cost-effective measures; and
- Develop a CDS within the context of one or more of the Rule's Compliance Alternatives.

Entergy has prepared this PIC that both addresses the requirements of the Rule and defines Entergy's recommended Phase II compliance program for the Waterford 3 Plant.

1.1 Goals, Process, and Timing of the Rule

The U.S. Environmental Protection Agency (EPA) has produced final regulations under Clean Water Act Section 316(b) that establish performance standards for existing CWIS for electricity generators using in excess of 50 million gallons per day (MGD). The Phase II Rule was published in the Federal Register on July 9, 2004 and became effective on September 7, 2004.

The Phase II Rule calls for a 60 to 90 percent reduction in entrainment and an 80 to 95 percent reduction in impingement mortality from the "calculation baseline," essentially the entrainment and impingement mortality rates at a similarly sized once-through shoreline CWIS with no impingement and/or entrainment reduction controls, other than 3/8 inch mesh traveling screens, at the same location. These rates of protection are deemed by EPA to be "commensurate with closed cycle cooling." There is no requirement for power plants to adopt closed-cycle cooling. The Rule also provides for site-specific BTA in the event that site specific costs of compliance are

"significantly greater" than either the costs estimated by EPA for the plant or for the monetized benefits of compliance at the plant.

The Rule allows for five different means of demonstrating compliance with the requirements of the Rule.

Compliance Alternative 1: Flow Reduction. Under Option 1(a) the plant owner can demonstrate that it uses closed-cycle cooling to show compliance with the Rule. Alternatively, if the through-screen velocity can be shown to be less than or equal to 0.5 ft/s, the performance goals relative to impingement mortality will be deemed to be met under Option 1(b). This latter approach does not address the potential entrainment performance goals, if applicable.

Compliance Alternative 2: Demonstrate that the current system achieves the relevant performance goals. Through the execution of a CDS, the plant can show that it is currently meeting the performance goals through some combination of technologies as well as operation and restoration measures.

Compliance Alternative 3: Demonstrate that a newly installed and operated system (i.e., technology and/or operation/restoration measures) will meet the performance goals. Again, through development of a CDS, the plant can design and implement a set of controls estimated to achieve the performance goals.

Compliance Alternative 4: Install and operate an approved technology. As part of the Rule, EPA designated wedge wire screens in a riverine environment as an approved technology. Proper installation and operation of this technology will meet the goals of the Rule. NPDES Permit Directors have the ability to designate other technologies as "Approved."

Compliance Alternative 5: Site-Specific BTA. Under this option, the plant can show that the actual costs of compliance for alternatives proposed are "significantly greater" than either the costs assumed by EPA or benefits expected from the installation and operation of the alternative. Under this option, the plant is still required to pursue "cost-effective measures."

These options are each associated with differing requirements relative to the CDS. Under Option 1(a), no CDS is required for assessment of impingement mortality, while under some of the other options, relatively extensive analyses may be required along with submittal of several documents.

1.2 CDS Schedule

The Waterford 3 Plant's current LPDES permit No. LA0007374 expires on January 31, 2010. Under the rule, the Comprehensive Demonstration Study (CDS) should be submitted with the

application for LPDES permit renewal and the CDS initially must be submitted no later than January 7, 2008. Completion of the CDS in this time frame should not represent a significant obstacle especially given the compliance approach proposed below.

1.3 Specific Goals of this PIC

The Waterford 3 Plant is only affected by the impingement performance goals of the Phase II Rule.

Entergy has taken one measure that mitigates impingement mortality at the Waterford 3 Plant:

- The CWIS is located away from the shoreline in deep, fast-moving water. The intake canal is formed by steel sheet piling driven into the river bottom and extends approximately 162 feet out from the face of the structure. The CWIS is also considered submerged since the end of the canal is equipped with a skimmer wall across its entrance which prevents floating debris and surface swimming organisms from entering. This submerged offshore location places the structure in relatively poor habitat compared to the shoreline of the Mississippi River and is, therefore, likely to reduce the rates of impingement relative to a structure located directly on the edge of the river itself. Entergy believes that there is a strong consensus in the literature and among fisheries researchers that the population density in the main channel of the river (with very high ambient water velocities) is substantially lower than in areas along the shore and in backwaters where the velocities are lower. This is borne out in the anecdotal observations of relatively low rates of impingement. It should be noted that during flood events, debris and fish may pass over the sheet piling and enter the CWIS. However, these episodes occur relatively infrequently. Flooding usually coincides with reduced pumping rates at the facility (3 out of 4 pumps running), and the fish density in the Mississippi River is also much reduced, minimizing impingement rates (see Appendix B).

Entergy believes that the above measure provides 93% reduction in impingement mortality (see Table 3-2). For these reasons, Entergy Operations, Inc. proposes to pursue Compliance Alternative 2 and demonstrate to the Director that "existing design and construction technologies" meet the performance standards in the Rule. Given the consensus regarding relatively low population densities in the river's main flow, we believe that a defensible and favorable comparison to the Calculation Baseline can be made without the collection of additional field data.

Entergy believes that no additional technology or operational measure available to reduce impingement mortality is likely to be feasible and cost-effective at the Waterford 3 Plant. This conclusion is based on the analyses presented in the following sections of this document. There are substantial technical difficulties with many of the potential technologies, partially due to the extreme flows found in the Mississippi River. The distance of the CWIS offshore complicates installation, operation, and maintenance of many technologies and is also likely to adversely affect

costs. Finally, many of the technologies that rely on screening (e.g., barrier net, wedgewire screen, etc.) will suffer from clogging associated with debris and biological growth. In assessing the potential costs of the Phase II Rule, US EPA estimated capital costs and total annualized costs for Waterford 3 to be $27.4M and $7.3M, respectively, based on the "addition of a passive fine-mesh screen system (cylindrical wedgewire) near shoreline with mesh width of 1.75 mm." These costs inappropriately cover compliance with both impingement mortality and entrainment performance standards. Adjusted costs to address only the impingement performance standard, using the procedures set out in the rule, are $12.4M and $3.4M, respectively, for capital and annualized costs. Based on impingement data at other like facilities, and anecdotal site-specific information, these costs far outweigh the potential benefits of compliance with the Phase II 316 (b) rule. Significantly, the installation of 1.75 mm wedgewire screens is not a feasible technology and would very likely be subjected to clogging in the river environment.

For these reasons, Entergy proposes to pursue the Rule's Compliance Alternative 2 (existing plant currently meets the performance standard) based on the current performance of the CWIS, and, alternatively, Compliance Alternative 5 (Site-specific BTA) based on the Cost-cost and Cost-benefit tests. Entergy believes that the existing biological data available from the plant and its environs are sufficient to support this analysis and therefore does not propose collection of additional data.

The goal of this PIC is to provide the information necessary to demonstrate that this proposal meets the requirements of the Rule.

1.4 Review of Document Organization

The following is a summary of the components of the PIC for the Waterford 3 Plant:

- Data on the physical configuration and flow of the Mississippi River are presented in Section 2;
- Discussion of existing and potential additional technologies and measures to mitigate impingement mortality are presented in Section 3;
- The nature of historical studies and the resulting data are summarized in Section 4. The potential use of these data to support the CDS is also discussed in this section;
- Section 5 presents a review of relevant agency consultations;
- Entergy's proposed compliance approach is summarized in Section 6; and
- Section 7 presents the proposed sampling work plan.

The PIC document is also supported by appendices that:

(1) Provides a general review of impingement mortality and entrainment mitigation measures (Appendix A);

(2) Reviews the general nature of the fisheries of the Mississippi River focusing on the 'Lower Mississippi River', including the plant-specific data (Appendix B); and

(3) Presents US EPA's estimated cost of compliance as summarized in the Phase II Rule (Appendix C).

2.0 SOURCE WATER BODY INFORMATION

This PIC provides LDEQ with information regarding the circumstances that affect operation and performance of the current Waterford 3 Plant CWIS, the potential additional measures to reduce impingement mortality, and the compliance approach that Entergy proposes to pursue. All three of these issues can be affected by the source water body flow rate as well as the physical configuration of the source water. Entergy believes it may be very productive to consider these issues as part of the PIC, though the rule anticipates their discussion either as a separate part of the CDS (i.e., the Source Water Body Flow Information – 40 CFR 125.95(b)(2) or the LDEQ application itself (i.e., the Source Water Body Physical Data Report - 40 CFR 122.21(r)(2)). In order to facilitate LDEQ evaluation of this data, Entergy has slightly expanded the scope of the PIC to include the discussion here.

2.1 Source Water Body Flow Information

The Phase II Rule requires consideration of Source Water Body Flow Information (40 CFR 125(b)(2)) under two circumstances:

(1) The CWIS is on a river or stream. In this case, documentation is needed to demonstrate whether the plant withdraws less or greater than 5% of the mean annual river flow. This information is used to determine whether the entrainment performance goals apply to the plant; and

(2) The CWIS is on a lake or reservoir and a proposed expansion of the CWIS flow might adversely impact the stratification of the water body. This is not applicable for the Waterford 3 plant since it withdraws cooling water from the Mississippi River.

Cooling water for Waterford 3 is withdrawn from the Mississippi River at a design flow rate of 1555.2 MGD, or 2406 cfs. The average flow in the Mississippi River in the vicinity of the Waterford 3 plant (RM 129.5) is estimated to be greater than approximately 500,000 cfs[1]. Based on this information, it is determined that Waterford 3 withdraws a maximum of approximately 0.48% of the flow in the Mississippi River; and in actuality this percentage is probably much less because of the additional, unaccounted for, streamflow contributions entering the Mississippi River downstream of the Vicksburg station and upstream of the Waterford 3 plant.

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[1] Exact flow rates are not available for the Mississippi River in the vicinity of the Waterford 3 plant, so the flow was estimated to be greater than the average flow rate of approximately 500,000 measured at Vicksburg (RM 435.7), which is located well upstream of the Waterford 3 plant and encompasses a smaller watershed area. The flow rate at Vicksburg was calculated using the average stage of 21 feet for the Mississippi River gage at Vicksburg, calculated from data taken from U.S. Army Corps of Engineers website www.rivergages.com, and the results of a USACE flow measurement at the Vicksburg plant taken at a stage of 20.7 feet.

Since Waterford 3 withdraws much less than 5% of the annual flow of Mississippi River flow, the facility is not subject to the entrainment performance goal.

2.2 Source Water Body Physical Data

The Phase II Rule requires, as part of the LDEQ permit application submission, the following information to support Phase II compliance:

i. *A narrative description and scaled drawings showing the physical configuration of all source water bodies used by your plant, including areal dimensions, depths, salinity and temperature regimes, and other documentation that supports your determination of the waterbody type where each CWIS is located;*

ii. *Identification and characterization of the source waterbody's hydrological and geomorphological features, as well as methods you used to conduct any physical studies to determine your intake's area of influence within the waterbody and the results of such studies; and*

iii. *Locational maps.*

The intake structure for the Waterford 3 plant is located approximately 162 feet from the western shore of the Mississippi River (see Figure 2-1). Cooling water brought into the intake structure is drawn from the Mississippi River at a plant capacity rate of 1555.2 MGD, through a series of intake pipes.

The width of the Mississippi River at the Waterford 3 plant is approximately 1,850 feet, the average stage is approximately 9.9 feet, and the average velocity is approximately 3.65 ft/sec. Bathymetric information for the Mississippi River at the Waterford 3 plant (RM 129.5) was available from the USACE from a hydrographic survey conducted by the USACE in 1992 indicating an average maximum depth of approximately 129 feet; cross-sections from that survey are available for download on the USACE New Orleans districts website[2]. The width was measured from a U.S. Geological Survey topographic map of the river, the average stage was estimated to be the average stage at the USACE's gage height measurement station at Bonnet Carre, located approximately 1.4 miles downstream, and the average velocity was determined from stage velocity relationships for USACE stations located at Baton Rouge (RM 229.7) and at New Orleans (102.8) at the stage of 9.9 feet.

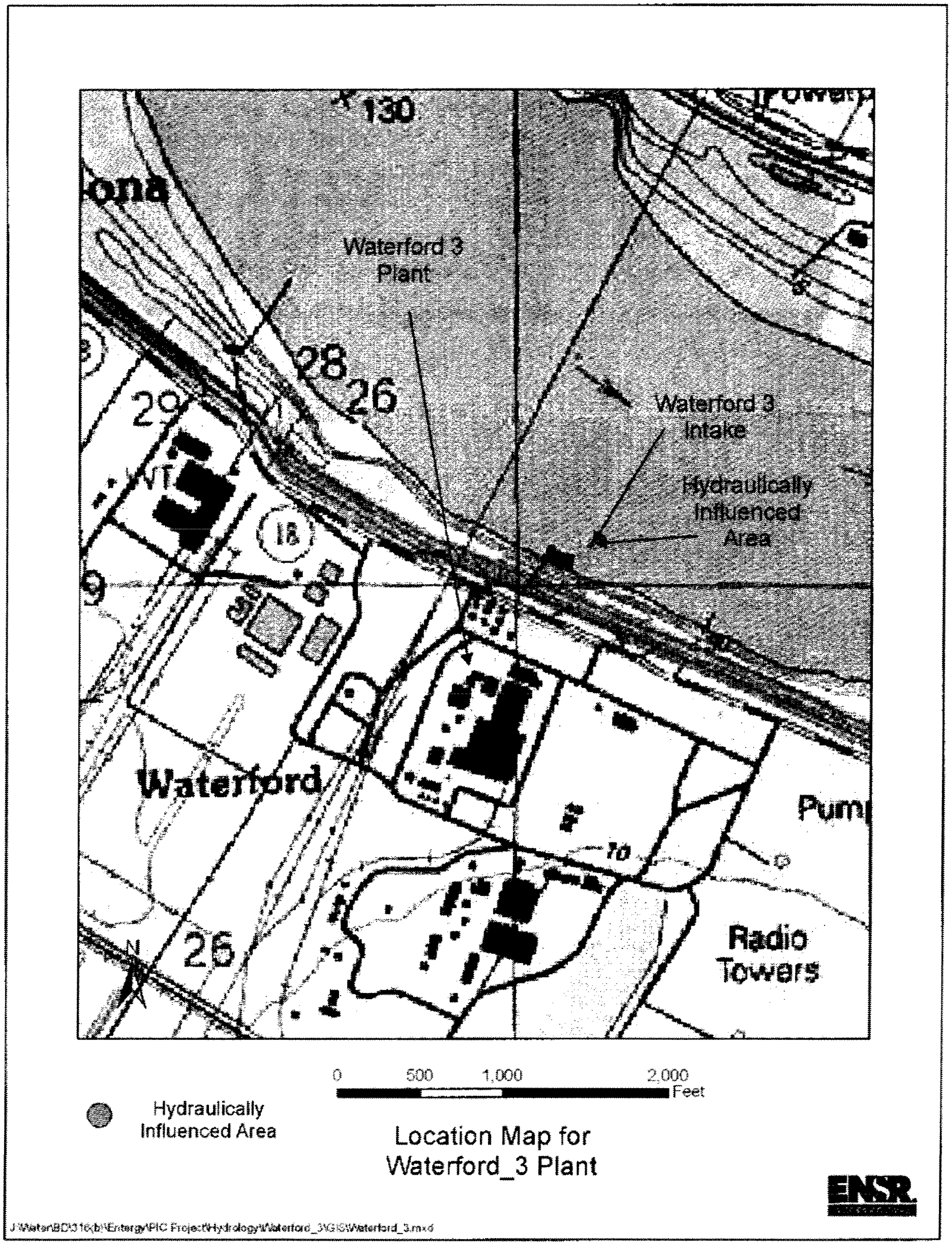
The hydraulic information describing the Mississippi River in the vicinity of the Waterford 3 plant was used to determine the area of hydraulic influence of the intake. The zone of hydraulic influence is being defined here as the area of a hemisphere through which all of the CWIS flow passes, and that is of sufficient size so that the velocity through the surface is equivalent to the ambient velocity in the

[2] Transect data for the Lower Mississippi River was taken from U.S. Army Corps of Engineers website http://www.mvn.usace.army.mil/eng2/edsd/misshyd/misshyd.htm.

water source. Therefore, in the case of the Waterford 3 plant, it is a hemispherical area that measures 659 square feet.

The size of the Mississippi River and its large flow in the vicinity of the Waterford 3 plant minimize the effects of the CWIS withdrawal. The area of the river hydraulically affected by the Waterford 3 intake is a negligible 659 square feet (Figure 2-1).

Figure 2-1: Plant Location



3.0 TECHNOLOGIES, OPERATIONAL, AND RESTORATION MEASURES

This section will review current and potential future technologies, operational, and restoration measures relative to their potential to meet the performance goals of the Rule in a cost-effective manner. As discussed earlier, only the impingement mortality goals are applicable to this plant. Therefore, only those solutions which address impingement mortality will be presented in this section; however, a more comprehensive discussion of technologies is provided in Appendix A, including options for impingement mortality and entrainment.

3.1 In-place Technologies

This section describes the current CWIS as well as its apparent performance relative to the goals of the Rule.

A concise summary of the Waterford 3 Plant, its CWIS, and the available data is provided in Table 3-1. The findings described in this table are presented in more detail below.

3.1.1 Review of Technologies and Operational Measures

The Waterford 3 CWIS is designed to provide 1,080,000 gpm of circulating cooling water to the station using water withdrawn from the Mississippi River. The CWIS was designed for normal operation within river high-water and low-water elevations of +23.6 feet msl and +0.8 feet msl, respectively. The CWIS consists of an intake canal, intake structure, eight trash racks, eight through-flow traveling water screens and three screen wash pumps. Figure 3-1 provides a cross-sectional illustration of these CWIS components.

The intake canal is formed by steel sheet piling driven into the river bottom and extending approximately 162 feet out from the face of the intake structure (see Figure 3-2 diagram). The canal has a skimmer wall across its entrance which inhibits floating debris from entering the canal. The elevation at the top of the sheet piles is +15.0 feet msl. The elevation at the bottom of the skimmer wall is -1 foot msl. The dimensions of the opening to the river are 36.9 feet in length by 34 feet in depth. The water velocity through the intake opening at the river boundary during maximum pump operation pump is approximately 1.9 ft/sec.

At the end of the intake canal (at the shoreline), the CWIS is comprised of eight intake bays (see Figure 3-3) that are defined by concrete wingwalls. Each intake bay is approximately 11 feet wide, and has a curtain wall (extending vertically from +15 feet to -4.0 feet, and across the width of each bay), trash rack and traveling water screen. The maximum design flow rate for each intake bay is 135,000 gpm. At the maximum design flow rate, the screen approach velocity is approximately 1.0 ft/sec in each bay. The four circulating water pumps (1 for two intake bays) are vertical mixed flow pumps. Each pump is rated for 3,500 hp at 273 rpm and is capable of

pumping 557 cfs (250,000 gpm) of water. Three service water pumps are located 12.5 ft upstream of the circulating pumps. Each service water pump is rated for 250 hp at 1,775 rpm and capable of providing 7 cfs (3,000 gpm) of service water. Cooling water is discharged 600 ft downstream of the CWIS.

The trash rack in each CWIS bay is designed to remove large debris. Each trash rack consists of a series of 1/2 inch by 3 1/2 inch bars spaced on 3 inch centers and oriented at an angle of approximately 10 degrees from vertical. Plant personnel clean the trash racks with a mechanical trash rack cleaner.

The traveling water screens are located 29 ft 9 in. upstream of the circulating water pumps and 19 ft 3 in. downstream from the trash racks and are composed of stainless steel wire mesh, most with 1/4-inch-square openings. Some screen panels (approximately 10%) have 3/8-inch mesh. The traveling screens are conventional through-flow screens, oriented perpendicular to the walls of the intake bays. Each traveling water screen is cleaned by a high pressure spray (80 psi) from two parallel headers located on the inside of the ascending side of the screen. Each header contains nine spray nozzles (for a total of 18 nozzles per screen), directed toward the river. The spray cleaning system can be operated manually or automatically based on a water level differential (18 inches) across the traveling water screens. The screens can operate at either high or low speeds (20 ft/sec and 5 ft/sec). Depending on the debris load, the screens might be rotated and cleaned anywhere from hourly to once each day.

It should be noted that the Waterford 3 Plant has an infrequent but recurring problem with debris carry-over from the traveling screens. The debris in the circulating water leads to macro fouling of the inlet water box side of the condenser, which causes associated integrity problems with the station condensers. This issue was identified during the last two Institute of Nuclear Power Operations (INPO)[3] inspections as an Area for Improvement. As such, any technological or operational change that possibly would increase the post-screen debris load could potentially create plant operational issues. This periodic carry-over problem is considered within this PIC document as potential technologies are evaluated and will be considered further as the CDS progresses.

3.1.2 Restoration Measures

No restoration measures have been performed to date at the Waterford 3 Plant. Potential restoration measures are discussed in Section 3.2.3.

[3] The nuclear electric utility industry created the INPO in 1979. U.S. organizations that operate nuclear power plants are INPO members. INPO and the Department of Energy (DOE) have a contract coordinated by the Office of Regulatory Liaison which involves sharing of information. INPO provides DOE employees access to INPO products and services including operating experience and data, workshops and training, and on-site special assistance visits.

3.1.3 Performance Estimates

Estimates of performance relative to the Rule's goals are contained in Table 3-2. The following bullets provide a listing of the data that were used to estimate these performances:

- Impingement data compiled at the Entergy Waterford 1 & 2 Plant (no quantitative impingement data is available for Waterford 3),
- A review of impingement rates at other plants located on the Mississippi River as well as summary of general distribution and habits of fisheries of the river (see Appendix B). No site-specific impingement studies data are available for the Waterford 3 CWIS, however ambient fisheries data is available in the general area of the plant;
- Local fisheries data provided by the Mississippi Museum of Natural History and other government agencies;
- Threatened and endangered species found in the area as listed by both the State of Louisiana and the U.S. Fish and Wildlife Service; and
- Best professional judgment based on the literature on CWIS technologies and likely biological responses.

The physical location of the CWIS away from the shoreline habitat and in deep, fast-moving water, discourages fish from migrating toward the intakes. The resulting impingement mortality reduction from a baseline calculation is estimated to be 93% based on literature values of the fish biomass present in different Mississippi River habitats (see Table 3-2 and Appendix B). Since the total impingement reduction is 93%, the plant appears to meet the performance standard. Although not credited towards the performance standard, it should be noted that the facility has increased total capacity by 78 MW Net since the EPA Questionnaire was submitted in February 2002 without any changes to CWIS flow.

The plant is currently considered a "base load" facility and has a current capacity factor greater than 15%. Future plans are to maintain the plant at its current operating status. Entergy cannot commit to the maintenance of any reduced capacity factor at this time and therefore, does not credit that toward the performance goal.

3.2 Potential Technologies

A summary of general technologies and operational measures available to address impingement mortality and entrainment are presented in Table 3-3. For the Waterford 3 Plant, only the impingement mortality goal is applicable. This table presents the technology, estimated effectiveness in addressing impingement mortality and entrainment, estimated technology cost, and notes on why the technology was or was not retained for further feasibility analysis as part of

the CDS. Appendix A provides a more in-depth analysis of each technology and operational measure considered in Table 3-3. A specific discussion of those technologies that Entergy considers most promising for the Waterford 3 Plant is provided in Section 3.2.1. A specific discussion on operational measures is provided in Section 3.2.2.

Because the cooling water intake is less than 5% of the river flow, entrainment performance goals do not apply to Waterford 3 Plant. As a result, entrainment is not considered further in this technology review.

3.2.1 Review of Technologies

The following criteria are used to assess the technologies and operational measures presented in Table 3-3:

- Technical feasibility and reliability;
- Effectiveness in meeting the Rule's performance goals;
- Costs relative to EPA estimate developed as part of the Rule-making; and
- Potential for other adverse effects.

Site-specific technologies considered for the Waterford 3 Plant included:

- Traveling screen modifications;
- Fixed screen devices;
- New intake location;
- Fish diversion and deterrence techniques; and
- Flow reduction.

In Table 3-3, the capital costs for technology installation have been estimated for planning purposes. These costs are approximate but they do account for a number of site specific aspects (e.g., distance from the river to the plant, number and capacity of CWIS, etc.). Table 3-3 also provides a qualitative discussion of potential operation and maintenance costs. Costs associated with plant downtime during construction are also likely but have not been estimated here due to the uncertainty in construction timing and the need to suspend operations. Given the consistent, 'baseload" operation of Waterford 3, the costs associated with facility downtime are likely to be very high. In the execution of the Cost-cost or Cost-benefit test, all of these issues will be revisited in a more formal fashion and their results expressed consistent with the requirement of the Rule.

The cost estimates for the various technologies were prepared by using the following resources:

- EPA Technical Development Document for the Final Section 316(b) Phase II Existing Facilities Rule, February 12, 2004. (EPA-821-R-04-007);
- EPA Technical Development Document for the Proposed Section 316(b) Phase II Existing Facilities Proposed Rule, April 2002. (EPA-821-R-02-003);
- Cost estimates and/or installed costs for similar equipment obtained by ENSR from vendors and other operating plants; and
- Brayton Point Plant 316(b) Demonstration.

Available costs were adjusted to account for size/capacity differences as follows:

- proportionally for components/equipment whose costs were judged to be proportional to size (e.g. pipe length); and
- by the 6/10ths rule[4] for those components whose costs were judged to not be directly proportional to size (e.g. pumps).

ENSR also applied the following factors, where appropriate:

- 10% Allowance for Indeterminants (AFI), a contingency[5] on costs of the items included;
- 30% contingency[5], to address unforeseen items, especially with regard to a plant retrofit; and
- Escalation based on the time frame of the basis cost estimate. Since the basis cost year varied, estimated costs were escalated based on 3% annual rate of inflation.

Traveling Screen Modifications

The CWIS has eight 10-foot wide, 51-ft high, 1/4 in. square mesh traveling water screens located 19 ft. 3 in. downstream from the centerline of the trash racks and 29 ft 9 in. upstream of the

[4] The 6/10ths rule or factor is a logarithmic relationship between equipment size and cost. In simple form, $C_n = r^{0.6}C$, where C_n = cost of new equipment, C = cost of existing equipment (or a known cost), and r = the ratio of the new to existing capacity or size. [reference: Chilton, C.H., "Six Tenths Factor," *Chemical Engineering*, April 1950, pp. 112-114.]

[5] The 10% AFI and 30% contingency were both chosen based on past experience and engineering judgment for this level of cost estimate.

cooling water pumps. Screen wash water enters a concrete sluice way common to all traveling screens and discharges to the Mississippi River.

As noted above, many of the finfish encountered at Waterford 1 & 2, and anticipated at the Waterford 3 Plant are relatively sensitive to handling. Thus, even the relatively costly upgrades discussed in this section are unlikely to greatly improve finfish survival.

Major modifications to the intake screens (dual flow, angled, or inclined) to reduce through-screen velocity or improve impingement mortality performance will pose significant engineering challenges and possible major modifications to the intake structure. Assuming that angled or inclined screens could be installed in the screen house with relatively minor intake structure modifications, the cost for either the angled or inclined screens was estimated to be $8M. If the number of intake bays is to be increased in order to reduce through screen velocity, the costs will increase dramatically from this estimate. Because the angled/inclined screens are not substantially more effective than conventional screens and have a higher cost than other modifications, this technology was not retained.

Dual Flow Screens

A dual flow screen option which, by design, would reduce the through screen velocity to 0.5 ft/s was also considered. To achieve this velocity, the existing flow through screens would be replaced with new 14-ft dual flow screens in the existing structure. Another intake bay would also be required to achieve a through screen velocity of 0.5 ft/s. The cost for dual flow screens was estimated to be $28.8M. The cost includes Ristroph features and a fish return flume.

Dual-flow screens are a technology that has been used to reduce or eliminate debris carry-over problems at cooling water intake systems. Dual-flow traveling screens are typically oriented parallel to the overall direction of the cooling water flow - or perpendicular to the orientation of conventional through-flow screens. With this technology, water is drawn through the screen from the outside of both the ascending and descending sides of the screens. Clean water from the inside of the screens is then pumped to the condensers. Carry-over is typically not a problem with dual-flow screens because any debris not cleaned off the screen on the first pass stays on the outside of the screen, only contacting unscreened, not screened, water. Unremoved debris then has a second (or more) opportunity to be removed from the screen by the spray wash system.

One of the common limitations with dual-flow screens is the flow disruption that is caused by the two 90-degree turns that cooling water must undergo to pass through the system. The hydraulic disruptions result in increased turbulence, velocity hotspots, and even local inducement of flow out of the screen. These hydraulic issues can result in poorer impingement performance. These issues can be minimized (but not eliminated) by proper hydraulic analysis and design.

Hydraulic issues are likely to be increased if the dual-flow screens are to be placed in relatively narrow channels such as the intake bays at Waterford 3. The extent of this concern depends on the width of the screen endplate relative to the bay width and the resulting channel width remaining for water to enter.

For example, at a power plant in Texas, approach velocities increased dramatically when through-flow screens in 11-foot wide intake bays were replaced with dual-flow (dual entry – single exit) screens. This screen retrofit resulted in an opening of approximately only one foot between either side of the screen endplate and the intake bay wingwall, for a total opening width of approximately two feet. Thus, the cross-sectional area of the approach channel decreased, and the corresponding screen approach velocity increased by approximately 80%. No studies have been conducted to determine the effect of this retrofit on impingement rates. However, it is unlikely that impingement has decreased at the facility. In fact, based on the increased approach velocity, it is possible that impingement has increased.

At another power plant, this one in New York, a dual-flow retrofit was accompanied by the installation of a fish escape passageway on the outside face of the bank of the traveling screens. This involved the removal of wingwalls and opening of the intake area to form one large intake embayment.

The installation of dual-flow screens at Waterford 3 without removal of the intake bay wingwalls will likely result in an increased screen approach velocity. If the dual-flow design is the same as that used at the Texas power plant mentioned above, the approach velocity would increase to approximately 5.5 ft/sec. Given this approach velocity, it is unlikely that any fish or other aquatic biota approaching the screens would be able to evade impingement. On the other hand, if properly designed, the increase in screen area associated with dual-flow design could result in a decrease in the through-screen velocity. This could increase the potential for survivability of impinged biota. However, because of the non-uniformity of flow on the face of and through the dual-flow screens, the increased survival is not guaranteed.

Removal of the wingwalls could result in a decrease in the intake approach velocity and could provide the framework for a fish escape passageway. Both of these would substantially reduce the potential for an increase in impingement. However, the cost for removal of the wingwalls, which would involve substantial construction as well as potential structural issues and plant shutdown for a period of time, would likely be significant. For these reasons, this technology was not retained for further evaluation.

Ristroph Screens

Ristroph screens are technologically feasible and would require the addition of a low pressure wash system and a fish return system. The design of the fish return will be critical to ensure survival of the fish being returned. The cost of these modifications (screen modifications, low

pressure wash, and new fish return system) is estimated to be $6.9M, assuming a 300 foot fish return flume.

Ristroph screen modifications have been demonstrated to significantly reduce impingement mortality at other facilities. For example, at a facility in New York, the survival of bay anchovy went from 0.4% to 50%, and the survival of gizzard shad went from 0% to 100% (based on three fish) after the installation of Ristroph screens. It should be noted, however, that Ristroph screens have not been shown to be consistent in significantly improving the survival of very sensitive species. In fact, substantially larger surveys at other facilities do not support this rate of gizzard shad survival with Ristroph-type screens.

A Ristroph screen modification would likely involve installation of the following:

- Smooth flat wire screens that minimize mortality when organisms are impinged on the screens;
- Fish buckets with a smooth surface and sides that retain water such that mortality is minimized when organisms are lifted out of the water during screen rotation;
- A low pressure spray before the high pressure spray such that mortality is minimized during screen cleaning; and
- A fish return trough with a smooth surface and sides that retain water such that organisms are gently returned to the Mississippi River without the use of hydraulic jets to maintain flow in the trough.

It should be noted that the advantages of a Ristroph screen modification for the protection of organisms may be compromised in situations with high debris loading such as experienced at Waterford 3. For example, if the fish buckets are filled or clogged with debris, organisms may not be retained in the water as designed. In addition, the debris load could reduce the effectiveness of the low pressure spray in removing organisms from the screens. Also, a high debris load in the return trough may block flow through the trough unless hydraulic jets are used to maintain flow. On the other hand, continuous rotation and washing of the screens, which is typical of Ristroph screen operation, could reduce the debris handling to a level such that the fish protection characteristics of the screens are maintained. Each of these items would need to be considered during design if Ristroph screen modifications were to be evaluated in detail. Due to the high costs and variable benefit as well as the high performance of the current system, Ristroph screens were not retained for further evaluation.

Fixed Screening Devices

Installation of a fixed screen in the water body can, under certain conditions, provide effective reduction in impingement. The continuous current in the Mississippi River provides a suitable sweeping velocity for such screens.

Cylindrical wedgewire screens with a 3/8-inch slot size could be considered for the Waterford 3 Plant. For a through screen velocity of 0.5 ft/s, at design flow rate, a possible configuration would include 57 72-inch diameter T-screens at the end of the intake canal. The screens would be cleaned with the air burst system mounted at each T-screen. Since the current configuration of the intake canal could not support the installation of T-screens, a newly constructed submerged offshore intake pipe would be required which would significantly increase costs. It was assumed that the required pipe length from the existing intake would be 300 feet. Given that screens would be located in the Mississippi River, there is always the concern of impact from navigational traffic. In addition, the screens are very likely to be subject to damage associated with debris (e.g., trees) moving down river. Estimated costs for constructing a submerged intake pipe and adding T-screens are estimated to be $30.3M. This technology is not retained due to its cost, issues associated with installation and operation, and the high performance of the current system.

A 370-ft long by 40-ft deep coarse mesh barrier net could be installed across the existing sheet piling (below the skimmer wall) at Waterford 3. A much taller net, approximately 60 feet, would be required if a net would be utilized during high flow periods. The induced through-net velocity would be less than 0.15 ft/s at normal water level. The estimated capital cost for the barrier net is $1M. In the Mississippi River, a barrier net is not practical because of significant changes in river level, the high potential for damage from debris and because of navigational impediments to heavy marine cargo traffic in the area. As a result, this technology was not retained.

A porous dike constructed around the intake would be of massive size with a 40+-ft depth and such a dike (like the barrier net) would also be an obstruction of navigation. A conceptual design would require a dike 40 feet high and 1,300 feet long. The estimated capital cost for this option is $10.3M. As with the barrier net, a much taller structure would be required during high flow periods. Such a dike would be an impediment to shipping and likely subject to damage during flood conditions. The dike materials would also be subject to clogging. Because of the high costs, impracticality, and uncertain performance, this technology was not retained.

Offshore Intake Structure

The existing intake canal extends approximately 162 feet from shore to a depth of 40 feet. The conceptual design of a retrofit of the existing offshore intakes would include extending the existing intake canal to a location an additional 300 feet (to total 460 feet) offshore with the expectation that biological diversity would be lower in mid-channel waters of the river. Installation of an extended intake canal is estimated to cost $18.4M. Because this alternative is not demonstrably

more effective than the existing offshore intake configuration (i.e., the current system already accesses the high velocities of the main channel resulting in a 93% reduction in biomass compliant with the IM performance standard) it was not retained.

Fish Diversion and Avoidance Devices

Louvers and bar racks can be effective in reducing impingement with a consistent sweeping flow of the river. The effectiveness varies significantly by species. Debris would also tend to accumulate in the louvers or bars reducing its effectiveness and reducing flow, an unacceptable condition for a nuclear station. If a set of louvers were installed to enclose the existing intake canal, the estimated cost would be $3.6M. It was not retained because of cost and likely difficulties in implementation.

Velocity caps on new offshore intakes have been shown to result in reduced impingement; however, it is not always clear whether the reported reductions are due to the velocity caps or the new offshore locations. Also, the response of fish to the velocity cap is species specific. The addition of velocity caps would require the construction of submerged intake pipes which would elevate costs significantly. The estimated total cost of installing intake pipes with velocity caps is $18.4M. Due to the relative ineffectiveness of this technology and its significant cost, this technology was not retained. This option would also pose potential navigation concerns.

Other behavioral barriers such as strobe lights, acoustic deterrent, bubbles, and chains have been used as fish deterrents. Their effectiveness is highly uncertain in an area like the Mississippi River and species-specific. The effectiveness of these devices can be hampered by the high turbidity conditions and the likelihood of the equipment to degrade and fail under microbiological fouling conditions observed in the Mississippi River. As a result, these technologies were not retained. If strobe lights or acoustic deterrents were installed at the end of the sheet piling intake canal, the estimated cost would be $0.8M.

3.2.2 Review of Operational Measures

Two operational measures are considered at the Waterford 3 Plant: more frequent rotation of the traveling water screens in order to reduce impingement mortality and flow reduction.

More Frequent Rotation of the Traveling Water Screens

More frequent rotation of the traveling screens may reduce impingement mortality by decreasing the time that impinged fish spend on the screen. Shad and other sensitive species most likely would not benefit significantly from increased screen rotation due to their intolerance to physical handling. Other species (e.g., river shrimp, catfish) could benefit from more frequent screen rotation as they are typically hardier. Although most of the fish returned to the Mississippi River are not observed due to the high discharge velocity, a small percentage is expected to survive.

Since Entergy believes the plant is currently in compliance with the impingement mortality performance standard, more frequent screen washing is not warranted and is not retained for further evaluation. As mentioned previously, an infrequent but recurring debris carry-over problem currently exists at the plant. Due to design problems, some debris is carried over the traveling water screens when they are running, inherent of once through traveling water screen systems. Debris clogging occurs in the water boxes at the tube sheets downstream of the traveling water screens. The debris causes fouling in the water box which leads to condenser tube pitting. More frequent screen rotation would increase the existing debris carry-over problem and could create NRC safety concerns as well. It should be noted that the rule (40 CFR 125.94(f)) notes that NRC requirements for safety can be considered while evaluating alternative technologies. Additionally, more frequent rotation of the screen will also increase operational costs and may require upgrade of one or more of the screen's components, potentially at considerable cost.

Flow Reduction

Variable speed pumps are most effective for those plants located in areas where intake water temperatures vary significantly because of season. If variable speed drives were installed on all eight cooling water pumps, the estimated cost is $4.2M. Because of the high cost and expected minor improvement in impingement, this alternative was not retained.

Evaporative cooling towers and dry cooling are much more costly than EPA's estimate for compliance and, therefore, will not be considered further. However, for reference, costs for these options are presented in Table 3-2.

3.2.3 Review of Restoration Measures

Restoration can be a very cost-effective measure for mitigating losses of aquatic organisms. Under some circumstances it may be possible to effect one-to-one replacement of important species or otherwise improve the ecosystem by an "out-of-kind" restoration, allowed by the Rule.

Possible restoration methods generally include:

- Fish restocking programs;
- Installation of fish diversion devices;
- Habitat creation;
- Habitat restoration; and
- Habitat enhancement.

Of these measures: two have some degree of precedent for the Mississippi River; (1) fish restocking programs; and (2) habitat enhancement.

Although paddlefish are not federally listed endangered, populations have declined in recent years due to habitat destruction and fishing pressure. Fish restocking programs may provide an opportunity to enhance the Mississippi River fisheries for a species bordering endangered status. Restocking programs for the endangered pallid sturgeon may also provide an opportunity for beneficial restoration measures. Restoration methods may be retained for further evaluation in the CDS.

3.2.4 Estimate of Technologies' Cost and Effectiveness

Costs for technologies and operational measures have been presented in Sections 3.2.1 and 3.2.2. Additionally, the costs are also presented in Table 3-3 along with estimated effectiveness of the technologies and operational measures. It should be noted that the anticipated reductions in impingement mortality are relative to existing improvements over the Calculation Baseline. Even relatively effective measures, on a percent reduction basis, are not likely to be cost-effective given the current high performance of the CWIS relative to the goals of the Rule.

3.2.5 EPA's Appraisal of Technologies

As part of the Rule making process, EPA developed an estimate of the cost of compliance with the Phase II Rule at each of the affected plants. These data are provided for the Waterford 3 Plant, with some slight modification to their presentation, as Appendix C. EPA has estimated the cost of compliance at the Waterford 3 Plant will be $27.4M in capital costs and $7.3M in total annualized costs. These costs inappropriately cover compliance with both the impingement mortality and entrainment performance standards. To adjust the EPA estimated compliance costs to address only the impingement performance standard, the costs in the rule should be reduced by a factor of 2.148 (a value provided by EPA in the rule). This brings the corrected EPA compliance costs to $12.4M for capital costs and $3.4M in total annualized costs.

This estimated cost serves as a basis of comparison under one of the options for a site-specific BTA assessment (i.e., Compliance Alternative 5). Under the Rule, if the actual costs of achieving the performance goals are "significantly greater" than US EPA's estimate of costs, the so-called Cost-cost test can be applied to support the determination of site-specific BTA. Thus, the US EPA costs are a regulatory baseline for evaluation of reasonableness of the cost of technologies at Waterford 3. The alternative process for the Site-specific BTA is the Cost-benefit test. In this case, if the site-specific costs of mitigation measures are significantly greater than the likely monetized benefits, a Site-specific BTA can be supported. Entergy will pursue the Cost-cost and Cost-benefit tests under Compliance Approach 5, as appropriate and as an alternative to Entergy's preferred method of demonstrating compliance by Compliance Approach 2. This will supplement the evaluation of whether the plant is currently meeting the performance standard (Compliance Approach 2).

3.3 Selection of Proposed Technologies, Operational and Restoration Measures

Based on our review of the technologies available and the circumstances at the Waterford 3 Plant, we conclude that restoration should be retained for additional consideration as part of the CDS. The decision to eliminate other technologies is based on the fact that the CWIS appears to be in compliance with the impingement mortality goal. As importantly, any technology to further reduce the rate of impingement mortality is subject to significant issues of performance and cost and the likely benefit of any such measure is likely to be significantly less than the cost.

Table 3-1:
Entergy Operations, Inc. - Waterford 3 Plant
Summary of Facility CWIS and Overall Information Collection Strategy

LPDES Permit No. LA0007374 - AI Number 35260

LPDES Permit Application Dates	Current Permit Expires on January 31, 2010; Renewal Application Due July 31, 2009
Setting	Mississippi River (Non-tidal)
Capacity Factor	Operation of the plant is above the 15% Capacity factor. Facility is not expected to decrease its level of operation.
Performance Goals	Impingement Mortality only; facility withdraws <5% Mississippi River flow so entrainment goal is not applicable.
Summary of CWIS	Single CWIS located on the western bank of the Miss. River; steel sheet piling driven into river bottom creates an artificial canal that extends 162 feet out into the Miss. River. Top and bottom sheet pile elevations are +15.0 feet msl and -1 foot msl. Canal opening measures 36.9 feet in length by 34 feet in depth. Water velocity through the intake opening at the river boundary during maximum pump operation is approximately 1.9 ft/sec. A skimmer wall exists at the end of the canal and reduces floating debris/surface swimming organisms from entering the canal. Plant design intake water capacity is 1,555 MGD; 4 circulating pumps rated at 250,000 gpm (557 cfs) each. Intake structure is divided into eight screen bays each equipped with a traveling screen. Most screens have 1/4 inch mesh; approximately 10% of the screen panels are equipped with 3/8 inch mesh. Screen operation depends upon debris load and varies between hourly to once a day. High pressure (80 psi) wash system removes impinged organisms which collect into a single concrete trough that returns to the river. Trash rack and traveling water screen approach velocities are 0.9 ft/sec and 1.0 ft/sec, respectively. Debris loading at the plant is sometimes an issue as debris tops the canal sheet piling during flood conditions. Cooling water discharge is located 600 feet downstream of the intake canal.
Number of Units	1 open cycle nuclear unit (1 CWIS)
Relationship to Baseline Condition	Changes in habitat or density of organisms between shoreline and offshore intakes. Credit for offshore CWIS location. Although not credited towards the performance standard, the plant has also increased capacity two times (total of 78 MW Net) since the EPA Questionnaire was submitted in February 2000 without increasing CWIS flow.
Availability of Historical Data	No impingement data available for this facility. Impingement data available for several facilities on the river including Waterford 1 and 2, Willow Glen, Baxter Wilson. The Waterford 1 and 2 Plant is located 2,100 feet upstream on the Mississippi River. Ambient fisheries data was collected during initial demonstration study for the Waterford 3 Plant between 1973-76. Ambient data is current up to the present. T&E species list is available. Plant personnel stated impingement is low and consist primarily of gizzard shad and blue catfish.
Applicability of Historic Data	Impingement rates from several other stations are available from the 1970s. Ambient species densities are generally consistent with impingement data encountered. Surveys on ambient fisheries populations available from both 1970s and current conditions. Small change in fisheries over time is likely (see Appendix B).
US EPA Compliance Cost and Technology Estimates	US EPA has estimated that the capital costs of compliance at the Waterford 3 Plant will be $27,395,451 see Appendix C. These costs incorrectly assumed entrainment was applicable at the plant. Updated costs without entrainment are estimated at $12,400,000 for capital costs and $3,400,000 in total annualized costs.
Outline of Compliance Strategy	1) Several positive distinctions from the baseline condition (i.e., offshore intake location and debris handling system). Likely that the CWIS meets the IM performance goal. 2) Technologies were reviewed and all are costly and several are infeasible and/or ineffective. 3) Pursue hybrid approach based on Alternatives 2 and 5 (Cost-cost and/or Cost-benefit tests). Emphasize weight of evidence regarding performance of current and potential technologies. Evaluate monetized benefits based on impingement rate estimates from other plants. No additional data collection. 4) Consider cost-effective mitigation measures that will yield tangible results (i.e., restoration).
Approach to Estimating Calculation Baseline; Comprehensive Demonstration Study	1) Minimize data collection based on availability of data at other "like" facilities. 2) Estimate calculation baseline based on literature, available site-specific data at Waterford 1&2, and Best Professional Judgment.

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Table 3-2:
Entergy Operations, Inc. - Waterford 3
Estimated CWIS Performance Relative to Calculation Baseline
AI Number 35260
Performance Goal: 80 to 95% Reduction in Impingement Mortality (IM)
Entrainment Reduction is Not Required

IM - Difference from Baseline	Estimated Reduction in IM (%)	Basis	Notes
Location of CWIS offshore	93	Intake structures is located on the shoreline, however, sheet piling creates a canal that extends 160 feet out into the Mississippi River and in deep, fast water. End of the canal is equipped with a skimmer to prevent floating debris and aquatic organisms from entering the intake structure. Curtain wall also exists at the intake bays to block floating debris from entering the intake bays. Literature shows that fish communities are reduced away from the shoreline and in areas of higher water velocity.	Approximate estimate. The literature which shows an order of magnitude difference in biomass between the main channel (21 kg/ha) and the channel border (327 to 748 kg/ha) (Schramm, 2005). Protection estimated as (1-21/327). Three researchers indicated that majority of river's fish biomass is located on river edges and in low velocity areas.
Total IM Protection	**93**	**Goal achieved with current control measures**	

Note: Although not counted as credit, the plant has increased total capacity by 78 MW Net without increasing CWIS flow since the February 2000 submittal of the 316(b) EPA Questionnaire.

Table 3-3:

Assessment of Mitigation Measures
Entergy Operations, Inc. - Waterford 3
AI Number 35260

BTA Alternative	Cost (Capital) $M	[illegible]	[illegible]	[illegible]	[illegible]	Basis of Decision
Traveling Screen Modifications						
Increased frequency of screen rotation/wash	0-1	No	Potential benefit to reduce residence time on the screen	0	No	Capital costs potentially very low but it may be necessary to retrofit portions of the traveling screen and the debris handling system. Impingement mortality benefits likely but uncertain. Increased operation and maintenance costs. Current performance is already high. Will add to existing post-screen debris problems.
Modified traveling screens (dual flow)	28.8	Yes	High if through-screen velocity <0.5 fps, meets alternative 1(b)	0	No	Existing screens would have to be replaced with new 14-ft. dual flow screens. Additional intake bays would be required to achieve a through screen velocity of 0.5 ft/s. Potential increase in flow-through velocity and impingement. Costs are significantly greater than US EPA's adjusted costs. Current performance is already high.
Modified traveling screens (Ristroph Screens)	6.9	No	> 80% with frequency rotation, low pressure wash, and fish return.	0	No	Potential to replace existing screens without a major retrofit but not likely effective. Costs affected by need to install low-pressure wash and optimize debris handling system to increase fish survival. Includes 300 ft fish return. Costs would be significantly greater if additional bays are necessary. Post-impingement fish survival is generally high if species is hardy; low survival for fragile species. Of the few fish impinged, shad are expected to dominate and are intolerant to physical handling. Current performance is already high.
Angled or modular inclined screens	8	No	May meet standard for certain species	none	No	No full scale application has been constructed/evaluated so potential reduction in impingement is unknown. Costs assume only minor intake structure modifications required. Potential for far greater cost. Current performance is already high.
Fixed Screening Devices						
Wedgewire Screens	30.3	Yes	> 80% if through screen velocity is low.	Unlikely effective unless site in area with low ichthyoplankton density.	No	Current configuration of the intake canal can not support the installation of T-screens and would require major modification consisting of a 300 ft offshore intake pipe. Slot size must be relatively large (i.e., 9.5 mm) in order to avoid clogging; technology therefore is no more effective than current technology. Costs significantly greater than US EPA's and other technologies.
Barrier Net	1.0	No	> 80%	0	No	Little potential for standard deployment due to high velocities and large debris load commonly found in the Mississippi River; significant damage potential. Structure would be required to surround the entire area of the intake canal and be 60 ft. tall to support high flow periods.
Porous Dike	10.3	No	> 80% if behavioral measures perform	Uncertain	No	Potential clogging by algae and debris - significant maintenance issues. Dike would have to be constructed around the entire intake canal and be at least 40 ft. high and 1,300 feet long. Strong potential for flood damage to dike as well as overtopping.

Table 3-3:

Assessment of Mitigation Measures
Entergy Operations, Inc. - Waterford 3
AI Number 35260

BTA Alternative	Cost (Capital) $M	Cost Significantly Greater than US EPA Estimates	IM Reduction/ Effectiveness	E Reduction/ Effectiveness	[illegible]	Basis for Decision
New Intake Location						
Offshore Intake Structure (with velocity cap)	18.4	Yes	Uncertain	Maybe high but only if well offshore	No	No significantly different habitat is readily accessible with movement farther offshore. Density of fish populations a stronger function of water velocity which is unlikely to change substantially with greater distance. Costs are significantly higher than US EPA's due to extended piping required.
Fish Diversion and Avoidance						
Diversion Devices: Louvers and Bar Racks	3.6	No	Uncertain	none	No	Fish behavioral avoidance; effective for some species but not others. Severe debris loading is likely to reduce effectiveness. Required by-pass system. Current performance is already high.
Velocity cap on offshore location	18.4	Yes	Possibly 90%, but uncertain	none	No	Deep deployment and major modification at the end of the canal required. Costs are significantly greater than US EPA's. Current system performance is already high.
Behavioral Barriers: Strobe Lights, acoustic deterrent, bubbles, chains	0.8	No	Uncertain	none	No	Effectiveness highly uncertain and species-specific. Location of deployment uncertain. Likely subject to debris damage. No more effective than current measures.
Flow Reduction						
Variable Speed Pumps	4.2	No	Low depending on frequency of flow reduction.	Low depending on frequency of flow reduction.	No	Flow reduction generally used to reduce entrainment. Effectiveness is likely to be low given the nature of the plant operation.
Evaporative Cooling Towers	212	Yes	>90%	>90%	No	Costs significantly higher than US EPA's. Reduction in plant efficiency. Visual impact from vapor plume. Consumption of water. Cost may be significantly greater if existing condensers not rated for additional pressure.
Dry Cooling Tower	460	Yes	>90%	>90%	No	Costs significantly higher than US EPA's. Significant reduction in plant efficiency. Adverse visual impact large towers. Adverse noise impact. Cost may be significantly greater if existing condensers not rated for additional pressure.
Increased Fish Production						
Restoration	0.1 - 2	No	Uncertain	Uncertain	Yes	Some restoration efforts (e.g., fish stocking, focused habitat improvement) likely to be cost-effective. Specific nature of potential programs uncertain at this point. Uncertainty associated with pending court decision on restoration.

Note: Capital costs do NOT include outage costs, O&M, or efficiency penalties

Figure 3-1 – Waterford 3 Cooling Water Intake Structure

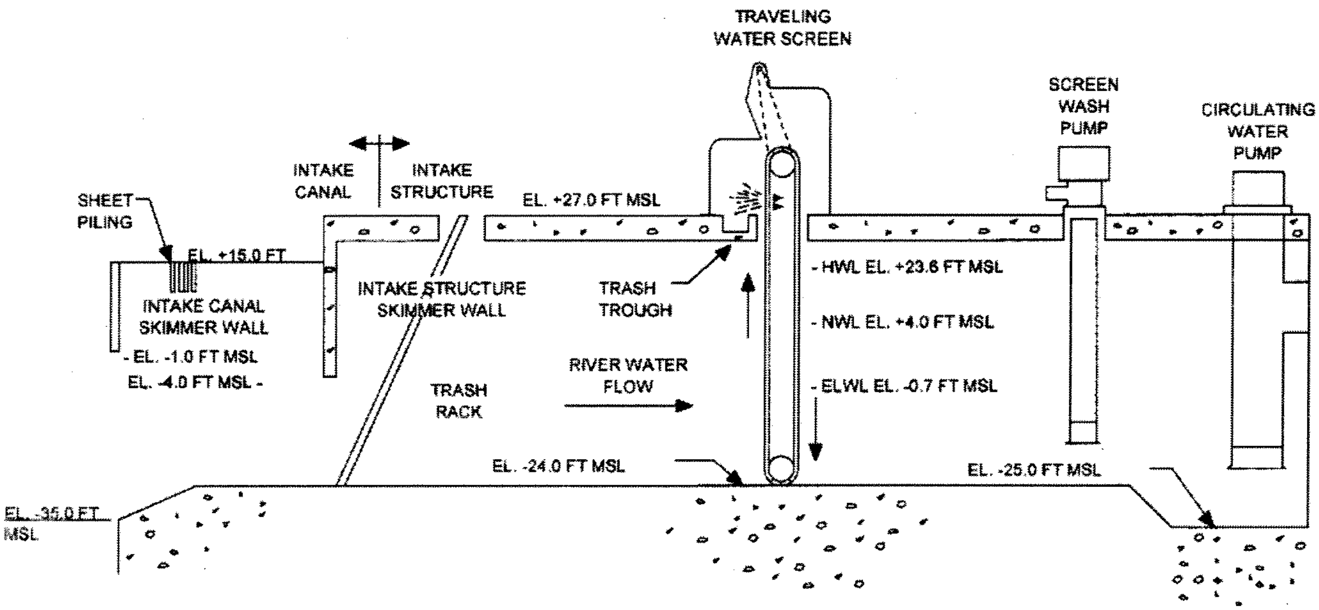


Figure 3-2 – Cooling Water Intake Canal

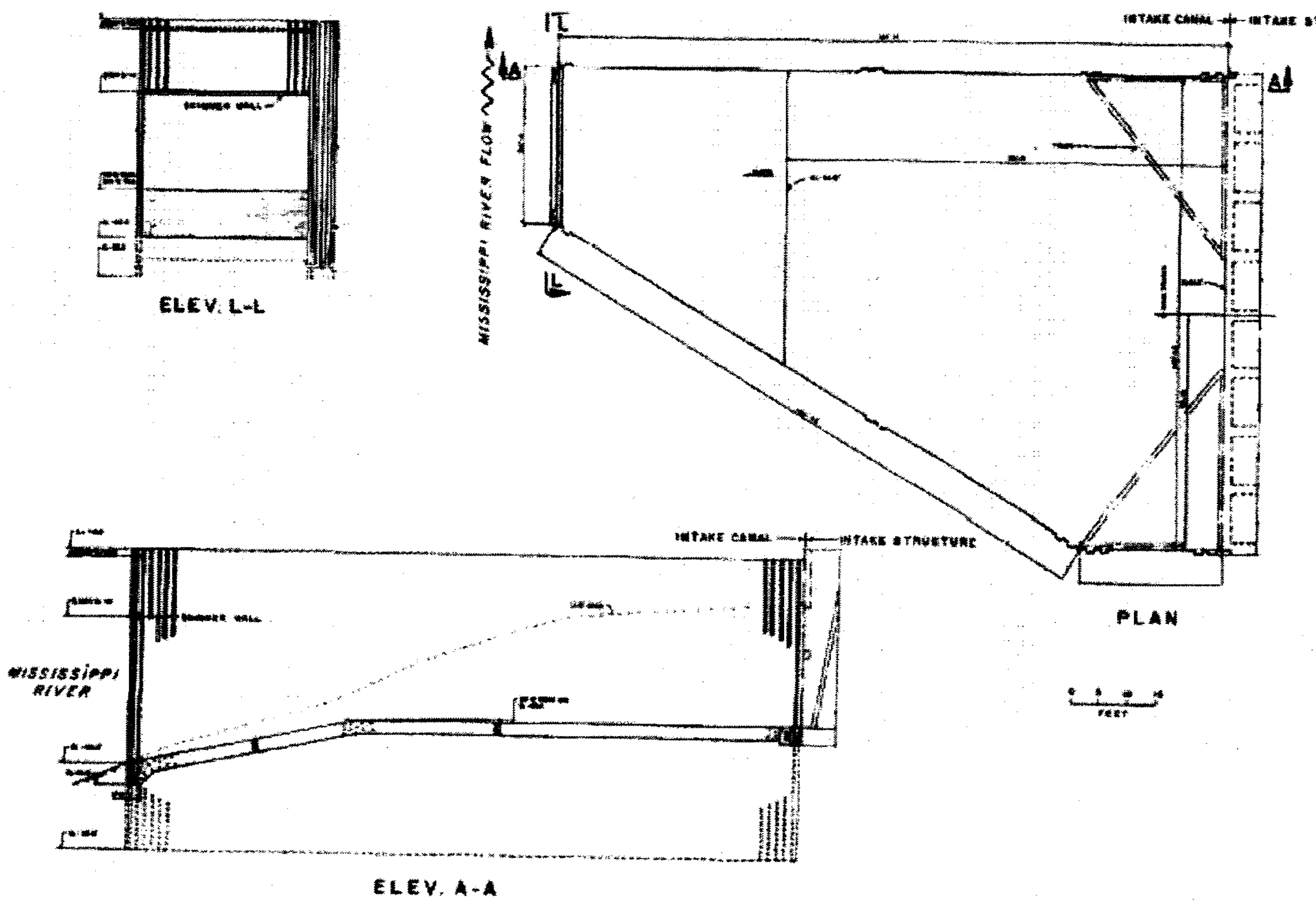
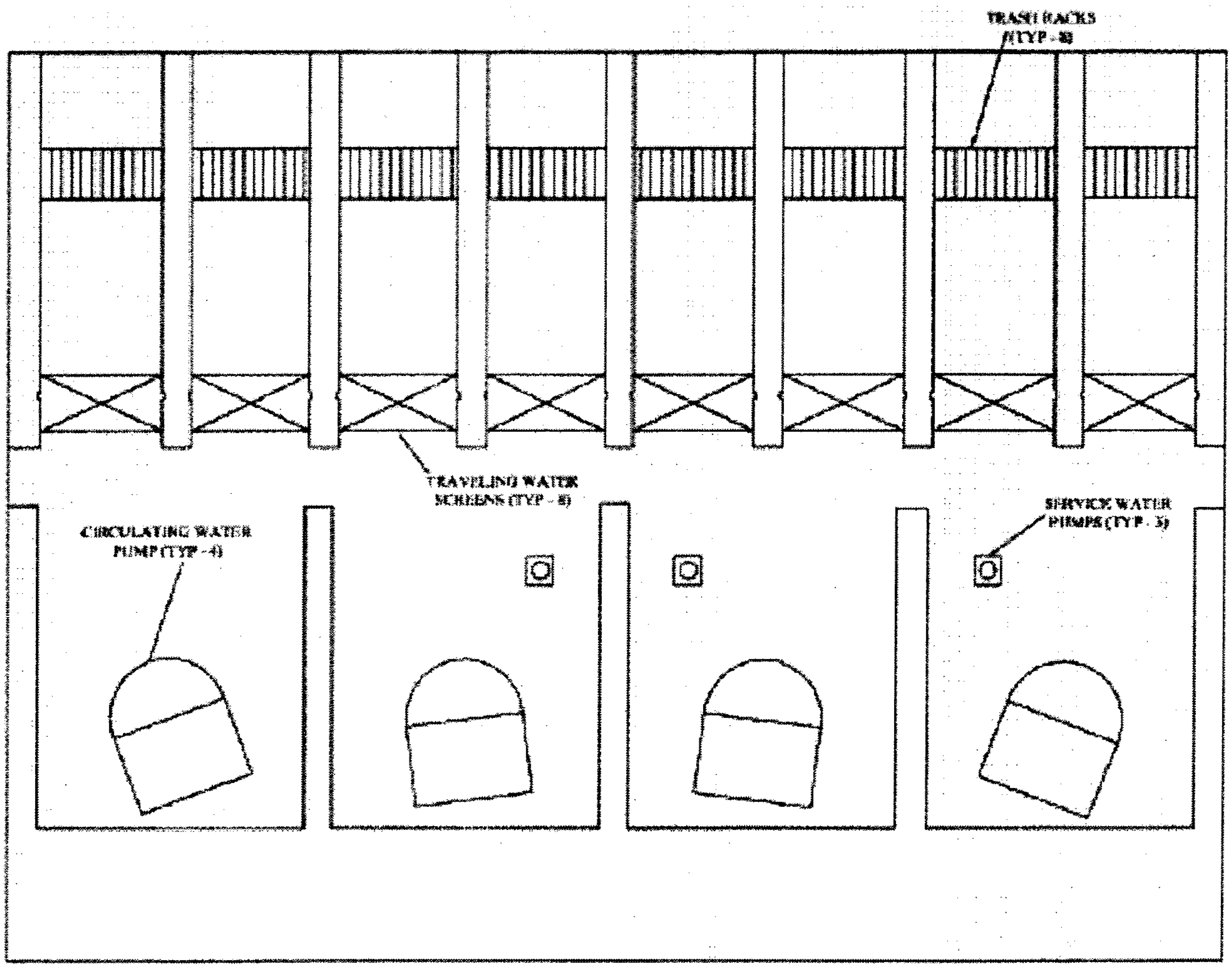


Figure 3-3 – Waterford 3 Intake Bays with Traveling Screens



4.0 HISTORICAL STUDY REVIEW

Relevant impingement studies have not been conducted at the Waterford 3 Plant but have been conducted at the Waterford 1 & 2 Plant located 2,100 feet upstream and other similar power plants on the Mississippi River. These studies are briefly discussed in Section 4.1. A more complete discussion of these studies, as well as data from other sources, is presented in Appendix B. The ability of the combined data set to support the requirements of the Phase II Rule, in particular the Impingement Mortality and Entrainment Characterization Study (IMECS), is discussed in Section 4.2.

Based on anecdotal observations at the Waterford 3 Plant, the taxa most often impinged are shad and blue catfish. River shrimp are also noted as being impinged with some regularity. These species are also numerically the dominant ones impinged at other stations located on the lower Mississippi River. Reducing their rate of impingement, showing that such reductions are not cost-effective, or demonstrating that current rates of impingement do not cause an "adverse environmental impact" are the goals of the Phase II Section 316(b) rule.

Pre-construction surveys for station licensing (performed 1973 - 1976), and impingement monitoring at Waterford 1 & 2 (performed 1976 – 1977) also provide information about the species most likely to be subject to impingement at Waterford 3. During the pre-construction surveys the majority of organisms collected were (in descending order of abundance): gizzard shad (*Dorosoma cepedianum* - 38%), blue catfish (*Ictalurus furcatus* - 18.1%), threadfin shad (*Dorosoma petenense*) (14.5%), striped mullet (*Mugil cephalus* -10.4%), and freshwater drum (*Aplodinotus grunniens*) (6.9%). Species that dominated the impingement sampling at Waterford 1 & 2 included river shrimp (*Macrobrachium ohione*), blue catfish, channel catfish (*Ictalurus punctatus*), freshwater drum, gizzard shad and threadfin shad. Shad species and blue catfish were the dominant impinged species.

Swimming speeds are available from studies (summarized in Appendix B) for some of the above species. Study results show the following maximum swimming speeds: gizzard shad – 2.3 ft/sec; channel catfish – 1.8 ft/sec; striped mullet – 4.3 ft/sec; drum (red drum - *Sciaeniops ocellata* used as surrogate for freshwater drum) – 3.0 ft/sec; freshwater shrimp (clam shrimp - *Eulimnadia texana* used as surrogate for river shrimp) – 0.02 ft/sec. The maximum swimming speeds for these fish are generally greater than the average water velocities in the intake bays (1.0 ft/sec) and the intake canal opening (1.9 ft/sec) at peak pump operation. Note that the maximum swimming speed for channel catfish (1.8 ft/sec) is slightly less than the average water velocity in the intake canal opening (1.9 ft/sec). However, it is likely that the water velocity near the bottom, where catfish reside, is likely to be somewhat less than the average velocity. These data indicate that many of the fish that enter the intake canal are likely to be able to swim against the induced intake current and have the potential to escape from the canal and re-enter the river.

The potential for mortality of impinged organisms varies substantially among the above representative species. The survivability of shad species and freshwater drum on traveling screens is generally low (less than 20%). However, the survivability of catfish species and river shrimp is generally high (greater than 70%).

4.1 Historical Biological and Physical Data

The following is an annotated bibliography of the relevant studies.

Annual Data Report. Waterford Power Plant Units 1 and 2. Screen Impingement Studies February 1976 Through January 1977. Espey, Huston & Associates, Inc. Prepared for Louisiana Power and Light Company.

> Study results show higher impingement rates in winter and spring. Facility location upstream of the Waterford 3 Plant located near Mississippi River mile marker 129.9 AHP. Species composition was dominated by river shrimp (49.6% of the total abundance), blue catfish (20.3%), threadfin shad (10.5%), bay anchovy (6.0%), freshwater drum (4.5%), and gizzard shad (2.9%). Annual impingement rates estimated to be 336,454 organisms. Weights and lengths measured for all organisms. Daily biomass ranged from 3.6 kg to 33.6 kg.

Louisiana Power & Light, April, 1979. Demonstration Under Section 316(b) of the Clean Water Act. Waterford Steam Electric Plant Unit No. 3.

> Fisheries data collected in the Mississippi River between Baton Rouge and New Orleans. Common species included gizzard shad, threadfin shad, blue catfish, freshwater drum, striped mullet, skipjack herring, channel catfish, river carpsucker, blue gill, and common carp. Most common species were consistent with literature for the Lower Mississippi River.

Willow Glen Power Station 316(a) and 316(b) Demonstrations Federal Water Pollution Control Act Amendments of 1972 (PL 92-500). 1977. Espey, Huston & Associates, Inc. Prepared for Gulf States Utilities Company.

> Impingement and entrainment data were collected from January 1975 through January 1976 at three of the five units (Units 1 & 2 and Unit 4) at Willow Glen Power Plant. Major species were freshwater drum, gizzard shad, threadfin shad, blue catfish, white and black crappie, river shrimp, and crayfish. Impingement rates were relatively low, 1.47 (Units 1 & 2) and 0.13 (Unit 4) organisms per 10,000 m^3. Approximately 126,000 organisms per year were estimated to be impinged with all five units in operation. Entrainment data collected during the study indicated that freshwater drum and gizzard shad were the common species (two sample collections). However, overall analysis suggests that larval fish are uncommon in the area of the plant. One pallid sturgeon (T & E species) was impinged over the course of the study.

Baxter Wilson Impingement Study - Mississippi Power & Light (MP&L). 1974. Grand Gulf Nuclear Plant Units 1 & 2. Environmental Report. (Baxter Wilson Impingement Study included within this report).

Impingement data collected from March 1973 through March 1974. Major species were gizzard shad, threadfin shad, freshwater drum, crappie, and channel catfish. The shad species and freshwater drum represented over 90% of the total abundance. Impingement rates were relatively low and calculated to be 160,730 individual organisms per year. No threatened or endangered species documented on the revolving screens, however paddlefish (species of concern) were impinged. Limited length and weight data. Common species were consistent with the literature for the Lower Mississippi River.

Grand Gulf Nuclear Plants 1 & 2 Impingement Study - Mississippi Power & Light (MP&L). 1974. Grand Gulf Nuclear Plant Units 1 & 2. Environmental Report.

Information on Mississippi River flow, velocities, stage. Surveys of fish populations in different habitats (e.g., backwaters, tributary and river bank.). Difficulty in sampling the river's main flow noted. Gizzard shad represented 37.4% of the total abundance followed by freshwater drum (10.3%), blue catfish (8.3%), flathead catfish (4.9%), and river carpsucker (4.8%).

A.B. Paterson & Michoud Steam Electric Generation Plants of the Biota of the Inner Harbor-Navigation Canal and the Mississippi River-Gulf Outlet, Orleans Parish, Louisiana. Submitted for New Orleans Public Service, Inc. Hollander, E.E. 1981.

Impingement data collected as well as fisheries in the ambient water. Most commonly collected species were estuarine in nature; Atlantic croaker, white shrimp, brown shrimp, bay anchovy, sand trout, blue crab, hardhead catfish, and Gulf menhaden. Annual impingement estimated to be 226,489 organisms at the Paterson Plant and 1,676,726 organisms at the Michoud Plant.

Application Addendum for a Louisiana Pollutant Discharge Elimination System Permit and Comprehensive Demonstration Study under the 316 (b) Rule for Track II. 2002. For Bonnet Carre Power, LLC LaPlace, Louisiana (Sempra) by CK Associates and URS.

Habitat analysis conducted at Mississippi River mile marker 132.2 AHP using the 13 distinct LMR habitats developed by Baker et al (1991). Six habitats were identified in the study area and each was reviewed specifically to determine the number of fish species (133 potential species found in the LMR), larval fish and eggs associated with each habitat type. Each habitat type was determined to have a significantly reduced number of aquatic organisms. The researchers concluded that a CWIS located offshore and at middle depth would significantly reduce the number of organisms potentially impinged and/or entrained.

Entergy, 2000. Industry Short Technical Questionnaire: Phase II Cooling Water Intake Structures. A-UT-0513. Waterford 3 Plant.

Basic operation information. Actual intake flow rates by cooling water intake structure by month. Water flow diagram.

4.2 Assessment of Data Sufficiency

Among the requirements of the CDS is the performance of a study of impingement mortality. The results of this study may be used to assess the performance of the current CWIS as well as evaluate additional potential technologies and measures. The rule sets out specific requirements for this study, and addressing these goals is an important aspect of the PIC. The Rule anticipates that it may be possible to base the CDS completely or in part on existing data. For these reasons, Table 4-1 presents the specific data requirements for the study and reviews the relevance of available data to these requirements. The table also comments on the potential necessity of additional field data.

Significant data are available on impingement mortality patterns at the Waterford 1 & 2 Plant. Biological conditions are expected to be very similar at the Waterford 3 Plant as they are only 2,100 feet apart and located on the same (west) side of the river at approximately the same distance from shore. In addition, impingement surveys at other similar plants on the Mississippi River provide a relatively comprehensive and, if deemed to be representative of current conditions, would meet the requirements of the IMECS set out in the Rule. The studies employed commonly accepted procedures and Quality Assurance techniques and were accepted for consideration by the relevant regulatory agencies. Appendix B discusses the data available at Waterford 3 Plant within the context of other relevant data including:

- Data on impingement collected at other power plants on the Lower Mississippi River (LMR). The other plants are in similar settings and the data were collected in the 1970s as well as more recently; and
- The general literature on fisheries, mitigation measures, etc. including habitat preferences and seasonality of important species.

Entergy believes that, taken together, these resources provide a complete picture of the nature of the fishery of the Mississippi River as well as its potential susceptibility to impingement mortality at the Waterford 3 Plant.

Table 4-1:
Assessment of Data Sufficiency

Rule Citation	Requirement	Historical Data Source	Notes	Additional Data Proposed?
125.95(b)(3)(i)	Taxonomic identifications of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) that are in the vicinity of the cooling water intake structure(s) and are susceptible to impingement and entrainment.	Site-Specific; Regional Literature	Historic data at the plant provide information on rates of impingement and entrainment of aquatic organisms. This can be confirmed by comparison to rates at other plants. Surveys of extant populations and reference materials can be used to assess historical trends and current populations in the area.	No
125.95(b)(3)(ii)	A characterization of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) identified pursuant to paragraph (b)(3)(i) of this section, including a description of the abundance and temporal and spatial characteristics in the vicinity of the cooling water intake structure(s), based on sufficient data to characterize annual, seasonal, and diel variations in impingement mortality and entrainment.	Site-Specific; Regional Literature	Plant-specific data will be used and supplemented by more recent data from other plants as well as surveys of extant populations and the general literature.	No
125.95(b)(3)(iii)	Documentation of the current impingement mortality and entrainment of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) identified pursuant to paragraph (b)(3)(i) of this section and an estimate of impingement mortality and entrainment to be used as the calculation baseline. Impingement mortality and entrainment samples to support the calculations required in Section 125.95(b)(4)(i)(C) and 125.95(b)(5)(iii) of the Rule must be collected during periods of representative operational flows for the cooling water intake structure and the flows associated with the samples must be documented.	Site-Specific; Regional Literature	Historic rates of impingement mortality and entrainment are believed to be representative of current conditions based on comparison to more recent data at other plants as well as surveys of extant populations.	No

Based on literature review presented in Appendix B, we have reached the following conclusions:

- <u>While water quality has improved since the 1970s surveys, other factors potentially affecting the fishery have changed little.</u> Most notably, management of the river for shipping and flood control has been consistent and invasive species have remained well established;

- The species makeup of the fishery of the LMR has been relatively constant over the last several decades. This suggests that improvements in water quality have not greatly changed the types of fish present in the river. This opinion is shared by several fisheries researchers in the area (see Appendix B);

- The fish/shellfish species that dominate impingement at other freshwater LMR power plants are also very important in the ambient surveys relative to the Waterford 3 Plant. These include river shrimp, blue catfish, channel catfish, freshwater drum, gizzard shad and threadfin shad;

- The rates of impingement observed at Waterford 1 & 2, Michoud, A.B. Paterson, Willow Glen and Baxter Wilson during the 1970s are likely to be reasonable estimates of current rates at the Waterford 3 Plant. There has been little or no change in the operation of the CWIS and changes to the river and its fishery appear to be relatively minor. Anecdotal observations by the plant operators confirm that organisms identified in those studies continue to be the dominant impinged species on the screens;

- The two shad species and bay anchovy do not tolerate handling well (as indicated by low rates of latent survival) and freshwater drum tolerates handling only moderately well. EPRI (2003) indicated that the median extended survival for freshwater drum and gizzard shad is 20% (8 studies) and 7% (43 studies), respectively. Extended survival rates were not available for threadfin shad but the median initial survival was only 15% (5 studies). Survival of other species is presented in Appendix B. Available data on survival rates suggests that any sort of debris (fish) handling and return system is not likely to achieve significant reductions in impingement mortality for these fish species occurring at Waterford 3. However, blue catfish comprise 55% of the impinged finfish during the Waterford 1 & 2 impingement study. Documented survival rates for this species are not available, however, a similar and related species, channel catfish, have an average survival rate 70%. This suggests that survival of these species might be improved by improved debris (fish) handling and return systems;

- Survival of crustaceans such as river shrimp and crawfish tends to be much higher than the sensitive finfish discussed above. This suggests that survival of these species might be improved by improved debris (fish) handling and return systems;

- Annual variation in the rates of impingement is not very significant. At Baxter Wilson plant, located well upstream, a 100-fold change in impingement rate was associated with the return of juvenile fish to the main channel following inundation of the flood plain. The annual cycle of the fish populations' age structure also contributed in that juveniles are more susceptible to impingement. At the Waterford 1 & 2 Plant the number of impinged fish is relatively steady (and low) during the year. The biomass does vary significantly (from 3,500 g/day to 34,000 g/day) but much of this variation is driven by the rare

impingement of individuals weighing over 500 g (i.e., large individuals such as flounder, striped bass, and carp). These trends are expected as well at the Waterford 3 Plant;

- The typical impinged fish is relatively small. The median mass of fish impinged at Baxter Wilson, Waterford 1 & 2, and Willow Glen is on the order of 4.9 grams (8 species) excluding the common carp whose median mass was 1,984 grams. This highlights the importance of juveniles in the impinged population, a group subject to high rates of natural mortality; and

- State or federally listed species are expected to be impinged only rarely at the Waterford 3 Plant. The Gulf sturgeon, a threatened species, has been documented in the LMR. However, younger individuals more prone to impingement tend to avoid high velocity areas and would not be expected in the vicinity of the CWIS. The endangered pallid sturgeon has been rarely documented downstream of Mississippi River mile maker 180 AHP (see Appendix B), therefore would not be expected to be observed at the Waterford 3 Plant. Despite this, it should be noted that a single juvenile pallid sturgeon was impinged at Waterford 1 & 2 during the 1970s.

In summary, Entergy believes that the wealth of data available on the Mississippi River will support the goals of the Rule in general and the IMECS in particular. This belief is reinforced by the fact that the Waterford 3 Plant will pursue simultaneously Compliance Alternate 2, based on the literature's finding that density of fish populations are far lower in the main channel of the river than along shore and Compliance Alternative 5 – Site-specific Best Technology Available (BTA) based on the Cost-cost and Cost-benefit tests (see Section 6). Entergy believes that modest changes in the specific rates of impingement mortality are unlikely to affect the outcome of the pursuit of either Compliance Alternative.

5.0 AGENCY CONSULTATIONS

The Rule's requirements for the PIC ask for a summary of any past or ongoing consultations with appropriate Federal, State, and Tribal fish and wildlife agencies that are relevant to this Study and a copy of written comments received as a result of such consultations. Entergy believes that the goals of this summary are to provide LDEQ with full perspective on the historical permitting of the CWIS as well as any potential concern by relevant fisheries management or other natural resources agencies. Such a summary has been prepared from the records retained by the plant and by Entergy corporate offices as well as the collective memories of the plant and environmental staffs.

5.1 Section 316(b)-Specific Consultations

Entergy has been unable to find any specific correspondence from LDEQ regarding the Section 316(b) compliance status of the Waterford 3 Plant. The current LPDES permit does not mention any conclusion by LDEQ relative to the BTA status of the CWIS at the Waterford 3 Plant.

However, the NPDES permit issued by the EPA Region 6 in 1991 states "The intake structure is approved in accordance with Section 316(b) of the Clean Water Act" which demonstrates that the CWIS met BTA in 1991 (NPDES Permit No. LA0007374 dated April 20, 1991 page 2, Section II. L.).

5.2 Other Relevant Consultations

Entergy has had limited consultation with fisheries or other agencies relative to impingement of fisheries at the Waterford 3 Plant. Entergy submitted a consultation letter to the U.S. Fish and Wildlife Service (USFWS) on February 20, 2004 requesting critical habitat information while preparing an environmental report for power uprate. The USFWS responded with a letter dated March 15, 2004 (See Appendix D for a copy of both letters). The USFWS listed only two species of potential concern near the Waterford 3 Plant; the endangered West Indian manatee (*Trichechus manatus*) and the endangered pallid sturgeon (*Scaphirhynchus albus*). The West Indian manatee has minimal impingement potential due to their large size even as juveniles. Communications with the U.S. Army Corps of Engineers (USACE) indicated that the pallid sturgeon is rarely collected below Mississippi River milemarker 180 (see Appendix B); therefore, should not be expected in the vicinity of the Waterford 3 Plant.

6.0 PROPOSED COMPLIANCE APPROACH

Entergy's proposed approach to Phase II Rule compliance is to demonstrate simultaneously to the Director that "existing design and construction technologies" currently meet the performance standard in the Rule and that no other technology to reduce impingement mortality is likely to be cost effective. Thus, Entergy plans to pursue a "weight-of-evidence" approach based on a combination of Compliance Alternatives 2 (existing plant currently meets the performance standard) and 5 (actual costs of compliance are "significantly greater" than EPA-projected costs and/or the benefits gained from meeting the performance standards). The strength of the argument relative to the current system's performance lies with the demonstration, based on the existing literature, that the density of fish populations is likely to be far lower in the high flows and suspended solid loading encountered in the main channel relative to the Calculation Baseline condition of a shoreline intake. As noted in Appendix B, there is a strong consensus among fisheries biologists that a significant difference in population density exists. On the other hand, demonstrating such a difference on a site-specific basis is likely to be very costly and, in the absence of highly specialized equipment, potentially hazardous to field crews. Finally, Entergy believes that no additional technology is likely to be cost-effective at further reducing impingement mortality. Entergy will consider the potential that restoration measures might provide cost effective reductions in impingement mortality. For all of these reasons, Entergy believes that it is reasonable to rely on the existing biological data to demonstrate the compliance status of the CWIS at the Waterford 3 Plant and to support the assessment with a focused application of the Cost-cost and/or Cost-benefit tests.

The Cost-cost and Cost-benefit tests will be applied, under the provisions for Site-specific BTA (Compliance Alternative 5), according to the procedures defined in the Rule in order to evaluate whether actual costs of compliance are "significantly greater" than the compliance costs estimated by EPA or the environmental benefits (IM reduction) gained by meeting the performance standards. The location of the plant, its size, and the nature of the Mississippi River system all affect the feasibility, performance, and cost of potential technologies. Finally it should be noted that the rule (40 CFR 125.94(f)) notes that NRC requirements for safety can be considered while evaluating alternative technologies. Given the fact the INPO has already expressed concern regarding the potential for debris to adversely affect cooling system operation; any technology that might exacerbate this situation should be avoided.

6.1 Outline of CDS Activities

According to 40 CFR Section 125.95(b), the "Comprehensive Demonstration Study (The Study) is to characterize impingement mortality and entrainment, to describe the operation of your cooling water intake structures, and to confirm that the technologies, operational measures, and/or restoration measures you have selected and installed, or will install, at your facility meet the

applicable requirements of §125.94." As outlined in Section 125.95(b), a CDS intended to support Compliance Alternatives 2 and 5 must include:

- Proposal for Information Collection;
- Source Waterbody flow Information (included within this PIC document);
- Impingement Mortality and/or Entrainment Characterization Study;
- Technology and compliance assessment information
  - Design and Construction Technology Plan
  - Technology Installation and Operation Plan;
- Restoration Plan (if appropriate);
- Information to support site-specific determination of best technology available for minimizing adverse environmental impact
  - Comprehensive Cost Evaluation Study
  - Valuation of Monetized Benefits of Reducing IM&E
  - Site-Specific Technology Plan; and
- Verification Monitoring Plan

Entergy will prepare each of these documents and submit them to LDEQ for review prior to the January 7, 2008 deadline stated in Waterford 3's LPDES permit.

6.2 Review of CDS Approach

The CDS approach for the Waterford 3 Plant will rely simultaneously on application of Compliance Alternatives 2 and 5. This will include providing the required information and submittals so that:

- Existing technologies to achieve the impingement mortality goal will be described and their effectiveness estimated based on currently available data. Restoration measures may also be assessed as a potentially cost-effective measure to further reduce impingement mortality; and
- Alternative technologies or measures to control impingement mortality will be evaluated for effectiveness, feasibility, and costs. We believe that each alternative technology and measure will be shown to have a significantly greater cost than resulting environmental benefits (IM reduction) at Waterford 3 and/or to have a significantly greater cost than EPA's cost-of-compliance for the facility.

6.3 Schedule

The following is a tentative schedule for the Waterford 3 CDS:

- PIC submittal by December 15, 2005;
- LDEQ comments of the PIC by February 15, 2005;
- March 15, 2005 through December 31, 2008;
  - Develop Impingement Mortality and Entrainment Characterization Study Report;
  - Develop technology and compliance assessment, including the Design and Construction Technology Plan (DCTP) and the Technology Installation and Operation Plan (TIOP);
  - Develop information to support the site-specific best technology available (BTA), including the Comprehensive Cost Evaluation Study (CCES), Valuation of Monetized Benefits of Reducing IM&E, and the Site-Specific Technology Plan (SSTP), and Verification Monitoring Plan;
- Submission of the application of LPDES permit renewal, materials called for under Section 122.21, and the CDS no later that January 7, 2008;

Entergy notes that this schedule is only an approximation. At this point, Entergy believes that it is likely, given the proposed compliance approach, that the various elements of the CDS can be completed earlier than the January 7, 2008 deadline. Entergy will discuss this potential with LDEQ and refine the schedule as appropriate.

7.0 PROPOSED SAMPLING PLAN

Based on the compliance approach presented in Section 6, Entergy does not propose biological sampling during the preparation of the IMECS or the balance of the CDS. As discussed elsewhere in this PIC, Entergy believes that the objectives of the IMECS can be achieved based on the data available at the plant and from other sources (Appendix B). In particular, the performance of the existing CWIS relative to the Calculation Baseline as well as the rates of impingement mortality to support the estimation of monetized benefits of additional controls can be estimated based on the available data.

APPENDIX A

TECHNOLOGY REVIEW

APPENDIX A

TECHNOLOGY REVIEW

General Technology Overview

This section provides a general review of a comprehensive list of potential mitigation methods to reduce impingement mortality and entrainment. The nature of the technology is briefly reviewed and its approximate costs[6] are presented. The effectiveness under the conditions at the Entergy plant is discussed and factors affecting performance, reliability, and other environmental issues are reviewed. In addition to CWIS technologies, plant operation and restoration measures are considered.

The following list of CWIS alternatives have been evaluated in this screening assessment:

Alternative 1 - Traveling Screen Modifications
- 1a - Dual Flow Screens (Impingement)
- 1b - Ristroph Screens (Impingement)
- 1c - Fine Mesh Screens (Impingement and Entrainment)
- 1d - Angled and modular inclined screens (Impingement)

Alternative 2 – Fixed Screening Devices
- 2a - Wedgewire Screens (Impingement and possibly entrainment)
- 2b - Perforated Pipes (Impingement)
- 2c – Barrier Net (Impingement)
- 2d – Aquatic Filter Barrier (Impingement and Entrainment)
- 2e – Porous Dike/Leaky Dam (Impingement and Entrainment)

Alternative 3 - Offshore Intake (Impingement and Entrainment)

Alternative 4 – Fish Diversion and Avoidance
- 4a – Louvers and Bar Racks (Impingement)
- 4b – Velocity Cap (Impingement)
- 4c – Strobe lights, acoustic deterrent, bubbles, chains (Impingement)

[6] This report presents estimates of the capital costs of potential mitigation measures as a means of illustrating their potential cost-effectiveness. The estimates should be considered approximate and final costs may vary by as much as factor of two or more. Cost estimates for mitigation measures do not account for facility down-time associated with construction nor operation/maintenance. These costs will be estimated with input from Entergy and included in the final CDS document especially in the information to support the Site-specific BTA. Costs will be annualized according the procedures defined in the rule.

Alternative 5 – Flow Reduction

- 5a - Variable Speed Pumps (Impingement and Entrainment)
- 5b - Capacity Factor Reduction (Impingement and Entrainment)
- 5c - Evaporative Cooling Towers (Impingement and Entrainment)
- 5d - Dry Cooling (Impingement and Entrainment)

Alternative 6 – Restoration (Impingement and Entrainment)

Table A-1 provides a brief review of ENSR's findings relative to the various technologies. The findings are supported by a more detailed evaluation below.

Alternative 1 - Traveling Screen Modifications with Fish Removal and Return System

- ***1a - Dual Flow Screens***

Description:

With dual-flow, single-exit screen, incoming water is filtered with both the upward and downward moving parts of the screen, and the water flows toward the pump from the interior through the open side of the screen. The screen faces are oriented parallel to the direction of flow. If space is available, the screen length can be extended outward such that the area of the screens can be greater than the area of a conventional flow-through screen in the same location. Therefore, the dual-flow design has the potential to reduce through-screen velocity compared to flow-through (single entry, single exit) design.

The dual-flow design also provides an advantage of eliminating the potential for debris that is stuck on the screen to be dislodged in the downstream side of the screen. This feature has an added benefit of lower wash water pressure requirements.

Technical Feasibility and Reliability:

For retrofit applications, the space available to install may be limited by the existing structure (trash racks upstream and pump vault downstream) and water body constraints (navigation). Such limitations will limit the ability to increase screen surface area, thereby limiting the ability to reduce through-screen velocity.

Hydraulic issues with a dual-flow screen are commonly encountered. One of the common limitations with dual-flow screens is the flow disruption that is caused by the two 90-degree turns that cooling water must undergo to pass through the system. These issues can be minimized (but not eliminated) by proper hydraulic analysis and design.

Dual flow screen are commercially available and have been in use for years.

For the site-specific evaluations, the dual-flow screens with conventional mesh are assumed to provide adequate screen area to reduce through-screen velocity to 0.5 feet per second (ft/s). Otherwise, there would be no advantage to changing from a through-flow screen to a dual-flow screen. In some cases, the required screen area may result in the need for additional new intake structures to accommodate the screens.

Cost Considerations:

The cost of dual-flow screens is expected to be up to 20% higher than comparable through-flow screens.

Effectiveness:

Dual flow screens have the potential to reduce through-screen velocities and therefore impingement mortality, with the addition of an appropriate fish handling and return system. However, depending on the proximity of other screens and structures, the full screen area may not be effectively used, and through screen velocities on parts of the screen may be substantially higher than design, thereby reducing the potential to reduce impingement. In fact, if dual-flow screens are placed in relatively narrow intake bays, the approach velocity to the screen will likely increase and the impingement rate could increase. In general, space constraints will limit effective application of this technology.

Potential for Other Adverse Effects:

An intake structure that is reconstructed to accommodate a larger dual-flow screen may interfere with navigation.

Overall Assessment of Alternative:

Installation of dual-flow screens could result in a reduction of impingement mortality but would not reduce entrainment. Site-specific constraints may limit effectiveness of this technology to reduce through-screen velocity.

- ***1b - Ristroph Screens***

Description:

This alternative would involve modification of the traveling screens so that fish which are impinged on the screens could be removed and returned to the source water body with minimal stress and mortality.

A range of measures could be pursued to optimize fish handling and return. This might include more frequent rotation of the screens, re-fitting the screen with fish buckets, institution of low-pressure wash, replacement of the fish return trough, and rerouting of the fish return to a more suitable location. A complete refurbishment might consist of the following measures: A low-pressure spray would be used for fish removal prior to the high- pressure debris removal spray wash. Fish would be carried in fish buckets – i.e. water-filled lifting buckets designed such that they will hold approximately 2 inches of water once they have cleared the surface of the water during the normal rotation of the traveling screens. The fish bucket would be designed to hold the fish in water until the screen reaches the point where the fish are washed by the low pressure spray onto a sluiceway. The modified traveling screens would be operated continuously during periods when fish are being impinged. Removed fish would be returned to the source water body by a sluiceway with a smooth surface and sides that retain water such that organisms are gently returned to a location removed at least 100 feet from the intake structure such that the potential for re-impingement would be minimized. All surfaces of the fish handling and return system would be smooth to minimize abrasion damage to organisms.

Technical Feasibility and Reliability:

The technology proposed for this alternative is well known and has been implemented for numerous power plants. However, a separate collection and piping system may need to be constructed to provide a separate return path for fish to the river or lake. This piping system would have to be constructed within the existing power plant footprint which could present engineering, construction, and logistics problems. Routine maintenance, primarily consisting of inspection and cleaning of the fish handing and return system, would be required but not expected to be extensive. Maintaining the system during icing conditions is likely to be complicated. The modified fish troughs extend farther out from the screens than conventional troughs. Therefore, space limitations may affect the cost and feasibility of installation.

Cost Considerations:

The retrofit of a fish removal and return system should consider complete replacement of the existing traveling screens. Installation of an effective fish return system can be complex and expensive. Operation and maintenance activities include frequent, if not continuous, screen operation and power costs for screen and water spray operation.

Effectiveness:

Modified screens and fish handling and return systems have been used to minimize impingement mortality at a wide number of plants throughout the United States. Studies have demonstrated survival of impinged fish over a wide range. Survival rates of 70-80% are typically achieved for some species. It is notable that many small schooling species (e.g., anchovies) suffer from high mortality at traveling screens, even those with Ristroph-type modifications.

Potential for Other Adverse Effects:

No adverse effects are expected from this alternative.

Overall Assessment of Alternative:

Modification to traveling screens would likely result in a reduction of impingement mortality and would not reduce entrainment.

- ***1c - Fine Mesh Traveling Screens***

Description:

Typical vertical traveling screens, with mesh sizes ranging from 1/8-inch to ¾-inch, are not designed to screen ichthyoplankton or eggs from the intake water. This alternative would involve replacement of the existing traveling screens with fine mesh screens having mesh spacing as small as one millimeter. This mesh spacing would result in a reduction of entrainment of fish eggs and larvae. In addition, an intake approach velocity of 0.5 ft/s or less would be necessary to minimize physical damage to plankton that would be impinged on the fine mesh screens.

Because of flow area for a screen with one-mm (about 1/32-inch) mesh is approximately two thirds that of a 3/8-inch mesh, the screen area would have to be increased by nearly 50% to maintain the same through-screen velocity. For most plants, the screen area would have to be further increased to maintain a 0.5 ft/s velocity to reduce mortality of impinged fish or shellfish. In most cases, the area around the existing pump house/screen house structure is not sufficient to allow for the increased number of fine mesh screens without substantial modification to the plants. The screens would be operated continuously to prevent excessive accumulation of debris and organisms.

The fine mesh screen structure would include curtain walls to protect against floating debris, bar racks to prevent submerged debris from damaging the fine mesh screens, and a screen wash and marine biota removal and open sluice biota return system (similar to that described for the Ristroph screen).

Technical Feasibility/Reliability:

The technology and construction techniques required for this option have been used at a limited number of power plants, often with limited reliability. At two power plants, Millstone and Brayton Point, the fine mesh screens were replaced with standard screen mesh after clogging incidents. Based on the available information, it is concluded that there is a relatively high potential for fouling of the intake screens and that extensive maintenance would likely be required.

In conclusion, because of the potentially large increase in screen area required, site-specific conditions may preclude the installation of a modified intake structure of sufficient size.

Cost Considerations:

The capital cost of the fine mesh screen alternative should include any necessary modifications to the intake structure, as well as construction of an effective fish return system to handle the more sensitive species or life stages of fish and shellfish. Operation and maintenance costs include one maintenance episode (6 days) each year, replacement parts, system monitoring by plant staff (10 hours per week), and power costs.

Effectiveness:

Fine mesh screens, with a low pressure wash and return system, have not been demonstrated to result in consistent effectiveness in reducing mortality at early life stages. This is a significant concern because organisms that are entrained and discharged may have a far greater chance of survival than if such organisms are impinged and subsequently washed back to the receiving water. Therefore, even though entrainment reductions of 50% to over 90% have been achieved at number of power plants using fine mesh screens, compliance with the impingement mortality performance standard could be in jeopardy. Because the calculation baseline levels of entrained organisms are typically far greater than the levels of impinged organisms, the reduction in impingement mortality will likely need to be nearly 100% for the early life stages to meet the 80-95% performance standard.

Potential for Other Adverse Effects:

The major potential adverse effect associated with the technology is the potential unreliability of the cooling water flow associated with clogging events.

Overall Assessment of Alternative:

Fine mesh screens can meet performance requirements for entrainment, but impose a relatively high potential for operational issues associated with screen clogging. Mortality of ichthyoplankton removed from the screens is likely to be high. The cost of the screen panels, as well as the cost of a revamped intake structure to accommodate the additional screen area required, is extremely high. Space limitations may preclude the installation of adequate screen area.

- ***1d - Angled and Modular Inclined Screens***

Description:

Angled and inclined screens use standard flow-through traveling screens set at an angle to the incoming flow. With these screens, the angle causes the fish to move toward the end of the screen, where a bypass facility returns the fish to the water body.

Technical Feasibility/Reliability

Angled screens have been used at Brayton Point. The installation requires considerably more space than conventional screens. Retrofit applications would likely require substantial modifications to the existing intake structure. The fish handling and return system requires independently induced flow, adding to the complexity of the system.

Cost Considerations:

Retrofit of angled or inclined screens should include the need to revamp the intake structure, as well as the installation of an effective fish return system.

Effectiveness:

Brayton Point has had mixed results with both diversion and latent survival, depending on fish species. EPA reports survival efficiency ranging from 0.1% for bay anchovy to 97% for tautog. The difference in effectiveness between angled screens and conventional screens with fish return is not evident.

Potential for Other Adverse Effects:

The bypass flow can be substantial, resulting in additional operating costs.

Overall Assessment of Alternative:

Angled or inclined screens are in limited use. Although they may be effective in reducing impingement mortality, it is not clear whether their performance differs from a conventional screen. Because there is no apparent advantage, angled or inclined screens are not considered further in this analysis.

Alternative 2 – Fixed Screening Devices

- ***2a – Wedgewire Screens***

Description:

Wedgewire screen is constructed of wire of triangular cross section such that the surface of the screen is smooth while the screen openings widen inwards. Fine mesh screens have slot spacing of less than 9.5 mm (3/8 inch) and are typically less than 3 mm. Slot size for coarse mesh screens is 9.5 mm or greater. The cylindrical screen design has been used at several non-nuclear power plant applications, however, most of these applications have been for closed-cycle cooling systems. Entergy is not aware of wedgewire screen approval or application at any nuclear power plant.

A typical installation would include an array of tee shaped cylindrical screens. If one-mm slot size were required, a plant with a 500 MGD cooling water flow would require approximately 15 7-foot diameter by 23-foot long screens. The screens would be placed in the intake water body at a depth such that it would not present a hazard to navigation.

The screens would be cleaned periodically with an automatic compressed air system when located near shore. A large plenum structure would be added to the front of the intake structure to distribute the flow from the intake array. The existing intake structure would remain intact and functional. It could be used as a backup to the wedgewire screen system. The plenum structure would have openings that would allow flow to pass in case of screen clogging. Alternatively, wedgewire screen must be sized to minimize clogging and is subject to periodic manual cleaning.

For far-offshore applications, a compressed air cleaning system is not practical. Under such conditions, the reliability of fine mesh screens is uncertain due to debris loading of the Mississippi River, and only coarse mesh wedgewire screens should be considered.

Technical Feasibility/Reliability:

Wedgewire screens have been widely used for hydropower diversion structures. The cylindrical screen structures have been used successfully for many years for water withdrawals up to 100,000 gpm. Withdrawals of larger quantities are rare. The wedgewire cylindrical screens have been implemented at only two relatively large power plants with once-through cooling systems: Campbell Unit 3 on Lake Michigan, and Eddystone Unit 1 on the Delaware River. The high number of wedgewire screens required for many plants is higher than has been previously used and likely poses impractical logistical issues associated with placement in the bay or river.

The long-term reliability of the wedgewire screens of the one-millimeter size is unknown. Although some vendors have proposed construction materials which would prevent mussel or other biological growth on the screens, the requirements for biofouling control are uncertain and differential pressures across the screens could create substantial unit reliability issues. The automatic back flushing would reduce screen fouling from both biological growth and suspended particulate matter. However, to be effective for screen cleaning, this system requires an ambient

current to transport the removed particles from the vicinity of the screens. In waters with minimal current, debris accumulation may be excessive and backwashing ineffective. Small or negligible currents in the intake water body could make wedgewire screens impractical, especially fine-mesh screens.

In addition, if the screens were to be located at a distance from the shore, considerable length of large diameter piping would be necessary to connect the screens to the existing cooling water system. Installation of such a system will result in significant cost as well as potential disruption of the site and the waterbody.

Cost:

The cost for the wedgewire screen alternative should consider the distance offshore, needed piping, and air-burst cleaning system. Operation and maintenance costs include two maintenance dives (6 days each) each year, replacement parts, and system monitoring by plant staff (10 hours per week).

Effectiveness:

Wedgewire screens have been demonstrated to essentially eliminate impingement and, for smaller slot sizes, reduce larval entrainment. The 1-mm slot size has been demonstrated to reduce entrainment by over 80 percent at some plants. However, achievement of such results is dependent on the presence of relatively high ambient currents that can sweep the plankton along past the screens.

Potential for Other Adverse Effects:

The primary adverse effect associated with this alternative is the potential for obstruction to navigation caused by multiple submerged structures in the waterbody near the plant. In addition, the presence of rock rip-rap around a large number of screen structures can result in a "reef effect," causing the fish population density to increase in the vicinity of the screen structure. This phenomenon is more likely in cases where there is very little spawning habitat near the intake location. As previously mentioned, the engineering requirements for biofouling control on the Mississippi River are uncertain and differential pressures across the screens could cause cavitation of circulating water pumps creating substantial unit reliability issues.

Overall Assessment of Alternative:

Wedgewire screens have the potential for clogging and interference with navigation. Without adequate sweeping velocity, a small enough slot size to reduce entrainment is not recommended. The cost of this alternative is high and is strongly dependent on the number of screens needed

and the length of new pipeline construction needed to interconnect all of the screens and to build a common tunnel to the shoreline.

- ***2b – Perforated Pipes***

Description:

With perforated pipes, water is drawn through perforations or slots in a pipe located in the waterbody. EPA included this technology in its discussion of intake technologies. However, perforated pipes have been used only in small water withdrawal applications. It is also subject to clogging and fouling. It is also similar in principal to wedgewire screens. Therefore, this technology alternative will not be discussed further.

- ***2c - Barrier Nets***

Barrier nets are wide-mesh nets that are placed in front of the intake structure entrance. The nets are sized to prevent the fish to pass through, and low velocities are maintained at the net to allow affected fish to swim away. Barrier nets would be mounted on a frame that would allow ease of cleaning or replacement.

Technical Feasibility and Reliability:

Barrier net systems involve technologies that are in widespread use especially in freshwater systems. Construction techniques that would be used for these systems are commonplace. Maintenance requirements include routine cleaning of debris and/or net replacement. Finally, placement of a barrier net at the intake has the potential to adversely affect boat traffic. Placement typically involves suspension from existing pylons or walls. Creation of a new set of anchors, etc. will complicate installation and increase costs.

Cost Considerations:

For typical power plants, the estimated capital cost for installation of barrier nets is $0.5M to $1.5M. The estimated operation and maintenance cost is approximately $50,000 per year for freshwater deployments. Operation and maintenance costs include monthly change out and deployment and removal.

Effectiveness:

Barrier nets have been shown to be effective for impingement reduction at a number of plants. Greater than 90% reduction in impingement has been realized at a number of plants. However, they are not effective in deterring fish eggs and larvae, or other planktonic organisms. There is

the potential for clogging with debris; hence a routine cleaning operation is essential. Adequate area to allow low through net velocity (<0.5 ft/s, often <0.1 fps) is important to prevent clogging and collapse.

Potential for Other Adverse Effects:

This alternative could pose limitations on navigation in the vicinity of the intake.

Overall Assessment of Alternative:

There have been a number of positive experiences with barrier nets for reduction in impingement, and the cost is very low compared to other technologies. Barrier nets will not address entrainment, routine cleaning is essential, and removal during flood conditions is necessary to avoid serious damage to the nets.

- ***2d - Aquatic Filter Barrier System***

Description:

Aquatic filter barrier systems are designed to completely enclose an existing intake structure and essentially filter the water drawn through the fabric to the intake structure. The best known manufacturer of aquatic filter fabric systems for power plant intake applications is Gunderboom. The Gunderboom system is a double panel, full water depth fabric curtain suspended from flotation billets at the water surface and secured in place by an anchoring system. The system includes mooring lines, ballast chain, anchoring system and an automated compressed air cleaning system. Automatic alarms and monitors may be installed in an appropriate control room to monitor the fabric alignment and system operation.

The standard design hydraulic loading rate of the Gunderboom fabric is 3-5 gpm per square foot with a generally recommended maximum range of 10-12 gpm per square foot. At the recommended design hydraulic loading and an assumed water depth of 15 feet, a length of fabric of more than one mile would be required for a 500 MGD cooling water flow. Therefore at a minimum, this alternative would require that a large area around the intake structure be encompassed by the fabric for most large power plants with once-through cooling.

Technical Feasibility/Reliability:

The technology and construction techniques required for this option have been fully implemented only at the Lovett Power Plant in New York State, a non-nuclear facility. Clogging of the Gunderboom is a routine maintenance issue. The length of fabric required would encompass a large area around an intake structure. Aquatic filter barriers are not likely to function correctly

under heavy debris loading, and high total suspended solids loading encountered in the Lower Mississippi River region.

Cost Considerations:

The estimated capital cost of the Gunderboom alternative is high compared to other near-shore technologies. The operation and maintenance costs include the mobilization and installation/ demobilization and removal of the system each year. They also include regular underwater inspections of the filter curtain each month and one thorough underwater inspection each year.

Effectiveness:

Aquatic filter barriers have been demonstrated to be effective in substantially reducing larvae entrainment and fish impingement losses at power plant intakes on the Hudson River. However, clogging and ambient conditions can increase the risk of fabric failure, rendering the system ineffective.

Potential for Other Adverse Effects:

Because this aquatic filter barrier application would require closing off much of the waterbody near the plant, marine navigation would be restricted. The potential for aquatic organisms to be impinged in the fabric is a concern. Nuclear safety issues arise from the possibility of failure and adverse impact on the CWIS itself.

Overall Assessment of Alternative:

Based on the logistical and potential navigation issues associated with the extensive area of the waterbody that would be encompassed by the aquatic filter fabric, and operational issues associated with potential clogging of the fabric, it is not likely that this alternative would be practical in any once-through application with large flow rates.

- ***2e - Porous Dams/Leaky Dikes***

Description:

Porous dams, also known as leaky dams or leaky dikes, are filters constructed of stones surrounding the cooling water intake. The core of the dike is composed of gravel or stone which allows water to be drawn through it. The exterior of the dike is armored with larger rocks. The dam serves as a behavioral and physical barrier to aquatic organisms. The reduced flow rate across the full face of the dam greatly reduces impingement; however, "hot spots" of high velocity

may be present in local areas of high porosity, and its effectiveness in screening fish eggs and larvae is not well established.

Technical Feasibility and Reliability:

Because of its size, a porous dam constructed around an intake structure may not be practical in waterbodies of limited size, because of potential impacts to navigation.

Cost Considerations:

Because of its large size, a large part of the capital cost of a porous dam is materials (stone and gravel). Operation and maintenance would include routine maintenance and potentially heavy cleaning or dredging every five years.

Effectiveness:

If the surface area is sufficiently large, the porous dam intake structure could result in a lower impingement rate, but may not decrease the entrainment rate. The porous dam would decrease impingement due to low intake velocity across the dam face and the physical barrier created by the stones used in the dam. The dam structure would need to be located such that its construction does not impact known spawning beds. The presence of the stone could create spawning areas where there were none and could actually serve to increase entrainment. Alternatively, potential spawning areas created by the porous dam may act as a restoration measure and increase the production of fish in the water body.

Potential for Other Adverse Effects:

Significant biofouling could be expected due to algae, aquatic weeds (e.g., watermilfoil), and zebra mussel. Biofouling of the porous dam would reduce plant cooling water intake rate. The size of the porous dam is large, and its construction has the potential to damage fish spawning areas. In smaller waterbodies, a dam of sufficient size to effectively reduce intake velocity could impede marine navigation. Significant permitting obstacles with the U.S. Corps of Engineers likely would arise.

Overall Assessment of Alternative:

A porous dam will likely be effective for reduction in impingement if designed for low intake velocity. Entrainment performance is uncertain. Reliability of water flow is uncertain because of the potential for fouling.

Alternative 3 - Submerged Offshore Intake Structure

Description:

An offshore intake structure alternative would consist of a structure with velocity cap (or other technology such as wooden cribs or wedgewire screens), and a single pipeline into the plant. The size of the structures would be designed to achieve a nominal intake velocity of 0.5 ft/s. The velocity cap on the structure provides horizontal flow that reduces the potential for fish impingement. The intake structures would be located in the water body at a water depth of at least 20 feet. The intake pipeline would be placed by either trenching or tunneling.

Technical Feasibility/Reliability:

The technology and construction techniques required for installation of submerged intake structures are well known and understood. Submerged intakes have been constructed at several plants and have been shown to be reliable in the long term. Considerations for designing and constructing the alternative include (1) technology associated with sub-surface placement of the pipe and potential impacts to the bottom along pipeline route, (2) the length of pipeline needed to reach sufficient depth, (3) prevention of fouling on the structure, (4) the potential for adverse impacts due to debris, and (5) the need to avoid obstruction of navigable waters.

Another technical consideration for the offshore intake structure alternative is that the intake water could have a reduced temperature which would potentially improve power plant performance.

Cost Considerations:

The estimated capital cost of submerged offshore intake is highly dependent on the length of new pipeline needed. One 6-day dive per year would be required for maintenance. However, maintenance dives may be considered impractical in the Mississippi River due to safety concerns and visibility issues.

Effectiveness:

The offshore intake structures could result in a lower impingement rate if designed with low intake velocity and velocity cap. Suitable placement of the intake off-shore may reduce the density of eggs and larvae subject to entrainment relative to an on-shore location. The intake structure construction could impact spawning beds. The presence of the intake structure and associated anchor stone and rip-rap could create new spawning areas that did not previously exist and could actually act to increase entrainment.

Overall Assessment of Alternative:

The submerged offshore intake has the potential for reducing impingement and entrainment, if the intake can be located where the density of eggs and larvae is low. Cost is high, and will depend on the required distance offshore. However, potentially cooler intake water temperature may improve power plant performance.

Alternative 4 – Fish Diversion and Avoidance

- ***4a – Louvers and Angled Bar Racks***

Description:

Diversion devices are physical structures intended to guide fish away from and out of the intake flow. Examples of such devices include angled bar racks and louvers, which are made of a series of evenly spaced, vertical slats placed across a channel at an angle leading to a bypass area. The louvers create localized turbulence that the fish detect and avoid. The louver systems have been tested at hydroelectric plants on rivers.

Typically, angled bar racks and louvers would be in semicircular fashion around a shoreline intake or placed across the mouth of an intake canal. Louvers would be constructed of material compatible with the environment (for example, polyethylene slats for louvers and nylon for nets), and would be mounted on a stainless steel frame, approximately 12 inches apart.

Technical Feasibility/Reliability:

Louver systems involve technologies that are in widespread use. Construction techniques that would be used for these systems are commonplace. Maintenance requirements could be potentially extensive. Divers will likely be required to routinely clean and/or replace the bar racks or louvers. The potential for damage and clogging from debris is real. Finally, placement of a louver at the intake has the potential to adversely affect boat traffic.

Cost Considerations:

The capital cost for installation of louvers should include consideration for debris loading and damage. Operation and maintenance costs include two 6-day dives per year to clean and maintain the louvers.

Potential Effectiveness:

These diversion devices are not effective in deterring fish eggs and larvae, or other planktonic organisms. Louvers have been tested only in rivers with a substantial current velocity along the bank. They are most effective in diverting migratory fish from intakes in confined river channels, and therefore would be less effective in lakeside applications.

Potential for Other Adverse Effects:

This alternative could pose limitations on navigation in the vicinity of the intake.

Overall Assessment of Alternative:

Louvers/bar racks can effectively reduce impingement of some species of fish, but would not be effective for reducing entrainment. This technology would be effective only with an ambient current, and would not be effective in a lake setting. This alternative has relatively high probability of clogging associated with debris, and biological growth and in some settings could impact navigation.

- ***4b – Velocity Caps (installed on existing offshore intake)***

Description:

A velocity cap is a cover placed on a vertical inlet of an offshore intake structure. The cover results in a horizontal flow to the intake, and may reduce impingement because fish tend to avoid rapid changes in horizontal flow. Intake velocities of 0.5 to 1.5 ft/s are common.

Technical Feasibility/Reliability:

Installation of a velocity cap on an existing offshore intake may be limited because of water depth and potential interference with navigation. For some applications, a velocity cap may require routine inspection and maintenance to remove accumulated debris.

Cost Considerations:

Costs of installation of a velocity cap on an existing offshore intake should consider intake modifications and materials of construction.

Potential Effectiveness:

Although velocity caps in new offshore intakes have been shown to result in reduced impingement, it is uncertain whether the reported reductions are due to the velocity caps or the new offshore locations. Velocity caps should be designed to minimize intake velocity through the intake structure openings; a maximum intake velocity of 0.5 feet per second should be considered to meet the Phase II intake velocity threshold. In some cases, additional measures (e.g. intake screen improvements, deterrent systems) may be needed to meet impingement performance goals. Velocity caps have no impact on entrainment, although the off-shore location may result in lower entrainment levels compared to an on-shore calculation baseline intake configuration.

Potential for Other Adverse Effects:

The addition of a velocity cap to an existing intake may interfere with navigation.

Overall Assessment of Alternative:

Velocity caps may reduce impingement, but have no effect on entrainment. If the maximum intake velocity is 0.5 feet per second, the Phase II velocity threshold in Compliance Option 1(ii) would be met. As noted above, the offshore location may result in compliance with the entrainment reduction standard.

- ***4c - Strobe Lights, Acoustic Deterrent, Bubbles, Chains***

General Description:

Behavioral barriers are intended to cause fish to actively avoid entry into the intake flow. Examples include sound barriers, light barriers, air bubble curtains, chains and cables, and electrical barriers. They are often implemented in combination with other devices such as physical barriers (e.g., fish nets). The potential behavioral barriers are briefly described below.

Sound barriers consist of devices located at the intake structure, which create sound that repels the fish. Three types of underwater sound have been tested for this application: low-frequency infra-wave sound, low-frequency sound generated by pneumatic/mechanical devices, and transducer-generated sound covering a wide range of frequencies. Low frequency, high-intensity devices have been shown to be effective. High frequency (125 kHz) devices have been reported to be effective in the Great Lakes. Pneumatic impact devices, "poppers", and "hammers" are examples of devices that have been effective in reducing impingement of some fish such as alewife at power plant intakes. There is some concern that pressure waves from pneumatic devices may be harmful to nearby organisms. In most cases, the use of high-intensity, multi-frequency sound has not been effective in repelling a wide range of fish species from intakes due to the diversity of species and sizes of species in the receiving water.

Light barriers consist of a series of underwater lamps that emit a constant or intermittent (strobe) beam of light. The effectiveness of light barriers as a deterrent has been variable, and even contradictory, in many studies. In some studies fish have been attracted to light while in others they have been repelled. Constant light has been more effective than strobe light in guiding young salmon whereas strobe light has been effective in repelling alewife and gizzard shad. Filtered mercury vapor light has been found to attract certain species of fish away from strobe lights in field studies in Europe. At the Nanticoke Generating Plant on Lake Ontario, smelt, shad, white bass and shiner have been successfully guided away from intake trash racks using mercury vapor light. However, evidence of consistently reliable effectiveness for a wide range of fish species does not exist.

Air bubble curtains or screens consist of a series of diffuser pipes mounted on the base of the intake structure. The diffusers create a continuous, dense curtain of bubbles, which can repel fish. Generally, the air bubble screens have not been successful. They are not effective at night and in turbid water. In one case, at Indian Point Generating Plant on the Hudson River, the air bubble screen actually attracted fish at night.

Chains or cables can be hung vertically from the top of the intake structure to form a physical, visible barrier to fish. The results of studies of this behavioral barrier have been contradictory. The effectiveness of chain barriers is dependent on flow velocity, turbidity and illumination. Debris buildup on hanging chains can disrupt hydraulic flow patterns at the intake.

Electrical barriers consist of a series of electrodes at either side of the intake structure. These barriers have had limited success and can present a safety threat.

Technical Feasibility/Reliability:

All of the behavioral barrier systems are technically feasible and reliable from the perspective of construction, operation, and maintenance. The behavioral barrier systems that have been implemented with the greatest frequency are sound and light barrier type systems. Each of these potential alternatives would consist of a metal support structure constructed at the front of the intake, sound or light emitting devices mounted on the supports, a power supply, controllers, power cables and mounting hardware. The construction and technology used for these alternatives have been regularly applied. To ensure long-term reliability of these systems, ongoing maintenance will be required. Maintenance of the systems would include cleaning and replacement of light bulbs (for light barrier systems) and prevention of corrosion of the supporting structure.

Cost:

The estimated capital cost of behavioral barriers (e.g. a strobe light barrier system) is generally lower than other technologies. Operation and maintenance costs include items such as the

replacement of strobe lights each year using divers, and 10 hours per week of on-site monitoring by plant staff. Costs for other behavioral barrier systems would be similar.

Effectiveness:

Because these barriers rely on the ability of the organism to respond to a stimulus, they often are not effective in protecting fish eggs and larvae, or other planktonic organisms. In addition, the effectiveness of these barriers varies among species and across age groups within species. These barriers are most effective when a single species of fish of the same size and age is to be protected. Many of the behavioral barriers have not been field-tested so their effectiveness has been extrapolated from laboratory studies. None of these devices has been demonstrated to be consistently reliable in obtaining an avoidance response from a wide range of fish species. Therefore, installation of behavioral barriers would not result in reduction of entrainment, and a reduction in impingement is possible but uncertain.

Potential for Other Adverse Effects:

A potential adverse effect of the behavioral barrier alternative is a slight potential for increased attraction of fish to the intake structure. Also, any structure installed near the intake has the potential to disrupt navigation.

Overall Assessment of Alternative:

Behavioral barrier technology will not reduce entrainment. However, the technology may effectively divert specific fish species and therefore could be a component of an overall impingement mortality reduction. Based on site- and species-specific variation in response, pilot testing is likely to be necessary.

Alternative 5 - Flow Reduction

- ***5a - Variable Speed Pumps***

Description:

Variable speed cooling water intake pumps are potentially useful for reducing cooling water flow and the associated entrainment and impingement during peak periods of biological activity. The decrease in cooling water flow results in an increase in plant condenser delta T (temperature increase through the condenser) and discharge temperature. Therefore, variable speed pumps are most appropriate during cold water periods of the year (winter and spring) in temperate climates where an increase in discharge temperature will not cause a significant increase in biological effects or cause discharge temperatures in excess of maximum acceptable levels.

For other plants, this alternative was considered with the assumption that variable speed pumps would be installed to decrease the cooling water flow by 25% during periods of potentially high entrainment and impingement. This alternative would require replacement of existing single speed drives with adjustable speed drives (ASD) on the circulating water pumps. An on-line condenser tube cleaning system is included in this alternative to alleviate tube fouling which could potentially occur because of lower water flow rates.

Technical Feasibility and Reliability:

The replacement of the existing single speed drives with ASDs is a technically feasible and reliable alternative. However, under full power production conditions using the existing condensers for the units, this alternative, specifically a 25% reduction in flow, could reduce the reliability and efficiency of the entire system. Specifically, the reduction in flow through the condensers could cause operational difficulties (i.e, condenser tube fouling), cause decreased thermal efficiency in the turbines, limit or reduce maximum power production, require condenser replacement, and alter the thermal plume effects at the discharge.

Cost:

The estimated capital cost of the variable speed pump alternative is between $0.5M and $1.1M per cooling water pump depending upon pump size. This capital cost assumes that replacement of the existing condensers would not be required. Operation and maintenance costs are difficult to estimate without input from the individual plants regarding thermal efficiency as well as market rates. It should be noted that costs associated with loss of thermal efficiency are likely to be partially offset by the gain in not operating the pumps at full capacity. This cost assumes that the plant could be operated at full capacity during reduced cooling water flow.

Effectiveness:

The use of variable speed pumps to decrease the flow of cooling water through the intake would effectively reduce the entrainment and impingement in the system; however, the resulting increase in temperature in the discharge could increase thermal plume effects. The alternative would amount to a relatively small reduction in flow – and corresponding reduction in impingement and entrainment effects – of approximately 25% for the entire plant during periods of time when the ASDs are in operation. Since the ASDs would not be used during the entire year, the overall reduction in impingement and entrainment would be substantially less than 25%.

Potential for Other Adverse Effects:

As noted above, reduction in cooling water flow during normal plant output would result in an increased discharge ΔT value which could, in turn, cause altered thermal plume effects.

Overall Assessment of Alternative:

By itself, this alternative will not likely achieve performance goals for impingement and entrainment reduction. However, it may be considered as one component of an overall compliance.

- ***5b – Capacity Factor Reduction***

Description:

A power plant can reduce impingement and entrainment by reducing cooling water requirements through reduced capacity factor of the plant. This approach would require a commitment on the part of the plant to limit cooling water flow to a level below the design flow rate. Unless a very low capacity factor is intended, this approach will likely be used in conjunction with other technologies to meet performance goals.

There is the potential that regulatory agencies will limit the applicability of this approach for plants with historically low capacity factor. Although the calculation baseline is based on design capacity, the commitment to set a capacity factor limit by a plant with historically low capacity factor may be viewed as an inappropriate approach to meeting the performance goals unless a restriction is included in the plant LPDES permit.

Technical Feasibility and Reliability:

Reduced water flow rate will limit the power production rate based on thermodynamics as well as the thermal discharge limits for the plant.

Cost Considerations:

Reduction on capacity of a plant will have very large financial impact on the ability of a plant to generate revenue. The capital cost to implement this approach could involve installation of equipment to limit operations; however, recordkeeping may be all that would be required to demonstrate the flow reduction achieved.

Effectiveness:

A capacity factor reduction and resulting reduced flow rate should at least reduce impingement and entrainment in proportion to flow reduction. Seasonal differences in density of aquatic life would need to be considered to determine the overall annual reductions in impingement and entrainment from the calculation baseline.

Potential for Other Adverse Effects:

This approach reduces power generation capacity, which would have to be made up elsewhere.

Overall Assessment of Alternative:

If acceptable to the regulating agencies, this alternative may be an important component of a well balanced compliance program.

- ***5c - Evaporative Cooling Towers***

Description:

The existing cooling water systems use river or lake water pumped through a steam condenser and discharged back to the source water body. These systems are generally referred to as open cycle or once-through cooling system because the water simply passes through the condenser (no recirculation) where heat is transferred from the steam to the cooling water prior to discharge. Closed cycle systems recirculate the cooling water in a closed piping system. The heated water from the condenser is cooled down in each cycle using evaporative cooling. This cooled water is then recirculated to the condenser to cool and condense the steam from the turbine. In the mechanical draft-cooling tower, fans are used to circulate air that flows against the heated water sprayed inside the tower. Cooled water is collected in the tower basin and returned to the condenser. Water must be introduced into the system at regular intervals to make up for losses due to blowdown and evaporation. The closed cycle evaporative cooling systems require a water withdrawal rate that is about 3 to 5% of the amount of water required in once-through cooling systems.

The makeup water flow for a mechanical draft-cooling tower is typically less than 5 percent of the flow required for once-through cooling. The makeup flow would be pumped to the circulating water system from the current intake structure. Blowdown would be discharged from the tower basin to the discharge canal.

Technical Feasibility and Reliability:

The technology proposed for this alternative is well known and has been implemented for similar power plants. However, this alternative requires substantial open space, consumes a substantial amount of electricity, and reduces the thermal efficiency of the system. In addition, the ability of the existing condensers to handle the higher pressures associated with the recirculating system is uncertain and could have a large effect on the costs for this alternative.

Costs:

The capital cost of the mechanical cooling tower alternative is very high. Operation and maintenance costs are typically estimated to be in the millions of dollars per year, primarily due to additional fan and pump power demands and water treatment requirements. Finally, the increased temperature of cooling water in the steam condensers will results in both efficiency and capacity loss for the generating units. During the hottest summertime conditions when electricity demand is highest, the efficiency and capacity losses could be as high as 10%. This results in the need to purchase replacement power at a premium because a public utility has an obligation to serve its customers and will be required to bear that expense.

Effectiveness:

The mechanical draft cooling tower alternative would effectively reduce both impingement and entrainment in proportion to the flow reduction, typically 95% or more. This technology meets both the impingement mortality reduction and entrainment reduction performance standards set by the 316(b) Phase II rule for existing plants.

Other Potential Adverse Effects:

The primary adverse effects for the mechanical draft cooling tower alternative are associated with increased water vapor content in the immediate area of the cooling towers. This will result in a visible plume for some periods and has the potential to result in fogging impacts. To reduce the potential for these effects, a plume abatement system would be employed. Because cooling tower drift cannot be eliminated completely, the tower would be located as far as possible from electrical equipment, off-site receptors, and sensitive vegetation. Space limitations may make it difficult to locate the cooling towers to minimize these effects. A cooling tower also imposes noise and aesthetic impacts. Another significant environmental effect is that the decrease in efficiency means that more fuel is burned per unit of electrical energy output. Depending on the weather conditions, the negative effect on efficiency could be anywhere from 1% to 10%.

Overall Assessment of Alternative:

A cooling tower alternative would be effective for reduction of both entrainment and impingement mortality; however, due to the very high costs and limited space available for construction, this alternative is not considered as a part of the compliance.

- ***5d – Dry Cooling***

Description:

With a dry cooling system air is used as a heat sink to condense steam in the system. Cooling water is essentially eliminated. However, a dry cooling system requires a large cooling surface, many cooling fans, and a more sophisticated steam ducting system, which would require extensive modifications to an existing plant. In addition, an annual average thermal efficiency penalty of 2% to 5% is likely for the power plant. During the hottest summer time conditions when electricity demand is highest, the efficiency and capacity losses could be well over 10%. Because of these high costs, dry cooling is not considered a part of the compliance for any existing plant.

Alternative 6 - Restoration

Description:

The Phase II rule allows the use of mitigation strategies for enhancing fish and aquatic biota populations to offset impingement and entrainment losses. These strategies typically involve habitat restoration methodologies, particularly the creation and improvement of important habitat types that support aquatic biota, as well as spawning and nursery areas. Alternatively, ENSR is aware of several fish-stocking efforts in the southern United States that are viewed as successful by all parties involved. Ideally, the restoration activity should result in mitigating the types of species that are affected by entrainment and impingement at the plant and result in quantifiable benefits near the plant. Alternatively, the rule allows for "out-of-kind" restoration, which might be simpler to institute and monitor.

For this alternative, various habitat restoration strategies considered for the Waterford 3 Plant include:

- Fish Stocking – this option is expected to be effective and is expected to be supported by the Louisiana Department of Environmental Quality and the Louisiana Game and Fish Commission.
- Shoreline wetland creation – this option is not likely to be effective and is more difficult to quantify.
- Offshore artificial habitat (i.e., reefs) creation – this option may have significant beneficial effects in estuarine environments but is not expected to have a noticeable effect on a large freshwater river.
- Habitat restoration on nearby tributaries – this measure is likely to be effective and is generally supported by state agencies.
- Dam removal – no opportunities on the Lower Mississippi River or its tributaries.

The restoration process would involve the following activities: (1) impingement data to assess target species and associated habitat restoration strategies, (2) reconnaissance surveys of the affected water bodies to assess potential areas for habitat creation and/or improvement, (3) selection of the most appropriate restoration strategies and areas for restoration, (4) determination of the species that would benefit for each habitat restoration, (5) evaluation of the extent of restored habitat needed to offset impingement losses, (6) implementation of selected restoration strategies, and 7) coordination with relevant resource agencies (e.g., LDEQ, US Fish and Wildlife) to gain approval.

Technical Feasibility/Reliability:

Each of the potential restoration methods has been used with success in a number of applications. Each of the restoration methods would require an assessment of whether any conditions in the water bodies would preclude long-term success. The potential for removal of the restoration option as a result of legal challenges to the Rule should be considered.

Cost Considerations:

The capital cost of this alternative is expected to range from $50,000 to $3,000,000 depending on the number and type of restoration efforts selected. Annual costs associated with monitoring range from $40,000 to $125,000.

Effectiveness:

There is little existing quantitative information on using increases in biological production at habitat areas to offset impingement and entrainment losses. However, restored habitat areas have been demonstrated to result in an increase in biota and spawning. Alternatively, a well-designed stocking program may be able to provide a more direct replacement of important species on an adult-equivalency basis.

Other Adverse Effects:

There are no likely adverse effects of the restoration alternative.

Overall Assessment of Alternative:

This alternative is technically feasible, may have relatively low costs, and is likely to be effective (though at this point it is difficult to quantify the degree of mitigation that would be obtained). The alternative would also provide an overall environmental benefit to the affected water bodies.

APPENDIX B

REVIEW OF MISSISSIPPI RIVER FISHERIES

APPENDIX B
REVIEW OF LOWER MISSISSIPPI RIVER FISHERIES

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EXECUTIVE SUMMARY

The Phase II rule developed under Section 316(b) requires consideration of the fishery of the cooling water source. The specific make up of a portion of the Comprehensive Demonstration Study (CDS), the Impingement Mortality and Entrainment Characterization Study (IMECS) is outlined by the rule. This Appendix will review these requirements within the context of the available literature for ten Entergy generating plants located on the Lower Mississippi River (LMR) and its associated tidal channels. The literature reviewed includes data collected at five of the stations as well as the more general literature and discussions with experts at universities and government agencies. This Appendix will evaluate whether these data are sufficient to support development of the IMECS and will also evaluate several important issues relative to the impingement and entrainment at the stations.

Two of the generating plants (i.e., Michoud and Paterson) are subject to performance goals for both impingement mortality and entrainment. The balance of the plants (i.e., Ritchie, Gerald Andrus, Baxter Wilson, Willow Glen, Little Gypsy, Ninemile, Waterford 1 & 2 and the Waterford 3 Nuclear Plant) are subject to the impingement goal alone. In every case except Waterford 3, US EPA has estimated, as part of the rule making process, that the likely capital and operation/maintenance cost of rule compliance at these stations will be negligible (i.e., $0). This cost estimate serves as the basis of the so-called Cost-cost test; the rule allows for a site-specific determination of Best Technology Available (BTA) if the costs of potential mitigation technologies are "significantly greater" than US EPA's assumed cost. These circumstances define a standard for the data necessary for the IMECS intended to support this Compliance Alternative; the results of the Cost-cost test will be driven by the costs and feasibility of the various mitigation measures. The biological data are much less likely to influence the outcome of this test.

For Waterford 3, US EPA estimated capital and total annualized costs to be $27.4M and $7.3M, respectively based on the "addition of a passive fine-mesh screen system (cylindrical wedgewire) near shoreline with mesh width of 1.75 mm." These costs inappropriately cover compliance with both impingement mortality and entrainment performance standards. Costs adjusted using procedures defined in the rule to reflect only the impingement performance standard are $12.8M and $3.4M respectively for capital and annualized costs. This cost estimate serves as the basis of the so-called Cost-cost; under which the rule allows assessment of whether the costs of potential mitigation technologies are "significantly greater" than the costs estimated by US EPA during rule making. Alternatively, if the site-specific costs of compliance are found to be significantly greater than the likely monetized benefits, the Cost-benefit test can be applied. Under either the Cost-cost or Cost-benefit tests the NPDES Director can find that a site-specific BTA is allowed and the applicable performance standards do not have to be fully achieved.

As shown below, Entergy has drawn the following conclusions based on the review of available literature:

- The historical studies at five of the plants represent sound efforts to estimate the annual rates of impingement including consideration of diel and seasonal variation. These studies were performed in the late 1970s and early 1980s.

- There is a strong consensus in the literature and among fisheries experts that the fishery of the LMR has not undergone significant changes since the collection of the impingement data. The dominant species as well as their population densities are unlikely to have changed significantly since the 1970s. This is consistent with informal observations by the plants' operators. Thus, the historically measured rates of impingement are likely to represent reasonable estimates of current rates of impingement.

- Entergy believes that available data support the rule's requirements of the impingement mortality and entrainment characterization study (IMECs). The available data provide a sound basis for characterizing the three general aspects of impingement mortality and entrainment required as part of the IMECS by 40 CFR 125.95(b)(3): (1) taxonomic identification of fish and shellfish within the zone of influence of the CWIS; (2) assessment of all life stages including temporal variation; and (3) estimation of current rates.

- The species impinged at the five plants change with movement toward the Gulf of Mexico in a logical fashion. As the salinity increases and with closer proximity to the Gulf, marine species increase in frequency.

- The distribution of plants with impingement data allows for inference of likely rates of impingement at nearby stations that have not rigorously quantified impingement.

- The most commonly impinged fish are also common in the source water. Despite this, several important fish in the source water are under-represented among the impinged organisms. This is likely due to their strong swimming ability and/or their avoidance of the habitat near the cooling water intake structure (CWIS).

- The ten most commonly impinged fish constitute 90.7 to 98.7% of the total numbers of fish. Thus, the species of concern at each plant are clear.

- At the plants located on freshwater, the most commonly impinged species are generally forage fish or shellfish with little commercial or recreational value. The numbers of impinged fish are generally low compared to plants with similar flows located in other settings.

- Three young pallid sturgeon were impinged at two stations and several juvenile paddlefish were impinged at the plants. While the populations of these fish have generally declined in the LMR, there is a potential for their impingement. This suggests that efforts at restoration of these species may be a productive mitigation measure.

- Fish and shellfish impinged at the two estuarine stations are of higher commercial and recreational value. Despite this, the annual losses of these organisms are very modest.

- The masses and lengths of impinged fish are available in the studies and the vast majority of impinged finfish are juveniles.

- Data with which to evaluate temporal changes in impingement rates are available. Little change is apparent during the day and generally rates of impingement are stable throughout the year. The exceptions to this appear to be increases in impingement as young of the year return to the main channel following floods, observed at one station, and with migration of marine species into the estuaries observed at Michoud and Paterson.

- All of the plants have operating fish handling and return systems. Given the sensitivity of many of the impinged species at the fresh water plants, these systems may not contribute significantly to reductions in impingement mortality. The importance of shellfish among impinged organisms at the two estuarine plants, and these organisms' tolerance of handling, suggests that the return systems are likely to contribute to significant reductions in impingement mortality relative to the Calculation Baseline.

- Several of the plants located on the river's main stem (i.e., Baxter Wilson, Ritchie, Willow Glen, Waterford 1 & 2, Waterford 3, Little Gypsy, and Ninemile) have CWIS that draw from deep, fast-moving water located several hundred feet offshore. There is a consensus that the population densities in these areas are far lower (95% lower) than in quieter, shallower water located along shore and in backwaters. This phenomenon contributes to each of these stations having greatly reduced rates of impingement relative to the Calculation Baseline (i.e., along shore) condition. In fact, these stations are very likely to be meeting the rule's performance goals for 80 to 95% reduction in impingement mortality.

- Few data are available on entrainment rates at Michoud and Paterson. Generally, the densities of ichthyoplankton at these stations should be low as most of the impinged species spawn well offshore in the Gulf. The importance of entrainment data is minimized by the fact that no technology intended to mitigate entrainment is either feasible or cost-effective. Data on the specific rates of entrainment is not likely to change the conclusions of the selected compliance alternative: the Cost-cost test or the Cost-benefit test.

1.0 INTRODUCTION

The Section 316(b) Phase II rule requires consideration of several biological issues during the evaluation of current and potential measures to mitigate impingement mortality and entrainment. Entergy owns and operates ten generating plants affected by the rule that are located along the Mississippi River in Arkansas, Mississippi, and Louisiana. This presents an opportunity to

consider the biological resources within a common context. This will be part of Entergy's approach to rule compliance and this Appendix represents the first step in that process: a review of the fishery resources of the relevant stretch of river and its implications for rule compliance.

1.1 Goals

This Appendix was generated to support the submittal of the Proposal for Information Collection (PIC) for Entergy's ten Lower Mississippi River (LMR) Plants. Much of this information will be incorporated into the Impingement Mortality and/or Entrainment Characterization Study (IMECS), part of the Comprehensive Demonstration Study (CDS) required in the Phase II Section 316(b) rules. These documents will be prepared for each plant and will include an expanded discussion of the data as well as a more complete discussion of the data's implications at the plant. The goal of this Appendix is to review fisheries-related data available for the LMR and the associated tidal channels. This review is intended to support the compliance options Entergy has elected to pursue in response to the regulations that pertain to the reduction of impingement mortality (IM) and entrainment (E) at electric power generating stations. In particular, this Appendix will address whether sufficient data are available to address the goals of the rule within the context of the compliance strategies outlined in the PIC. This Appendix evaluates ambient fish and shellfish populations and impingement data available on the LMR. The rates of impingement and entrainment will be considered within the context of our understanding of the biological resources of the Mississippi River in order to address several important questions relevant to the assessment of current and potential controls on IM and E. Potentially relevant questions are presented in Section II (below).

The aquatic biology of the Mississippi River is relatively well characterized by various agencies as well as private entities. In an effort to determine species that may be subject to impingement or entrainment at Entergy's facilities located on the LMR in Arkansas, Mississippi, and Louisiana, an extensive literature review was conducted. In addition, experts at museums, Universities, and regulatory agencies were contacted for additional information as well as their perspective on important ecological trends. State agencies were contacted as well as the United States Fish and Wildlife Service (USFWS), the U.S. Geological Survey (USGS), and the United States Army Corps of Engineers (USACE).

This Appendix reviews impingement data collected at the following Entergy plants: Baxter Wilson, Willow Glen Units 1 and 2, Willow Glen Unit 4, Waterford 1 and 2, Paterson, and Michoud. These data provide important perspective on the biological performance of the CWIS and, when coupled with other literature data, may provide a sufficient basis for the Impingement Mortality and Entrainment Characterization Study (IMECS) called for by the rule. The absolute rates of impingement will be considered relative to the location, design, and operation of the CWIS, and temporal trends will be discussed. The relative frequency of the species impinged will be discussed relative to population surveys of the LMR. Finally, a brief discussion of habitats of

several commonly impinged species as well as potential rare, threatened, or endangered species will be presented.

Although many relevant data sources were obtained during the literature review, it should be noted that several sources contacted had limited biological data. These sources cited the lack of appropriate sampling equipment and under-sized boats as part of the reason for the lack of sampling effort on the Mississippi River. High water velocities are common on the Mississippi River and create safety concerns for routine sampling efforts. Such issues should be considered when planning any population survey that might be considered as part of the 316(b) compliance process.

Other agencies noted that relatively extensive data have been collected but has yet to be collated and evaluated. It may be appropriate to assess these data as part of the IMECS for the Entergy facilities.

1.2 Organization of Document

A review of the rule's goals is provided outlining the requirements for the IMECS. A general review of the LMR is then presented. Taxonomic identification of the most important species is provided and divided into freshwater and estuarine sections so the information can be more easily associated with a given plant[1]. A summary of the fisheries in the ambient water follows with species-specific discussions including habitat preference, spawning habits, food preference, swimming speeds, and handling survivability. Species with clear economic benefit and recreational importance are discussed as well as threatened and endangered (T&E) species.

A characterization of all life stages follows focusing on the life stages subject to impingement mortality (IM) and entrainment (E). Impingement data is summarized for the freshwater plants followed by the estuarine plants. The information was reviewed with a focus on potential temporal variations in IM and E. The importance of spatial differences in population densities is also discussed focusing on available literature and conversations with researchers.

Documentation of current IM and E at the plants follows focusing on actual measurements and anecdotal evidence. The representativeness of historical data is addressed considering potential fisheries trends in the LMR and whether the impingement data were collected under normal operating conditions. Available data were analyzed to determine their sufficiency to estimate the Calculation Baseline. The sufficiency of the data is also discussed as it pertains to supporting the other goals of the CDS.

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1 The Paterson and Michoud plants use brackish water and are likely to affect estuarine species. The balance of the generating plants are located on the Mississippi River main stem and use water that is nearly always fresh.

Lastly, a discussion is presented that answers whether the available data is sufficient in supporting the IMECS. The most common species impinged and entrained are listed in this section. Implications for CWIS placement, design, and operation are discussed as well. All references cited are found at this end of this Appendix.

2.0 REVIEW OF THE RULE'S GOALS

The Phase II rule provides relatively specific requirements for the IMECS in amendments to 40 CFR 125.95(b)(3) (see excerpt, below). Entergy understands that these requirements are intended to support the assessment of the current CWIS as well as its alternatives within the context of the various Compliance Strategies. Among the specific questions that might be relevant are:

- What are the species potentially affected by the CWIS? Do they include species of potential concern such as those with high commercial or recreational value or those receiving special protections?
- Do the characteristics of the relevant species (e.g., temporal and spatial distributions, size of larvae and eggs, swimming speed) provide a basis for selection and design of mitigation technologies or measures?
- What are the actual rates of impingement and entrainment in order to calculate the monetized benefit of potential mitigation measures?
- How do the current rates of impingement and entrainment relate to those of the hypothetical Calculation Baseline? That is, what is the effect of any mitigation measures expressed as a percent reduction, relative to the Calculation Baseline, in impingement mortality and entrainment?

As noted in the PIC, the relative importance of these questions will vary significantly depending on the Compliance Strategy selected. Although current data on the rates of impingement mortality and entrainment may be more useful to the Cost-benefit test than to the Cost-cost test, available data is likely to allow a conservative estimate of potential monetized benefits. Similarly, it is likely to be much simpler to demonstrate consistency for some mitigation technologies than for others and the nature of the necessary data collection will vary accordingly. For example, there is a consensus that population densities in high velocity portions of the river are much lower than along the shore or in backwaters. Thus, demonstrating compliance with performance goals for CWIS located in the main flow of the river should be relatively simple. On the other hand, due to site- and species-specific variation, showing that a fish handling and return system results in sufficient impingement survival may require direct testing.

The following is the rule's requirements for the IMECS:

a) *125.95(b)(3)(i). Taxonomic identifications of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) that are in the vicinity of the cooling water intake structure(s) and are susceptible to impingement and entrainment.*

b) *125.95(b)(3)(ii). A characterization of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) identified pursuant to paragraph (b)(3)(i) of this section, including a description of the abundance and temporal and spatial characteristics in the vicinity of the cooling water intake structure(s), based on sufficient data to characterize annual, seasonal, and diel variations in impingement mortality and entrainment.*

c) *125.95(b)(3)(iii). Documentation of the current impingement mortality and entrainment of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) identified pursuant to paragraph (b)(3)(i) of this section and an estimate of impingement mortality and entrainment to be used as the calculation baseline. Impingement mortality and entrainment samples to support the calculations required in Section 125.95(b)(4)(i)(C) and 125.95(b)(5)(iii) of the Rule must be collected during periods of representative operational flows for the cooling water intake structure and the flows associated with the samples must be documented.*

Within the context of the selected Compliance Strategies, these requirements will serve as the basis for assessing the sufficiency of the existing data to support the IMECS (see Section 4 of the PIC).

The following three sections of this Appendix will be organized consistent with the three separate provisions of the rule relative to the IMECS.

3.0 TAXONOMIC IDENTIFICATIONS [125.95(B)(3)(I)]

40 CFR 125.95(b)(3)(i) sets out the requirements of the IMECS relative to identification of fish and shellfish taxa potentially affected by impingement mortality and entrainment. The goals of this effort are to identify these species that are likely to dominate impingement mortality and entrainment with a special focus on those that have commercial or recreational importance. In addition, any species subject to special protections (e.g., state- or federally-listed threatened or endangered species) must be noted.

This section will review the available information in order to identify the relevant species and will provide a brief review of the nature of several important species. Separate discussions will be provided for the freshwater and estuarine systems. The discussions rely on station-specific data, industry-generated summaries of the ambient populations, the more general literature, and recent discussions with experts on the fishery of the LMR.

3.1 Mississippi River Species Composition

The fishery of the LMR changes with progression toward the Gulf of Mexico. The change is driven by the increase in salinity as well as physical proximity to the ocean. The first factor is especially important in the shipping channels near the Michoud and Paterson plants where the typical salinity can approach one-third of that of seawater. On the river's main stem (e.g., at the Ninemile station), the salinity is far lower but estuarine species become more common. Thus, we expect that with movement from Entergy's Gerald Andrus, Ritchie, and Baxter Wilson plants to those stations located closer to New Orleans, more estuarine species will be encountered. In fact, this is borne out both in ambient sampling as well as the measured rates of impingement.

3.1.1 Freshwater

The boundary between the Upper Mississippi River (UMR) and LMR is typically considered to be near Alton, Illinois, a few kilometers above the confluence with the Missouri River. The LMR is approximately 1,834 km and flows un-dammed to the Gulf of Mexico (Schramm 2004). Levees have severed connection to the river from 90 percent of its historic 103,000 km^2 floodplain which historically extended almost 200 km from the riverbank (Schramm 2004).

The Mississippi River is a highly turbid waterbody with high current velocity. The productivity of the system is limited by light penetration and high suspended solids concentrations, as well as stability and habitability of the available substrate. As a result, the Mississippi River food chain is considered to be detrital-based, because phytoplankton occur in low densities and do not seem to be the major energy source. This is typical of larger southeastern and Midwestern rivers (LL&P 1974).

The flow regime of the LMR is considered to be an important determinant of the fish community. Flow records have been maintained on the LMR since 1900. The flow in the river varies substantially throughout the year and water levels fluctuate an average of 10 m (Schramm 2004). For example, at the Waterford Unit 3 facility (owned and operated by Entergy), located between Baton Rouge and New Orleans, average seasonal flows are estimated to be 580,000, 650,000, 280,000 and 240,000 cfs for winter, spring, summer, and fall, respectively. Average velocity in this portion of the river averages as high as 3.9 fps in April and as low as 1.1 fps (39-year avg.) in September (LP&L 1979). In the vicinity of Baxter Wilson flows as rapid as 8 knots (i.e., in excess of 10 fps) have been observed.

3.1.1.1 Summary of Literature

Fish species diversity typically increases from headwater to river mouth. Vertical distribution is patchy, with highest numbers at the river surface and at the bottom with the mid-depth virtually devoid of fish, probably due to very high currents located mid-depth (MP&L 1974). The most common freshwater species in the LMR include the gizzard shad, threadfin shad, goldeye, carp, river carpsucker, smallmouth buffalo, blue catfish, channel catfish, flathead catfish, river shiner, and freshwater drum. Bluegill, largemouth bass, and black and white crappie are also fairly common. In addition to the fish, two species of shrimp (*Macrobrachium ohione* and *Palaemonetes kadiakensis*) and a crayfish (Cambarinae) are abundant.

Large floodplain rivers like the Mississippi are dynamic and diverse ecosystems. These rivers are composed of several habitats including the main channel, side channel, floodplain, and backwater lakes that allow a diverse assemblage of organisms to persist. 195 species of freshwater fishes have been recorded to occur in the main-stem of the Mississippi and Atchafalaya rivers, representing almost one-third of the freshwater fish species in North America. Sixty-seven (67) species inhabit the headwaters, 132 species inhabit the Upper Mississippi River, and about 150 species inhabit the Lower Mississippi and Atchafalaya Rivers (Fremling *et al.* 1989). Baker *et al.* (1991) also estimated that 91 species of freshwater fishes inhabit the LMR, with 30 or more other species present intermittently.

Schramm (2004) identified three distinct habitat zones in the LMR: main channel, channel border, and backwater. The main channel is the portion of the river that contains the thalweg and the navigation channel. The channel border is the zone from the main channel to the riverbank and the backwater zone includes lentic habitats lateral to the channel border that are connected to the river at least some of the time in most years. These habitat zones are extremely relevant when considering species with the most potential for impingement and/or entrainment in the LMR habitat. This study, as well as additional habitat information is discussed further in this Appendix in sections *Review of Habitats* and *Differences in Fisheries Population Densities.*

The rule defines the Calculation Baseline condition as, among other factors, being located at the surface along the shoreline. This is considered to be the worst-case for both impingement mortality and entrainment. The discussion above supports the concept that a CWIS located along the shoreline or in a back-water will be much more likely to be in habitat with increased populations of fish relative to those in the main channel.

The LMR provides plentiful habitat for fishes that thrive in swiftly flowing water but few species can tolerate the high current velocities of the upper and middle water column of the channel (Baker *et al.* 1991). Most fishes likely inhabit areas near the banks (Pennington *et al.* 1983) and the channel bottom, where the current is slower (Baker et al. 1991). Several fish species forage in the floodplain of the LMR when it is inundated by high water levels (Baker *et al.* 1991); these include gars, bowfin, common carp, buffalos, river carpsucker, channel catfish, blue catfish, white bass,

crappies, and freshwater drum. Many fishes also use the inundated floodplain for spawning. Densities of larval fishes in the LMR are highest in backwaters, which are important nurseries for fishes, and which contain a larval fish assemblage differing from that of the main-stem river (Beckett and Pennington 1986).

Dr. Todd Slack with the Mississippi Museum of Natural Science was contacted to retrieve an updated list of species in the general area of each of Entergy's facilities located on the LMR. To date, lists have been provided for the vicinities of the Baxter Wilson facility near Vicksburg, Mississippi; the Gerald Andrus facility near Greenville, Mississippi; and the Ritchie facility near Helena, Arkansas. The results of the queries also contain upstream and downstream reaches, direct tributaries to the Mississippi River, and oxbow lakes. The list was compiled from the Museum's current database and the Inland Fishes of Mississippi, authored by Dr. Stephen Ross (Ross 2001). Dr. Slack stated that the list is very extensive and should include all common fish in the area. This information was used primarily to determine potential occurrence of T&E species at these three plants, as well as to confirm the species identified in the Baxter Wilson impingement study.

Camp, Dresser & McKee, Inc. (CDM) and Limnetics (1976) conducted an ecological study of the LMR to determine the species composition, abundance, and biomass of the biological communities in the river. Six sites were selected for fish collections near Mississippi River mile marker 786, 730, 665, 522, 301 and 175 AHP (Ahead of Pass) (with focus on the river near 522, 730 and 785 AHP). At each of the sites three habitats were sampled; (1) river channel; (2) clay-bank area; and (3) backwater area. A total of 65 species were collected during the study; 46 species at Mississippi River mile marker 785 AHP, 49 species at mile marker 730 AHP, and 57 at mile marker 522 AHP. The most commonly captured fish included the gizzard shad, threadfin shad, goldeye, carp, river carpsucker, smallmouth buffalo, blue catfish, channel catfish, flathead catfish, river shiner, and freshwater drum. In addition to the fish, two species of shrimp (*Macrobrachium ohione* and *Palaemonetes kadiakensis*) and a crayfish (Cambarinae) were collected.

Although many of the species observed in the plant impingement samples are similar in composition and relative abundance to the species found in the LMR itself, some species are noticeably absent or under-represented from the impingement samples. For example, of the most common fish in the LMR, shiners, smallmouth buffalo, and largemouth bass are rarely observed in the impingement samples. Skipjack herring, while common in the LMR, only account for a small percentage of the total number of fish impinged (generally less than 1%). This is confirmed by two surveys conducted on the LMR by Entergy at the Waterford 3 and Grand Gulf plants (see Table B-1). While quantitative comparisons are difficult, it is apparent that several species that dominate the ambient samples are poorly represented in impingement samples collected at near by stations. The differences in composition and frequency of fish known to be common in the LMR and those observed in the impingement samples is likely to due to habitat preferences

and/or escape potential. The ambient river studies utilized different gear which has the potential to bias the results of the sampling event making inter-survey comparisons difficult.

3.1.1.2 Species-Specific Discussion

The following is a brief summary of the primary freshwater species expected to be impinged and/or entrained in power plant CWIS located in the LMR. A more in-depth biological profile will be included with the IMECS submittal. This list was compiled using data from LMR impingement studies and ambient river fisheries studies. Handling tolerance and swimming speeds are discussed as well as general biology, habitat and feeding preferences.

Handling Tolerance

Table B-2 presents data summarized by EPRI (2003) on the observed impingement survival of different fish species. This review does not include all species but does summarize an extensive set of studies for many important species. To support the assessment of potential survival upon fish handling and return, the species that are both common in the LMR and commonly impinged were assessed relative to the average and median rate of survival following removal from traveling screens.

EPRI (2003) indicated that the median extended survival for freshwater drum and gizzard shad is 20% (8 studies) and 7% (43 studies), respectively. Extended survival rates were not available for threadfin shad but the median initial survival was only 15% (5 studies). This suggests that any sort of fish handling and return system is not likely to achieve significant reductions in impingement mortality for the three finfish species that dominate impingement at the LMR freshwater plants. Of the two common invertebrate species impinged in CWIS, the initial survival for freshwater shrimp was 50% (1 study). Available data for other relevant taxa (including estuarine species) are also presented in Table B-2.

Swimming Speeds

US EPA states "intake velocity is one of the key factors that can affect the impingement of fish and other aquatic biota". In the immediate area of the intake structure, the velocity of water entering a CWIS exerts a direct physical force against which fish and other organisms must act to avoid impingement and entrainment" (Sempra 2002). In addition, technologies (wedgewire screens and velocity caps) may reduce CWIS velocities, and hence impingement and entrainment. In the LMR the typical high velocities assist in reducing impingement and entrainment by adding a force larger than the intake structure suction force at a 90° angle to the intake. This reduces the number of fish entering the CWIS. When the ambient water velocity is higher than the intake approach velocity, the major impetus is to pull the aquatic organisms downriver and not towards the CWIS intake pipes.

A species' swimming speed is important in determining its ability to avoid the suction force of CWIS intake pipes. Swimming speed information can be useful when considering the application of potential construction technologies, especially if the species in the vicinity of the CWIS are known. Thus, this information may be an important part of the IMECS. Available data for important species are presented in Table B-2.

Analysis of the impingement data showed moderate correlations between a species' swimming speed and its potential for impingement. River shrimp swim very slowly; adult males swim on average 7.6 mm/s. This species dominated impingement (as high as 57% of the total abundance) at the Willow Glen and Waterford 1 & 2 impingement studies. These high impingement rates were probably due, in part, to the shrimps' inability to break away from the suction created at the intakes. Alternatively, gizzard shad and threadfin shad both have moderate swimming speeds when compared to other finfish (optimum of 23 cm/s for fish 25-50 mm) and were two of the most abundantly impinged fish in the impingement studies. Larger freshwater drum are able to swim relatively fast (optimum speed of 90 cm/s for 300 mm fish), however this species was the most abundantly impinged fish at Baxter Wilson, Willow Glen 1 & 2 and Willow Glen 4. Carp (optimum speed of 166 cm/s for 36-77 mm fish) and bluegill (critical speed of 101 cm/s for 64 mm fish) are able to swim relatively fast and were impinged in low numbers, likely due to their ability to swim faster than the approach velocity at the intakes.

Although a species' swimming speed is likely a key element in determining its impingement potential, there are many factors that are important including individual size, behavioral cues, feeding habits, preferred location within the water column and relative to the CWIS location, and the tendency to school.

River shrimp

Ohio Shrimp (Macrobrachium ohione) may grow up to 4 inches long, live in fresh and brackish water along the eastern United States seaboard to the Gulf of Mexico, and are the only species of *Macrobrachium* found in the Mississippi River. Once common in the Mississippi River below St. Louis, they supported commercial fisheries that once existed near Chester and Cairo, Illinois, Ohio shrimp were thought to be extirpated (locally extinct) in the Mississippi River bordering Missouri and Illinois since 1962. In 1991, however they were rediscovered. The decline in the population of Ohio shrimp is thought to be related to the channelization of the river (Hrabik 1999).

In the LMR, however, this species is still quite abundant. M. *ohione* are the most common freshwater shrimp in Louisiana and can be found in the Atchafalaya and lower Mississippi Rivers, where almost all of the current production is used for bait.

Gizzard Shad

Gizzard shad occur primarily in freshwater and are most abundant in large rivers and reservoirs, avoiding high gradient streams. The species is most often found in large schools. Spawning generally takes place in late spring, usually in shallow protected water. Gizzard shad are planktivorous. The young feed on microscopic animals and plants, as well as small insect larvae, while adults feed by filtering small food items from the water using their long gill rakers. Gizzard shad generally grow to 14 inches and provide forage for most game species (Chilton 1997). Ross (2001) also noted that young gizzard shad tend to occur along shorelines in very shallow water, gradually moving offshore into deep water as they grow. Individuals older than age class 3 rarely occur in shallow water (Bodola 1966).

Schramm (2004) stated that this species is abundantly taken in the LMR. He also states that the gizzard shad is a backwater dependent species that may be found in all three main habitat zones; the main channel, channel border and backwaters. Gizzard shad have little commercial or recreational importance although they likely serve as forage for game fish.

Threadfin Shad

Like gizzard shad, threadfin shad are most commonly found in large rivers and reservoirs. However, threadfin shad are most likely to be found in waters with a noticeable current and are usually found in the upper five feet of water. Spawning begins in the spring and continues through summer. Adults are considerably smaller than gizzard shad and rarely exceed 6 inches in length (Chilton 1997). The threadfin shad is a pelagic schooling species that primarily occupies the areas between the surface and the thermalcline with the greatest densities near the surface (Netsch *et al.* 1971). Schramm (2004) stated that this species is abundantly taken in all LMR surveys. He also states that the threadfin shad is a backwater dependent species that is most likely to be found in the channel border and backwaters. Again, threadfin shad serve as forage fish but have little other commercial or recreational importance.

Freshwater Drum

Freshwater drum occur in a wide variety of habitats, and is one of the most wide latitudinal-ranging fish in North America. They inhabit deep pools of medium to large rivers and large impoundments spending most of their time at or near the bottom. Young drum feed on small crustaceans and aquatic insect larvae, and adults feed on snails, small clams, crayfish, small fishes, and insect larvae (Swedberg 1968; Robison and Buchanan 1992). They are often found rooting around in the substrate or moving rocks to dislodge their prey (Chilton 1997). The freshwater drum is a pelagic spawner, usually spawning in the spring. The eggs are semi-buoyant and pelagic. In Wisconsin, schools of spawning fish have been observed milling at the surface with backs out of the water (Becker 1983; Chilton 1997). Schramm (2004) stated that this species is taken abundantly in all river surveys in the LMR. He also states that the freshwater drum is a

riverine dependent species that is most likely to be found in the channel border and backwaters. Freshwater drum is taken on a commercial basis.

Blue catfish

The blue catfish is primarily a large-river fish, occurring in main channels, tributaries and impoundments of major river systems. They are native to major rivers of the Ohio, Missouri, and Mississippi river basins. They tend to move upstream in summer in search of cooler temperatures, and downstream in winter for warmer temperatures. Blue catfish do not mature until reaching 24-inches. They spawn in late spring or early summer when water temperatures reach 75° F. Males select nest sites which are normally dark secluded areas such as cavities in drift piles, logs, undercut banks, rocks, cans, etc. The blue catfish diet is quite varied but smaller fish tend to eat invertebrates, while larger fish eat fish and large invertebrates (Chilton 1997).

Common Carp

Common carp were first introduced in North America in 1877 and are now one of the most widely distributed fish in North America. They are primarily a warm-water species, and do very well in warm, muddy, highly productive (eutrophic) waters. Adults are primarily benthic and omnivorous, feeding on both plant and animal material. Common carp may grow as big as 75 pounds, but are generally considered a nuisance by North American anglers (Chilton 1997).

Ross (2001) states that carp occur in a variety of habitats but are more common in deep pools of streams or in reservoirs, especially in or near vegetated areas with mud or sand substrata. They are fairly tolerant of poor water quality and can survive low oxygen levels and high turbidity. Schramm (2004) stated that this species is commonly taken in most surveys in the LMR. He also states that the common carp is a backwater dependent species that is most likely to be found in the channel border and backwaters. Schramm notes the importance of invasive species in the Mississippi River and stated the most important species presently established in the river include the common carp, grass carp, silver carp, bighead carp, and zebra mussel. Since the carp is a nuisance, any reduction in their numbers (i.e. impingement mortality) would be a benefit to the aquatic ecosystem as this would allow the proliferation of indigenous, non-invasive species.

3.1.2 Brackish Waters

The following is a summary of the species composition relative to Entergy's estuarine plants, i.e. Michoud and Paterson.

3.1.2.1 Summary of Literature

The majority of the LMR is fresh water; however, the water becomes brackish near the river mouth and during severe drought periods, the saltwater may rarely reach as far upstream as New

Orleans, LA. The water is also brackish in the back channels and backwater lakes near the mouth of the river. Notably the shipping channels on which Paterson and Michoud are located are brackish in nature. As the water becomes more brackish, bay anchovy, striped mullet, blue crab, Atlantic croaker, seatrout, gulf menhaden, and penaeid shrimp may be found in the lower reaches of the LMR. These species typically utilize the Mississippi River for spawning, as nursery grounds, and for protection. These species are even more important in the shipping channels where the typical salinity is much higher.

Many of the species observed in the Michoud and Paterson plant impingement samples are similar in composition and relative abundance to the species found in the lower reaches of the LMR. However, species-specific properties such as habitat preference and escape potential, as well as intake placement can affect the composition of the impingement samples.

3.1.2.2 Species-Specific Discussion

Handling Tolerance

Initial and extended survival rates have also been determined for 15 estuarine species (Table B-2). The species with the highest initial and extended survival probabilities include brown shrimp, white shrimp, and blue crab which are common at the two brackish water plants, Michoud and Paterson. The species-weighted survival of these species at these two plants is discussed in Section 3 of the PICs for those plants. These species are also observed at lower frequencies among impinged organisms at Waterford 1 and 2 and are likely to be encountered at Ninemile, Waterford 3, and at Little Gypsy.

Swimming Speed

Spotted seatrout (cruising speed of 81 cm/s for 300 mm fish) swim at moderate speeds and were impinged in small numbers at the Michoud and Paterson plants. Bay anchovy (cruising speed of 21 cm/s for 90 mm fish) swim relatively slowly and were impinged in higher abundance at these same two plants (Table B-2). Although swimming speeds are not available for blue crab, white shrimp, and brown shrimp, these species are relatively slow swimmers and were impinged in moderate abundance (up to 20% total abundance) at Paterson and Michoud. These results suggest a connection between impingement rate and escape potential, with stronger swimming species capable of escaping the flow field of the intake and vice versa.

Atlantic croaker

The croakers are perhaps the most characteristic group of northern Gulf inshore fishes. In numbers of individuals, or biomass, they are among the top three (others being mullet and anchovies) in the Gulf. Most species spawn in the shallow Gulf, with the larvae entering the bays, where they spend their first summer in brackish water. Although most species are adapted to

living on muddy bottoms, a few are found in more sandy habitats, and a few are adapted to rocky habitats.

The Atlantic croaker is one of the most common bottom-dwelling estuarine species with the young occurring in the deeper parts of the bays in the summer but departing in the fall. Only a few fish live past their first year but very large croaker are found at the mouth of the Mississippi River.

Sand seatrout (white seatrout)

The sand seatrout (croaker family) is a sport fish of some importance and is popular with most anglers. These fish spawn in deeper channels of the bays or in the shallow Gulf, the young staying over muddy bottoms. This species becomes almost entirely piscivorous at a relatively small size.

White Shrimp and Brown Shrimp

Bay systems serve as a nursery area for several commercially important species of penaeid shrimp, primarily white and brown shrimp. In the upper Gulf of Mexico brown shrimp are typically the dominant species from May through July, while white shrimp are dominant from August through April (Baxter *et al.* 1988). The natural diet of post larval penaeid shrimp includes copepods, amphipods, tanaids, and polychaetes, which account for 53% of their growth, with plankton accounting for the remainder (Minello *et al.* 1989).

Penaeid shrimp are most active at night, often swimming to the surface in shallow water. White shrimp seldom burrow as brown shrimp do, but they do usually rest on the bottom during the daylight hours. Mating and spawning for penaeid shrimp takes place offshore. Brown shrimp breed year-round at depths of 50-120 meters; individuals in shallower water do not breed in the coldest months, i.e., January and February. White shrimp breed in shallower water (14 to 50 meters) and spawn mostly in the fall. When conditions are suitable the females release between 0.5 and 1 million eggs. Twenty-four hours later the drifting eggs hatch as nauplii and begin a planktonic existence. After five molts the egg yolk is exhausted, and the nauplius transforms into a protozoea, a mysis, and finally a postlarva, which enters the bays to become a bottom dweller. They remain in the bays and estuaries until they are nearly mature then they migrate offshore to breed (Fotheringham 1980).

Bay anchovy

The anchovies are the most abundant of the schooling, pelagic fishes. The bay anchovy is an extremely common fish, restricted to the bays and close inshore areas. The species ranges from Maine to Florida and also occurs throughout the Gulf of Mexico. Adults usually attain a size of four inches (Hoese and Moore 1977). Bay anchovy are planktonic feeders. Although they are not important commercially, they do serve as a major forage species for many game fish. This

species is able to exploit a wide variety of habitats and are also known to overpopulate, and can be used to indicate poor water quality (Monaco *et al.* 1989).

<u>Blue crab</u>

Both species of blue crab, *Callinectes sapidus*, and *Callinectes similis* are common along the northern Gulf of Mexico. Blue crabs are very tolerant and adapt much better to a variety of habitats compared to other species. A commercial blue crab fishery has existed in the Gulf of Mexico for several decades. The larger *C. sapidus* reaches a maximum carapace width of 21 cm compared to 12 cm for *C. similis*. Berried (egg mass) female *C. Sapidus* are found nearly year round with the peak of the breeding season being in June and July. After mating, the female migrates into deeper water where she attaches the fertilized eggs to her pleopods. The eggs hatch in two weeks releasing the young as zoeae which eventually molts into a megalops and then transforms into a diminutive adult form. The crabs mature in one year, begin breeding and live perhaps two more years. Blue crabs are omnivores, feeding on fish, bottom invertebrates, vascular plants, and detritus (Fotheringham 1980).

3.2 Historical patterns

The riverine ecosystem of the Mississippi River has undergone many changes. Habitat loss and degradation, point and non-point pollution, toxic substances, commercial and recreational fishing and navigation, deterioration of water quality during drought periods, reduced availability of key plant and invertebrate food sources, and invasion of nonindigenous species are believed to have contributed to recent declines in the river's flora and fauna (McHenry *et al.* 1984; Bhowmik and Adams 1989). Although several key native organisms including submersed plants, native pearlymussels, fingernail clams, and certain fishes have decreased along substantial reaches of the river in recent years or decades, most species have changed little over time.

Consultation with several leading authorities from the universities and the agencies concerning historical patterns of fish populations in the LMR has been conducted. Dr. Rutherford and Dr. Kelso of Louisiana State University, Dr. Killgore of the USACE, and Hal Schramm with the USGS each indicated that the species characterization in the river has remained fairly consistent over the last 20 to 30 years and they would not anticipate a significant change in species for much of the river from well above the state of Mississippi down to Mississippi River mile marker 90 AHP, just southeast of New Orleans, Furthermore, estimates of population densities (relative abundance) for the major species occurring in the river have remained relatively stable during the same time period.

Gizzard shad, threadfin shad, freshwater drum, and blue catfish were all described as species that were abundantly taken in river surveys both recently and historically. Carp, white crappie, skipjack herring, and bluegill were also commonly collected. Since these species were the most abundant collected in the 1970's studies, and are still collected in abundance in the present day,

we can conclude there have been no significant changes in the LMR fisheries since the impingement studies in the 1970's. The most abundant freshwater invertebrates collected historically were river shrimp and crayfish, which dominated the impingement samples at many of the plants in the 1970s. Their abundance in the present day is unknown.

Based on the literature, the species currently present in the tidal portions of the LMR (e.g. white and brown shrimp, blue crab, Atlantic croaker, Gulf menhaden, bay anchovy, sand trout and hardhead catfish) are similar in composition and relative abundance to the species present historically (i.e., 1970 studies). These species are very typical of upper Gulf of Mexico estuaries and tidal river systems. Overall community structure does not appear to have changed the past several decades although saltwater commercial fishing harvest in Louisiana has declined somewhat. According to NMFS statistics, finfish landings have declined between 1984 and present day, however shellfish landings have remained relatively steady. The long-term decline in fin-fish harvest is primarily due to the corresponding decline in wetland habitat.

3.3 Commercial and Recreational Species

The most commonly impinged species at Entergy's LMR plants have no significant recreational or commercial value, for example the commonly impinged shad species have no commercial or recreational significance. This is true for the plants located on the freshwater portions of the river. At the two stations located on tidal channels, Paterson and Michoud, commercial species are more important. Despite this, adverse impacts to their populations or to the commercial harvest are not expected since the annual impingement rates associated with CWIS are typically low.

<u>Commercial Fisheries</u>

Freshwater

Commercial harvest in the UMR is dominated by four groups of fishes including the common carp, buffalos (bigmouth and smallmouth), catfishes (channel and flathead), and freshwater drum which together represent 95% of the total commercial catch in the UMR and 99% of the monetary value (Fremling *et al.* 1989). The common carp has ranked first among species in commercial catch for decades.

The same species harvested in the UMR also dominate the commercial fisheries for the freshwater portions of the LMR. Commercial harvest of fishes in the LMR is difficult to assess because of inconsistencies in methods of gathering and reporting data, however limited information indicates commercial harvest is increasing (Schramm 2004). According to Schramm neither the commercial nor recreational fisheries appear to be over harvested, however fisheries for sturgeon and paddlefish should be carefully monitored. He also notes that future fisheries production may be threatened by loss of aquatic habitat, altered spatial and temporal aspects of floodplain inundation and nuisance invasions. In addition, navigation traffic affects fish survival

and recruitment via direct impacts and habitat alteration, and is expected to increase in the future (Schramm 2004).

Schmitt (2002) states that although water quality in most reaches has improved substantially from formerly severely degraded conditions, fish health remains impacted by various contaminants, in particular bioaccumulative organic compounds, throughout the river. Meade (1995) also states that due to the extensive agriculture in the Mississippi floodplain and scattered urban areas, the river is an inland sink for fertilizers, pesticides and domestic and industrial wastes.

In the LMR, NMFS statistics for 1954-1977 show catches of 6-12 million kg and increasing over time (Risotto and Turner 1985). Self-reported commercial harvests have been collected by the Tennessee Wildlife Resources Agency since 1990 and by the Kentucky Department of Fish and Wildlife resources since 1999. Annual catch for the Mississippi River bordering Tennessee during 1999-2000 varied from 36-125 tones. Landings of blue catfish and flathead catfish have increased substantially, while harvests of common carp, buffalo fishes, channel catfish and freshwater drum have been highly variable. In Kentucky waters, catch ranged from 18-56 tones between 1999-2001, and buffalo and catfishes dominated the catch as well. Schramm (2004) notes that other states on the LMR either do not measure commercial catch or do so sporadically. In Louisiana commercial catch is measured but are not assigned to specific waters.

Brackish Water

In the brackish portions of the LMR the blue crab and penaeid shrimp (primarily white, brown and pink shrimp) are the two most important commercial groups. The blue crab commercial fishery in Louisiana is one of the largest crab fisheries in the U.S. in terms of biomass. A rapid growth in fishing effort occurred in the 1980's but by the mid-1990's the fishery exhibited declining catch rates. Although landings in Louisiana have decreased in recent years, landings averaged 42.9 million pounds during the 1990's which is 72.7% of the total Gulf of Mexico production. Marsh loss and habitat changes are two of the most important factors associated with the decreased production of blue crabs as well as excessive fishing effort, various environmental factors (reduced salinities), and illegal and incidental fishing mortality (LBCR 2005).

Commercial species represented 32% of the species (16 species of fish and 6 species of invertebrates) collected at the Paterson Plant during the 1977-79 impingement study. Commercial fish comprised 57% of the total impingement by number and commercial invertebrates represented 14% of the total impingement by number. At Michoud, 28% of the species (19 species of fish and 6 species of invertebrates) collected were commercially important species. Commercial fish comprised 31% and commercial invertebrates comprised 39% of the total impingement by number.

Blue crab represented 9.0% of the impinged organisms at Michoud (1977-79), 10.5% of the total at Paterson and 0.2% at Waterford 1 & 2 (1976-77). Based on estimated annual impingement

rates (see Section IV), biomass measurements (from the Waterford 1 & 2 study), and high extended survivability rates, loss of blue crab from these facilities is insignificant, estimated to be much less than 0.1% of the total Louisiana landings. There should be no entrainment issues associated with blue crab also as they typically spawn in higher salinity waters.

Louisiana has the nation's most productive commercial shrimp fishery, landing about 100 million pounds a year at a dockside value of $150 million. The white shrimp and brown shrimp represent the vast majority of the landings. White shrimp represented 2.4% of the total abundance at Paterson and 20.0% of the total abundance at Michoud during the impingement studies in 1977-79. Using the estimated annual impingement rate for the Michoud Plant (see Section IV), extended survival probability of 50%, and 35 harvested shrimp per pound (LSU 2005), loss of white shrimp at these two plants is insignificant to the fisheries (<0.1%). Entrainment of white shrimp should also not pose a concern in the LMR as spawning typically occurs as far as 9 km from the shore in water depths of at least 9 meters (Whitaker 1983).

In 1977 and 1978 Gulf menhaden was the leading Louisiana species in volume and ranked third in value. In 1978 Gulf menhaden landings were a record 1,508 million pounds (Hollander 1981). In 2003 landings for all species harvested in Louisiana waters was 1.2 billion pounds. Mississippi landings were much less at 212 million pounds (NMFS 2005). Loss of organisms, due to impingement and/or entrainment at CWIS located in the LMR, are insignificant when compared to these figures.

Recreational Fisheries

The recreational fishery has not been rigorously defined in the LMR. Schramm (2004) states that fresh-water fishing catch rates are relatively high: but efforts are extremely low. Because of the large size, swift and dangerous currents, the presence of large commercial vessels and lack of public access, recreational fishing on these reaches has been largely discouraged. Providing access is difficult due to the large fluctuations in river levels and separation of many of the remaining floodplain lakes from the river during low water stages. Although recreational fishing has been somewhat limited historically on the main channel of the LMR, management agencies have initiated measures to improve access and increase public education regarding the fishing opportunities (Schramm 2004).

According to the literature, the recreational species targeted most often in the freshwater portions of the LMR include the bass, catfish, crappie, gar, and carp species. In the lower portions of the LMR increased salinity allows estuarine species to be targeted as well. Some species such as the spotted seatrout and southern flounder are usually not found in low salinity areas and would have minimal potential to be impinged and/or entrained at Entergy's lower plants. The sand seatrout (white seatrout) also a favorite of recreational fisherman, do inhabit areas within the tidal channels as demonstrated by the impingement data at the Patterson and Michoud (Mississippi River mile marker 92.6 AHP) plants where this species represented 12.6% and 4.2% of

impingement, respectively. Blue crabs are also targeted by recreational fishermen and have been documented at the Paterson and Michoud plants as well.

3.4 Threatened and Endangered Species

The following threatened and endangered (T&E) species discussion focuses on federal and/or state listed species in Arkansas, Louisiana and Mississippi that have the potential to be impinged or entrained in the LMR. The federal T&E list (USFWS) and state lists (Louisiana and Mississippi) were reviewed and those species with any potential for impingement and/or entrainment are provided in Table B-3, located at the end of this Appendix. Literature was reviewed for the listed species, specifically for documented and expected occurrence in the LMR. The T&E lists can be queried per county/parish to determine the status of each species on a more regional level. Therefore the counties bordering the Mississippi River in Arkansas, Louisiana and Mississippi were the focus of the literature review. As a result of the literature review, very few species appear to have any potential to be impinged and/or entrained in the LMR.

T&E species suspected to inhabit, or that have been documented in the literature in the general vicinity of Entergy's LMR plants were retained for further consideration. A more in-depth analysis will be performed for the Comprehensive Demonstration Study (CDS). Most species were eliminated based on minimal potential to be found in the LMR, or due to their large size or non-aquatic nature (i.e., birds, whales, manatee, etc). The Cumberlandian combshell (a freshwater mussel), for example, has only been documented in Tishomingo County (northeast corner of Mississippi), therefore is not expected to inhabit the LMR. The Ozark cavefish listed in Arkansas, only inhabits underground caves, therefore should not be found in the LMR. Other species including the bayou darter was eliminated as a species of concern even though it has been documented in a county bordering the LMR. This species has been documented near the Mississippi River in both Claiborne and Lincoln counties, however it is apparently restricted to Bayou Pierre and the lower reaches of its tributaries: White Oak Creek, Foster Creek, and Turkey Creek in Mississippi (Ross 2001). Due to this species' apparent restriction to Pierre Bayou, and its habitat preference for shallow riffles and runs over coarse gravel or pebbles, it was not retained for further consideration since it has minimal potential for impingement and/or entrainment in the LMR. Other species eliminated from consideration were done so based on similar reasoning.

Bob Hoffman with the National Oceanic and Atmospheric Administration (NOAA) was contacted to determine the potential for sea turtles to inhabit the lower reaches of the LMR and tidal channels near the Michoud and Patterson Plant's (Hoffman 2005). Mr. Hoffman indicated that the loggerhead sea turtle is sometimes caught in commercial shrimp trawls in Lake Pontchartrain which is just north of these two plants. He stated the numbers in this area were fairly low. Two additional sea turtle species, the Kemp's Ridley and green, also inhabit the lower reaches of the LMR; however, Mr. Hoffman stated they would be rare this far up the river. He also stated that few sea turtles should be found above Mississippi River mile marker 90 AHP. According to Mr. Hoffman, the average size of most sea turtles in the area is between 1 and 2 feet in diameter

(carapace size). Based on the use of intake racks, relatively low intake velocities, and the size of sea turtles in the area, he believes that potential impact to sea turtles associated with CWIS would be almost nonexistent. Based on this information, sea turtles were determined to have no impingement potential in the LMR.

Pallid Sturgeon (Endangered)

The pallid sturgeon is listed as endangered by the USFWS, Mississippi and Louisiana. This species can weigh up to 80 pounds and reach lengths of 6 feet, whereas the closely related shovelnose sturgeon rarely weighs more than 8 pounds.

Pallid sturgeons evolved and adapted to living close to the bottom of large, silty rivers with a natural hydrograph. Ross (2001) also states that this species is essentially restricted to the main channels of the Missouri and Mississippi Rivers. He states the principal habitat of the pallid sturgeon is the main channel of large, turbid rivers, although some have been captured from mainstem reservoirs on the Missouri River. Schramm (2004) stated that this species is considered rare in the UMR and occasionally collected in the LMR. He also states that the pallid sturgeon is a riverine dependent species that is most likely to be found in the main channel or channel border.

Sexual maturity for males is estimated to be 7-9 years, with 2-3 year intervals between spawning. Females are not expected to not reach sexual maturity until 7-15 years, with up to 10-year intervals between spawning. Pallid sturgeons are long lived, with individuals perhaps reaching 50 years of age (USFWS 1998). According to Ross (2001) spawning coincides with spring runoff, and occurs between March and June throughout the species' range. Fishes in Louisiana and Mississippi begin spawning earlier than those in more northern areas.

Today, pallid sturgeons are scarce in the upper Missouri River above Ft. Peck Reservoir; scarce in the Missouri and lower Yellowstone Rivers between Ft. Peck Dam and Lake Sakakawea; very scarce in the other Missouri River reservoir reaches; scarce in the Missouri River downstream of Gavins Point Dam; scarce but slightly more common in the Mississippi and Atchafalaya Rivers; and absent from other tributaries (USFWS 1998).

All of the 3,350 miles of riverine habitat within the pallid sturgeons range have been adversely affected by man. Approximately 28% has been impounded, which has created unsuitable lake-like habitat; 51% has been channelized into deep, uniform channels; the remaining 21% is downstream of dams which have altered the river's hydrograph, temperature, and turbidity. Commercial fishing and environmental contaminants may have also played a role in the pallid sturgeon's decline (USFWS 1998).

Jack Killgore with the USACE in Vicksburg was contacted for further information related to the pallid sturgeon (Killgore 2005, personal communication). He stated they have conducted species-specific sampling in the LMR and have not collected pallid sturgeon below Mississippi river mile

marker 180 AHP. He stated the young of the year (YOY) fish <120 mm only swim 50 cm/sec., therefore would be of some concern at CWIS. Larger fish swim >3.0 fps and can out-swim typical intake velocities. Dr. Killgore stated that the pallid sturgeon almost always swims against the current and often employs a tactic called "hunkering" or substrate oppression. This is where the fish extends the pectoral fins and uses available substrate to hold on to. Doing this allows fish to alternately swim and rest when in strong currents.

Pallid sturgeon were impinged at the Waterford 1 & 2 plant in 1976 (2 juveniles) and at the Willow Glen plant (1 juvenile) in 1975. Based on the habitat and salinity at Michoud and Paterson, pallid sturgeon are not expected there.

Gulf sturgeon

The USFWS (2003) provides the following summary of the Gulf sturgeon, *Acipenser oxyrinchus*. This species is an anadromous fish (breeding in freshwater after migrating up rivers from marine and estuarine environments), inhabiting coastal rivers from Louisiana to Florida during the warmer months and overwintering in estuaries, bays, and the Gulf of Mexico.

Historically, the Gulf sturgeon occurred from the Mississippi River east to Tampa Bay. Its present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida. Sporadic occurrences have been recorded as far west as the Rio Grande River between Texas and Mexico, and as far east and south as Florida Bay. Due to its present range, the Paterson and Michoud plants are the only two plants of concern.

Gulf sturgeon feeding habits in freshwater vary depending on the fish's life history stage (i.e., young-of-the-year, juvenile, subadult, adult). Young-of-the-year Gulf sturgeon remain in freshwater feeding on aquatic invertebrates and detritus approximately 10 to 12 months after spawning occurs. Juveniles less than 5 kg (11 lbs) are believed to forage extensively and exploit scarce food resources throughout the river, including aquatic insects (e.g., mayflies and caddisflies), worms (oligochaetes), and bivalve mollusks. Subadult (age 6 to sexual maturity) and adult (sexually mature) Gulf sturgeon do not feed in freshwater.

Gulf sturgeon are long-lived, with some individuals reaching at least 42 years in age. Age at sexual maturity for females ranges from 8 to 17 years, and for males from 7 to 21 years. Gulf sturgeon eggs are demersal (they are heavy and sink to the bottom), adhesive, and vary in color from gray to brown to black. Mature female Gulf sturgeon weighing between 29 and 51 kg (64 and 112 lb) produce an average of 400,000 eggs. Habitat at egg collection sites consists of one or more of the following: limestone bluffs and outcroppings, cobble, limestone bedrock covered with gravel and small cobble, gravel, and sand (USFWS 2003).

The Gulf sturgeon has been documented in the LMR and Lake Pontchartrain; however, there is no record of Gulf sturgeon impingement at any of the Entergy plants.

Southern redbelly dace

The endangered southern redbelly dace is only listed by the state of Mississippi. It is a slender minnow, ranging from 1.6 to 2.8 inches in length, with extremely small scales and two narrow dusky stripes along its side. This species prefers permanent brooks of clear unpolluted water which flow between wooded banks and contain long pools of moving water (ODNR 2005). According to Ross (2001) this species occurs in upland streams of the Great Lakes and the Mississippi River Basins from Minnesota into the lower Tennessee River drainage of Tennessee, Alabama, and Mississippi. He also states the fish are typical of small, cool, clear streams with gravel, rubble, silt, and sand substrata. Dace are quite habitat specific, so they are highly susceptible to localized environmental disturbance. Sites where they have disappeared are characterized by erosion and loss of forest canopy cover, often associated with increased urban development.

The southern redbelly dace feeds in groups along the bottom on herbaceous material (ODNR 2005). Based on studies conducted in Minnesota and Kentucky, southern redbelly dace consume bottom sediments, including large quantities of sand, silt, and organic detritus and lesser amounts of aquatic insects (Ross 2001).

In Kentucky, southern redbelly dace spawn from late March to July. Total ova range from 5,708 to 18,887 in fish of 70-78 mm total length. Southern redbelly dace are nest associates, spawning over nests or mounds of *Semotilus*, *Campostoma*, and *Nocomis*. As a consequence hybrids are common with other nest building fish. The total life span of the southern redbelly dace is approximately 3-4 years (Ross 2001).

According to Ross (2001) southern red-bellied dace is known in three drainages and four river systems in Mississippi: the lower Mississippi River South (Clark Creek, Hatcher Bayou), the Tennessee River (Clear Creek and unnamed tributary to Indian Creek), the Tallahatchie River (Murphy Branch), and the Yazoo River (Bliss Creek and Skillikalia Bayou and tributaries. Ross notes that recent attempts to collect the species in the vicinity of Vicksburg indicate that populations still remain in portions of Bliss Creek and Skillikalia Bayou in Warren County (Yazoo River system), and in Murphy Branch, Tallahatchie County (Tallahatchie River system). Compared to historical data, populations in Bliss Creek and Skillikalia Bayou have declined and Southern redbelly dace are apparently extirpated from Hatcher Bayou (lower Mississippi River South system) in Warren County.

In Arkansas southern redbelly dace have been documented primarily in the northwestern portion of the state. A few individuals have been documented in the northeastern portion of the state inland from the Mississippi River (Robison and Buchanan 1992). Schramm (2004) stated that this species has been collected in the Mississippi River but there have been no records of collection since 1978. The southern redbelly dace has been reported in backwaters but is most likely to be found at the channel border in the Mississippi River. This species has not been documented in

any of the impingement studies reviewed. Finally, the habitat encountered at all of the CWIS is poorly suited to this species. Therefore, their potential impingement and/or entrainment appear very minimal.

Crystal darter

The endangered crystal darter is listed only by the state of Mississippi. The species prefers clean sand and gravel raceways of large rivers (Ross 2001). The crystal darter buries itself with only eyes protruding, as it lies in wait for passing prey. Spawning likely occurs in early spring in Mississippi, based on development of breeding tubercles in males (Collette 1965) and on the January-April spawning season documented for crystal darters in Arkansas. The presence of several size classes of oocytes suggests that this species produces multiple egg clutches. Mature or ripening eggs are 1.0 – 1.2 mm in diameter, and clutch sizes vary from 106 to 576 in fish of 62-87 mm standard length (SL). In Arkansas, mature male crystal darters averaged 76 mm SL and mature females averaged 66 mm SL. Both sexes reach maturity after their first year. The life span of this species is between 2.5 and 4 years (George *et al.* 1996).

In Mississippi the crystal darter has been documented in several locations including Claiborne County, which borders the Mississippi River south of the Baxter Wilson Plant, however it appears limited to Bayou Pierre (Ross 2001). In Arkansas, this species inhabits the lower reaches of moderately sized rivers, mainly below the Fall Line, where it is typically found in strong current over a sand or fine gravel substrate (Robison and Buchanan 1992). In Louisiana the crystal darter has only been documented from the Ouachita and Pearl River systems at locations inland from the Mississippi River (Douglas 1974).

Shramm (2004) considers the crystal darter rare in the LMR. He also states that this species is riverine dependent and is most likely to be found on the channel border or backwaters of the LMR. This species has some potential to be found in the LMR, therefore was retained as a T&E species of concern. Since this species is only listed by the State of Mississippi, impingement concerns are primarily focused on the Gerald Andrus and Baxter Wilson Plants. This species has not been documented in any of the impingement studies reviewed in this Appendix therefore their potential for impingement and/or entrainment appears very minimal.

Pyramid pigtoe

The endangered pyramid pigtoe mussel is listed only by the state of Mississippi. It has been documented in several counties including two counties that border the Mississippi River; Washington and Warren counties. The Gerald Andrus and Baxter Wilson Plants are located in these two counties, respectively. This species has not been documented in any of the impingement studies reviewed therefore their potential for impingement and/or entrainment appears very minimal. This species was retained as a species of concern due to their historical presence near the above mentioned two plants.

Fat pocketbook

The endangered fat pocketbook mussel is listed statewide for both Arkansas and Mississippi and by the USFWS. This species has not been documented in any of the impingement studies reviewed therefore their potential for impingement and/or entrainment appears very minimal. According to the USFWS (1997), today the fat pocketbook is found only in the lower Wabash and Ohio rivers, and in the lower Cumberland River. Impoundments and dredging for navigation, irrigation and flood control have altered or destroyed much of this mussel's habitat, silting up its gravel and sand habitat and probably affecting the distribution of its fish hosts. This species was retained for further consideration due to its wide historical range and state-wide listing.

This mussel prefers sand, mud, and fine gravel bottoms of large rivers. It buries itself in these substrates in water ranging in depth from a few inches to eight feet, with only the edge of its shell and its feeding siphons exposed (USFWS 1997).

Reproduction requires a stable, undisturbed habitat and a sufficient population of fish hosts to complete the mussel's larval development. When the male discharges sperm into the current, the females downstream siphon in the sperm, in order to fertilize their eggs, which they store in their gill pouches until the larvae hatch. The females then expel the larvae. Those larvae that manage to find a host fish to clamp onto by means of tiny clasping valves, grow into juveniles with shells of their own. At that point they detach from the host fish and settle into the streambed, ready for a long (possibly up to 50 years) life as an adult mussel (USFWS 1997).

Paddlefish

Paddlefish, which were once prevalent in all of the tributaries of the Mississippi River, have been in decline due to habitat destruction and river modification, and were proposed for listing under the Endangered Species Act (ESA) in the 1990s. Although they were not listed under the ESA, trade in paddlefish became regulated under the CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora in 1992. Fish and Wildlife studies and state reviews caused several states to list and protect paddlefish, while adjacent states continued to maintain sport and commercial fisheries. This interstate problem was addressed in the 1991 founding of the Mississippi Interstate Cooperative Resource Association (MICRA) and its development of regional plans and research projects. MICRA continue to address the issues of inter-jurisdictional problems posed by the migratory paddlefish (Rasmussen and Graham 1998).

In Louisiana and Mississippi the paddlefish is given an S3 ranking (National Heritage Ranking System) which means it is rare and local throughout the state, or found locally (even abundantly at some of its locations) in a restricted region of the state, or because of other factors making it vulnerable to extirpation (21 to 100 known extant populations).

Populations still occur in 22 states. Fourteen states allow sport fishing for paddlefish while only six states allow commercial harvesting. Ten states currently stock paddlefish to supplement natural populations or re-establish paddlefish in areas where they had formerly occurred (Graham 1997). Schramm (2004) stated that this species is occasionally taken in the LMR. He also states that the paddlefish is a riverine dependent species that is most likely to be found in all three major habitat zones (river channel, channel bank, and backwaters).

Paddlefish spawn in the spring and usually require fast flowing water (floods which lasts several days), and clean sand or gravel bottoms for successful spawning. During spawning paddlefish gather in schools. Young fish grow quickly, as much as six inches in several months. Fish generally become mature at 5-10 years and may live to be 20-30 years old. Paddlefish are plankton feeders inhabiting open waters where they can filter large quantities of water (Chilton 1997).

Paddlefish have been documented in several of the LMR impingement studies reviewed in this Appendix. At Waterford 1 & 2 four paddlefish were impinged in June/July 1976; at Willow Glen (Unit 1 & 2) 5 individuals were impinged in June/July 1975; at Willow Glen (Unit 4) 2 individuals were impinged in July and December 1976; and at Baxter Wilson 104 individuals were impinged in 1973/1974 throughout the year. Although paddlefish numbers have declined the past several decades, impingement rates today are not expected to be at this same level. However, the data indicate paddlefish do utilize habitats near intake screens in the LMR; therefore, they are a species of concern.

4.0 CHARACTERIZATION OF ALL LIFE STAGES [125.95(B)(3)(II)]

The rule calls for the characterization of all stages that might be subject to impingement and, if appropriate, entrainment. This characterization is necessary to ensure the full scope of any potential impact is understood and that any implications for selection of mitigation measures are known. Entergy believes that the general literature supports understanding of the potential impacts to all life stages. As importantly, the impingement studies that are available were designed to facilitate understanding of diel and annual variations.

4.1 Life Stages Subject to IM and E

Life stages subject to entrainment are determined primarily by intake screen mesh size which is typically ⅜". Any life stage of fish or invertebrates less than the screen mesh size, is subject to entrainment including egg and post-larval individuals. Eggs are more susceptible as they lack any swimming capabilities. Post-larval organisms do have some swimming capabilities, although limited, and can at times escape the approach velocity associated with CWIS. As the organism grows larger than the mesh size of the CWIS screens, they become subject to impingement.

Most of the plants considered in this Appendix are only subject to performance goals for impingement mortality. The requirement to control entrainment is dispensed due to the low proportion of average annual river discharge used by the plant. US EPA concluded that, under this circumstance, any entrainment loses are likely to be minimal relative to the existing population.

Life stages subject to impingement include all stages greater than the intake screen mesh size. Impingement varies with species but young of the year (YOY) individuals dominated historical LMR impingement studies (based on length and weight data and observations). Exceptions were smaller species that typically do not exceed several inches in length even as adults. Current anecdotal observations also indicate that YOY currently dominate impingement at LMR CWIS. Impingement data from other water bodies (including Galveston Bay) also show a dominance of YOY on traveling water screens compared to adult organisms. Due to the placement of trash racks and debris screens on intake pipes, and due to their ability to out-swim intake approach velocities, larger organisms are not typically subject to impingement. Some exceptions include invertebrates (e.g., shrimp, crayfish, blue crab) which are generally smaller than fin-fish and have reduced swimming abilities. Adults of these species may become impinged in addition to juveniles.

Length data collected during the 1970's impingement studies demonstrate that YOY or juveniles typically dominate impingement. Average lengths for impinged individuals are as follows: gizzard shad (11.5 cm), threadfin shad (6.3 cm), freshwater drum (8.6 cm), blue catfish (8.7 cm), river shrimp (5.6 cm), channel catfish (7.2 cm), bluegill (4.6 cm), skipjack herring (11.9 cm) and common carp (39.9 cm) (Table B-2). Lengths for all of these species, except the common carp, are more typical of younger individuals than for adults.

4.1.1 Review of Impingement Data at the Freshwater Plants

Historic impingement data from Baxter Wilson, Waterford Units 1 and 2, Willow Glen Units 1 and 2 and Unit 4 are summarized in Table B-4. Impingement rates were calculated based on effort and flow. Impingement rates calculated based on effort resulted in an estimate of the number of organisms impinged per sampling event (typically 24 hours in duration) that was then extrapolated to an annual rate. The impingement rates calculated based on flow resulted in an estimate of the number of organisms impinged per volume of water sampled during the study, which was standardized to 10,000 cubic meters.

<u>Baxter Wilson Impingement Study</u>

Between March 12, 1973 and August 20, 1973, and between August 31, 1973 and March 1, 1974, an impingement study was conducted at Entergy's Baxter Wilson plant (Mississippi River mile marker 433.2 AHP) (MP&L 1974). The study was conducted to verify estimates of fish impingement for the Grand Gulf Nuclear Station. The data for this study was compiled and

submitted in two separate documents. Samples for the spring through summer 1973 were collected daily for the first two months and thereafter twice a week for either 24 or 48 hours and resulted in the collection of 36,326 fish and 1,186 invertebrates (37,512 total). Fifty-four fish species and twelve species of invertebrates were collected in the study. The samples for the August 1973 through March 1974 collection period consisted of a total of 18 sample days at Unit 1 and 14 sample days at Unit 2. A total of twenty-five species of fish and eight invertebrate species were collected (2,517 total individuals). With few exceptions, all of the fish were juveniles. The exceptions were the minnows, threadfin shad, bullheads and an occasional mature species of a larger fish such as gar or suckers. The majority of the river shrimp, however, were mature adults (MP&L 1974).

The shad species (gizzard, threadfin, and shad *spp.*) dominated impingement rates representing 56.3% of the total abundance followed by freshwater drum (31.7%), carp (2.7%), river shrimp (2.6%), white crappie (1.5%), sucker (1.3%), channel catfish (0.7%) and skipjack herring (0.4%). The estimated annual impingement rate is 160,730 individuals which equates to 1.96 individuals per 10,000 m^3 of water pumped through the plant.

Impingement rates were higher for Unit 2 by a ratio of 3.5 to 1 prior to July and 1.3 to 1 after July (March through July 1973). The differences observed in impingement rates between Unit 1 and Unit 2 were explained by two factors; (1) differences in design between the CWIS; and (2) differences in intake velocities (Unit 2 was higher) (MP&L 1974).

From March through June average daily impingement was relatively low (average of 25.6 organisms per day at the combined units). A sharp increase began in late June and peaked in mid-July reaching 3,916 organisms per day at Unit 1 and 4,952 organisms per day at Unit 2. By the end of August rates returned to pre-July values. The increased rate of impingement in mid-July was likely precipitated by two factors: (1) river stage decreased below flood stage, resulting in increased fish density in the river's main channel and (2) the importance of juveniles in the population. One of the effects of flooding is decreased fish density in the river proper, particularly during the reproductive period, as fish disperse into flooded backwaters. When the river returns within its banks, fish densities increase again. (MP&L 1974). Another factor contributing to the increased impingement in July is that larval fish, which previously were entrained in the spring, had grown significantly and were more prone to being impinged. In addition, these juvenile fish were more susceptible to impingement, due to their reduced swimming speed.

The decline in impingement after the mid-July peak was probably caused by the following two factors. YOY fish typically have an annually mortality rate of 95 to 99% and many of the fish died; and as the fish grow their swimming ability increases and they can avoid being impinged (MP&L 1974).

Waterford 1 and 2 Impingement Study

Espey, Huston and Associates, Inc. (1977) conducted a study between February 1976 and January 1977 at Entergy's Waterford Unit 1 and 2 CWIS. The purpose of the investigation was to evaluate the impact of the existing intake structures on the biota of the Mississippi River. The facility is located at Mississippi River mile marker 129.9 on the west descending bank of the Mississippi River in Killona, Louisiana. Impingement sampling was conducted for 24 hours every two weeks for one year for a total of 24 samples. The report generated from this study includes individual lengths and weights for all species for each sampling event.

Results of this study show that many more fish were impinged compared to invertebrates. Total sample weight for each 24-hour sample ranged from 3,593 grams to 33,560 grams. Organisms varied in length from 25-30 mm to over 600 mm for some of the carp and American eels. River shrimp dominated numerically and represented 49.7% of the total abundance followed by blue catfish (20.3%), threadfin shad (10.5%), bay anchovy (6.0%), freshwater drum (4.5%), gizzard shad (2.9%), skipjack herring (2.4%), channel catfish (2.1%), striped mullet (0.3%), and blue crab (0.2%). These ten species represented 98.7% of the total abundance. Annual impingement rates were estimated to be 336,454 individuals which equates to 4.33 individuals per 10,000 m^3 of water pumped through the plant.

Willow Glen Plant

The Willow Glen Plant is located on the Mississippi River near mile marker 201.6 AHP. Units 1 & 2 and Unit 4 were sampled individually. The sluiceways were sampled for thirty-minutes four times per day, and four times per month (April-July) or two times per month (remainder of the year) between January 1975 and January 1976. The screens were rotated just prior to each sampling and, taken together; these samples represent a complete characterization of impingement over the relevant 24-hour period. Impingement rates based on flow were calculated individually for Units 1 & 2 and Unit 4 and then weighted to estimate the annual impingement when all five units were in operation. The annual weighted impingement was estimated to be 126,449 organisms per year, assuming maximum operation of all five units.

Unit 1 and 2

River shrimp represented 57.3% of the total abundance followed by freshwater drum (22.1%), gizzard shad (5.7%), threadfin shad (5.1%), crayfish, *procambarus spp.* (2.6%), blue catfish (2.4%), black crappie (0.7%), skipjack herring (0.6%), bluegill (0.6%), and white crappie (0.5%). These top ten species represented 97.4% of the total abundance. Using the figures from this study, annual impingement at Units 1 and 2 is estimated to be 26,210 organisms based on effort. Using the flow information recorded during the study, the impingement rate was 1.47 individuals per 10,000 m^3 of water pumped through the two units or 50,013 organisms per year.

Biomass and total abundance were analyzed for seasonal differences. Biomass varied somewhat throughout the year, however it was much higher in the spring and early summer (mid-March through early July) compared to the rest of the year. Total abundance showed similar trends with much higher rates in the summer (mid-June through early August). The river shrimp contributed much of the observed seasonal difference observed.

Unit 4

River shrimp also dominated the collections at Unit 4 and represented 27.5% of the total abundance followed by crayfish (27.0%), freshwater drum (12.5%), gizzard shad (9.3%), threadfin shad (7.5%), blue catfish (5.8%), bluegill (1.4%), white crappie (1.4%), channel catfish (1,2%) and skipjack herring (0.9%). These ten species represented 95.4% of the total abundance. Based on effort the annual impingement at Unit 4 is estimated to be 5,037 organisms. Using the flow information recorded during the study, the impingement rate was 0.13 individuals per 10,000 m^3 of water pumped through the Unit or 5,897organsims per year.

Total abundance showed similar trends observed at Unit 1 and 2 with higher rates in the summer (mid-June through early August). River shrimp and crayfish contributed much to this apparent peak in the warmer months of the year.

4.1.2 Review of Impingement Data at the Brackish Plants

A.B. Paterson Plant

The A.B. Paterson (Paterson) Plant is located in the New Orleans Parish on the Inner Harbor Navigational Canal (IHNC) just south of Lake Pontchartrain. The IHNC splits from the Mississippi River near mile marker 92.6 AHP. A total of 523 samples (10-minute samples collected every 4-hours every other Thursday) were collected between August 1977 and December 1979 at the plant. Again, the samples can be grouped to represent a complete characterization or the impingement rate for a 24 hour period. A total of 68 species were collected from the sluiceway during the study. Atlantic croaker represented 32.3% of the impinged organisms followed by bay anchovy (17.1%), white (sand) seatrout (12.6%), blue crab (10.5%), Gulf menhaden (6.6%), sea catfish (4.5%), white shrimp (2.4%), spot croaker (1.9%), spotted seatrout (1.8%) and hogchoker (1.1%). These ten species represented 90.7% of the total abundance in the study.

Using the figures from this study, annual impingement is estimated to be 226,489 organisms which equates to 5.42 individuals per 10,000 m^3 of water pumped through the plant. Weighted extended survival of the primary species impinged at the facility show that 37% of the organisms will survive impingement which significantly reduces any potential adverse impact created by the plant. Results of this study showed that "during 1978-1979 estimated impingement impact for both stations (Patterson and Michoud) is less than the estimated impact of one local commercial

fisherman operating half the time during the shrimping season". Estimated impingement impact of the Paterson Plant was 2.5% (1978) and 0.5% (1979) of 1 commercial fishing boat.

Since samples were collected every four hours, potential daily (diel) impingement fluctuations were analyzed. Minimum impingement rates were observed at 0400 and 2400 at Unit 1; 0400 and 1600 at Unit 3 and 0400 and 2000 at Unit 4. Maximum impingement rates were observed at 0800 at Unit 1; 2000 at Unit 2; 0800 and Unit 3; and 0800 at Unit 4. Although impingement rates were somewhat variable depending upon the unit, the very early hours of the day (0400) showed the lowest impingement rates, and the mid-morning hours (0800) had the highest impingement rates. Potential seasonal variations were also analyzed at the plant and it was determined that the impingement rates were higher January through March in 1978 and in January in 1979.

Michoud Plant

The Michoud Plant is also located in the New Orleans Parish on the Intercoastal Waterway (ICWW) which splits from the Mississippi River near mile marker 92.6 AHP. A total of 666 samples were collected at this plant between August 1977 and December 1979 (10-minute samples collected every 4-hours every other Thursday). A total of 91 species were collected from the sluiceway during the study. Atlantic croaker represented 21.5% of the organisms collected followed by white shrimp (20.0%), bay anchovy (13.5%), brown shrimp (10.5%), blue crab (9.0%), sea catfish (7.8%), white seatrout (4.2%), gafttopsail catfish (1.8%), least puffer (1.6%) and blackcheek tonguefish (1.4%). These ten species represented 91.2% of the total abundance in the study.

Using the figures from this study, annual impingement is estimated to be 1,676,726 organisms which equates to 9.41 individuals per 10,000 m^3 of water pumped through the plant. Weighted extended survival of the primary species impinged at the facility show that 57% of the organisms will survive impingement which significantly reduces any potential adverse impact created by the plant. Results of this study were the same as the Patterson Plant study that showed "during 1978-1979 estimated impingement impact for both stations (Patterson and Michoud) is less than the estimated impact of one local commercial fisherman operating half the time during the shrimping season". Estimated impingement impact of the Michoud Plant was 12.7% (1978) and 2.2% (1979) of 1 commercial fishing boat.

Since samples were collected every four hours, potential daily (diel) impingement fluctuations were also analyzed at the Michoud plant. Minimum impingement rates were observed at 0400 and 1600 at Unit 1; 0400 and 1600 at Unit 2 and 1600 at Unit 3. Maximum impingement rates were observed at 0800 at Unit 1, 2, and 3. Although impingement rates were somewhat variable depending upon the unit, the very early hours of the day (0400) and mid-day (1600) showed the lowest impingement rates, and the mid-morning hours (0800) showed the highest impingement rates, consistent with the Paterson data.

Seasonal variations were also analyzed in this study and it was determined that impingement rates were highest in April, August and September in 1978, and in February and May in 1979.

4.2 Temporal variations in IM and E

Understanding of the temporal variations in impingement and entrainment is important for two potential reasons:

- In order to characterize accurately impacts of impingement mortality and entrainment. For example, if impingement events were more significantly common during the night, failure to sample during both day and night would bias the daily estimates of impingement. Entergy believes that the existing data sets address this issue by inclusion of sampling throughout the year as well as both day and night conditions.

- In order to assess whether periodic flow reduction might serve as a mitigation measure. For example, if it can be demonstrated that impingement mortality occurs during a specific season and the plant can be idled or run with reduced cooling water flow during that period, this might present an effective mitigation strategy. At this point, Entergy is not able to commit to such operational measures.

4.2.1 Annual

Temporal variations in IM and E are the result of both biological factors (e.g., spawning season, migrations, etc.) and non-biological factors (e.g., river stage, plant operational status, etc.). Due to the multitude of factors that can potentially affect impingement mortality and entrainment at a given location, temporal variations are difficult to ascertain. Specific knowledge of the waterbody, plant CWIS, and the dominant species in the area can allow temporal variations to be estimated. Much of this information is available from the literature. One obvious factor that can affect impingement mortality and entrainment, and which takes precedent over biological factors is the operational status of a plant. With the exception of nuclear, many plants operate on a "peaking reserve" status and only operate on a limited basis when energy production is needed. Typically power demand increases in summer, thus increasing impingement mortality and entrainment rates during the warmer months due to the increase in water withdrawal. As noted above, none of the Entergy plants can commit to such seasonal reductions in capacity. It should also be noted that the data available from the plants were collected during normal operating conditions and, therefore, do not reflect any bias associated with differential plant operation.

Spawning season is one of the most important biological factors affecting impingement mortality and entrainment rates. The primary period of reproduction and peak abundance of most LMR taxa is during the months of spring (typically March through May). The peak time of egg recruitment is during early spring, while larval recruitment is primarily late spring and early summer. Spring and summer therefore appear to be the most important seasons in the LMR in

regards to entrainment as this is the time eggs and larval organisms are most abundant. Many of these organisms will be able to avoid entrainment later in the year as they grow larger, and increase their swimming ability.

It is interesting to note that the spawning period in the LMR correlates to the seasonal flooding/high water period. At the Waterford Unit 3 plant, for example, seasonal average flows have been calculated to be 580,000, 650,000, 280,000 and 240,000 cfs for winter, spring, summer, and fall, respectively. Elevated flows most likely push the eggs and larval fish past the CWIS more so than the rest of the year due to increased velocities.

In the Baxter Wilson impingement study previously discussed, it was observed that daily impingement was relatively low from March through June, with a sharp increase in late June peaking in mid-July. The increased rate of impingement in mid-July was likely precipitated by the reduction in river volume and the growth of juvenile fish. The reduction in impingement after mid-July was most likely caused by high natural mortality associated with most species, and an increase in swimming ability.

In the Waterford 1 & 2 study previously discussed, the most abundant species were also analyzed for seasonal variations in impingement rates. River shrimp were much more abundant from April through October with very few individuals impinged in the winter and early spring. The species with the most noticeable seasonal variation was bay anchovy which averaged well below 100 organisms per 24-hours except for the October 1976 sample where a marked increase occurred to 1100 individuals per 24-hours. Blue catfish impingement rates were variable throughout the year with no noticeable increase during any particular season, although winter rates were the highest observed. Freshwater drum showed an increase in impingement rates primarily during the summer (June through September). Threadfin shad impingement rates were relatively constant except for an increase in July and an increase in the winter months (December through January). Gizzard shad impingement rates were constant throughout the year except for a slight increase in the early winter from November through January. When all species were considered, there was no apparent seasonal difference in impingement rates, although temporal variations were observed with individual species.

Biomass and total abundance were analyzed for seasonal differences at the Willow Glen plant as well (Unit 1 & 2, and Unit 4). Biomass was variable, however higher values were observed in spring and early summer (mid-March through early July) compared to the rest of the year. Total abundance showed similar trends with higher rates in the summer (mid-June through early August). River shrimp and crayfish contributed much to this apparent peak in the warmer months of the year.

Potential temporal (seasonal) variations were also analyzed at the Paterson plant and it was determined that the impingement rates were higher January through March in 1978 and in

January in 1979. Seasonal variations at the Michoud plant showed higher impingement rates in April, August and September in 1978, and in February and May in 1979.

4.2.2 Diel

As discussed previously, samples were collected at the Paterson Plant every four hours. Although impingement rates were somewhat variable depending upon the unit, the very early hours of the day (0400) showed the lowest impingement rates, and the mid-morning hours (0800) had the highest impingement rates.

Although impingement rates were variable at the Michoud Plant and were unit dependent, minimum impingement rates were typically observed in the very early hours of the day (0400) and mid-day (1600). The mid-morning hours (0800) showed the highest impingement rates consistent with the Paterson plant data.

Diel variations observed are most likely caused by species-specific daily patterns associated with rest and feeding periods. Organisms are much more active and mobile when feeding, and therefore have a higher chance of becoming impinged during these periods. In general most aquatic organisms are more active in the morning hours at daybreak which was demonstrated at the Paterson and Michoud Plants.

4.2.3 Importance of Temporal Variations

Power plants typically operate at consistent levels due to electricity demand and to reduce equipment stress and Operation & Maintenance (O&M) costs. For power plants that operate on an annual basis, temporal variations in impingement mortality and entrainment (both seasonal and diel) have no bearing on their operations. Since power plant production is driven by demand, which is typically higher in the warmer months, operational measures to specifically reduce impingement mortality and entrainment would be difficult to establish. Therefore, temporal variations have little bearing on the evaluation of potential mitigation measures. As noted above, Entergy believes that the available data were collected over the full range of diel and annual variation allowing for a complete assessment.

4.3 Spatial Differences in IM and E

Spatial differences in population densities are caused by many factors including habitat, water depth, and velocity. Most studies show higher fish densities at the channel bank and backwaters compared to the main channel. This is primarily due to increased habitat area, shallow water depths, and reduced river velocities. Beckett and Pennington (1986) stated that densities of larval fishes in the LMR are highest in backwaters, which are important nurseries for fishes, and which contain a larval fish assemblage differing from that of the main-stem river. Although the LMR provides plentiful habitat for fishes that thrive in swiftly flowing water, few species can tolerate the

high current velocities of the upper and middle water column of channel areas for very long. Most fish prefer the channel bottom where current is slower (Baker *et al.* 1991). Most fishes likely inhabit areas near the banks, and most generally prefer the shallow, slower inside edge of a river as opposed to the deeper, faster current of the cut-bank edge (Pennington *et al.* 1983 and Sempra 2002). Since many fish exhibit specific preference for certain types of habitat, stream or river locations with diverse habitats may be expected to contain more fish species than locations with fewer habitat types (Schlosser 1982; Angermeier and Karr 1984; Reeves *et al.* 1993).

Since many fish species feed on invertebrates, their habitat preference is important as well. Rocky substrates associated with dike structures on the LMR support higher total densities of aquatic invertebrates than abandoned channels, natural river banks, dike fields, temporary secondary channels, sandbars, revetted banks, main channel, and permanent secondary channels (habitats listed in order of decreasing invertebrate density) (Wright 1982). This apparent habitat preference for invertebrates further substantiates the fact that most fish will be associated with closer inshore (bank) habitats than deeper offshore habitats.

During the development of the Phase I 316(b) rules, the US EPA specifically notes that the selection of the location of the CWIS is one construction and design technology which can be used to minimize the impact of impingement mortality and entrainment (Sempra, 2002). The Phase II 316(b) rule also allows the highest density of organisms in the vicinity of the CWIS to be used as the Calculation Baseline. Using the reasoning for the Phase I rule and the Phase II Calculation Baseline, the location of *existing* intake structures (away from shoreline and in high velocity waters) could be used to "claim" credit for the reduction of impingement mortality and entrainment.

For Sempra's Phase I 316(b) Comprehensive Demonstration Study on the LMR near Mississippi River mile marker 132 AHP, they selected an offshore (between 150 and 675 feet depending on river stage) "middle" depth (between 16 and 30 feet depending on river stage) location for the CWIS for the sole purpose of minimizing the number and species of fish affected.

Most of Entergy's plants located on the river have their CWIS in a similar location.

4.3.1 Review of Habitats

Preferred habitat is defined as an area or habitat that an animal frequents most often, due to the unique characteristics of the habitat. Baker and his colleagues (Baker *et. al.* 1991) conducted an extensive study on aquatic habitats and fish communities in the LMR in which they identified all the potential habitat types found in the LMR and the species that prefer each habitat. The researchers found 13 distinct aquatic habitat types with six of these in the river main-stem (channel, natural step bank, revetted bank, lotic and lentic sandbars) and seven associated with the floodplain (e.g., seasonally inundated floodplain, oxbow lake, pond). Although individual sites within the river are frequently modified by many variables (erosion, deposition, etc.), the variety,

distribution, and characteristics of the preferred habitats remain constant over time, unless the river undergoes a fundamental change in either flow or sediment load (Sempra 2002).

Habitat preference for adult fish is summarized for the dominant species impinged in the 1970's studies conducted at the Entergy plants along the LMR. Gizzard shad are considered abundant (A) or common (C) in all habitat zones except for the channel where they are considered uncommon (U). Threadfin shad are considered abundant or common in most habitats except lotic sandbars where they are considered uncommon. No ranking was given for threadfin shad in the channel. Freshwater drum are considered abundant or common in all habitats except floodplain ponds where they were not given a ranking. Freshwater drum are considered common in the channel. Of the 133 species analyzed in the Sempra 316(b) CDS (Sempra 2002), 48 species (only 36% of the species) were assigned a ranking for the main channel. Twenty-three (23) species are considered probable (P) and likely to occur but records are lacking or inconclusive; 8 species are considered common; 8 species are considered uncommon; 5 species are considered abundant (shortnose gar, blue sucker, small mouth buffalo, blue catfish and flathead catfish); 3 species are considered rare; and 1 species (striped bass) is considered typical (T) in the channel where it occurs regularly but in low numbers.

4.3.2 Differences in Fisheries Population Densities

The following section discusses the differences in population densities of the different relevant habitats as they relate to the CWIS at the different Entergy plants.

4.3.2.1 USGS

No comprehensive ichthyofaunal surveys have been conducted on the LMR in at least the past 30 years (Schramm 2005, personal communication). The most difficult habitat to sample is the main channel, where current velocities and debris load are highest, and extensive commercial navigation occurs. Because researchers historically could not effectively sample the main channel, relatively little is known about the extent that fish use this habitat (Illinois Natural History Survey-INHS 1997). A current assessment of Mississippi River fishes was compiled from four different sources and reviewed by six ichthyologists familiar with Mississippi River fauna (Schramm 2004). Mr. Schramm notes the lack of *standardized* habitat classification for Mississippi River fishes. He therefore assigned one or more of three habitat zones to each species: main channel, channel border, and backwater. He defines the habitat zones as follows:

- Main channel - the portion of the river that contains the thalweg and the navigation channel where the water is relatively deep and the current, although varying temporally and spatially, is persistent and relatively strong;

- Channel border - the zone from the main channel to the riverbank. Current velocity and depth will vary, generally decreasing with distance from the main channel, but the channel

border is a zone of slower current, more shallow water, and greater habitat heterogeneity. Channel border includes secondary channels and sloughs, islands and their associated sandbars, dikes and dike pools, and natural and revetted banks;

- Backwater zone - includes lentic habitats lateral to the channel border that are connected to the river at least some time in most years. This zone includes abandoned channels (including floodplain lakes) severed from the river at the upstream or both ends, lakes lateral to the channel border, ephemeral ponds, borrow pits created when levees were built, and the floodplain itself during overbank stages.

Fishes are considered backwater dependent if they require conditions such as little or no current, soft-sediment bottom, or aquatic or inundated terrestrial vegetation during at least some portion of their life cycle. Riverine-dependent fishes are those that require flowing water and sand, gravel, or rock substrate during at least some part of their life-cycle; these conditions may be found in the main channel or channel border zones. Schramm considered species peripheral (channel border) to the Mississippi River if available life history information indicated that the species inhabits tributary rivers or streams, prefers small rivers or streams, or avoids or is rare in large rivers.

Of the 137 resident species that Dr. Schramm researched, he was able to assign border habitat to 24 species and backwater habitat to 50 species. No species were expected to reside in main channel habitats throughout their life-cycle. The following fish species are noted by Schramm as 'backwater dependent' species: gizzard and threadfin shad, common carp, bluegill, largemouth bass, black and white crappie. The following were noted to be 'riverine dependent' species: pallid sturgeon, shovelnose sturgeon, paddlefish, river carpsucker, and freshwater drum. The following species were also noted by the author as species that were abundantly taken in most surveys in the open river segments of the Mississippi River: gizzard and threadfin shad, emerald shiner, river carp sucker, smallmouth buffalo, blue catfish, flathead catfish and freshwater drum. Other species commonly taken in the open river include: longnose and shortnose gar, skipjack herring, red shiner, river shiner, common carp, silver carp, speckled chub, silver chub, bigmouth buffalo, channel catfish, brook silverside, warmouth, bluegill, and largemouth bass.

Fish production on the LMR has not been estimated and biomass estimates are highly variable but tend to range from 300-900 kg/ha^{-1}. Schramm (2004) stated that standing stocks in the LMR appear greater than the UMR. He reviewed biomass results from 5 studies that sampled, in a consistent and comparable fashion, 13 different habitats and noted the following:

- The lowest biomass estimate (21 kg/ha) was in the main channel (Dettmers *et al.* 2001) compared to the channel borders and backwaters that often exceeded 500-600 kg/ha. One backwater (abandoned channel not connected to river) habitat sampled resulted in a biomass estimate of 911 kg/ha (Lowery *et al.* 1987). The highest observed ratio of observed biomass densities between the river main stem and other habitats is 21 kg/ha/327 kg/ha or 6.4%, a 93% implied reduction with movement from the river side to

the main flow. Other, higher biomass estimates would yield even larger estimates of reduction.

INHS scientists, in collaboration with the USGS and the USACE, sampled the fishes in the main channel of the Mississippi in 1996 with a specialized trawling vessel (INHS 1997). In the Mississippi River near Grafton, Illinois, 24 fish species were collected. Abundant species included freshwater drum, channel catfish, gizzard shad, smallmouth buffalo, and carp. Other fishes caught less frequently in the main channel included the shovelnose sturgeon, lake sturgeon, and blue sucker. The researchers note that many of the fish use the main channel during the entire year such as gizzard shad, channel catfish, and smallmouth buffalo as they are suited for life in fast-flowing river conditions. Many other fishes use the main channel only seasonally. The study's most diverse catches occurred in September and October when the river was at its lowest and temperatures were moderate. In these conditions, fish common to backwaters (e.g., bigmouth buffalo, shortnose gar, and black crappie) can be found in the main channel. Although this study focused on the fishes in the UMR main channel, the species are similar to those documented on the lower portions of the river (INHS 1997).

The river shrimp (Ohio shrimp), *Macrobrachium ohione,* was collected in high abundance during several of the 1970's impingement studies previously discussed. The Missouri Department of Conservation conducted a recent study of this species (Barko and Hrabik 2003) in the unimpounded Upper Mississippi River. In this study four physical habitats were sampled: main channel border, main channel border with wing dike, open side channel, and closed side channel. The objective of the study was to assess the association of river shrimp abundance with environmental factors and habitat types to understand the ecology of this species in a channelized river system. Ohio shrimp were most abundant in the open side channels. Inter-annual variability in catch per unit effort (CPUE) was observed with CPUE highest in 1996 and lowest in 2000. Approximately 8% of variation in Ohio shrimp abundance was explained by Secchi disk transparency (water turbidity). Current impingement rates for the Ohio shrimp in the LMR are most likely reduced at power plants with offshore CWIS compared to shoreline CWIS due to this species' apparent preference for side channel habitats compared to main channel border habitats.

4.3.2.2 Statements from Fisheries Researchers

After an extensive literature review two major conclusions can be made regarding fisheries in the LMR: (1) population density and diversity are higher at the channel bank and backwaters compared to the main channel; and (2) the overall fisheries in the LMR have not changed significantly since the 1970's. Several top fisheries researchers were contacted via telephone to verify these conclusions including Dr. Bob Kelso and Dr. Allen Rutherford with Louisiana State University Baton Rouge, LA; Dr. Jack Killgore with the U.S. Army Corps of Engineers (USACE) in Vicksburg, MS; Dr. Steve Gutreuter with the USGS in La Crosse, WI, and Hal Schramm with the USGS at the Mississippi Cooperative Fish and Wildlife Research Unit Mississippi State. A summary of the conversations is provided below.

Dr. Jack Killgore

Dr. Killgore stated that the fisheries in the Lower Mississippi River have remained relatively consistent since the 1970's, although the Upper Mississippi River (dammed portion) has undergone significant changes. In the LMR some species have declined including the pallid sturgeon and some of the sucker species; however, the overall community has changed very little. He stated he agreed that the most abundant species impinged in the 1970's studies (i.e., gizzard shad, threadfin shad, and freshwater drum) would be the same dominant species today. He stated gizzard shad is probably the most numerically and biomass dominant species on the river and "nothing can reduce their numbers".

Dr. Killgore also agreed that the density (abundance) and diversity of organisms is higher along the bank and backwaters compared to the main channel. He also agreed that the extension of power plant intake pipes offshore and in deeper waters would reduce the amount of impingement and entrainment. He followed by stating that most larval fishes and juveniles do not utilize the deeper portions of the river (Killgore 2005, personal communication).

Dr. Bob Kelso and Dr. Allen Rutherford

Both professors agreed that the abundance and densities of fish in the river have remained consistent over the last 20 to 30 years. Species we have identified from the literature are consistent with what we would find in the river today. Dr. Rutherford also indicated that there shouldn't be a significant change in fish composition until you get to Mississippi River Mile Marker AHP 90. This is the region of the river where significant mixing of salt water takes place. He did indicate that there would be influxes of estuarine species that are tolerant of fresh water as far upstream as Baton Rouge; however, these numbers are insignificant in comparison to the overall abundance in the river. As noted above, this is very consistent with the observed rates of impingement at the various Entergy plants located along the river.

Dr Kelso indicated that there would be a significant shift in abundance of fish and species diversity moving from the shoreline habitats out to the main channel of the river. Abundance numbers would drop by as much as 95%. Literature on the majority of the fish in the river should indicate that most of these fish are littoral in nature and require a significant level of structure which is not available in the main part of the channel. He further indicated that eggs and larvae associated with these species would also decrease proportionally. He stated most species spawn up near the shoreline habitats where there is structure, cover, and lower flow velocities.

Both indicated that species of fish occurring in the river are adapted to specific conditions occurring in the river. Most species, however, cannot sustain populations out in the main areas of the river due to the high velocities that occur there. Those few species that do occur in the main channel are usually fairly large in size, live close to the bottom, and have high swimming speeds, sufficient to avoid the intake structures (Kelso and Rutherford 2005, personal communication).

Dr. Steve Gutreuter

Dr. Gutreuter has been involved with several extensive projects involving sampling of the Mississippi River main channel (see Detmers *et al.* 2001). He agreed that abundance and diversity was lower in the main channel compared to the side channel and backwaters. He did indicate that more recent studies show higher biomass than previously seen in the main channel primarily due to better gear and calibration. He stated much of this biomass is due to the typically larger fish that inhabit the deeper waters of the main channel[2]. Dr. Gutreuter stated the more recent studies would not be published for at least one year, however he stated he was still comfortable with the general conclusions of the 2001 study (i.e., that population densities decrease sharply with movement into high velocity portions of the river) (Gutreuter 2005, personal communication).

Hal Schramm - USGS

Mr. Schramm agreed that fish abundance and diversity is typically higher along the shoreline compared to the main channel. He also stated that several groups are currently conducting fisheries research in the main channel of the LMR and they have been getting interesting results. Specifically, several minnow species apparently utilize the main channel more so than was previously thought. Therefore, Mr. Schramm does have concerns for these smaller species due to their potential for impingement and/or entrainment. He stated additional research is needed to better understand these species as well as the other larger species that utilize the main channel. Mr. Schramm stated that due to the extensive area (habitat) the main channel encompasses, impingement is likely to have only a relatively small effect on the fish populations.

Mr. Schramm also stated that the precision of fish abundance values in the LMR is usually very poor primarily due to sampling techniques that are size, and/or species selective. Nevertheless, he agreed that abundance of the primary species observed in the LMR in the 1970's impingement studies (i.e., fresh water drum, gizzard shad, threadfin shad) would probably be the most abundant species impinged today as their numbers have probably changed little over time (Schramm 2005, personal communication).

4.3.2.3 Data Presented by SEMPRA

In the Sempra (2002) study conducted at Mississippi River mile marker 132.2 AHP, it was determined that although there are 13 distinct habitat types found in the LMR, only a few dominate the river's landscape in the lower reaches. The researchers used the habitats developed by

[2]Such large fish are very likely to be able to resist impingement. A fact reflected in the very low frequency of impingement of large fish at Baxter Wilson, Waterford 1 & 2, and Willow Glen.

Baker and his colleagues (Baker *et al.* 1991) to determine a species' abundance potential in the study area. They defined Baker's 13 habitat zones as Habitat Zone Distribution which is the correlation of a species to their preferred habitat throughout their life cycle. Preferred habitat also includes Habitat Range Distribution, which is the water column distribution most favored by the species throughout their life cycle. This is a key correlation component of the Habitat Zone Distribution for each species to identify a high probability habitat.

In the Sempra study, six habitats were reviewed specifically to determine the number of fish species and eggs associated with each type. Each habitat zone was determined to have a reduced number (from 133 potential species found in the LMR) of fish, egg and larval species associated with the habitat. This further validates the fact that the placement of a CWIS can reduce both impingement mortality and entrainment due to the reduction of species utilizing the habitat. Habitat at each of Entergy's LMR plants should be evaluated in the future to determine the number of species that potentially use the habitat associated with the CWIS placement.

5.0 DOCUMENTATION OF CURRENT IMPINGEMENT MORTALITY AND ENTRAINMENT [125.95(B)(3)(III)]

The rule requires the estimation of current rates of impingement mortality and, when appropriate, entrainment. These data may be necessary to support three potential activities:

- Estimation of the CWIS performance relative to the Calculation Baseline;
- Assessment of additional mitigation measures; and
- Estimation of the monetized benefit of potential mitigation measures under the Cost-benefit test.

The Waterford 3 Plant proposes the use of the Cost-benefit compliance approach making this use of the data relevant. Most of the Entergy plants on the River will avail themselves, at least in part, of the Cost-cost test, the results of which are insensitive to the specific rates of impingement or entrainment. In addition, several of the plants, including Waterford 3 differ significantly from the Calculation Baseline by a simple and tangible measure: placement of the CWIS in the high velocities of the main channel. Thus, Entergy will pursue a weight-of-evidence approach based on Compliance Alternatives 2 and 5. We believe that these alternatives can be supported based on the available data. In particular, the Calculation Baseline to support Alternative 2 can be estimated based on relative population densities from the literature and the rates of impingement to support the Cost-benefit test will be estimated from the literature and the rates of impingement available from nearby plants adjusted for flow rates.

We believe that the data available on impingement at Baxter Wilson, Waterford 1 & 2, Willow Glen, Michoud, and Paterson are very likely to be representative of current conditions. In particular, the data were collected under the same plant operating conditions currently in effect and, as noted above, there is a consensus that the fishery of the LMR and the associated tidal channels has changed little since the data were collected.

5.1 Current Status of Fishery Population

The composition and relative abundance of the current fishery population is similar to population observed in the 1970s. This is consensus view from the literature as well as a group of experts that Entergy has contacted recently (see above). Based on this, Entergy believes that the available data will be adequate to support the goals of the rule and the development of an IMECs.

5.2 Current Rates of IM and E

The following discussion focuses on likely current rates of impingement mortality and, where appropriate, entrainment.

5.2.1 Anecdotal Evidence

Plant operations personnel were interviewed at each of the plants to determine the current levels of organisms impinged, dominant species impinged, seasonal and diel variations of organism impinged. Information provided for each plant indicates that shad (threadfin and gizzard), freshwater drum, catfish (blue catfish and channel catfish), river shrimp, and crawfish are the most abundant species observed on the screens for the plants in the freshwater regions of the river (including the plant farthest downriver, Ninemile). Species most abundant on the screens in the tidally-influenced segments (i.e., Paterson and Michoud) consisted of croaker, shad (gizzard and menhaden), anchovy, white shrimp, brown shrimp and blue crab. Observed abundances (screens are operated on average twice per day for 10 to 15 minutes each shift) of organisms on the screens are reported to be low. Plant personnel indicate that there appears to be an increase in organisms on the screens as the river begins receding after floods. This is similar to the behavior document at Baxter Wilson.

Seasonal variations were identified as being relatively low. Shad and catfish species appear to have the greatest fluctuations in abundance with the greatest peaks occurring during the summer and fall months. Diel variations could not be determined due to the operation of the screens at the same time each day (once in the morning and once in the evening).

No threatened and endangered species have been observed by plant operations personnel on the screens.

5.2.2 Summary of IM and E Data

Based on the available evidence, we believe that the historically observed rates of impingement (as summarized in Table B-4) serve as reasonable estimates of current impingement behavior. Given the position of the various stations along the river, it is likely to be productive to consider them in the hierarchy demonstrated in Table B-5.

5.3 Sufficiency of Historical Patterns/Densities of Fish

Biological data used to address current impingement mortality and entrainment rates for the plants located on the Mississippi River are derived from a series of impingement mortality and entrainment studies conducted at the identified power plants (Willow Glen, Baxter Wilson, Waterford 1 & 2, Waterford 3, A. B. Paterson, and Michoud) between the years 1973 and 1979. A total of six impingement mortality and entrainment studies were conducted in association with 9 plants located along the river. In general, these studies were conducted to evaluate and characterize the organisms impinged and entrained during the operation of each of these plants. Each of the studies was designed to quantify the number, species, rate, seasonality, and diel variations of impingement and entrainment occurring at each of the plants.

To date no other documented studies have been conducted at these plants by either the utility company nor by other state agencies and universities. The relevancy of the existing historical data can be shown to be representative of the species and relative abundances present in current conditions. The temporal data gap has been bridged by consulting with several leading authorities from the universities and the agencies concerning the relevance of the historical data. Dr. Rutherford and Dr. Kelso of Louisiana State University, Dr. Killgore of the USACE, and Hal Schramm with the USGS each indicated that the species characterization in the river has remained fairly consistent over the last 20 to 30 years and they would not anticipate a significant change in species for much of the river from well above the state of Mississippi down to Mississippi River Mile Marker 90 AHP, just southeast of New Orleans, where saltwater mixes with the freshwater and the habitat associated with the river becomes more estuarine in nature. Furthermore, they indicated that estimates of population densities (relative abundance) for the major species occurring in the river have remained relatively stable during the same time period. In addition, each mentioned the lack of quantitative data to fully assess the fishery in the Mississippi River.

Our review of the literature suggests the lack of data is due to the feasibility of safely and effectively designing and coordinating a sample program to fully assess the fishery. It is therefore, our opinion and the opinion expressed by Dr. Kelso, Dr. Rutherford, Dr. Killgore, and Mr. Schramm that the existing data reviewed for the development of this document is the most current and applicable dataset available and the data presented in these studies is in fact relevant to current and existing conditions at each of the plants. Furthermore, it is our opinion that data from

these plants can be used to support, supplement, and be used in lieu of data for other plants located on the river.

5.4 Representativeness of Historical Data

The riverine ecosystem of the Mississippi River has undergone many changes. Most of the natural changes have occurred gradually over hundreds of thousands of years, whereas human-induced changes have occurred rapidly and recently. Several factors have apparently contributed to the recent declines in the river's flora and fauna, including habitat loss and degradation, point and non-point pollution, toxic substances, commercial and recreational fishing and navigation, deterioration of water quality during drought periods, reduced availability of key plant and invertebrate food sources, and invasion of nonindigenous species (McHenry *et al.* 1984; Bhowmik and Adams 1989). Many of the biological changes observed in the Mississippi River have occurred over the past century and not just the last several decades. Johnson (1987), for example noted that many fish species such as the river sucker and blue catfish have declined in the UMR due to dredging extending back 150 years, and dam construction during the 1930's, which both had a dramatic effect on the availability of fast-flowing water and rock-bottom habitats. Although several key native organisms including submersed plants, native pearlymussels, fingernail clams, and certain fishes have decreased along substantial reaches of the river in recent years or decades, most species have changed little over time.

At present, the Mississippi River's native fish assemblage appears intact (Fremling *et al.* 1989; Gutreuter 1997; Weiner at al. 1998). Shramm (2005) states that although some species are considered rare, with the exception of sturgeon, sport and commercial fisheries show no signs of over fishing and may even support increased effort in harvest.

Schramm (2005) compiled four relatively current studies dated 1989, 1991, 1995, and 2000, and reported the abundance category of the fish species inhabiting the Lower Mississippi River. The most abundant fish species collected in the impingement studies discussed in this Appendix are as follows with their associated abundance category: gizzard shad, threadfin shad, freshwater drum, and blue catfish were all described as species that were abundantly taken in all river surveys. Carp, white crappie, skipjack herring, and bluegill were categorized as species that were commonly taken in most surveys. Since these species were the most abundant collected in the 1970's studies, and are still collected in abundance in the present day, we can conclude there have been no significant changes in the LMR fisheries since the impingement studies in the 1970's. The most abundant freshwater invertebrates collected were river shrimp and crayfish, which dominated the impingement samples at many of the plants. Their abundance in the present day is unknown.

Estuarine species and invertebrates were not analyzed in Schramm's study so abundance values could not be obtained for these species from his study. The most common estuarine species collected in the Michoud and Paterson impingement studies included white shrimp, Atlantic

croaker, bay anchovy, sand seatrout, blue crab, Gulf menhaden, sea catfish, and striped mullet. A search of the literature shows that these species are the dominant species in the LMR in the present day as well.

5.5 Sufficiency of Data to Estimate Calculation Baseline

A complete and thorough review of current and historical data was performed to assess the quantitative value of existing data and to determine if the basis of the data were sufficient to support estimating calculation baselines for the plants identified in this review.

Current data available in the literature suggests that existing research may not provide an adequate quantitative assessment of the existing fisheries in the river. Most of the studies conducted were designed to sample specific regions of the river, such as backwater areas and littoral zones, and to study specific species, such as the pallid sturgeon and paddle fish. Independently, these data may only provide a small subset of information on the overall fishery in the river. However, when looked at cumulatively, the extent of this data, combined with all the available data from the impingement and entrainment studies conducted at the plants, does provide a good qualitative assessment of the fish diversity and relative abundance in the river. Our findings have been corroborated by leading fishery biologists from LSU and the USACE.

Data collected in the previously discussed impingement and entrainment studies were initially evaluated based on operating condition at the time the study was conducted. These operating conditions are estimated to be at or near maximum operating capacity. Evaluating this data and applying it to current operating conditions requires several assumptions:

- Approach velocities and through screen velocities are assumed to be the same;
- Intake structures have not undergone any type of retrofit or substantial change in operation; and
- Densities of fish and shellfish and their diversity have not changed.

Based on the available information, we believe that each of these assumptions is valid. Therefore, the historical data can be deemed to be representative of current conditions.

Data reviewed in the literature and from existing impingement and entrainment studies provide a qualitative assessment of the fisheries in the Mississippi River and at the plants. These data provide an analysis of the fish assemblages, specifically juvenile and adult fish, occurring in different habitat zones associated with the river. The limits of this data include insufficient information pertaining to the egg and larval distribution associated with the identified adult species. However, this lack of data is not significant as entrainment rates are expected to be minor.

Since the spawning period for most LMR freshwater species occurs in spring and early summer, which is typically the time of the year for flood conditions, minimal entrainment rates are expected at the freshwater plants. This is primary due to the effects of dilution and swift currents which most likely will push the organisms past the CWIS. This concept is most likely to be observed at those CWIS located offshore and in swift waters. As discussed previously, velocities in the LMR often exceed 10 fps which is much greater than the CWIS approach velocities.

The lack of entrainment data at the estuarine plants (Michoud and Paterson) is also unlikely to have any relevance as minimal entrainment rates are expected at these plants as well. Minimal entrainment rates are expected based on the literature, and other estuarine entrainment studies in the upper Gulf of Mexico. The entrainment study (1974-75) conducted at Entergy's Sabine Plant located on Sabine Lake, Texas showed that copepods and barnacle nauplii dominated the samples. These organisms are extremely numerous in most estuarine systems and any reduction in their numbers would most likely not have any impact on their local populations. Fish eggs and larvae were apparently not found in any of the Sabine entrainment samples although fish, blue crab, and shrimp dominated the impingement samples. This is not surprising given the location of this plant and the spawning behavior of most of the fish species found on the screens and in Sabine Lake during the impingement studies. Many of these species spawn in the near-shore Gulf (croakers, menhaden) with the larval or juvenile stages entering the bays and migrating to the marshes, where they continue their growth and development. These species tend to be impinged as opposed to entrained because they are largely absent from the upper estuaries as larvae and eggs.

Similar to the Sabine Lake estuarine community, most of the species impinged at the Michoud and Paterson Plants either spawn off-shore in the Gulf (penaeid shrimp, Atlantic croaker, menhaden, etc.), or carry their fertilized eggs under their abdomen until they hatch (blue crabs). Moreover, female blue crabs migrate to areas of higher salinity than that found in the area of the Michoud and Paterson Plants, for their eggs to hatch. Consequently, entrainment of the eggs and larvae of these species is expected to be minimal at the Michoud and Paterson Plants.

6.0 SUFFICIENCY OF DATA IN SUPPORTING THE IMECS

6.1 Most Common Species Impinged/Entrained

The most commonly impinged species are listed in Table B-4 and described in Section III.

6.2 Implications for CWIS Placement, Design, and Operation

Entergy believes that the data available on the fishery of the Mississippi River provides important perspective on the historically observed rates of impingement at Entergy's power plants. There

are three sources of information that can support evaluation of impingement at Entergy's plants as well as understand the nature of the fishery of the Mississippi River:

- Site-specific data collected by Entergy during the 1970s. These data are very consistent with the goals of the rule. The potential for ecosystem changes to render them unrepresentative of current conditions should be considered, however a preliminary assessment has determined that minimal ecosystem changes have occurred since the data were collected.

- Data collected by other, nearby power stations on impingement rates. In some cases, these data sets are both more extensive and more current. The general patterns of impingement (e.g., relative frequency of species) are consistent with those observed from impingement studies conducted at Entergy plants in the 1970s. As importantly, the literature has been relatively consistent over the last few decades suggesting that the impingement data are still representative of current conditions.

- The general literature on fisheries of the Mississippi River. This literature can provide important background regarding the behaviors of important species such as the timing and distribution of their eggs and larvae, their likely survival upon impingement, their habitat preferences, etc.

When this literature is considered as a whole, we believe that there are sufficient data currently available to complete an IMECS consistent with the goals of the rule (see Section 4.2). The following conclusions relative to impingement can be drawn:

- The assemblage of impinged organisms changes with movement toward the Gulf of Mexico. At Baxter Wilson, the impinged organisms are strictly freshwater species. At Willow Glen, located 230 miles closer to the Gulf, one estuarine species appears among the ten most commonly impinged species. Seventy miles further downstream, three estuarine species are noted among the most commonly impinged. At Michoud and Paterson, located in brackish, tidally-influenced channels adjacent to the river, few organisms occur that favor freshwater.

- The fish species that dominated impingement at the Entergy stations are also very important in the ambient surveys at similar locations. These include threadfin and gizzard shad, freshwater drum, and river shrimp which account for the vast majority of impinged organisms at the freshwater stations and Atlantic croaker, bay anchovy, and blue crab at the brackish water stations. Some species that are important in ambient surveys (notably catfish, carp) are under represented among impinged fish likely due to their strong swimming ability and/or their avoidance of the habitat near the CWIS.

- While water quality has improved since the 1970s surveys, other factors potentially affecting the fishery have been little changed. Most notably, management of the river for shipping and flood control has been consistent and invasive species have remained well established.

- The species makeup of the fishery of the LMR has been relatively constant over the last several decades. This suggests that improvements in water quality have not greatly changed the types of fish present in the river. This trend is evident in the literature and has been confirmed by direct communication with the relevant experts.

- The rates of impingement observed at Entergy stations during the 1970s appear to be reasonable estimates of ongoing rates. There has been little or no change in the operation of the CWIS (although the capacity factor has been significantly reduced at most plants) and changes to the river and its fishery appear to be relatively minor. Anecdotal observations by the station operators confirm that the dominant impinged species are the same. Finally, the compliance strategies outlined at each of the stations are insensitive to modest changes in the rates of impingement or, when relevant, entrainment.

- The gizzard shad, threadfin shad, freshwater drum and bay anchovy do not tolerate handling well (as indicated by low rates of latent survival) and Atlantic croaker tolerates handling only moderately well. EPRI (2003) indicate that the median extended survival for freshwater drum and gizzard shad is 20% (8 studies) and 7% (43 studies), respectively. Extended survival rates were not available for threadfin shad but the median initial survival was only 15% (5 studies). The average extended survival for bay anchovy is 10% with an average initial survival of 30%. The median extended survival of Atlantic croaker, the most commonly impinged fish at the brackish water stations, was 36%. This suggests that any sort of fish handling and return system is not likely to achieve significant reductions in impingement, particularly for the three species that dominate impingement at the freshwater stations and bay anchovy, which is common at the brackish stations.

- Some other species, notably the crustaceans, survive handling much better. Data summarized by EPRI (2003) suggest that shrimp and crabs survive at rates of approximately 50% or better.

- The river's main channel harbors much lower densities of fish than the river's edges and backwaters. Data suggest that population densities in the main channel are less than 10% of what is observed in the backwaters. This trend appears to be a consensus view among fisheries biologists. The relatively low densities are driven by the high velocities and reduced preferred habitat, as well as significant suspended sediment load. This suggests that placement of the CWIS in the main channel is likely to significantly reduce the rates of impingement relative to placement along the shore or in a backwater.

- Annual variation in the rates of impingement may be significant. A significant change in impingement rate may be associated with the return of juvenile fish to the main channel following inundation of the flood plain. The annual cycle of the fish populations' age structure also may contribute in that juveniles are more susceptible to impingement. While this change was observed in one data set, it is notably absent from two others.

- The typical impinged fish is relatively small. The average fish impinged is on the order of 20 grams in mass (not including carp which average about 1500 g). This highlights the importance of juveniles in the impinged population, a group subject to high rates of natural mortality.

- State or federally listed species are not likely to be substantially impacted. Young paddlefish, a species of concern to several state agencies, were impinged in small numbers. Three pallid sturgeon were impinged at two stations. The effects, while small, may present an opportunity for restoration to improve their stocks in the river. Impacts to other species are not anticipated either in the riverine or estuarine plants.

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Table B-1
Results of Ambient Fisheries Assessment at Grand Gulf and Waterford 3 Plants

Study Title	Location	River Mile	Period of Sampling	Sampling Frequency	Sampling Duration	Sampling Location		Six Most Common Species
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 410	June 1972 - August 1973	Monthly		Main River - Stations 1, 3, 5, 6, 8 & 10		**Total 69.7%** - Gizzard shad (37.4%) freshwater drum (10.3%), blue catfish (8.3%), flathead catfish (4.9%), river carpsucker (4.8%) smallmouth bufallo (4.0%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 408	June 1972 - August 1973	Monthly		Near Shore - Stations 1 & 8		**Total 91.8%** - Threadfin shad (30.8%) emeral shiner (25.5%), river shiner (14.1%), silvery minnow (11.6%), shiner spp. (6.9%), cypress minnow (2.9%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 408	August 1973	Once		Near Shore - No current - Station 1		**Total 97.1%** - Threadfin shad (36.2%), gizzard shad (31.5%), silvery minnow (23.6%), red shiner (2.6%), cypress minnow (2.3%), shiner spp. (0.9%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 408	August 1973	Once		Near Shore - Moderate current - Station 1		**Total 79.0%** - Channel catfish (22.8%), silver chub (20.8%), mooneye (15.0%), freshwater drum (8.8%), shiner spp. (6.2%), silvery minnow (5.4%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 408	August & September 1973	5 trawl efforts conducted in August, 3 trawl efforts in September	15 minute tow (trawling)	Mississippi River Channel - Stations 3 & 6	Average Number of fish caught per hour: 37.07	**Total 91.7%** - Bluecatfish (29.2%), River shrimp (13.9%), shovelnose sturgeon (13.9%), Silver chub (12.5%), gizzard shad (5.6%), speckled chub (5.6%), grass shrimp (5.6%), channel catfish (5.6%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 410	September 1972 - August 1973	Dominant fish species in 3 macrohabitats		Backwater: Station 1		**Total 68.3%** - gizzard shad (30.2%), blue catfish (10.0%), river carpsucker (7.8%), freshwater drum (6.5%), Shovelnose sturgeon (6.0%), White crappie (5.8%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 410	September 1972 - August 1973	Dominant fish species in 3 macrohabitats		River Bank: Stations 3,5, 6, 8		**Total 86.3%** - gizzard shad (52.3%), freshwater drum (15.5%), silver chub (5.6%), flathead catfish (5.2%), blue catfish (4.9%), river carpsucker (2.8%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2	400 - 410	September 1972 - August 1973	Dominant fish species in 3 macrohabitats		Tributary: Station 10		**Total 68.3%** - gizzard shad (18.4%), shortnose gar (13.3%), blue catfish (12.4%), freshwater drum (11.0%), smallmouth buffalo (6.9%), Bowfin (6.3%)
Environmental Field Measurements Program	Grand Gulf Units 1 & 2		August 1973	Electrofishing	1.8 hours of effort	Hamilton & Gin Lakes	Average number of fish collected per hour: 275.3	**Total 94.3%** - bluegill (35.5%), threadfin shad (27.2%), gizzard shad (21.9%), sunfish sp. (3.8%), black crappie (3.1%), largemouth bass (3.1%)
Environmental Field Measurements Program - Larval fish	Grand Gulf Units 1 & 2	400 - 408	July 1973	Ichthyoplankton - Three replicate samples collected from surface using 0.505 mm mesh plankton net, twice per month	15 minute tow	Mississippi River Channel - Diurnal - Stations 3 & 6	Density of fish: 0.5415 per m3	**Total 92.4%** - Shad (42.0%), minnows (30.1%), drum (17.1%), crappie (2.6%), sunfish. (0.4%), sucker (0.2%)
Evaluation of the Waterford 3 Generating Station - Surveillance Program	Waterford 3	129.5	April 1973 - September 1976	Intermittently using a combination of gear types: surface trawls, otter trawls, gill nets and electroshockers		Vicinity of Waterford 3		**Total 90.1%** - Gizzard shad (38.0%), blue catfish (18.1%), threadfin shad (14.5%), striped mullet (10.4%), freshwater drum (6.9%), skipjack herring (2.2%)
Louisiana Pwer and Light 316(b) Demonstration	Waterford 3	129.5	April 1973 - September 1976	Three years using gill nets and electroshocking	48 hour gillnetting & 2 hr electroshicking	RM 126 - 132	Average Number of fish caught per hour: 1.22	**Total 90.1%** - Gizzard shad (38.0%), blue catfish (18.1%), threadfin shad (14.5%), striped mullet (10.4%), freshwater drum (6.9%), skipjack herring (2.2%)
Louisiana Pwer and Light 316(b) Demonstration	Waterford 3	129.5	April 1973 - September 1976	Three years using gill nets and electroshocking	48 hour gillnetting & 2 hr electroshicking	RM 126 - 132 - shallow stations	Average Number of fish caught per hour: 0.77	
Louisiana Pwer and Light 316(b) Demonstration	Waterford 3	129.5	April 1973 - September 1976	Three years using gill nets and electroshocking	48 hour gillnetting & 2 hr electroshicking	RM 126 - 132 - deep stations	Average Number of fish caught per hour: 1.04	
Louisiana Pwer and Light 316(b) Demonstration	Waterford 3	129.5	April 1973 - September 1976	Three years using gill nets and electroshocking	48 hour gillnetting & 2 hr electroshicking	RM 126 - 132	Minimum and Maximum Length of Fish (mm)	Gizzard shad (25 - 341), blue catfish (17 - 655), threadfin shad (17 - 190), striped mullet (68 - 397), freshwater drum (13 - 306), skipjack herring (20 - 325)

Table B-2
Length, Weight, Survival, and Swimming Speed Characteristics for Species Commonly Impinged at Entergy's Power Plants

Common Name	Scientific Name	Length (mm)[1]		Weight (g)[2]		Initial Survival[3]		Extended Survival[4]		Swimming Speeds (cm/s)	
		Average	Median	Average	Median	Average	Median	Average	Median	Median/Mean	Critical/Optimum
Freshwater Species											
Freshwater Drum	*Aplodinotus grunniens*	86.4	84.8	41.9	4.5	0.545	0.528	0.227	0.204	90 d	NA
Ohio river shrimp	*Macrobrachium ohione*	55.5	55.8	3.0	3.6	0.500	0.500	NA	NA	0.76 e	NA
Gizzard Shad	*Dorosoma cepedianum*	115.2	109.5	66.0	2.4	0.693	0.884	0.284	0.070	2 - 4 a	10 a
Threadfin Shad	*Dorosoma petenense*	63.3	53.5	4.7	1.5	0.325	0.153	NA	NA	2 - 4 a	10 a
Common carp	*Cyprinus carpio*	398.0	398.0	1545.3	1984.2	0.595	0.630	0.469	0.472	NA	166 h
Black crappie	*Pomoxis nigromaculatus*	NA	NA	NA	NA	0.524	0.507	0.119	0.014	NA	NA
Crappies	*Pomoxis* sp.	NA	NA	NA	NA	0.493	0.493	0.290	0.290	NA	NA
Channel Catfish	*Ictalurus punctatus*	71.8	62.8	18.8	2.8	0.843	0.800	0.897	0.588	50 f	55.2 g
Bluegill	*Lepomis macrochirus*	46.3	44.8	8.6	4.0	0.905	1.000	0.926	0.971	NA	101 - 130 j
Sucker family	Catostomidae	NA	NA	NA	NA	0.562	0.538	0.480	0.438	NA	169 - 259 k
Smallmouth buffalo	*Ictiobus bubalus*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bigmouth buffalo	*Ictiobus cyprinellus*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Skipjack herring	*Alosa chrysochloris*	119.4	112.0	42.8	8.1	NA	NA	NA	NA	NA	NA
Alosa species	*Alosa* sp.	NA	NA	NA	NA	0.736	0.839	0.206	0.061	NA	NA
Blue catfish	*Ictalurus furcatus*	86.8	83.8	22.4	12.1	NA	NA	NA	NA	30 b	NA
Brackish Species											
White shrimp	*Penaeus setiferus*	NA	NA	NA	NA	0.689	0.706	0.806	0.806	NA	NA
Brown shrimp	*Penaeus aztecus*	NA	NA	NA	NA	0.815	0.907	0.830	0.850	NA	NA
Bay anchovy	*Anchoa mitchilli*	NA	NA	NA	NA	0.295	0.178	0.100	0.000	21.1 i	NA
Gulf menhaden	*Brevoortia patronus*	NA	NA	NA	NA	0.249	0.251	0.136	0.136	NA	NA
Blue Crab	*Callinectes sapidus*	NA	NA	NA	NA	0.858	0.921	0.664	0.735	NA	NA
Hardhead sea catfish	*Arius felis*	NA	NA	NA	NA	0.434	0.277	0.710	0.703	NA	NA
Sand weakfish	*Cynoscion arenarius*	NA	NA	NA	NA	0.239	0.194	0.265	0.265	NA	NA
Spotted seatrout	*Cynoscion nebulosus*	NA	NA	NA	NA	0.544	0.400	0.000	0.000	81 l	NA
Sea trouts, Weakfishes	*Cynoscion* sp.	NA	NA	NA	NA	0.157	0.157	0.579	0.579	NA	NA
Striped mullet	*Mugil cephalus*	NA	NA	NA	NA	0.599	0.574	0.426	0.396	32 - 83 c	50 - 130 c
Atlantic croaker	*Micropogon undulatus*	NA	NA	NA	NA	0.689	0.827	0.416	0.357	NA	NA
Spot	*Leiostomus xanthurus*	NA	NA	NA	NA	0.622	0.718	0.410	0.332	NA	NA
American Shad	*Alosa sapidissima*	NA	NA	NA	NA	0.658	0.870	0.067	0.001	NA	NA
Least puffer	*Sphoeroides parvus*	NA	NA	NA	NA	0.738	0.729	0.610	0.610	NA	NA
Blackcheek tonguefish	*Symphurus plagiusa*	NA	NA	NA	NA	0.778	0.770	0.796	0.796	NA	NA

Notes:
NA - Data not available
1 Average and median length of impinged organisms from Waterford 1 & 2 and Willow Glen 4
2 Average and median weight of impinged organisms from Waterford 1 & 2, Willow Glen 1 & 2, and Willow Glen 4
3 Initial Survival. EPRI 2003.
4 Extended Survival (24 - 120 hours after impingement) EPRI 2003.
a Median and optimum swimming speeds. Barnes, J. 1977.
b Mean sustained speed. Venn Beecham et al., 2003.
c Median and optimum swimming speeds for fish 2.5-6.5 cm. Rulifson, R.A. 1977.
d Mean cruising speed for red drum. Wakeman and Wohlschlag. 1982
e Mean speed for freshwater shrimp. Medland, et al., 2000
f Mean sustained speed. Venn Beecham et al. 2003.
g Critical speed. Sylvester 1992.
h Optimum speed. Wolter and Arlinghaus. 2003
i Cruising speed for Northern anchovy. Huntley and Zhou. 2004.
j Critical speed. Wolter and Arlinghaus. 2003.
k Critical speed for white sucker. Wolter and Arlinghaus. 2003
l Mean cruising speed. Huntley and Zhou. 2004.

Table B-3
Potential for Threatened and Endangered Species to Inhabit the Waters in Vicinity of Entergy's Power Plants Located on the Lower Mississippi River

Common Name	Taxonomic Name	State Status	Federal Status	Potential for Impingement or Entrainment (upstream ⟶ downstream)									
				Ritchie (AR)	Gerald Andrus (MS)	Baxter Wilson (MS)	Willow Glen (LA)	Little Gypsy (LA)	Waterford 1& 2 (LA)	Waterford 3 (LA)	Nine mile (LA)	Paterson (LA)	Michoud (LA)
Dace, southern redbelly	*Phoxinus erythrogaster*	MS (E)	Not Listed		Yes	Yes							
Darter, crystal	Ammocrypta aspella	MS (E)	Not Listed		Yes	Yes							
Pigtoe, pyramid	*Pleurobema perovalis*	MS (E)	Not Listed		Yes	Yes							
Pocketbook, fat	*Potamilus capax*	MS (E)	E	Yes	Yes	Yes							
Sturgeon, gulf	*Acipenser oxyinchus desotoi*	LA (T) MS (E)	T									Yes	Yes
Sturgeon, pallid	*Scaphirhynchus albus*	LA (E) MS (E)	E	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Paddlefish	*Polyodon spathula*	Not Listed S3 (MS, LA)	Not Listed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		

Threatened (T), Endangered (E), Arkansas (AR), Louisiana (LA), Mississippi (MS), S3 – rare and local throughout the state (National Heritage Ranking System)

Table B-4
Summary of Historical Impingement Studies at Entergy's Power Plants

Location	Study Title	River Mile	Period of Sampling	Sampling Frequency	Sampling Duration	Sampling Location	Measured Annual Impingement Rate (organisms/yr)[a]	Plant Capacity (gpm)	Impingement per 10,000 m[3 b]	Ten Most Common Species
Baxter Wilson	Baxter Wilson Impingement Study	433.2	March 12, 1973 - August 20, 1973	March 12 - May 11, 1973: Daily; May 12 - August 20, 1973 : Twice per week; August 31, 1973 - March 1, 1974: Once per week for 24 hours	24 hours	Screen wash trough	180,730	412,000	1.96c	Total 97.1% - Freshwater drum (31.7%), Gizzard shad (30.8%), Shad spp. (22.2%), Threadfin shad (3.3%), Carp (2.7%), River shrimp (2.6%), White crappie (1.5%), Sucker (1.3%), Channel catfish (0.7%), Skipjack herring (0.4%)
Willow Glen Units 1 & 2	Willow Glen 316(a) and 316(b) Demonstration	201.6	January 1975 - January 1976	April - July: 4 times per month; 2 times per month remainder of year. 30 minute samples collected 4 times over 24 hours	24 hours	Sluiceway	26,210	171,000	1.47d	Total 97.4 % - River shrimp (57.3%), Freshwater drum (22.1%), Gizzard shad (5.7%), Threadfin shad (5.1%), Crayfish (2.6%), Blue catfish (2.4%), Black crappie (0.7%), Skipjack herring (0.6%), Bluegill (0.6%), White crappie (9.5%)
Willow Glen Unit 4	Willow Glen 316(a) and 316(b) Demonstration	201.6	January 1975 - January 1976	April - July: 4 times per month; 2 times per month remainder of year. 30 minute sampled collected 4 times per day	24 hours	Sluiceway	5,037	228,000	0.13d	Total 94.5% - River shrimp (27.5%), Crayfish (27.0%), Freshwater drum (12.5%), Gizzard shad (9.3%), Threadfin shad (7.5%), Blue catfish (5.8%), Bluegill (1.4%), White crappie (1.4%), Channel catfish (1.2%), Skipjack herring (0.9%)
	Willow Glen Plant						Weighted-average	902,400	0.70	
Waterford 1 & 2	Screen Impingement Studies	129.7	February 1976 - January 1977	24 samples; 4 times per month	24 hours	Screen wash trough	336,454	429,000	4.33d	Total 98.7% - River shrimp (49.7%), Blue catfish (20.3%), Threadfin shad (10.5%), Bay anchovy (6.0%), Freshwater drum (4.5%), Gizzard shad (2.9%), Skipjack herring (2.4%), Channel catfish (2.1%), Striped mullet (0.3%), Blue crab (0.2%)
Paterson	Impingement Impact of A.B. Paterson & Michoud Stations	branches off at RM 92.6	August 1977 - December 1979	Every other Thursday. 10-minute samples collected every 4 hours for 24 hours	24 hours	Sluiceway	226,489	149,561	5.42d	Total 90.7% - Atlantic croaker (32.2%), Bay anchovy (17.1%), White seatrout (12.6%), Blue crab (10.5%), Gulf menhaden (6.6%), Sea catfish (4.5%), White shrimp (2.4%), Spot croaker (1.9%), Spotted seatrout (1.8%), Hogchoker (1.1%)
Michoud	Impingement Impact of A.B. Paterson & Michoud Stations	branches off at RM 92.6	August 1977 - December 1979	Every other Thursday. 10-minute samples collected every 4 hours for 24 hours	24 hours	Sluiceway	1,676,726	529,760	9.41d	Total 91.2% - Atlantic croaker (21.5%), White shrimp (20.0%), Bay anchovy (13.5%), Brown shrimp (10.5%), Blue crab (9.0%), Sea catfish (7.8%), White seatrout (4.2%), Gafftopsail catfish (1.6%), Least puffer (1.6%), Blackcheek tonguefish(1.4%)

a - Impingement rate estimated based on integration of sampling effort
b - Impingement rate estimated based on flow rate recorded during study
c - Flow rate used to calculate impingement rate were assumed to be at maximum plant capacity
d - Flow rates were recorded during impingement study and used to calculate impingement rate

Table B-5
Historically Observed Impingement as a Means of Representing Current Rates

Station(s)	Historical Data That Is Representative of Current Conditions
Gerald Andrus	Baxter Wilson
Baxter Wilson, Ritchie	Baxter Wilson
Willow Glen	Willow Glen
Waterford 1&2, Waterford 3, Little Gypsy, Ninemile	Waterford 1 & 2
Paterson	Paterson
Michoud	Michoud

APPENDIX C
EPA COST ESTIMATE

Appendix C:
Summary of US EPA-Estimated Compliance Costs based on the Model Plant Approach for the Section 316(b) Phase II Final Rule

Source: Appendices A and B of the Final Rule

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Waterford 3	AUT0513	n/a	1,296,772		$27,395,451.00	$170,929.00	$603,316.00	$4,332,883.00	$35,923,245.00	n/a	$2,975,512.00	I&E	4	2.5787

[1] The design flow adjustment slope (m) represents the slope that corresponds to the particular plant using the technology in column 3.
[2] Discount rate = 7%.
[3] Amortization period for capital costs = 10 years.
[4] Amortization period of downtime and pilot study costs = 30 years.
[5] EPA Technology Codes:
1. Addition of fish handling and return system
2. Addition of fine mesh screens to an existing traveling screen system.
3. Addition of a new, larger intake with fine-mesh screens and fish handling and return system in front of existing screen.
4. Addition of passive fine-mesh screen system (cylindrical wedgewire) near shoreline with mesh width of 1.75 mm.
5. Addition of fish net barrier system.
6. Addition of an aquatic filter barrier system.
7. Relocation of existing intake to a submerged offshore location with passive fine-mesh screen inlet with mesh width of 1.75 mm
8. Addition of a velocity cap inlet to an existing offshore intake.
9. Addition of passive fine-mesh screen to an existing offshore intake with mesh width of 1.75 mm
10. Not used
11. Addition of a dual-entry, single-exit traveling screen (with fine mesh) to a shoreline intake system.
12. Addition of passive fine-mesh screen system (cylindrical wedgewire) near shoreline with mesh width of 0.76 mm
13. Addition of a passive fine mesh screen to an existing offshore intake with a mesh width of 0.76 mm
14. Relocation of an existing intake to a submerged offshore location with passive fine-mesh screen inlet with mesh of 0.76 mm.

APPENDIX D

USFWS LETTER AND RESPONSE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
646 Cajundome Blvd.
Suite 400
Lafayette, Louisiana 70506

March 15, 2004

Mr. David Rupe
FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, Arkansas 72211

Dear Mr. Rupe:

Please reference your February 20, 2004, letter requesting our review of an industrial facility near the Bonnet Carre Spillway in St. Charles and St. John Parishes, Louisiana. The U.S. Fish and Wildlife Service (Service) has reviewed the information you provided, and offers the following comments in accordance with the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.).

The pallid sturgeon (*Scaphirhynchus albus*) is an endangered fish found in both the Mississippi and Atchafalaya Rivers (with known concentrations in the vicinity of the Old River Control Structure Complex); it is possibly found in the Red River as well. The pallid sturgeon is adapted to large, free-flowing, turbid rivers with a diverse assemblage of physical habitats that are in a constant state of change. Detailed habitat requirements of this fish are not known, but it is believed to spawn in Louisiana. Habitat loss through river channelization and dams have adversely affected this species throughout its range.

Federally listed as endangered, West Indian manatees (*Trichechus manatus*) occasionally enter Lakes Pontchartrain and Maurepas, and associated coastal waters and streams during the summer months (i.e., June through September). Manatees have been reported in the Amite, Blind, Tchefuncte, and Tickfaw Rivers, and in canals within the adjacent coastal marshes of Louisiana. Although rare and infrequent, sightings have occurred on the Mississippi River, and one sighting is referenced of a manatee observed for several consecutive days within the three mile project boundary in 1975. They have also been occasionally observed elsewhere along the Louisiana Gulf coast. The manatee has declined in numbers due to collisions with boats and barges, entrapment in flood control structures, poaching, habitat loss, and pollution. Cold weather and outbreaks of red tide may also adversely affect these animals. Should you observe manatees in the project area during proposed work activities, please notify this office.

We appreciate the opportunity to provide comments in the planning stages of this proposed project. If you need further assistance, please contact Angela Culpepper (337/291-3137) of this office.

Sincerely,

Ronald Paille

Ronald Paille
Acting Supervisor
Louisiana Field Office

cc: LDWF, Natural Heritage Program, Baton Rouge, LA