To NWRC/Scott

US Army Corps of Engineers
Vicksburg District

RED RIVER WATERWAY PROJECT
SHREVEPORT, LA TO DAINGERFIELD, TX REACH
REEVALUATION STUDY

IN-PROGRESS REVIEW DOCUMENTATION

ENVIRONMENTAL SUMMARY

MAY 1994

Red River Waterway Project
Shreveport, LA, to Daingerfield, TX, Reach
Reevaluation Study In-Progress Review

ENVIRONMENTAL SUMMARY REPORT

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SHREVEPORT, LA, TO DAINGERFIELD, TX, REACH
REEVALUATION STUDY IN-PROGRESS REVIEW

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INTRODUCTION

1. In October 1988 (Fiscal Year 1989), the U.S. Army Corps of Engineers, Vicksburg District, was directed by Congress to initiate a reevaluation of the feasibility of the Shreveport, LA, to Daingerfield, TX, reach of the Red River Waterway Project. Subsequent funding was provided by Congress in Fiscal Years 1990-1993.

2. In December 1992, an in-progress review of the feasibility of extending navigation on the Shreveport to Daingerfield reach was completed. The review was a preliminary assessment of project costs, benefits, and environmental impacts. The review revealed that construction of this reach of the project was not economically feasible. The project was also found to result in significant environmental impacts for which mitigation was not considered to be practicable. The reevaluation studies were terminated as a result of the in-progress review.

3. The purpose of this report is to discuss the environmental investigations (water quality, ground water, wetlands, terrestrial, waterfowl, and aquatic) that were underway at the time of the in-progress review so that the information might be usable and understandable by the public. The studies are summarized in the main body of this report. Details of the studies are presented in the technical appendixes.

4. Additional documents have been prepared to more fully present the results of the reevaluation study to the public. These documents include the In-Progress Review Documentation prepared in December 1992 and separate reports on regional economic development, public involvement activities, recreation, mussel survey, historic watercraft survey, geotechnical investigations, and geomorphic investigations. Copies of these reports have also been placed in the local depositories (see Attachment 1) established during the reevaluation study. Copies of all the reports can be obtained from the Vicksburg District for the cost of reproduction.

GENERAL

5. The currently authorized navigation project is shown on Plate 1. The authorized project includes a 9- by 200-foot

navigation channel, three lock structures, and one dam structure. Two of the locks would be built in conjunction with the existing dams at Caddo Lake and Lake O' The Pines. The authorized project extends from upstream of Shreveport, LA, to the head of navigation in Lake O' The Pines, a distance of about 76 miles.

6. During the reevaluation study, alternative navigation plans were formulated for consideration and evaluation. These plans included (1) alternate channel routes, (2) alternate channel and lock sizes, (3) alternate lock locations, (4) mechanical lift system at Ferrells Bridge Dam (Lake O' The Pines), and (5) termination of navigation at Jefferson, TX. The final array of alternatives evaluated in the in-progress review is presented in Table 1.

TABLE 1
FINAL ARRAY OF ALTERNATIVES

Plan No.	Alternatives
1	Two Barge to Daingerfield, Authorized Alignment
2	Two Barge to Daingerfield, Goose Prairie Cutoff
3	Two Barge to Jefferson, Authorized Alignment
4	Two Barge to Jefferson, Goose Prairie Cutoff
5	Four Barge to Daingerfield, Authorized Alignment
6	Four-Barge to Daingerfield, Goose Prairie Cutoff
7	Four-Barge to Jefferson, Authorized Alignment
8	Four Barge to Jefferson, Goose Prairie Cutoff

7. The comparison of the alternative plans presented in the In-Progress Review Documentation is shown in Table 2. None of the alternative plans were economically feasible with the ratios of annual benefits to annual costs ranging from 0.4 to 0.5. The features and economics of the alternative plans are discussed in detail in the In-Progress Review Documentation.

TABLE 2
COMPARISON OF ALTERNATIVES

Plan	Total Project Costs ($000)	Average Annual Costs ($000)	Average Annual Transportation ($000)	Benefit-Cost Ratio	Excess Benefits Over Costs ($000)
1	601,981	70,230	29,860	0.4	-40,370
2	640,421	74,429	29,860	0.4	-44,569
3	296,145	29,655	15,514	0.5	-14,141
4	334,493	33,339	15,514	0.5	-17,825
5	675,877	78,303	33,480	0.4	-44,823
6	718,015	82,906	33,480	0.4	-49,426
7	331,989	33,099	17,962	0.5	-15,137
8	374,025	37,137	17,962	0.5	-19,175

8. The projected environmental effects presented in this report are restricted to the four-barge system with the authorized alignment to the authorized head of navigation (Lake O' The Pines). Only one alternative was used to display the potential project-induced impacts since none of the alternatives were economically feasible.

WATER QUALITY

GENERAL

9. As part of the reevaluation study, extensive and intensive water quality investigations were conducted. The purposes of the water quality investigations were (1) identify preproject base-line water quality conditions in the study area, (2) evaluate the suitability of the sediments for dredging, and (3) determine the potential project impacts to water quality. The investigations involved the extensive use of existing information and the collection of additional data. The additional data included the collection of both surface water and sediment samples. The general water quality parameters analyzed included in-situ, solids and ions, metals, nutrients, physio-chemical, bacteria, and priority pollutants (pesticides and polychlorinated biphenol (PCB's), base neutral acid (BNA) compounds, volatile

organic compounds, explosives, and oil and grease). A detailed discussion of the water quality studies and projected project impacts is presented in Appendix 1.

10. Routine monthly surface water samples were taken by the U.S. Geological Survey (USGS) at nine monitoring stations throughout the project area. Three intensive surveys were conducted by the Vicksburg District where surface water, sediment, sediment cores, and elutriate samples were collected. Analyses of the routine surface water samples were made by USGS. Analyses of the intensive survey samples (surface water, sediment, sediment cores, and elutriate) were conducted by the U.S. Army Engineer Waterways Experiment Station (CEWES), Environment Laboratory, Vicksburg, MS.

11. The historical data indicate that the water quality within the project area is generally good. Occasional exceedances of chloride, sulfate and heavy metal water quality criteria have been reported. Dissolved oxygen (DO) levels have occasionally been recorded below minimum standards. These occasional exceedances do not restrict the use of these waters for recreation or public water supply.

12. Past studies and historical data indicate that the sediments in the study area may be contaminated with heavy metals, PCB's, TNT derivatives, and polynuclear aromatic hydrocarbons (PAH's). Data reported within Lake O' The Pines indicated the presence of elevated heavy metals. PCB's have been detected in the sediments of Caddo Lake by the Texas Department of Water Quality. Trace levels of TNT derivatives in Caddo Lake and Twelvemile Bayou were reported in a prior Corps study.

13. The water quality sampling program was developed using guidance from the Tiered Testing Approach as described in 40 Code of Federal Regulations (CFR) 230.4-1. The first tier evaluates existing information to determine if there is a reason to believe that contaminants are present. If the information is inadequate or indicates that contamination may be likely, then Tier II testing is recommended.

14. Tier II testing consists of bulk sediment analysis and elutriate or water column toxicity testing. Major emphasis is generally placed on heavy metals, PCB's, PAH's, pesticides, and other contaminants of ecological or human health significance. If there is reason to believe that toxic substances are bioavailable, a third tier of testing may be required.

15. Tier III testing consists of benthic bioassay and bioaccumulation impacts. The bioassay tier testing is used to determine whether there is a reason to believe contaminants in the dredged material will result in an unacceptable adverse impact to the benthic component of the aquatic environment.

16. The information presented in this section and Appendix 1 are the results of Tier II testing. No Tier III testing was undertaken because of the results of the tests completed at the time of the in-progress review and the early termination of the reevaluation studies.

SUMMARY

Surface Water

17. The water quality data suggest that Lake O' The Pines, Caddo Lake, and Twelvemile Bayou have elevated nutrient levels. Numerous aquatic macrophytes grow in abundance along the shores and in shallow areas in Lake O' The Pines and Caddo Lake. The two lakes would be classified as eutrophic based on their mean total phosphorus levels. Big Cypress Bayou would be classified as mesotrophic and Twelvemile Bayou as highly eutrophic. Caddo Lake, Big Cypress Creek and Lake O' The Pines had turbidity means < 10 Nephelometric Turbidity Units (NTU) indicating a pristine environment.

18. Dissolved oxygen concentrations at the water surfaces were usually near saturation levels while DO near the bottom sediments were frequently less than 1.0 million gallons per liter (mg/l) in the routine samples. Dissolved oxygen profiles taken during the intensive surveys indicated concentrations near the water surface were usually near saturation and dropped very rapidly to below 1 mg/l at the bottom.

19. Data were collected on 11 metals (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc) during the routine and intensive surveys. With the exception of iron and manganese, metals were seldom detected in the routine surveys. The metal concentrations in the intensive survey were generally higher than in the routine survey. Six of the 11 metals (arsenic, copper, iron, lead, manganese, and zinc) were detected at levels exceeding Environmental Protection Agency (EPA) criteria in the intensive survey. One reason for this is that the USGS measured dissolved metal concentrations, while the Corps measured total metal concentrations. Another reason that the metal concentrations in the intensive survey may be higher than those reported in the routine survey is that the intensive survey samples were collected near the sediment water interface.

Metal concentrations for some metals are higher in deeper, lower oxygen zones than samples collected from zones near the surface.

20. Analyses were performed for 119 priority pollutants. No priority pollutants were ever detected in any of the routine survey samples. In the intensive survey samples, only five were detected. All detected values were below the EPA detection limits for contract laboratories. The five pollutants were butylbenzyl phthalate, bis (2-ethylhexyl) phthalate, diethyl phthalate, methylene chloride and heptachlor. These parameters except for heptachlor are common analytical lab contaminants and their actual presence in the water samples is suspect. The only pesticide detected in the water samples was detected in Caddo Lake. Heptachlor was reported as 0.005 ug/l which is well below the detection limit of 0.03 ug/l.

21. Mean total coliforms monitored by the USGS ranged from 12 to 899 colonies/100 ml of sample. The highest readings were observed in Lake O' The Pines. Twelvemile Bayou and Caddo Lake had the second and third highest concentrations of total coliforms respectively. Fecal coliforms were also highest in Lake O' The Pines. The highest mean fecal coliform count was 6,220 colonies/100 ml. Big Cypress Bayou at Karnack had the second highest fecal coliform mean of 6,036 colonies/100 ml. Caddo Lake's highest mean was 112 colonies/100 ml. The drinking water standard for fecal coliforms is set at a maximum of 2,000 colonies/100 ml. The drinking water standard for total coliforms is set at a maximum of 10,000 colonies/100 ml. The Texas contact recreation criteria for fecal coliforms is 200 colonies/100 ml and the secondary contact criteria is 4,000 colonies/100 ml. The criteria are based on an average of at least 5 samples taken within a 30-day period. Although bacteria counts were only made every 30 days and should be made more frequently to properly use these criteria, these data suggest that a problem with coliform bacteria may exist within the project area.

<u>Surface Sediments</u>

22. Presently there are no sediment quality criteria with which to evaluate sediment quality in regards to metals contamination. The tiered testing approach which is based on a "reason to believe" philosophy was used to evaluate these sediments. If these data or other factors provide a "reason to believe" contaminants or biological effects may be possible, then the next level of tiered testing would be recommended. To determine whether these sediments would likely be contaminated, they were compared to two bench mark levels, ER-L and ER-M, reported by the National Oceanic and Atmospheric Administration (NOAA, 1990). The ER-L represents the 10th percentile level of accumulated environmental

effects data. It represents a low level bench mark. Sites with concentrations below this level would not be considered contaminated, and no further evaluation would be required. The ER-M represents the 50th percentile of the range of contaminant levels that produce environmental effects. Sediment concentrations in excess of the ER-M could be considered contaminated. Concentrations falling between the ER-L and ER-M bench marks are within a level of concern and should be thoroughly evaluated.

23. There has not been any well-established literature and practical experience showing general relationships between the concentrations of chemical contaminants in sediment and the impact that sediment-associated contaminants could have on water quality (NOAA, 1990). In spite of these limitations, these bench marks represent the best available indicators of potential sediment toxicity. Therefore, these bench marks were used to determine if there was a reason to believe that the sediments are contaminated.

24. The sediment concentrations of metals reported in the surface sediments are within the natural ranges found in the earth's crust (Bowen, 1966). In a few samples the concentrations of cadmium, manganese, mercury, and zinc exceeded these normal ranges. Lead and zinc exceeded the ER-M concentrations at one station in Lake O' The Pines. Surface sediments in Caddo Lake exceeded the ER-L's for lead, mercury, nickel, and zinc but not the ER-M levels. Surface sediments collected in Twelvemile Bayou and Big Cypress Bayou did not exceed the ER-L levels.

25. The surface sediments were also analyzed for the 119 priority pollutants. Only trace amounts of a few of these pollutants were found. However, trace amounts of several PAH's were detected in upper Lake O' The Pines and mid-Caddo Lake. All surface sediment samples were analyzed for PCB's because of the past reports of PCB's reported in Caddo Lake. These analyses never reported any detections of PCB's. Due to the low number of reported detectable quantities of pesticides and the lack of multiple pesticides being reported at any one station, there is little reason to believe that sediments are contaminated with pesticides.

26. Seventeen sediment samples were analyzed for explosives. Of these, 9 were collected in Caddo Lake, 4 in Twelvemile Bayou, 2 in Big Cypress Creek and 2 in Lake O' The Pines. It was anticipated that if explosives were present, they would be found in Caddo Lake or Twelvemile Bayou. Samples collected in Lake O' The Pines and Big Cypress Bayou were used as background control as they were not likely to be contaminated with explosives. No explosives were reported in any of the samples.

Sediment Cores

27. The metals lead and zinc were frequently reported above the ER-L bench marks in these samples. Levels of arsenic, cadmium and mercury above the ER-L bench mark was detected in one sample in Lake O' The Pines. Levels of lead above the ER-M bench mark were detected in four samples in Lake O' The Pines and were above the ER-L bench mark in another sample. Five samples in Lake O' The Pines reported zinc levels in excess of the ER-M bench mark. Zinc levels above the ER-L bench mark were detected in one sample in Lake O' The Pines.

28. No heavy metals were reported above the ER-M bench marks in any of the Caddo Lake sediment cores. However, the metals lead, mercury, nickel and zinc were reported in excess of their respective ER-L's.

29. Based on these findings there is a reason to believe that some sediments in the project area are contaminated with heavy metals, in particular arsenic, cadmium, lead, mercury, nickel and zinc.

30. Because of the detected amounts of PAH's in the surface sediments, sediment cores were taken in Lake O' The Pines and Caddo Lake. Four cores were taken in Lake O' The Pines, and one in Caddo Lake. One sample from Lake O' The Pines had elevated levels of PAH's and one sample had trace levels. PAH's were not detected in the sediment core from Caddo Lake. The data clearly show that PAH's are present in the sediments in the most upstream reaches of Lake O' The Pines. PAH's are extremely insoluble in water and are usually associated with particulates in the water column (AWWA, 1990). Because PAH's have been detected in the upper portion of Lake O' The Pines, Tier III testing would be required to evaluate the toxicity of these sediments. The core sample collected in Caddo Lake was also analyzed for PCB's. There were no detections of even trace amounts of PCB's in any of the core sediment samples collected during the study.

Elutriate Tests

31. Due to results of the bulk sediment testing, elutriate tests were performed at six sites--four sites in upper Lake O' The Pines and two sites in Caddo Lake. A total of six elutriate tests were performed on the bottom sediments to determine if any of the contaminants identified in bulk sediment analysis would likely be released into the water during dredging operations. The test does not take into account a mixing zone or any dilution that occurs once the dredge material is discharged into open water. The elutriate data indicated that water concentrations of iron and manganese would probably exceed secondary drinking water

criteria at every station. Lead exceeded the drinking water criteria at every station except one station in Caddo Lake. Copper and zinc exceeded the Fresh Water Acute criteria at all six stations. Barium exceeded its criteria for drinking water at one station in Lake O' The Pines and at both stations in Caddo Lake. Due to the high levels of heavy metals reported by the elutriate tests, water column bioassays would have to be performed to further evaluate the effects that may occur to aquatic life.

32. Both Caddo Lake and Lake O' The Pines are used for public water supplies. The elutriate test results indicate that during construction, the concentrations of some heavy metals may exceed the MCL's in the immediate vicinity of the dredge.

CONCLUSION

33. The routine and intensive water quality surveys did not detect any major problems concerning water quality. Based on these surveys and past studies the surface water quality in the study area is good. The intensive sediment survey found high levels of heavy metals, particularly lead and zinc, in the sediments of both of the lakes within the study area. The high levels of heavy metals were localized to the upper mile of Lake O' The Pines and the central area of Caddo Lake. The elutriate tests indicated that there is the potential for the release of several heavy metals in excess of their respective MCL's in the immediate vicinity of a dredge. The highest levels of PAH's and heavy metals in Lake O' The Pines are found in sediments 8 to 12 inches below the sediment-water surface. Because these contaminated sediments are buried, they should not pose any problems to aquatic life.

GROUND-WATER RESOURCES

GENERAL

34. The purpose of the ground-water study was to identify preproject baseline ground-water conditions and identify potential project-induced ground-water impacts. The ground-water study was similar in scope to that performed on the lower Red River Waterway and was a cooperative effort involving the Vicksburg District, USGS, and the Soil Conservation Service (SCS). The details of the ground-water study are presented in Appendix 2.

35. An observational approach was taken for the ground-water study. It was decided that no predictive digital modeling would be appropriate for this study because boundary conditions (i.e.,

lock and dam sites, channel alignments) were not adequately known at this time and could change during the detailed design stage. A program was developed to establish existing ground-water conditions and its relationship to existing surface water levels. The investigative program consisted of four major components. These components included geologic mapping, ground-water monitoring, water level and water quality analyses, and crop-pasture-woodland observations.

36. The Vicksburg District contracted with CEWES to develop a series of geologic maps for the project area. These maps are contained in the CEWES Technical Report (GL-92-1) dated February 1992, which has previously been placed in the local depositories. The geologic maps show the different patterns of alluvium and Tertiary formation which have been deposited or outcrop throughout the proposed project reach. The maps also describe the different lithologies associated with these units as well as characterizing the environments of deposition for the recent alluvium. The report gives a general overview of the geohydrology that can be expected from the different subsurface groups and formations. Cross sections have also been included which show the association and varying thicknesses for the topstratum and substratum alluvium as well as the depths to the upper boundaries for the Tertiary formations which subcrop beneath the overlying sediment.

37. The Vicksburg District installed a series of monitoring wells and piezometers at 27 sites. The site locations were chosen jointly with the USGS and SCS. Ground-water levels were measured quarterly in the monitoring wells and piezometers by USGS. Water quality analyses were conducted on samples from selected wells annually.

38. To evaluate the impacts of any project-induced changes in the adjacent ground-water levels, raised or lowered, on current land uses, SCS established observation plots for agricultural crops, pastureland and woodlands. These plots were established on soils representative of the major soil types found within the project area. Nine observation plots were installed at varying land surface elevations on soils producing the major crops of the project area: soybeans, forages, and timber. Tree species observed include loblolly and shortleaf pines, willow oak, water oak, white oak, black gum, sweet gum and baldcypress. Forage species evaluated were common Bermuda grass, Dallis grass, and Pensacola Bahia grass. Forage and soybean observation plots were monitored every 10 days during the growing season (March - October). Woodland observation plots were monitored annually in the dormant season (November - February) to establish preproject conditions.

SUMMARY

39. Twelvemile and Big Cypress Bayous flow directly on sediments that comprise the alluvial aquifer throughout the project area. The exchange of water between these bayous and the underlying alluvial aquifer is governed by (1) the degree to which the bayou has penetrated the sediments comprising the aquifer, (2) the hydraulic conductivity and thickness of the materials that make up the stream bed, hereafter referred to as streambed conductance, and finally (3) the direction of the hydrostatic gradient; i.e., the difference between the hydrostatic head in the aquifer and the bayou.

40. The two aspects of the project that have the potential to affect stream-aquifer interaction in the study area are (1) dredging the navigation channel which could alter the streambed conductance, and (2) changes in flow lines that will result from navigation improvements; i.e., construction of locks and dams.

41. Construction of the navigation channel by dredging could impact ground-water levels in the alluvial aquifer adjacent to the project by changing the hydraulic conductivity of the streambed. In general, the alluvial aquifer becomes coarser and thus more transmissive with depth. Thus, if the improved navigation channel was significantly deeper than the thalweg of the existing channel, the stream aquifer connection would be improved allowing a greater flux of water to the stream from the aquifer or to the aquifer from the stream depending on the hydraulic gradient.

42. For the purposes of this study the project area was divided into the seven reaches. These reaches were:

a. Twelvemile Bayou - Soda Lake Area (mile 17.6 - 22.2).

b. Caddo Lake - Subreach 1 (mile 23.1 - 43.6).

c. Highway 43 to Jefferson - Subreach 1 (mile 51.9 - 64.0).

d. Jefferson to Lake O' The Pines - Subreach 1 (mile 70.2 - 73.7).

e. Jefferson to Lake O' The Pines - Subreach 2 (mile 73.7 - 77.2).

f. Jefferson to Lake O' The Pines - Subreach 3 (mile 77.2 - 80.7).

g. Jefferson to Lake O' The Pines - Subreach 4 (mile 80.7 - 84.3).

43. The effects of dredging alone (without construction of locks and dams) would have significant impacts along two areas of the project. The first is the Highway 43 to Jefferson reach and the second is the upper most reach of Big Cypress Bayou, Jefferson to Lake O' The Pines (Subreach 4). Channel dredging in these reaches would result in significant increases in streambed conductance.

44. Impoundment, the construction of locks and dams, would have effects on several reaches of the project. The impacts of inundation vary widely from marginal to severe. Five of the seven reaches, or subreaches would be impacted by inundation. The areas impacted include Twelvemile Bayou and Big Cypress Bayou between Jefferson, TX, and Ferrells Bridge Dam. Twelvemile Bayou stages would be increased because of the navigation pool provided by Lock and Dam No. 5, located downstream of Shreveport, LA, which would provide the navigation pool to Caddo Lake Dam. The portion of Big Cypress Bayou impacted would be the result of the proposed Lock and Dam No. 7 at Jefferson, TX, which would provide a navigation pool at elevation 185 feet, National Geodetic Vertical Datum. The potential impacts for the various reaches are summarized below:

a. Twelvemile Bayou would be affected by a rise in ground-water levels on an average of 3 feet immediately adjacent to the channel.

b. Jefferson to Lake O' The Pines subreach 1 would be affected by a rise in ground-water levels on an average of 15 feet in the adjacent aquifer.

c. Jefferson to Lake O' The Pines subreach 2 would be affected by a rise in ground-water levels on an average of 9 feet.

d. Jefferson to Lake O' The Pines subreach 3 would be affected by a rise in ground-water levels on an average of 4.8 feet.

e. Jefferson to Lake O' The Pines subreach 4 would be affected by a rise in ground-water levels on an average of 2.3 feet.

WETLAND RESOURCES

GENERAL

45. An assessment of the impact of the proposed project to the adjacent wetlands was performed by the Environmental Laboratory,

CEWES. The assessment was limited to the wetlands that are regulated under Section 404 of the Clean Water Act of 1970. The details of the wetlands assessment are presented in Appendix 3.

46. Bottom-land hardwood wetlands are the principal wetland land class in the project area. Wetlands within the project area would be impacted by the construction of the navigation channel and structures, the disposal of excavated material, and changes to the hydraulic regime. Impacts to the wetlands would include changes to their functions in regard to floodflow alteration, sediment stabilization, sediment and toxicant retention, nutrient removal and transformation and production export.

SUMMARY

47. About 1,100 acres of bottom-land hardwood wetlands would be cleared for the navigation channel and structures. About 1,400 acres of bottom-land hardwood wetlands would be cleared for the disposal areas. For a 2-year frequency flow event, the improved conveyance of the navigation channel will result in the loss of overbank flooding to about 2,400 acres. The construction of the proposed Lock and Dam No. 7 at Jefferson, TX, would result in the permanent inundation of about 270 acres of bottom-land hardwoods and would significantly increase ground-water elevations. The increased duration of soil saturation within the root zone could induce changes in vegetation composition or the eventual death of bottom-land hardwood stands. The total bottom-land hardwood wetlands that would be impacted are about 5,200 acres.

48. No accepted, rapid, on-site procedure is available to quantitatively evaluate the loss of the functional value of the impacted wetlands which then can be used to develop compensatory mitigation replacement ratios. The minimal acceptable mitigation requirement is a 1 to 1 acreage replacement. The complexity of topography, vegetation, and hydrology for the project area wetlands may make on-site and in-kind replacement impossible. The suggested mitigation type is the restoration of bottom land hardwoods by the reforestation of frequently flooded agricultural or fallow fields.

TERRESTRIAL RESOURCES

GENERAL

49. Close coordination was maintained throughout the reevaluation study with Federal and state environmental agencies. The habitat evaluation team was made up of representatives from the U.S. Fish and Wildlife Service (FWS), Louisiana Department of Wildlife and Fisheries, Texas Parks and Wildlife Department, EPA,

and environmental specialists from the Vicksburg District and our environmental contractor. Study funds were transferred to the FWS for their participation in the evaluation and the preparation of study documentation. Three documents were prepared by the FWS. These documents are presented in Appendix 4 and include a Planning Aid Report (PAR), dated January 1991, and two PAR's, dated October 28, 1992, and May 19, 1993.

50. The purpose of the January 1991 report was to highlight the significant environmental resources within the project area to ensure that these resources received the appropriate attention during the project formulation and evaluation process. The October 28, 1992, report presented the without-project conditions used in the In-Progress Review Documentation plus the terrestrial impacts associated with the construction of the navigation channel and structures, locks and dam. Subsequent to the October 1992 report, information on the terrestrial impacts associated with the disposal of the material excavated from the navigation channel was developed along with the mitigation requirements.

51. The May 1993 report was prepared at the request of the Vicksburg District in an effort to fully document the environmental impacts associated with extending navigation on the Shreveport to Daingerfield reach and to make the information available to interested parties. This report presents the anticipated impacts of the construction of the navigation channel and structures, the disposal of the excavated channel material, and the changes in the hydraulic regime of the area's existing stream and lake stages. The impact of changes in the hydraulic regime was restricted to three cover types--bottom-land hardwood forest, baldcypress swamp, and riparian--because these types are the most environmentally significant and more likely to be impacted.

SUMMARY

52. Eight cover types were used in the habitat acreage impact evaluation--cropland, shrubland, grassland, bottom-land hardwood, baldcypress swamp, pine, pine-hardwood, and riverine-riparian. The total acres impacted were about 7,700 acres; 2,200 acres by channel, 2,800 acres by disposal sites, and 2,700 acres by changed hydraulic regime. The most impacted habitat type was bottom-land hardwoods with about 3,600 acres, 700 acres by channel, 700 acres by disposal sites, and 2,200 acres by changed hydraulic regime. Of the 2,200 acres impacted by changes in hydraulic regime, about 270 acres would be permanently inundated upstream of the proposed lock and dam at Jefferson, TX. The remaining lands would experience reduced flooding. Over 28,000 acres of forested habitats would be required to fully compensate/mitigate for the potential project impacts. About

50 percent of the mitigation lands, 14,300 acres, would be bottom-land hardwoods. About 33 percent of the mitigation lands, 9,300 acres would be baldcypress swamp.

53. Mitigation of the impacts would necessitate the identification and acquisition of separable tracts for wildlife management. It is doubtful that such a large amount of mitigation land could be located and/or economically acquired, and cypress swamps in particular managed so as to compensate for project-related impacts. Direct construction and secondary hydrological impacts to lands contiguous to the project would make it difficult to manage these lands efficiently for mitigation purposes and could require expensive remedial measures such as levees, water control structures, and reforestation.

WATERFOWL RESOURCES

GENERAL

54. A study of the project area's waterfowl resources was conducted by FWS. The purpose of the study was threefold.

a. To identify the relative importance of the general project area to eastern Texas and western Louisiana in terms of historic trends of wintering waterfowl.

b. To document the baseline wintering waterfowl carrying capacity in the project area.

c. To document project-induced changes and impacts to those baseline conditions.

Impacts were calculated for the construction of the navigation channel and structures, the disposal sites for excavated material from the channel, and the changes in hydraulic regime. The details of the study are presented in Appendix 5.

SUMMARY

55. Continental waterfowl populations experienced long term change during the 1960's, 1970's, and 1980's. Populations were at high levels during the mid-1950's and then declined in the early 1960's. Populations increased during the late 1960's and early 1970's and remained at fairly high levels throughout the 1970's. Total duck breeding populations reached record lows in the late 1980's and remain alarmingly below the long term average.

56. The plight of waterfowl in eastern Texas and northwestern Louisiana mirrors the historic loss of wetlands. In 1980, a very extensive, detailed, and accurate statewide inventory of

vegetation was completed by the Wildlife Division of the Texas Parks and Wildlife Department using data from the Landstat satellite system. The amount of bottom-land hardwood and associated riparian vegetation occurring prior to the settlement of Texas is estimated at 16 million acres. The remaining bottom-land vegetation (excluding swamps) inventoried by Landstat was 5,793,000 acres in 1980, indicating a 63 percent loss of the original bottom-land component. Most of these bottom-land hardwoods occur in east Texas.

57. Construction of the project is estimated to result in the net annual loss of about 1,200 acres in available winter foraging habitat. The net annual loss in seasonal duck-day use was about 125,000 days or 105 duck-days per acre. To mitigate these impacts separate mitigation tracts would have to be selected for development and management. Predicated on the assumption that reforestation of cleared lands is the best mitigation technique and that any reforested acres are subject to frequent and sustained winter flooding, the FWS estimates that the available average annual duck-days per acre for mitigation lands would range from about 560 days per acre to 625 days per acre. Subtracting the net loss of 105 duck-days per acre from the available duck-days from the mitigation land, a range of about 275 to 240 acres of mitigation land would be required.

AQUATIC RESOURCES

GENERAL

58. The analyses of the aquatic resources were conducted by the Aquatic Habitat Group, Environmental Laboratory, CEWES. The habitat evaluation team included team members from the Texas Parks and Wildlife Department, FWS, and Louisiana Department of Wildlife and Fisheries. The results of the analyses are detailed in Appendix 6.

59. The objectives of the study were (1) establish baseline conditions for ichthyofauna and physical habitat, and (2) apply habitat evaluation techniques and quantify impacts of the proposed waterway on fishery resources. Habitat assessments were conducted separately for streams, lakes, and flood plains. To determine the best methods of habitat assessment, meetings were held among cooperating agencies. The decisions of the interagency team were: (1) reservoirs would be modeled using regression equations developed by the National Reservoir Research Program, FWS; (2) streams would be modeled using Instream Flow Incremental Methodology; (3) evaluation species would be chosen from different ecological guilds to broaden representation of the

fish community; and (4) existing models of stream fish-habitat relationships (i.e., suitability indices) would be used, with modifications based on field data from this study.

SUMMARY

60. Ichthyofauna of the Cypress Bayou and Twelvemile Bayou system is diverse and unusual. Over 80 species are documented from Big Cypress Bayou and its principal tributaries, many of which are rare and/or at the westernmost limits of the distribution.

Reservoirs

61. Five evaluation species were selected for the reservoir analyses--spotted gar, threadfin shad, channel catfish, bluegill, and largemouth bass. Regression models were used to calculate estimated standing crops of fish under pre- and postproject conditions. The results of the analyses indicate that unless the proposed navigation project would have a significant effect upon the water quality in the lakes, there would be no discernable project-related change in fish standing crops. It is possible that the proposed project could have a net positive impact on threadfin shad, bluegill, and largemouth bass.

Streams

62. Eight evaluation taxa were selected for the stream impact analyses: pickerels, blacktail shiner, iron color shiner, spotted sucker, flathead catfish, spotted bass, bluntnose darter, and blackside darter, These species represent five ecological guilds comprised by 56 species. Physical habitat and relative abundance of fishes were sampled at 21 stations. Fishes were collected using a seine and overnight gillnets. Suitability indices (SI's) for physical habitat variables were confirmed, modified, or generated based on collected data and comments from members of the interagency fish-habitat evaluation team.

63. Direct impacts of the proposed waterway on channel habitat were evaluated by using Instream Flow Incremental Methodology to simulate changes in habitat that would occur with the project in place. Pre- and postproject SI's were compared to determine the project impact on the various evaluation species. The results of the analyses indicated that the proposed navigation channel would have a net positive effect on all the evaluation species. The habitat gains reflect increases in habitat volume with minor, if any, reductions in habitat quality. The creation of double channels in some reaches and channel enlargement in other areas will more than offset negative impacts such as reductions in cover and increases in depth.

64. The impact of the navigation channel on the aquatic production of the adjacent flood plain lands was also evaluated. Because the navigation channel would alter the existing hydraulic regime by reducing the incidence and depth of flooding on these lands, the adverse impact of the project on the flood plain habitat within the project area would be substantial. It is estimated that over 3,600 acres of flood plain habitat would have to be created to mitigate for the loss in aquatic productivity.

CONCLUSION

65. In December 1992, the Vicksburg District completed an in-progress review of the feasibility of extending navigation on the Shreveport, LA, to Daingerfield, TX, reach of the Red River Waterway Project. The review was a preliminary assessment of project costs, benefits, and environmental impacts. The assessment revealed that the extension of navigation was not economically feasible. Based on this finding, study efforts were terminated.

66. The studies underway at the in-progress review indicated that the environmental impacts of extending navigation on the Shreveport to Daingerfield reach would be significant. The primary adverse impacts would be to the wetland, terrestrial, and aquatic resources in the project area. These impacts would be the result of construction activities and changes to the existing hydraulic regime. A total of about 7,700 acres of terrestrial habitat would be adversely impacted, 5,000 acres by construction and 2,700 acres by changes in the hydraulic regime. It is estimated that over 28,000 acres of forested habitat would be required to mitigate for these impacts.

67. About 68 percent of the acres impacted, 5,200 acres, are wetlands. About 2,500 acres would be loss due to the construction activities and 2,700 acres would be impacted by changes in hydraulic regime. The minimum mitigation level for restoring the lost and impaired functional value for these wetlands would be a 1 to 1 acre replacement assuming the complexity of the topography, vegetation and hydrology could be replicated.

68. The project would not adversely affect the existing stream and lake fisheries in the project area because of the additional habitat that would be provided by the navigation channel. However, the changes in the hydraulic regime resulting from the navigation channel would adversely impact the aquatic productivity of the adjacent flood plain. It is estimated that over 3,600 acres of flood plain habitat would have to be created to mitigate the loss of aquatic productivity.

69. Due to the magnitude of the impacts; the reduced potential for mitigation within the project area due to the impact of the project on the remaining adjacent lands; the interactive uniqueness of the area's topography, vegetation, and hydraulics; the location of the environmental resources at the western limit of many of the species and the scarcity of these type environmental resources within the state of Texas; mitigation of the potential environmental impacts is not considered to be practicable.

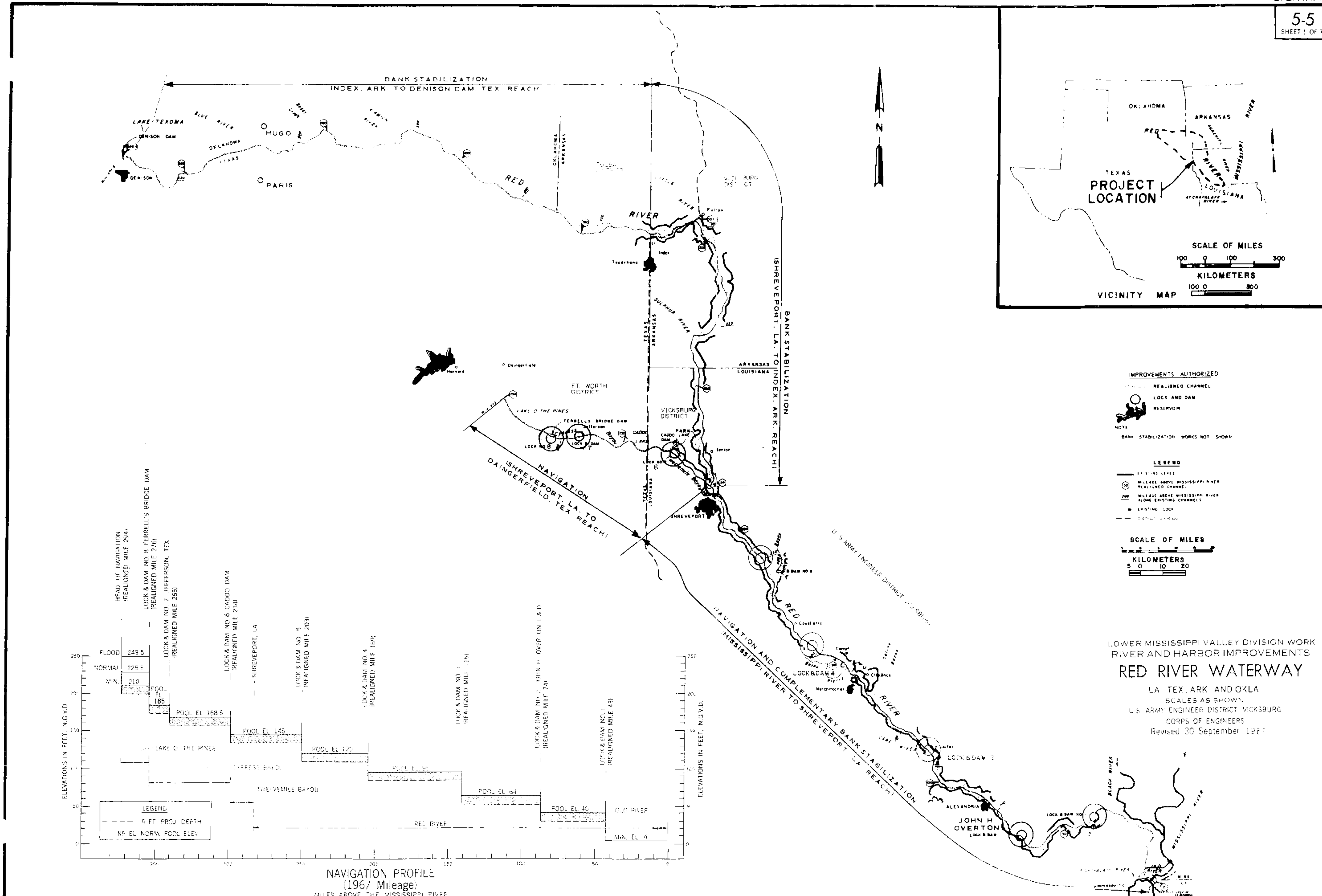
5-5
SHEET 1 OF 7
BANK STABILIZATION
INDEX, ARK. TO DENISON DAM, TEX REACH
LAKE TEXOMA
DENISON DAM
DENISON
HUGO
PARIS
RED
RIVER
OKLAHOMA
TEXAS
BLUE RIVER
KIAMICHI RIVER
SULPHUR RIVER
ARKANSAS
LOUISIANA
Fulton
Index
Texarkana
BANK STABILIZATION
(SHREVEPORT, LA. TO INDEX, ARK. REACH)
Daingerfield
FT. WORTH DISTRICT
VICKSBURG DISTRICT
LAKE O' THE PINES
FERRELLS BRIDGE DAM
Jefferson
CADDO LAKE
SHREVEPORT
NAVIGATION
(SHREVEPORT, LA. TO DAINGERFIELD, TEX REACH)
NAVIGATION AND COMPLEMENTARY BANK STABILIZATION
(MISSISSIPPI RIVER TO SHREVEPORT, LA. REACH)
U.S. ARMY ENGINEER DISTRICT VICKSBURG
LOCK & DAM 4
Natchitoches
LOCK & DAM 3
ALEXANDRIA
JOHN H. OVERTON
BLACK RIVER
MISSISSIPPI RIVER
N
OKLAHOMA
ARKANSAS
TEXAS
PROJECT LOCATION
LOUISIANA
SCALE OF MILES
100 0 100 300
KILOMETERS
100 0 300
VICINITY MAP
IMPROVEMENTS AUTHORIZED
REALIGNED CHANNEL
LOCK AND DAM
RESERVOIR
NOTE
BANK STABILIZATION WORKS NOT SHOWN
LEGEND
EXISTING LEVEE
MILEAGE ABOVE MISSISSIPPI RIVER REALIGNED CHANNEL
MILEAGE ABOVE MISSISSIPPI RIVER ALONG EXISTING CHANNELS
EXISTING LOCK
DISTRICT DIVISION
SCALE OF MILES
KILOMETERS
5 0 10 20
HEAD OF NAVIGATION (REALIGNED MILE 294)
LOCK & DAM NO. 8, FERRELL'S BRIDGE DAM (REALIGNED MILE 276)
LOCK & DAM NO. 7, JEFFERSON, TEX (REALIGNED MILE 265)
LOCK & DAM NO. 6 CADDO DAM (REALIGNED MILE 234)
SHREVEPORT, LA.
LOCK & DAM NO. 5 (REALIGNED MILE 203)
LOCK & DAM NO. 4 (REALIGNED MILE 169)
LOCK & DAM NO. 3 JOHN H. OVERTON L & D (REALIGNED MILE 74)
LOCK & DAM NO. 1 (REALIGNED MILE 43)
FLOOD 249.5
NORMAL 229.5
MIN. 210
POOL EL 185
POOL EL 168.5
POOL EL 145
POOL EL 125
POOL EL 64
POOL EL 40
LAKE O' THE PINES
CYPRESS BAYOU
TWELVEMILE BAYOU
RED RIVER
OLD RIVER
MIN. EL 4
LEGEND
9 FT. PROJ. DEPTH
NP EL NORM. POOL ELEV.
ELEVATIONS IN FEET, N.G.V.D.
NAVIGATION PROFILE
(1967 Mileage)
MILES ABOVE THE MISSISSIPPI RIVER
LOWER MISSISSIPPI VALLEY DIVISION WORK
RIVER AND HARBOR IMPROVEMENTS
RED RIVER WATERWAY
LA. TEX. ARK. AND OKLA.
SCALES AS SHOWN
U.S. ARMY ENGINEER DISTRICT VICKSBURG
CORPS OF ENGINEERS
Revised 30 September 1967

PLATE 1

ATTACHMENT 1

LOCAL DEPOSITORIES

ATTACHMENT 1
LOCAL DEPOSITORIES

Service League Library
Carthage, Texas

Upshur County Library
Gilmer, Texas

Franklin County Library
Mr. Vernon, Texas

Quitman Public Library
Quitman, Texas

Carnegie Public Library
Jefferson, Texas

Red River County Public Library
Clarksville, Texas

Rusk County Memorial Library
Henderson, Texas

Texarkana Public Library
Texarkana, Texas

Caddo-Pine Island Oil and Historical Society Museum
Oil City, Louisiana

Delta County Public Library
Cooper, Texas

Longview Public Library
Longview, Texas

Paris Public Library
Paris, Texas

Tyler Public Library
Tyler, Texas

Noel Memorial Library
Shreveport, Louisiana

Daingerfield Public Library
Daingerfield, Texas

Marshall Public Library
Marshall, Texas

Pittsburg/Camp County Library
Pittsburg, Texas

Shreve Memorial Library
Shreveport, Louisiana

Atlanta Public Library
Atlanta, Texas

Dallas Public Library
Dallas, Texas

Fort Worth Public Library
Fort Worth, Texas

Sulphur Springs Public Library
Sulphur Springs, Texas

Red River Waterway Project
Shreveport, LA, to Daingerfield, TX, Reach
Reevaluation Study In-Progress Review

APPENDIX 1
WATER QUALITY

RED RIVER WATERWAY PROJECT
SHREVEPORT, LOUISIANA, TO DAINGERFIELD, TEXAS
REEVALUATION STUDY IN-PROGRESS REVIEW

APPENDIX 1
WATER QUALITY

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RED RIVER WATERWAY PROJECT
SHREVEPORT, LOUISIANA, TO DAINGERFIELD, TEXAS, REACH
REEVALUATION STUDY IN-PROGRESS REVIEW

APPENDIX 1
WATER QUALITY

INTRODUCTION

PURPOSE AND SCOPE

1. The water quality study is one part of the reevaluation study of the Shreveport, Louisiana, to Daingerfield, Texas, Waterway Project. The purpose of the reevaluation study is to fully evaluate a range of alternatives for extending navigation to the vicinity of Daingerfield, Texas.

2. The purpose of the water quality study is to identify preproject baseline water quality conditions in the study area, to evaluate the suitability of the sediment for dredging, and to determine the potential project impacts to water quality. This report describes the water and sediment quality studies conducted by the U.S. Army Corps of Engineers, Vicksburg District, during 1991-1992. An analysis of the data and discussion of these results are included.

EVALUATION OF EXISTING INFORMATION

LAKE O' THE PINES

3. Water quality data has been collected in Lake O' the Pines by a number of agencies since 1975. The U.S. Geological Survey (USGS) collected water quality data in Lake O' The Pines from October 1975 through September 1984. Analyses of the samples were limited to water temperature, specific conductance, sulfate, chloride, dissolved oxygen (DO), hydrogen ion (pH), dissolved solids, nitrate, ammonia-nitrogen, silica, fluoride, total and non-carbonate hardness, sodium, potassium, iron, manganese, total phosphorus (TP), carbonate, alkalinity, and carbon dioxide. Bacteriological analysis for fecal coliforms was also performed. The water quality was generally good, with the water meeting the Texas criteria for potable water. Occasional exceedances of the Texas criteria for chloride (80 milligrams/liter (mg/L)), sulfate (50 mg/L), and dissolved oxygen (5.0 mg/L) were observed. During the winter, average concentrations of DO throughout the lake are more than 10 mg/L. During the summer months, average DO concentrations ranged from 0.3 mg/L near the dam to 2.0 mg/L near the headwater at the bottom of the lake. In addition to the above

exceedances, the Environmental Protection Agency's (EPA) maximum contaminant levels (MCL) were exceeded occasionally for the following metals: cadmium, chromium, copper, iron, lead, manganese, mercury, and zinc. High concentrations of iron and manganese were reported near the dam. In the deeper portion of the lake, near the bottom, iron and manganese were much higher than mean concentrations at the surface. Fecal coliforms were in compliance with the Texas Surface Water Quality Standards of 200 colonies/100 ml (log average). No previous studies on Lake O' the Pines have analyzed water samples for priority pollutants. The Texas Water Quality Board (TWQB) analyzed sediment samples for polychlorinated biphenyl compounds (PCB's) and pesticides and detected PCB's in one sample.

BIG CYPRESS BAYOU

4. The State of Texas collected water quality data on Big Cypress Bayou at Karnack from 1976 to 1988. They collected in situ and nutrient data approximately every 2 months and twice annually respectively. No metals or pesticide data were collected from the water column. Two sediment samples were collected in 1976 and 1978 and analyzed for pesticides, PCB's, and heavy metals. Comparing the available data to the Texas water quality criteria for drinking water, the water quality was good. There have been no reported exceedances of the water quality criteria.

CADDO LAKE

5. Within the project area, Caddo Lake is the most well-studied. It has been previously studied by the EPA, the State of Texas, and the U.S. Army Corps of Engineers. In addition, it has been studied by several consulting firms and has been the subject of at least four masters theses. The waters have generally been found good for water supply, but occasionally state and Federal water quality criteria have been exceeded. The lake waters have exceeded the Texas drinking water criteria for chloride and the DO has dropped below the freshwater fish criteria of 5.0 mg/L. Low DO is found in the swampy region in the northwestern part of the lake and near the bottom in the main lake. The EPA's MCL for copper, iron, and manganese have also been exceeded.

6. The TWQB reported the first sediment and water samples at Caddo Lake in 1977. These data were reported in report #IMS-50 "Intensive Surface Water Monitoring Survey for Segment 0401." This survey reported that data collected in the Texas portion of the lake was indicative of good water quality and reported no significant water quality problems in Caddo Lake. The sediment data collected by TWQB in Caddo Lake were reported to be rich in

organic material and frequently contained slight hydrogen sulfide odors. Reported concentrations of chromium, mercury, and nickel were below those reported for natural soils. Arsenic, cadmium, copper, manganese, and silver only slightly exceeded the average levels reported for natural soils and were comparable to levels observed in other Texas reservoirs. Reported concentrations of lead and zinc exceeded average levels reported for natural soils. Water samples were not analyzed for heavy metals or pesticides. Pesticides were not detected in the sediments. PCB's were the only organic contaminants reported in the sediments. The highest sediment PCB concentration was 115 microgram/kilogram (μg/kg) and the mean was 48.3 μg/kg. This report stated that this was the second highest PCB concentrations for any of the lakes tested in Texas.

7. In August 1982, three sediment and water samples were collected by the Texas Department of Water Resources (TDWR). Ten additional sediment and water samples were collected by the U.S. Army Corps of Engineers, Fort Worth District, in December 1982. Of the three stations sampled by the TDWR, only one station detected any PCB's. This station was located in the upper portion of Caddo Lake and contained the highest concentration ever reported in the lake, 676 μg/kg. Of the ten samples collected by the Fort Worth District, four reported detectable levels of PCB's. The four stations were scattered throughout Caddo Lake. The station reporting the highest concentration, 23.4 μg/kg, was in Goose Prairie Bayou. During sampling by TDWR and the Fort Worth District, PCB's were reported only twice in the water column (5.06 and 0.17 μg/L).

8. Among the past studies on Caddo Lake is a 1983 masters thesis, "Physicochemical Limnology of Caddo Lake, Texas and Louisiana," by A. A. Hartung. The thesis examined the physicochemical limnology of Caddo Lake and evaluated the possible affect of off-shore oil production on the lake's water quality. Mr. Hartung collected in situ and chemistry data over a one year period from nine stations throughout Caddo Lake. His results determined that the lake was eutrophic due to high levels of nitrogen and phosphorus. In addition, he attributed the high sediment organic content to oil production within the lake.

9. A 1985 water supply study by the Vicksbury District reported trace levels of several trinitrotoluene (TNT) derivatives in the surface waters of Caddo Lake. The Longhorn Ammunition Plant in Karnack, Texas, used TNT extensively in the 1940's. The drainage from the ammunition plant enters Caddo Lake through Goose Prairie and Harrison Bayous. Although TNT was not detected in Caddo Lake sediments, the study recommended that any future studies look for TNT and its derivatives in the waters and sediments.

TWELVEMILE BAYOU

10. A fair amount of historical data is available for Twelvemile Bayou. The USGS has collected in situ data since 1943. Limited water chemistry data collection was initiated in 1965 for conservative ionic constituents like calcium and chloride. Nutrient, metals, and pesticide data have been collected semiannually since 1979. The result of these studies is that water quality in Twelvemile Bayou varies considerably on a seasonal basis. The water quality is generally good when water is flowing over Caddo Lake Dam. During the summer and fall, water releases from Caddo Lake are minimal, and the water quality is significantly reduced. The dissolved mineral content increases and the conductivity can exceed 2,000 micromhos per centimeter (μmhos/cm). The source of the dissolved solids (primarily sodium chloride) is Black Bayou which drains the area northeast of Caddo Lake. In addition to seasonally high dissolved solids, Twelvemile Bayou frequently has high levels of dissolved iron and manganese and occasional high levels of dissolved copper. High mean levels of fecal streptococci and fecal coliform bacteria were present. Past studies have reported trace amounts of TNT derivatives in the surface water and sediments of Twelvemile Bayou (U.S. Army Corps of Engineers, 1985).

SUMMARY

11. The historical data indicate that the water quality within the project area is generally good. Occasional exceedances of chloride, sulfate, and heavy metal water quality criteria were reported throughout the study area. DO levels were occasionally reported below minimum standards. These occasional exceedances do not restrict the use of these waters for public water supply.

12. Past studies and historical data indicate that the sediments in the study area may be contaminated with heavy metals, PCB's, TNT derivatives, and polynuclear aromatic hydrocarbons (PAH's). Data reported within the Lake O' The Pines indicated the presence of elevated heavy metals. PCB's were detected in the sediments of Caddo Lake by the TDWQ. The Caddo Lake Enlargement Study reported trace levels of TNT derivatives in Caddo Lake and Twelvemile Bayou.

WATER AND SEDIMENT SAMPLING PROGRAM

13. A sampling program was developed using guidance from the Tiered Testing Approach as described in 40 Code of Federal Regulations 230.4-1. The first tier evaluates existing information to determine if there is a reason to believe that contaminants are present. If this information can provide suitable

information indicating that the dredged material is similar to the material at the disposal site, no further testing is required. If the information is inadequate or indicates that contamination may be likely, then Tier II testing is recommended.

14. Tier II testing consists of bulk sediment analysis and elutriate or water column toxicity testing. Bulk sediment analysis is basically an inventory of contaminants of concern and is used to compare the chemical composition of the dredged material to the composition of the material at the disposal site. Major emphasis is generally placed on heavy metals, PCB's, PAH's, pesticides, and other contaminants of ecological or human health significance (EEDP-04-8). Elutriate testing is used to evaluate the potential for the release of contaminants into the dredging or disposal site water. Results of the elutriate test are compared to water quality standards after consideration of a mixing zone described in Section 404(b)(1) guidelines. If appropriate standards are not available or determined to be inadequate, a water column liquid and/or suspended particulate phase bioassay may be conducted along with consideration of mixing. If the dredged material is found to have substantially greater concentrations than those in the disposal area or if there is a reason to believe that toxic substances are bioavailable, a third tier of testing may be required.

15. Tier III testing consists of benthic bioassay and bioaccumulation impacts. Acute bioassay are conducted to evaluate the potential for toxicity and bioaccumulation effects which can result from dredging operations. The bioassay tier testing is used to determine whether there is a reason to believe contaminants in the dredged material will result in an unacceptable adverse impact to the benthic component of the aquatic disposal environment.

16. A Tier I evaluation of existing information was achieved in the previous section. From this preliminary assessment, a two-part water quality monitoring program was designed. The first part involved monthly sampling of surface water at nine stations for general water quality parameters. This data was to be used to evaluate the existing base-line water quality conditions. This routine monthly sampling was performed by the Texas and Louisiana Districts of USGS. The second part of the sampling program was an intensive water sediment survey, which involved the collection of many water, sediment, and sediment core samples. This information would be used to identify and quantify pollutants and to evaluate the suitability of the sediment for dredging. The intensive sampling was performed by the Vicksburg District, Water Quality Section.

CURRENT STUDY

Monthly Surface Water Sampling

17. To evaluate existing baseline water quality conditions along the project, nine stations were sampled monthly by USGS. These stations are listed in Table 1 and shown in Figure 1. These stations were selected based on accessibility and historical data. The surface water samples were monitored for the parameters shown in Table 2. Three times during the routine sampling effort, samples were analyzed for the priority pollutants listed on Table 3. Sampling began in July 1991 and concluded in June 1992.

TABLE 1
USGS ROUTINE WATER QUALITY STATIONS

Lake O' The Pines			
Station	Latitude	Longitude	Description
USGS 1	325411	944316	Hwy 26 Bridge, north of Ore City, TX
USGS 2	325100	944203	Hwy 155 Bridge, near Cedar Springs, TX
USGS 3	324518	943001	Near Lake O' The Pines Dam
Big Cypress Bayou			
USGS 4	324458	942955	Downstream of Lake O' The Pines Dam near Jefferson, TX
USGS 5	324148	941115	Hwy 43 Bridge north of Karnack, TX
Caddo Lake			
USGS 6	324218	935510	Hwy 1 Bridge, near Mooringsport, LA
USGS 7	324215	935644	At Caddo Lake Dam
Twelvemile Bayou			
USGS 8	324200	935438	Hwy 169 Bridge near Mooringsport, LA
USGS 9	323845	935240	Hwy 173 Bridge near Dixie, LA

TABLE 2
GENERAL WATER QUALITY PARAMETERS

General Water Quality Parameters		
In-Situ	Solids & Ions	Metals
Temperature Dissolved Oxygen Ph Conductivity Turbidity	Calcium Potassium Sodium Sulfate Chloride	Arsenic Barium Cadmium Chromium Copper Iron Lead Manganese Mercury Nickel Zinc
Nutrients	Physio-Chemical	Bacteria
Total Organic Carbon (TOC) Total Kjeldahl Nitrogen (TKN) Ammonia Nitrogen (NH3-N) Nitrite Nitrogen (NO2) Nitrate Nitrogen (NO3-N) Total Phosphorus Total Dissolved Phosphorus	Biochemical Oxygen Demand (BOD) Total Dissolved Solids Total Suspended Solids Hardness Alkalinity	Total Coliform Fecal Coliform Fecal Streptococci

TABLE 3
PRIORITY POLLUTANTS

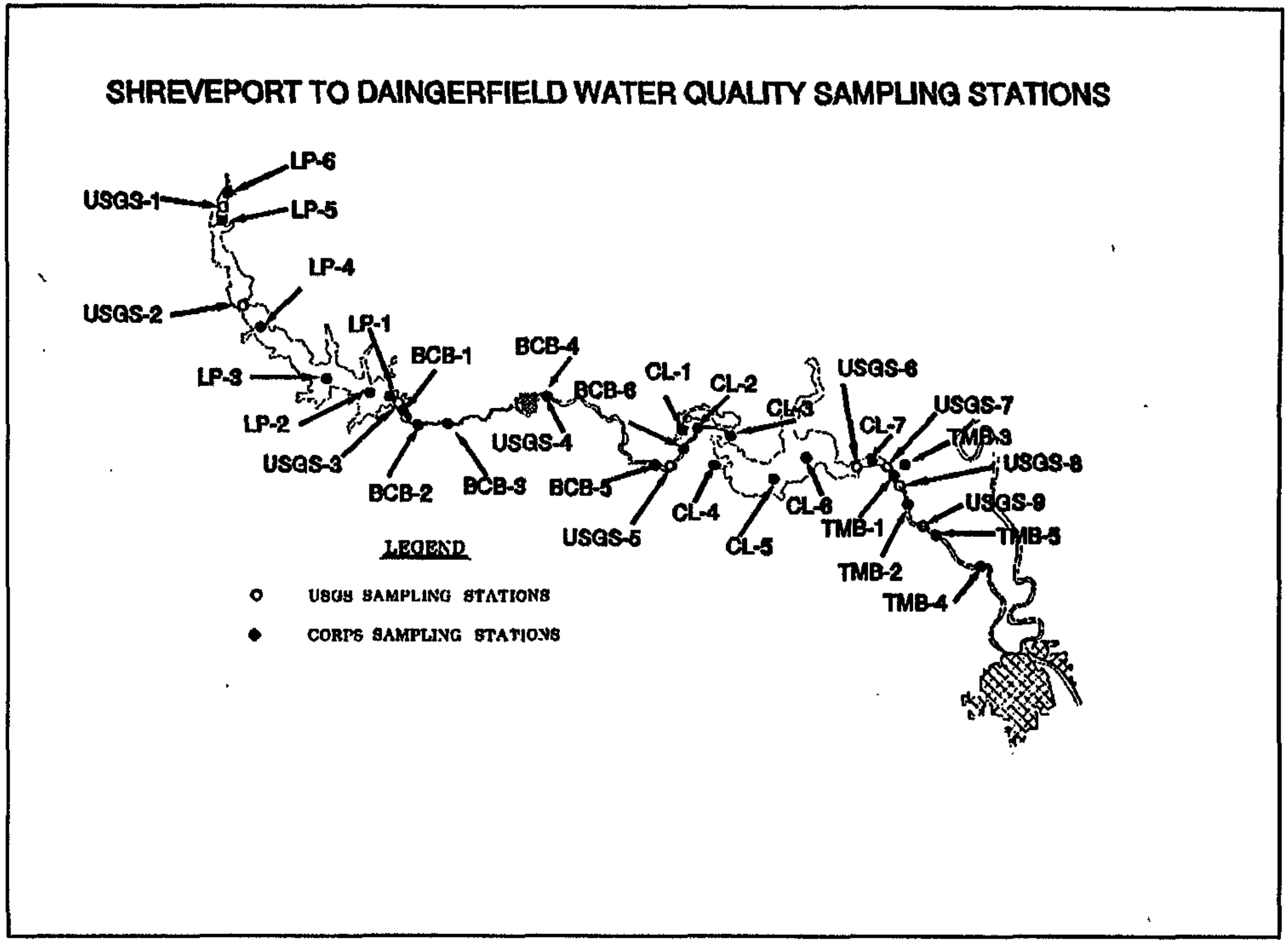
Pesticides and PCB's		
Aldrin	Endrin	Aroclor-1016
Alpha-BHC	Endosulfan I	Aroclor-1242
Beta-BHC	Endosulfan II	Aroclor-1248
Delta-BHC	Endosulfan Sulfate	Aroclor-1254
Gamma-BHC (Lindane)	Endrin Keytone	Aroclor-1260
4,4'-DDE	Heptachlor	
4,4'-DDD	Heptachlor Epoxide	
4,4'-DDT	Methoxychlor	
Dieldrin	Toxaphene	

Priority Pollutants Base-Neutral Extractable (BNA) Compounds	
Phenol	Acenaphthene
bis(2-Chloroethyl) Ether	2,4-Dinitrophenol
2-Chlorophenol	4-Nitrophenol
1,3-Dichlorobenzene	Dibenzofuran
1,4-Dichlorobenzene	2,4-Dinitrotoluene
Benzyl Alcohol	2,6-Dinitrotoluene
1,2-Dichlorobenzene	Diethylphthalate
2-Methylphenol	4-Chlorophenyl-phenylether
N-Nitroso-di-n-Propylamine	Fluorene
Isophorone	4-Nitroaniline
2-Nitrophenol	4,6-Dinitro-2-Methylphenol
2,4-Dichlorophenol	N-Nitrosodiphenylamine
Benzoic Acid	4-Bromophenyl-phenylether
bis(2-Choroethoxy)Methane	Hexachlorobenzene
2,4-Dichlorophenol	Pentachlorophenol
1,2,4-Trichlorobenzene	Phenanthrene
Naphthalene	Anthracene
4-Chloroaniline	Di-n-Butylphthalate
Hexachlorobutadiene	Fluoranthene
4-Chloro-3-Methylphenol	Pyrene
2-Methylnaphthalene	Butylbenxylphthalate
Hexachlorocyclopentadiene	3,3'-Dichlorobenzidine
2,4,6-Trichlorophenol	Benzo(a)Anthracene
2,4,5-Trichlorophenol	bis(2-Ethylhexyl)Phthalate
2-Chloronaphthalene	Chrysene
2-Nitroaniline	Di-n-Octyl Phthalate
Dimethyl Phthalate	Benzo (b) Fluoranthene
Acenaphthylene	Benzo (k) Fluoranthene
3-Nitroaniline	Benzo (a) Pyrene
	Indeno(1,2,3-cd) Pyrene
	Dibenz(a,h) Anthracene
	Benzo (ghi) Perylene

TABLE 3 (Cont)
PRIORITY POLLUTANTS

Priority Pollutants Volatile Organic (VOA) Compounds	
Chloromethane	Trans-1,2-Dichloropropene
Bromomethane	Trichloroethene
Vinyl Chloride	Dibromochloromethane
Chloroethane	1,1,2-Trichloroethane
Methylene Chloride	Benzene
Acetone	cis-1,3-Dichloropropene
Carbon Disulfide	2-Chloroethylvinylether
1,1-Dichlorethane	Bromoform
1,1-Dichlorethene	4-Methyl-2-Pentanone
1,2-Dichloroethene (total)	2-Hexanone
Chloroform	Tetrachloroethene
1,2-Dichlorethane	1,1,2,2-Tetrachloroethane
2-Butanone	Toluene
1,1,-Trichlorethane	Chlorobenzene
Carbon Tetrachloride	Ethylbenzene
Vinyl Acetate	Styrene
Bromodichloromethane	Total Xylenes
1,2-Dichloropropane	
Explosives	
GMX	Tetryl
RDX	TNT (2,4,6)
TNB	2,4 DNT
DNB	2,5 DNT
Oil and Grease	
Total Oil & Grease	
Total recoverable petroleum hydrocarbons	

Figure 1
Location of Water Quality Stations



Intensive Sampling

18. Three surveys of the project area were conducted between June 1991 and August 1992. During these surveys 30 sediment, 45 water, and 17 sediment cores were collected. Additional water and sediment was collected in August 1992 for elutriate analysis. The general locations of the sampling sites are shown in Figure 1. These samples were analyzed for the same parameters listed in Tables 2 and 3. A brief description of sampling procedures and analytical methods are provided in Attachment A-1.

RESULTS OF CURRENT STUDY

Results of Routine Water Quality Sampling

19. Table 4 lists the means of general water quality parameters collected during the monthly sampling of the nine stations by USGS. Overall the data suggest that Lake O' The Pines, Caddo Lake, and Twelvemile Bayou have elevated nutrient levels. Numerous aquatic macrophytes grow in abundance along the shores and in shallow areas in Lake O' The Pines and Caddo Lake. The two lakes would be classified as eutrophic based on their mean TP levels. Big Cypress Bayou would be classified as mesotrophic and Twelvemile Bayou as highly eutrophic. DO concentrations at the water surfaces are usually near saturation levels while DO near the bottom sediments are frequently less than 1.0 mg/L. With the exception of iron and manganese, metals are seldom detected in the surface waters but are commonly found in the sediments. In particular, the sediment lead and zinc levels were elevated above the levels observed in the soils of the region. Total coliforms and fecal coliforms were reported in excess of criteria for recreational uses.

20. In order to evaluate the results of the routine monthly sampling data, the means at each station (Table 1) were evaluated with an analysis of variance (ANOVA). The station's means were grouped with Duncan's multiple range test. The ANOVA showed that for most parameters there were no significant differences between the stations within a reach. For example, the ANOVA did not find significant differences between the two stations on Twelvemile Bayou or the two stations on Caddo Lake for most parameters. The exception to this finding is that station 1 was generally significantly different from the other two stations on Lake O' the Pines. Due to these findings, the data from stations within the same reach were grouped, and an ANOVA was performed on the means of these new groups. Station 1 was still treated as a separate station. The results of these ANOVA will be presented as the

TABLE 4
MEAN CONCENTRATION OF THE ROUTINE WATER QUALITY SAMPLES

Water Quality Parameter	USGS1	USGS2	USGS3	USGS4	USGS5	USGS6	USGS7	USGS8	USGS9	Criteria
Temperature (°C)	20.0	20.9	21.1	19.6	19.8	21.1	20.3	20.5	20.9	32°C (max)
pH (Standard Units)	7.0	6.9	6.9	6.5	6.4	6.7	6.7	6.9	6.8	6.0-8.5
Dissolved Oxygen (mg/L)	8.0	8.7	8.7	8.8	7.5	8.5	9.2	8.7	8.6	>5.0
Conductivity (μmhos/cm)	206	139	101	107	92	101	102	159	175	
Turbidity (NTU)	14	5	2	3	9	9	9	27	26	
Alkalinity (mg/L as $CaCO_3$)	34.2	15.4	11.1	6.5	12.1	14.4	14.4	26.3	26.8	
Total Suspended Solids (mg/L)	18.0	9.3	3.5	2.5	5.9	13.8	11.7	31.8	37.7	
Total Dissolved Solids (mg/L)	62.6	91.0	73.8	75.4	70.5	66.8	68.0	99.7	110.2	
Biochemical Oxygen Demand mg/L	1.8	1.5	1.0	1.0	1.2	2.7	3.0	2.6	2.6	
Total Coliforms	899	12	20	97	266	188	185	841	451	
Fecal Coliforms	6220	54	25	6036	4585	112	47	54	400	200/100ml
Fecal Streptococci	1240	212	1592	188	5541	53	47	267	209	
Total Phosphorus (mg/L as P)	0.10	0.06	0.02	0.03	0.05	0.05	0.06	0.08	0.08	
Total Dissolved Phosphorus (mg/L)	0.03	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.02	
Total Kjeldahl Nitrogen (mg/L as N)	0.60	0.58	0.39	0.53	0.44	0.71	0.70	0.75	0.68	
Nitrite-Nitrate Nitrogen (mg/L as N)	0.019	0.168	0.087	0.097	0.094	0.029	0.046	0.057	0.081	10
Ammonia Nitrogen (mg/L as N)	0.04	0.03	0.04	0.12	0.040	0.02	0.02	0.03	0.03	
Arsenic (dissolved μg/L)	<1.0	1.0	1.0	1.2	1.0	1.0	1.0	1.0	1.0	50
Barium (dissolved μg/L)	64.0	44.3	42.8	61.7	49.9	47.0	54.0	60.5	67.0	1000
Cadmium* (dissolved μg/L)	3.5	4.0	3.4	4.0	4.6	1.0	1.0	1.0	1.0	10
Chromium (dissolved μg/L)	1.0	1.0	1.0	1.3	1.0	1.0	1.0	1.0	1.0	50
Copper* (dissolved μg/L)	3.7	4.3	3.5	4.1	5.5	10.0	10.0	10.0	10.0	12[f]
Iron (dissolved μg/L)	279.5	148.3	70.8	294.8	608.1	191.7	161.7	168.3	156.8	300[c]
Lead* (dissolved μg/L)	28.0	34.0	28.0	34.0	40.6	13.3	9.2	10.5	1.0	50
Manganese (dissolved μg/L)	90.8	43.2	15.5	602.3	103.4	20.0	13.3	25.0	25.8	50[c]
Mercury (dissolved μg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	2
Nickel* (dissolved μg/L)	2.3	2.2	1.25	1.6	1.6	1.5	1.3	2.0	1.3	160[f]
Zinc* (dissolved μg/L)	10.3	6.9	4.9	7.9	9.7	8.6	8.8	8.8	7.6	110[f]

All criteria are drinking water standards.
* - Hardness dependent parameter. Criteria are based on a hardness of 100 mg/L as $CaCO_3$.
f - Criteria listed is for the protection of chronic freshwater aquatic life.
c - Criteria listed is for the safe human consumption of water and fish.

data are discussed. The following abbreviations will be used to identify the groups used in the second ANOVA:

USGS 1 = Lake O' The Pines - H
USGS 2 & USGS 3 = Lake O' The Pines
USGS 4 & USGS 5 = Big Cypress Bayou
USGS 6 & USGS 7 = Caddo Lake
USGS 8 & USGS 9 = Twelvemile Bayou

The solid bars beneath the means will indicate groupings made by Duncan's Range Test. ANOVA results will be reported only when Pr>F is less than 0.05.

In-Situ Parameters

21. During routine monitoring by USGS, measurements of temperature, DO, pH, and specific conductance were conducted at the nine routine stations. Readings were made approximately 1 foot below the water surface.

a. Temperature. Temperatures did not vary significantly between stations. Only seasonal temperature variations were observed. Mean temperatures ranged from 19.6 to 21.1 degrees Celsius (C). Water temperatures during the study ranged from 6.0 to 32.5 degrees C. Temperature values during the summer months equaled or exceeded the maximum criteria of 32 degrees C on three occasions. The stations which equaled the temperature criteria were USGS 3 in Lake O' The Pines near the dam and USGS 6 and USGS 7 in Caddo Lake. The temperature measured at station USGS 6 in Caddo Lake during September exceeded the state criteria. These were the only times temperatures exceeded the criteria. Temperature readings collected during the intensive surveys were similar to those reported by USGS.

b. Dissolved Oxygen. Mean DO measurements ranged from 7.4 to 9.2 mg/L. There were no significant differences between stations. These levels were higher than those collected during the intensive surveys. The routine measurements of DO monitored in Lake O' The Pines at USGS 1 and in Big Cypress Bayou at USGS 5 in June 1992 were below the minimum criteria of 5.0 mg/L. These were the only occurrences in which DO concentrations fell below the 5.0 mg/L criteria. DO profiles collected during the intensive surveys frequently reported readings near saturation at the surface but concentrations quickly fell lower than 5.0 mg/L below the water surface. Readings reported near the bottom were usually less than 1.0 mg/L.

c. Hydrogen Ion. Mean pH concentrations ranged from 6.4 to 7.0 Standard Units (SU). The largest range in pH was 2.5 SU, which was reported in Lake O' The Pines at the most upstream station, USGS 1. The range in pH for Caddo Lake was 1.5 SU. The monthly pH values monitored at the nine stations ranged from slightly acidic to slightly basic. The pH in Lake O' The Pines at station USGS 1 was once reported above 8.0 SU. The pH was measured below 6.0 SU in Lake O' The Pines at station USGS 2, in Big Cypress Bayou at stations USGS 4 and USGS 5, and once in Caddo Lake at station USGS 7. There were no significant differences between the means at the different stations. The slightly acidic nature of the waters is due to their low alkalinities.

Mean Conductivity by USGS Station (µmhos/cm)									
1	9	8	2	4	7	6	3	5	crit.
206	175	159	139	107	102	101	101	92	<500

d. Conductivity. Mean conductivity concentrations ranged from 92 to 206 µmhos/cm. Conductivity values were highest in Lake O' The Pines at station USGS 1. Although there are no criteria for conductivity, waters having conductivities less than 500 µmhos/cm are considered of good quality. An ANOVA between the mean conductivity concentrations grouped stations USGS 3, USGS 4, USGS 5, USGS 6, and USGS 7 as those having the lowest conductivity concentrations. These stations are located in Big Cypress Bayou, Caddo Lake, and in the lower portion of Lake O' The Pines. The next highest conductivity concentrations occurred in Twelvemile Bayou at stations USGS 8 and USGS 9. In general, conductivity decreased as the water moved through the system until it reached Twelvemile Bayou where conductivity again increased.

Mean Turbidity by USGS Station (NTU)									
8	9	1	6	7	5	2	4	3	crit.
26.8	25.6	13.8	8.9	8.9	8.6	5.3	2.7	2.0	<25
Duncan's Groupings Pr>F=.0001									
TMB		LOP-H		CL		BCC		LOP	
21.8		13.8		8.9		5.6		3.7	

e. Turbidity. Turbidity measurements ranged from 2 to 27 Nephelometric Turbidity Units (NTU's). Mean turbidity levels were highest in Twelvemile Bayou at stations USGS 8 and USGS 9. The lowest measurements occurred at stations USGS 3 and USGS 4. The ANOVA showed that the means from USGS 1 and the Twelvemile Bayou stations were significantly higher than the means from the other three groups of stations. Texas has no numerical criteria for turbidity. Louisiana has a numerical criteria of 25 NTU's for freshwater lakes and 50 NTU's for streams and rivers. Turbidities less than 10 NTU's are generally found only in pristine environments. Turbidities less than 25 NTU's are generally accepted to indicate good water quality. The means of the turbidity values all met these respective criteria, and Caddo Lake, Big Cypress Bayou, and Lake O' The Pines had means less than 10 NTU's indicating a pristine environment.

Physicochemical Parameters

Mean Total Suspended Solids by USGS Station (mg/L)									
9	8	1	6	7	2	5	3	4	Crit
37.7	31.8	18.0	13.8	11.7	9.3	5.9	3.5	2.5	<100
Duncan's Groupings Pr>F=.0001									
TMB		LOP-H		CL		LOP		BCC	
34.7		18.0		12.8		6.4		4.2	

f. Total Suspended Solids. Total suspended solids (TSS) reflect the amount of material suspended in the water. Total dissolved solids (TDS) reflect the water's dissolved mineral content. The mean TSS concentrations ranged from 2.5 to 37.7 mg/L. The highest concentration of TSS occurred in Twelvemile Bayou with the Lake O' The Pines headwaters having the next highest concentrations. The ANOVA of the grouped stations showed that the mean from Twelvemile Bayou was significantly higher than all other stations. The mean from Twelvemile Bayou (34.7 mg/L) was nearly twice the next highest mean and seven times higher than the lowest mean (4.2 mg/L) in Big Cypress Bayou. All stations' means were less than the State of Mississippi's benchmark of 100 mg/L.

Mean Total Dissolved Solids by USGS Station (mg/L)									
1	9	8	2	4	3	5	7	6	crit.
149.4	110.2	99.7	91.0	75.4	73.8	70.5	68.0	66.8	<500

g. Total Dissolved Solids. The highest TDS concentrations occurred in Lake O' The Pines at station USGS 1. Mean TDS concentrations ranged from 66.8 to 149.4 mg/L. The lowest mean TDS concentrations occurred in the lower portion of Lake O' The Pines, Big Cypress Bayou, and Caddo Lake. Results of an ANOVA performed on mean TDS concentrations agreed with those performed on the conductivity concentrations. Station USGS 1 was significantly higher than all other stations. The means from stations 2, 3, 4, 5, 6, and 7 were significantly lower than stations 1 and 8. Texas has a criteria of 300 mg/L for TDS in the Big Cypress Bayou basin. Louisiana lists 100 mg/L and 500 mg/L as the criteria for Caddo Lake and Twelvemile Bayou, respectively. These criteria were not exceeded during this study.

Mean Alkalinity by USGS Station (mg/L CaCO3)									
1	9	8	2	7	6	5	3	4	crit.
34.2	26.8	26.3	15.4	14.4	14.4	12.1	11.1	6.5	
Duncan's Groupings									
LOP-H		TMB		CL		BCC		LOP	
34.17		26.56		14.42		13.48		13.25	

h. Alkalinity. Alkalinity is the sum of all titratable bases down to a specified end point. It is a measure of the water's buffering capacity for acidic inputs. Waters with an alkalinity of less than 50 mg/L are generally considered poorly buffered and occur in regions with noncalcareous soils. The means from all of the other stations were less than 40 mg/L. The ANOVA found that the alkalinity from stations USGS 1, USGS 8, and USGS 9 were significantly higher than all other stations. The ANOVA of the grouped stations found Lake O' The Pines and

Twelvemile Bayou were significantly higher than all other stations and significantly different from each other. In general within the study area, the pH decreases with decreasing alkalinity.

Mean Total Phosphorus by USGS Station									
1	8	9	2	7	6	5	4	3	Crit
0.098	0.085	0.085	0.062	0.057	0.055	0.052	0.030	0.020	0.150
Duncan's Groupings Pr>F=.0001									
LOP-H		TMB		CL		LOP		BCC	
0.098		0.085		0.056		0.041		0.041	

i. Total Phosphorus. Mean TP concentrations ranged from 0.02 to 0.098 mg/L. The highest and lowest concentrations occurred within Lake O' The Pines at stations USGS 3 and USGS 1, respectively. An ANOVA grouped Caddo Lake, Big Cypress Bayou, and the lower station in Lake O' The Pines (USGS 3) as having the lowest TP concentrations. Although there are no numeric criteria for phosphorus, the State of Mississippi uses a benchmark of .150 mg/L to evaluate waters. Carlson uses TP levels to trophically rank lakes. Lakes with TP greater than 0.050 are considered eutrophic. TP concentrations greater than 0.02 mg/L have been shown to cause eutrophication problems in lakes (Lucas, 1988). The ANOVA of the grouped stations determined that Lake O' The Pines and Twelvemile Bayou had significantly higher mean levels of TP.

Mean Total Dissolved Phosphorus by USGS Station (mg/L)									
8	1	9	2	6	7	5	4	3	crit.
0.033	0.032	0.025	0.024	0.024	0.023	0.021	0.015	0.011	<0.02

j. Total Dissolved Phosphorus. Mean total dissolved phosphorus (TDP) concentrations ranged from 0.01 to 0.03 mg/L. The highest concentration occurred in Twelvemile Bayou at station USGS 8 and the lowest occurred in Lake O' The Pines at station USGS 3. An ANOVA indicated that no statistically valid differences could be determined between the nine stations in regards to TDP concentrations. TDP concentrations greater than 0.010 mg/L indicate that sufficient phosphorus is available for algal blooms. The mean at all stations exceeded that benchmark.

Mean Ammonia by USGS Station (mg/L)									
4	1	3	5	2	8	9	7	6	crit
.116	.044	.039	.035	.033	.033	.032	.023	.022	
Duncan's Groupings									
BCC		LOP-H		LOP		TMB		CL	
.075		.044		.036		.033		.022	

k. Ammonia Nitrogen. Mean ammonia nitrogen (NH3) concentrations ranged from 0.02 to 0.12 mg/L. The highest mean concentration occurred in Big Cypress Bayou at station USGS 4. The lowest occurred in Caddo Lake at station USGS 6. An ANOVA indicated that station USGS 4 (Black Cypress Bayou at Karnack) was significantly different in regards to ammonia concentrations. The high levels at Jefferson are likely due to the hypolimnetic releases from Lake O' The Pines. Earlier studies by the Fort Worth District found that the hypolimnetic waters were much higher in NH3 and TP than the surface waters. The mean NH3 for the intensive samples from Lake O' The Pines was 0.075 mg/L, which is twice as high as the mean from the routine sampling.

Mean Total Kjeldahl Nitrogen (mg/L)									
8	6	7	9	1	2	4	5	3	crit
0.75	0.71	0.70	0.68	0.60	0.58	0.53	0.44	0.39	<1.0
Duncan's Groupings Pr>F=0.0001									
TMB		CL		LOP-H		BCC		LOP	
0.717		0.702		0.600		0.488		0.483	

l. Total Kjeldahl Nitrogen. Mean total Kjeldahl nitrogen (TKN) concentrations ranged from 0.39 to 0.75 mg/L. The highest mean concentration occurred in Twelvemile Bayou at station USGS 8. The lowest concentration occurred in Lake O' The Pines at station USGS 3. Caddo Lake had the second highest TKN concentrations. High levels of TKN are found in eutrophic waters. There are no numeric criteria for TKN. The State of Mississippi uses 1.0 mg/L as a benchmark. The maximum observed levels in the headwaters of Lake O' the Pines and in Caddo Lake and Twelvemile Bayou exceeded this benchmark. Mean levels did not exceed the benchmark. The ANOVA of the grouped stations found significant differences, but Duncan's Test did not discern clear groupings as USGS 1 was grouped with both the high and low end pairings.

Mean Nitrate by USGS Station (mg/L)									
1	2	4	5	3	9	8	7	6	crit
.643	.168	.097	.094	.087	.081	.057	.049	.029	<1.0
Duncan's Groupings Pr>F=.0001									
LOP-H		LOP		BCC		TMB		CL	
0.643		0.128		0.096		0.070		0.038	

m. Nitrite and Nitrate Nitrogen. Mean nitrite and nitrate concentrations ranged from 0.03 to 0.64 mg/L. The highest concentration occurred in Lake O' The Pines at station USGS 1. The lowest concentration occurred in Caddo Lake at station USGS 6. An ANOVA indicated that station USGS 1 was significantly higher than the other stations. Nitrate is a source of nitrogen for phytoplankton and macrophytes. The only criteria for nitrogen is the drinking water standard of 10.0 mg/L as nitrate (NO_3) and Mississippi uses a benchmark of 1.0 mg/L. The MCL limit is used to provide protection of infants from the ill effects of methemoglobinemia caused by ingestion of high concentrations of nitrate. The benchmark levels is used to determine if nonpoint source pollution is a problem. USGS 1 had a maximum NO_3 concentration of 1.9 mg/L. The means and maximum for all the other stations were well below the benchmark level.

Mean Biochemical Oxygen Demand by USGS Station (mg/L)									
7	6	8	9	1	2	5	4	3	crit.
3.0	2.7	2.6	2.6	1.8	1.5	1.2	1.0	1.0	
Duncan's Groupings Pr>F=.0001									
CL		TMB		LOP-H		LOP		BCC	
2.94		2.58		1.83		1.24		1.16	

n. Biochemical Oxygen Demand. The 5-day biochemical oxygen demand (BOD) ranged from 1.0 to 3.0 mg/L. The highest mean BOD concentration was reported in Caddo Lake at station USGS 7. The second highest BOD concentration (2.7 mg/L) was also reported in Caddo Lake at station USGS 6. The lowest BOD values were reported in the lower portion of Lake O' The Pines at station USGS 3 and in Big Cypress Bayou (stations USGS 4 and USGS 5). The station ANOVA found that the mean BOD levels in Caddo Lake and Twelvemile Bayou were significantly higher than the other sites. The grouped ANOVA also found that Caddo Lake and Twelvemile Bayou had significantly higher BOD levels.

o. Bacteria. Mean total coliforms monitored by the USGS ranged from 12 to 899 colonies/100 ml of sample. Mean total coliform counts were highest in Lake O' The Pines at station USGS 1. Twelvemile Bayou and Caddo Lake had the second and third highest concentrations of total coliforms, respectively. Fecal coliforms were highest in Lake O' The Pines at station USGS 1. The mean fecal coliform count at this station was 6,220 colonies/100 ml. Big Cypress Bayou at Karnack had the second highest fecal coliform mean of 6,036 colonies/100 ml. Caddo Lake's highest mean was 112 colonies/100 ml at station USGS 6. The drinking water standard for fecal coliforms is set at a maximum of 2,000 colonies/100 ml. The drinking water standard for total coliforms is set at a maximum of 10,000 colonies/100 ml. The Texas contact recreation criteria for fecal coliforms is 200 colonies/100 ml and the secondary contact criteria is 4,000 colonies/100 ml. The criteria is based on an average of at least five samples taken within a 30-day period. Although bacteria counts should be made more frequently than every 30 days to properly use these criteria, these data suggest that a problem with coliform bacteria may exist within the project area.

Metals Data

22. The results of the ANOVA for metals found no significant differences between stations. The mean metals data referenced in the following paragraphs are found in Table 4.

a. Arsenic. Arsenic was detected only nine times during the routine monthly sampling. Six stations (USGS 1, USGS 2, USGS 4, USGS 5, USGS 8, and USGS 9) reported dissolved arsenic detections. The maximum concentrations measured was 2.0 μg/L at Big Cypress Bayou at station USGS 4. The EPA has set the MCL in drinking water for arsenic to be 50 μg/L (EPA, 1986). The EPA has proposed setting this limit to 5.0 μg/L (American Water Works Association (AWWA), 1990). No arsenic concentrations were ever reported to exceed either MCL.

b. Barium. Barium ranged from 42.8 to 64.0 μg/L. The current MCL for barium in drinking water is 1,000 μg/L (EPA, 1986). The measured levels of barium at all nine stations were below the MCL.

c. Cadmium. Cadmium was detected only twice during the routine sampling program. Cadmium was reported at the detection limit of 1.0 μg/L in Caddo Lake (USGS 6) and Twelvemile Bayou (USGS 8). The drinking water MCL for cadmium is 10 μg/L (EPA, 1986). The EPA has proposed lowering this limit to 5 μg/L (AWWA, 1990). The detected levels for cadmium were below both MCL's.

d. Chromium. Chromium was detected at stations USGS 3, USGS 4, USGS 5, USGS 6, USGS 7, USGS 8, and USGS 9 a total of 14 times. Of the total 14 detections, chromium was detected only three times above the detection limit of 1.0 μg/L. The maximum concentration of 4.0 μg/L was reported in Big Cypress Bayou at station USGS 4. The current drinking water MCL for chromium is 50 μg/L (EPA, 1986). The EPA has proposed lowering this criteria to 10 μg/L (AWWA, 1990). All measured concentrations of chromium were below both MCL's.

e. Copper. Copper was detected at every station and ranged from 6.0 μg/L to less than 1.0 μg/L. The highest concentration occurred in Twelvemile Bayou at station USGS 9 and in Caddo Lake at station USGS 6. Presently, there are no drinking water criterion other than those for corrosion control. The most stringent criteria for copper is 12.0 μg/L which is for the protection of freshwater aquatic life, freshwater acute (FWA), (EPA, 1986). All reported concentrations for copper were below the 12.0 μg/L FWA.

f. Iron. Mean dissolved iron concentrations ranged from 71 μg/L to 651 μg/L. The highest mean iron concentration occurred in Big Cypress Bayou at station USGS 5. After the October 1991 sampling, iron concentrations at nearly every station increased significantly. Since no change in sampling method or analytical procedure occurred during this sampling program, it is likely that the dissolved iron loadings within the project area increased in October 1991. The MCL for iron in domestic water supplies is 300 μg/L and the FWA for iron is 1,000 μg/L (EPA, 1986). The domestic drinking water MCL was exceeded on numerous occasions at every station except USGS 3, Lake O' The Pines near the dam. The FWA was exceeded in Big Cypress Bayou once in August 1991 at station USGS 4 (1,300 μg/L) and in April and May of 1992 at station USGS 5 (1,000 and 1,100 μg/L).

g. Lead. Lead was detected only five times during the routine sampling program. Big Cypress Bayou at station USGS 5 reported one concentration at the detection limit of 1.0 μg/L. Caddo Lake at station USGS 6 reported two concentrations of 1.0 and 7.0 μg/L. Twelvemile Bayou at station USGS 8 reported two concentrations of 3.0 and 2.0 μ/L. All other lead concentrations were reported as less than detection limits. The most stringent criterion for lead is for the protection of freshwater aquatic life. This criteria is 3.2 μg/L (EPA, 1986). The drinking water MCL for lead is 50 μg/L (EPA, 1986). Caddo Lake at station USGS 6 exceeded the FWA criteria once in April 1992. No lead concentrations were reported above the drinking water MCL.

h. Manganese. Mean manganese concentrations ranged from 10.4 to 602 μg/L. The highest concentrations occurred in Big Cypress Bayou at station USGS 4. The domestic water supply MCL for manganese is 50 μg/L and the FWA is 100 μg/L (EPA, 1986). Manganese was frequently reported in Lake O' The Pines at station USGS 1 and in Big Cypress Bayou at stations USGS 4 and USGS 5 to exceed these criteria. Mean concentrations reported at stations USGS 1 (90.8 μg/L), USGS 4 (602 μg/L), and USGS 5 (103 μg/L) exceed the domestic water supply criteria. With the exception of USGS 1, they also exceed the FWA criteria.

i. Mercury. Mean concentrations of mercury ranged from less than 0.1 μg/L to 0.15 μg/L. Mercury was detected five times during the routine sampling. Mercury was detected twice in Lake O' The Pines at stations USGS 1 and USGS 2 and twice in Caddo Lake at stations USGS 6 and USGS 7. Mercury was detected only once in Twelvemile Bayou at station USGS 8. Of the five detections, only two were above the detection limit of 0.1 μg/L. The highest reported mercury concentration was 0.7 μg/L which occurred in Caddo Lake at station USGS 7. The current EPA drinking water criterion for mercury is 2 μg/L (EPA, 1986). No mercury concentrations were reported above the MCL.

j. Nickel. Mean concentrations of nickel ranged from 1.2 to 2.3 μg/L. The highest concentrations of nickel occurred in Lake O' The Pines at stations USGS 1 and USGS 2. The lowest concentration of nickel was reported in Twelvemile Bayou at station USGS 9. The FWA for nickel is 160 μg/L (EPA, 1986). Concentrations of nickel reported by USGS are below the FWA criteria.

k. Zinc. The mean concentrations of zinc ranged from 4.9 to 10.3 μg/L. The highest zinc concentration of 21 μg/L occurred in Lake O' The Pines at station USGS 1. The EPA's criterion for the chronic protection of freshwater species, freshwater chronic (FWC), is 110 μg/L. Zinc levels are below the FWC criteria.

Priority Pollutants

23. The priority pollutants listed in Table 3 were analyzed three times during the routine sampling. No priority pollutants were ever detected in the water samples at any of the stations.

Results of Intensive Survey

24. The first survey of the area was conducted between 24 and 28 June 1991. Table 5 lists the stations and the parameters which were sampled during this survey. On the first survey, 24 water and sediment samples and 1 sediment core was collected. On the second survey, which was performed between 30 September and 3 October 1991, 4 sediments, 6 water samples, and 1 soil sample was collected. Table 6 lists these stations and the parameters which were analyzed. The last survey, which was conducted between 12 and 14 August 1992, 16 sediment cores, 15 water samples, and 6 elutriate samples were collected.

In Situ Parameters

25. Table 2 lists the parameters for which the water samples were analyzed. Table 7 lists the mean concentrations of the surface waters that were surveyed. DO profiles were taken at every station during the intensive surveys. The surface water was usually near saturation and dropped very rapidly to below 1.0 mg/L at the bottom. These DO levels were significantly lower than those reported by USGS. Temperature, pH, conductivity, and turbidity values were similar to those observed in the routine monthly sampling program.

TABLE 5
INTENSIVE SURVEY SAMPLING STATIONS

Lake O' The Pines	
Station	Description
LP-1	Approximately 1 mile upstream of Ferrell's Bridge Dam.
LP-1A	Hurricane Creek, approximately 1 mile downstream of State Hwy 729 bridge.
LP-2	Approximately 1/4 mile southwest of Johnson Creek Park.
LP-2A	Johnson Creek, approximately 2000 feet downstream of State Hwy 729 bridge.
LP-3	Approximately 1 mile southwest of Lakeside Motel and Marina.
LP-4	Approximately 1/2 mile west of Oak Valley Park
LP-5	Approximately 1/3 mile south of Lone Star Boat Ramp
LP-5A	Approximately 200 feet upstream of State Hwy 729 bridge near Lone Star Boat Ramp.
LP-6	Approximately 1 mile southwest of US Hwy 259 and State Hwy 729 intersection.
LP-6A	Approximately 1/4 mile upstream of Ferrell's Bridge Dam.
Big Cypress Bayou	
BCB-1	Downstream of Lake O' The Pines Dam.
BCB-2	Approximately 3 miles below Lake O' The Pines Dam.
BCB-3	Approximately 10 miles below Lake O' The Pines Dam.
BCB-4	Approximately 1 mile below Jefferson, Tx.
BCB-5	Approximately 1 mile upstream of State Hwy 43 bridge.
BCB-6	Approximately 1 mile downstream of State Hwy 43 bridge.
Caddo Lake	
CL-1	Carter Lake, approximately 3 miles downstream of Caddo State Park.
CL-2	Upper Caddo Lake near Annie Glade Bluff.
CL-3	Upper Caddo Lake near Devil's Elbow.
CL-4	Goose Prairie Bayou.
CL-5	Southeast of John T. Island, near channel marker CM100.
CL-6	Big Lake near channel marker CM60.
CL-6A	Lower Caddo Lake near channel marker G30.
CL-7	Lower Caddo Lake approximately 1000 feet upstream of spillway.
CL-8	Harrison Bayou.
CL-8A	Approximately 1000 feet downstream of Harrison Bayou, near the intersection of boat roads F and E.
Twelvemile Bayou	
TMB-1	Twelvemile Bayou downstream of Caddo Lake Spillway.
TMB-2	Twelvemile Bayou, State Hwy 169 bridge , approximately 1 mile downstream of Caddo Lake.
TMB-3	Black Bayou, approximately 1/4 mile upstream from its convergence with Twelvemile Bayou.
TMB-4	Twelvemile Bayou, US Hwy 71 bridge north of Shreveport, La.
TMB-5	Twelvemile Bayou, State Hwy 173 bridge north of Shreveport, La.
Little Cypress Bayou	
LCB-1	Little Cypress Bayou, approximately 1000 feet upstream of its convergence with Big Cypress Bayou.

TABLE 5 (Cont)
INTENSIVE SURVEY SAMPLING STATIONS

August 1992 Sediment Core and Water Quality Stations	
LPC1	Upper Lake O' The Pines, approximately 1 mile downstream of Lone Star Boat Ramp.
LPC2	Upper Lake O' The Pines, approximately 3/4 miles downstream of Lone Star Boat Ramp.
LPC3	Upper Lake O' The Pines, approximately 1/4 miles downstream of Lone Star Boat Ramp.
LPC3A	Upper Lake O' The Pines, approximately 1/4 miles downstream of Lone Star Boat Ramp.
LPC4	Upper Lake O' The Pines, near Lone Star Boat Ramp.
LPC5	Upper Lake O' The Pines, approximately 1/4 miles upstream of Lone Star Boat Ramp.
CLC1	Goose Prairie Bayou.
CLC2	Downstream of Uncertain, Tx.
CLC3	Near Swanson's Landing.
CLC4	Crips Landing.
CL-1	Carters Lake.
CLL-1	Clinton's Lake.
CLC6	Station CL-6, near Boat Marker CM60.
CLC6A	Near Boat Marker G30.
JB1	Jim's Bayou near Boat Marker E34.

TABLE 6
PARAMETERS ANALYZED DURING INTENSIVE SURVEY BY STATION

June 1991 Sediment Survey						
LP1	TOC	BNA2		MET	PEST	EXP
LP2	TOC	BNA2		MET	PEST	
LP3	TOC	BNA2		MET	PEST	
LP4	TOC	BNA	VOA	MET	PEST	
LP5	TOC	BNA	VOA	MET	PEST	EXP
LP6	TOC	BNA2		MET	PEST	
CLP5	TOC			MET	PEST	
BCB1	TOC	BNA	VOA	MET	PEST	
BCB2	TOC	BNA2		MET	PEST	
BCB3	TOC	BNA2		MET	PEST	EXP
BCB4	TOC	BNA	VOA	MET	PEST	
BCB5	TOC	BNA2		MET	PEST	
BCB6	TOC	BNA2		MET	PEST	
CL1	TOC	BNA2		MET	PEST	EXP
CL2	TOC	BNA2		MET	PEST	EXP
CL3	TOC	BNA2		MET	PEST	EXP
CL4	TOC	BNA	VOA	MET	PEST	EXP
CL5	TOC	BNA2		MET	PEST	EXP
CL6	TOC	BNA	VOA	MET	PEST	EXP
CL7	TOC	BNA2		MET	PEST	EXP
TMB1	TOC	BNA2		MET	PEST	EXP
TMB2	TOC	BNA2		MET	PEST	EXP
TMB3	TOC	BNA	VOA	MET	PEST	EXP
TMB4	TOC	BNA2		MET	PEST	EXP
TMB5	TOC	BNA	VOA	MET	PEST	EXP
October 1991 Sediment Survey						
LP5A	TOC	BNA	VOA	MET	PEST	
LCB1	TOC	BNA	VOA	MET	PEST	
CL6A	TOC	BNA	VOA	MET	PEST	EXP
CL8	TOC	BNA	VOA	MET	PEST	EXP
LP4S	TOC			MET		

TABLE 6 (Cont)
PARAMETERS ANALYZED DURING INTENSIVE SURVEY BY STATION

June 1991 Water Quality Survey								
LP1	NUT	BNA	VOA	MET	PEST	EXP	O&G	TRPH
LP2	NUT	BNA	VOA	MET	PEST		O&G	TRPH
LP3	NUT	BNA	VOA	MET	PEST			
LP4	NUT	BNA	VOA	MET	PEST			
LP5	NUT	BNA	VOA	MET	PEST	EXP	O&G	TRPH
LP6	NUT	BNA	VOA	MET	PEST			
BCB1	NUT	BNA	VOA	MET	PEST			
BCB2	NUT	BNA	VOA	MET	PEST			
BCB3	NUT	BNA	VOA	MET	PEST	EXP	O&G	TRPH
BCB4	NUT	BNA	VOA	MET	PEST			
BCB5	NUT	BNA	VOA	MET	PEST			
BCB6	NUT	BNA	VOA	MET	PEST			
CL1	NUT	BNA	VOA	MET	PEST	EXP		
CL2	NUT	BNA	VOA	MET	PEST	EXP	O&G	TRPH
CL3	NUT	BNA	VOA	MET	PEST	EXP		
CL4	NUT	BNA	VOA	MET	PEST	EXP	O&G	TRPH
CL5	NUT	BNA	VOA	MET	PEST	EXP		
CL6	NUT	BNA	VOA	MET	PEST	EXP	O&G	TRPH
CL7	NUT	BNA	VOA	MET	PEST	EXP	O&G	TRPH
TMB1	NUT	BNA	VOA	MET	PEST	EXP		
TMB2	NUT	BNA	VOA	MET	PEST	EXP		
TMB3	NUT	BNA	VOA	MET	PEST	EXP	O&G	TRPH
TMB4	NUT	BNA	VOA	MET	PEST	EXP		
TMB5	NUT	BNA	VOA	MET	PEST	EXP	O&G	TRPH
October 1991 Water Quality Survey								
LP1	NUT			MET				IONS
LP5A	NUT	BNA		MET				IONS
LCB1	NUT	BNA	VOA	MET				IONS
CL7	NUT	BNA	VOA	MET	PEST	EXP		IONS
CL8	NUT	BNA	VOA	MET	PEST	EXP	O&G	IONS
BB1	NUT							IONS

Key:
NUT - Nutrients listed in Table 3
BNA - Priority pollutant BNA compounds listed in Table 3
BNA2 - Priority pollutant BNA compounds listed in Table 3, analysis was performed in December 1991.
VOA - Priority pollutant VOA compounds listed in Table 3
MET - Metals listed in Table 3
PEST - Pesticide and PCB parameters listed in Table 3
EXP - Explosives listed in Table 3
IONS - Ionic species listed in Table 3

TABLE 7
MEAN CONCENTRATIONS OF THE INTENSIVE WATER SAMPLES

Water Quality Parameter	Lake O'The Pines	Big Cypress Bayou	Caddo Lake	Twelvemile Bayou	Criteria
Chloride (mg/L)	13.1	9.6	9.9	86.0	185
Total Organic Carbon (mg/L)	4.0	3.2	4.0	3.9	
Total Phosphorus (mg/L as P)	0.20	0.01	0.26	0.02	
Total Kjeldahl Nitrogen (mg/L as N)	0.81	0.53	0.94	0.79	
Nitrite-Nitrate Nitrogen (mg/L as N)	0.12	0.06	0.05	0.05	10
Ammonia Nitrogen (mg/L as N)	0.04	0.04	0.01	0.02	
Metals (total µg/L)					
Arsenic	23	<5.0	8.0	9.0	50
Barium	66.7	62.7	63.8	133	1000
Cadmium*	0.3	0.3	0.2	1.4	10
Chromium	6.2	27	7.4	1.7	50
Copper*	26.2	7.7	8.8	63.2	12[f]
Iron	1256	843	1474	1002	300[c]
Lead*	4.3	2.3	2.0	2.5	50
Manganese	382	523	393	253	50[c]
Mercury	0.3	<0.2	0.2	0.3	2
Nickel*	10.2	4.1	12.4	2.2	160[f]
Zinc*	74.4	26.0	28.8	37.2	110[f]

All criteria are drinking water standards unless noted otherwise.
* - Hardness dependent parameter. Criteria are based on a hardness of 100 mg/L as $CaCO_3$.
f - Criteria listed is for the protection of chronic freshwater aquatic life.
c - Criteria listed is for the safe human consumption of water and fish.

Physio-chemical Parameters

26. Table 7 lists means of the surface water data collected during the intensive surveys. Mean TKN concentrations were slightly higher for these samples than were reported by USGS. Average TKN concentrations were 0.81, 0.53, 0.94, and 0.79 mg/L for Lake O' The Pines, Big Cypress Bayou, Caddo Lake, and Twelvemile Bayou, respectively. Water samples collected during the intensive survey were taken approximately 1 foot above the bottom sediment. Samples collected by USGS were taken approximately 1 foot below the water surface. This is the likely reason that the nitrogen levels were different. Mean nitrate-nitrite concentrations were highest in Lake O' The Pines which had a mean concentration of 0.12 mg/L. This was nearly twice that of Big Cypress Bayou (0.06 mg/L), Caddo Lake (0.05 mg/L), and Twelvemile Bayou (0.05 mg/L). NH_3 levels were highest in Lake O' The Pines and Big Cypress Bayou in which both had a mean of 0.04 g/L. The lowest mean ammonia concentration was in Caddo Lake (0.01 mg/L). TP concentrations averaged 0.20, 0.01, 0.26, and 0.02 mg/L for Lake O' The Pines, Big Cypress Bayou, Caddo Lake, and Twelvemile Bayou, respectively. The mean TOC concentrations were 4.0 mg/L for both Lake O' The Pines and Caddo Lake. Big Cypress Bayou had a mean TOC of 3.2 mg/L and Twelvemile Bayou had a mean concentration of 3.9 mg/L.

Metals Data

27. Six of the 11 metals shown in Table 7 (arsenic, copper, iron, lead, manganese, and zinc) were detected at levels exceeding EPA criteria. The metal concentrations in the intensive study were generally higher than in the routine survey. One reason for this is that USGS measured dissolved metal concentrations, while the Corps measured total metal concentrations. Another reason that the metal concentrations in the intensive study may be higher than those reported in the routine study is that the intensive study samples were collected near the bottom near the sediment water interface. Metal concentrations for some metals are higher in deeper, lower oxygen zones than samples collected from zones near the surface.

a. Arsenic. Arsenic was detected 10 times in 45 samples. Only one concentration exceeded EPA drinking water criteria (50 μg/L). Station LP5A in the upper reach of Lake O' The Pines reported a concentration of 131 μg/L.

b. Copper. Copper was detected in 24 of 45 samples. Mean concentrations of copper listed in Table 7 show that Lake O' The Pines and Twelvemile Bayou exceed the 12 μg/L FWA. The highest reported concentration, 308 µg/L, was reported in Twelvemile Bayou at station TMB1. The highest concentrations reported in Lake O' The Pines was 141 µg/L, which was reported at station LP1. The likely reason that the copper concentrations were higher than those reported by USGS is that the water samples were collected near the bottom rather than near the surface.

c. Iron. Iron concentrations were found throughout the project area exceeding the FWC (1,000 µg/L) criteria. All mean concentrations of iron in Table 7 exceed the domestic drinking water supply criteria (300 µg/L). Mean concentrations reported in Lake O' The Pines, Caddo Lake, and Twelvemile Bayou exceed the FWC (1,000 µg/L). The maximum iron concentration was 3,800 µg/L, which was reported in Big Cypress Bayou.

d. Lead. Lead was detected in 24 of 45 samples. Neither mean nor maximum lead concentrations exceeded the EPA drinking water criteria. The highest lead concentration was 28 µg/L which was reported in Lake O' The Pines at station LP1. Lake O' The Pines, Big Cypress Bayou, Caddo Lake, and Twelvemile Bayou all had stations reporting concentrations above the FWA of 3.2 µg/L. Lake O' The Pines had two stations in addition to LP1, LP5A (5.0 µg/L) and LPC3-1 (6.9 µg/L). Big Cypress Bayou, Little Cypress Bayou, and Twelvemile Bayou each had one station, BCB4 (7.0 µg/L), LCB1 (7.0 µg/L), and TMB3 (6.0 µg/L). Caddo Lake had two stations CL7 (5.0 µg/L) and CLC2-1 (4.6 µg/L). Although lead was not detected above the drinking water criteria, it may be of concern to the aquatic environment.

e. Manganese. Manganese was detected in every sample. All reported manganese concentrations were above the 100 µg/L MCL for domestic water supplies. The highest manganese concentration was 1,880 µg/L, which was reported in Lake O' The Pines at station LP3.

f. Zinc. Zinc was detected in 28 of 45 samples. Mean zinc concentrations ranged from 26 to 74 µg/L. All mean concentrations were below the FWC of 110 µg/L. Maximum concentrations of zinc in Lake O' The Pines, Caddo Lake, and Twelvemile Bayou exceeded the FWC. The highest zinc concentrations occurred in Lake O' The Pines, 214 µg/L, while Caddo Lake had the next highest, 190 µg/L.

Priority Pollutants

28. Of the priority pollutants monitored in the surface water samples, only five were detected. All detected values were below the EPA detection limits for contract laboratories. The five pollutants were butylbenzyl phthalate, bis (2-ethylhexyl) phthalate, diethyl phthalate, methylene chloride and heptachlor. These parameters except for heptachlor are common analytical lab contaminants and their actual presence in the water samples is

suspect. Butylbenzyl phthalate was detected in Lake O' The Pines at stations LP3 and LP5 and in Caddo Lake at station CL7. The concentrations reported at these stations were below the detection limits and were reported as the best estimate by the analyst. The reported concentrations for butylbenzyl phthalate were 4.4, 6.4, and 4.5 $\mu g/L$ at stations LP3, LP5, and CL7, respectively. Bis (2-ethylhexyl) phthalate and diethyl phthalate were detected with the greatest frequency but the method blanks indicated that these samples were likely contaminated. Methylene chloride was detected in Caddo Lake at stations CL7 and CL8, but the method blank was also contaminated. The only pesticide detected in the water samples was detected in Caddo Lake at station CL7. Heptachlor was reported as 0.005 $\mu g/L$ which is well below the detection limit of 0.03 $\mu g/L$.

INTENSIVE SURVEY OF SEDIMENTS

29. Between June 1991 and August 1992, 28 sediment samples, 15 cores samples, and 1 soil sample were collected. Table 6 lists the stations and the group of parameters for which the surface sediments were analyzed. Tables 2 and 3 list the different parameters in each group listed in Table 6. Originally 8 samples from the first 24 samples collected in June 1991 were analyzed to determine if priority pollutants were present. If a particular group of pollutants were not detected in this first set of data, they would not be analyzed in the remaining samples. These data were separated by reach and means calculated from all stations within each reach. These data are shown in Table 8. The maximum value reported within each reach and the normal ranges found in the earth's crust are also listed in the table.

Sediment Metals Data

30. Presently there are no sediment quality criteria with which to evaluate sediment quality. The Tiered testing approach which is based on a "reason to believe" philosophy was used to evaluate these sediments. If these data or other factors provide a "reason to believe" contaminants or biological effects may be possible, then the next level of Tiered testing would be recommended. To determine whether these sediments would likely be contaminated, they were compared to two benchmark levels, ER-L and ER-M, reported by the National Oceanic and Atmospheric Administration (NOAA), 1990. The ER-L represents the 10th percentile level of accumulated environmental effects data. It represents a low level benchmark, and sites with concentrations below this level would not be considered contaminated and no further evaluation would be required. The ER-M represents the 50th percentile of the range of contaminant levels that produce environmental effects. Sediment concentrations in excess of the ER-M could be considered contaminated. Concentrations falling between the ER-L and ER-M benchmarks are within a level of concern and should be thoroughly evaluated.

TABLE 8
MEAN CONCENTRATIONS OF THE INTENSIVE SURFACE SEDIMENT SURVEY

Sediment Quality Parameter	Lake O'Pines		Big Cypress Bayou		Caddo Lake		Twelvemile Bayou		ER	
Units = mg/kg	Avg	Max	Avg	Max	Avg	Max	Avg	Max	ER-L	ER-M
Total Organic Carbon	10994	21975	4927	13191	19288	39440	5932	11463		
Arsenic (0.1-40)	5.9	11.8	3.19	12.8	5.0	11.2	1.94	3.67	33	85
Barium	142	244	43.8	157	169	329	181	328		
Cadmium (0.1-0.7)	1.86	5.50	<0.4	<0.9	0.89	1.90	0.52	0.60	5	9.0
Chromium (5-3000)	19.8	40.8	5.35	16.6	18.7	36.5	13.2	19.3	80	145
Copper (2-100)	14.1	35.8	1.60	5.7	12.8	37.1	6.10	9.20	70	390
Iron (7000-550,000)	27300	47900	6762	21300	28400	53700	14100	20500		
Lead (2-200)	61.5	170	9.6	23.6	28.8	58.9	13.2	25.3	35	110
Manganese (100-4000)	782	1280	200	543	1780	12400	385	591		
Mercury (0.01-0.3)	0.176	0.405	<0.1	<0.1	0.132	0.262	<0.1	<0.1	0.15	1.3
Nickel (10-1000)	14.5	28.8	3.19	12.8	20.3	39.3	12.2	18.1	30	50
Zinc (10-300)	216	568	17.1	62.9	88.1	160	32.4	47.7	120	270

Ranges in parenthesis are typical ranges within uncontaminated soils (Bowen, 1966).

31. These percentiles were determined from numerous published sediment biological assays. The majority of the assays were co-occurrence assays, where frequently many contaminants were present. No determinations were made to isolate which contaminant was responsible for the observed biological effect. All contaminants present were considered responsible for the observed effect. In addition, secondary conditions resulting from the assay may have been responsible for the observed effect. For example ammonia, hydrogen sulfide, and low DO which have toxic effects to aquatic life may have influenced these tests. Presently, there has not been any well-established literature and practical experience showing general relationships between the concentrations of chemical contaminants in sediment and the impact that sediment-associated contaminants could have on water quality (NOAA, 1990). In spite of these limitations, these benchmarks represent the best available indicators of potential sediment toxicity. Therefore, these benchmarks were used to determine if there was a reason to believe that the sediments are contaminated.

32. The stations which reported the overall highest metal concentrations within each reach were LP5, LP5A, BCB5, CL5, CL6, CL6A, TMB3, and TMB4. The sediment concentrations reported in this study are within the natural ranges found in the earth's crust (Bowen, 1966). In a few samples, the concentrations of cadmium, manganese, mercury, and zinc exceeded these normal ranges. Lead and zinc exceeded the ER-M concentrations in Lake O' The Pines at station LP5. Surface sediments in Caddo Lake exceeded the ER-L's for lead, mercury, nickel, and zinc but not the ER-M levels. Surface sediments collected in Twelvemile Bayou and Big Cypress Bayou did not exceed the ER-L levels.

Metal Analyses of Core Samples

33. To further evaluate the sediments, core samples were collected in August 1992. Results of the heavy metal analyses of the core samples are shown in Table 9. Each core was subdivided into as many 4-inch segments as possible. The metals lead and zinc were frequently reported above the ER-L benchmarks in these cores. The third segment of the core collected at station LPC5 reported levels of arsenic, cadmium, and mercury above the ER-L benchmarks and lead and zinc above the ER-M levels. Lead was reported in Lake O' The Pines at stations LPC3, LPC3A, and LPC5 in excess of the ER-M benchmark. These levels were detected in the first 16 inches of the cores. Station LPC2 reported lead above the ER-L in the top 4 inches of its core. Zinc was reported in Lake O' The Pines in excess of the ER-M at stations LPC2, LPC3, LPC3A, and LPC5. Zinc in the top 4 inches at station LPC4 exceeded the ER-L.

34. No heavy metals were reported above the ER-M benchmarks in any of the Caddo Lake sediment cores. The metals lead, mercury, nickel, and zinc, however, were reported in excess of their respective ER-L's. Lead and zinc were found in excess of the ER-L in the bottom core segment at station CLC6A in Caddo Lake. Nickel was found in excess of the ER-L at stations CLC3, CLC6A, and CLC6. Mercury was detected in the first 18 inches above the ER-L at stations CLC2, CLC6A, and CLC6. Based on these findings, there is a reason to believe that some sediments in the project area are contaminated with heavy metals in particular arsenic, cadmium, lead, mercury, nickel, and zinc.

TABLE 9
SEDIMENT CORE METAL DATA

Lake O' The Pines Sediment Core Data													
STATION	DEPTH	TOC	AS	BA	CD	CR	CU	FE	MN	PB	HG	NI	ZN
LPC1-1	0-4	1000	1	37	0.04K	4.4	2.8	6100	110	3.4	0.11K	3.1	14
LPC1-2	4-8	450	0.9	38	0.04K	5.3	2.8	6300	82	3.9	0.11K	2.9K	14
LPC1-3	8-12	1000	0.9	33	0.04K	3.3	2.4	5200	53	3.5	0.11K	2.9K	11
LPC1-4	12-16		0.4	21	0.04K	2.2	2.4	2900	26	2.7	0.11K	2.9K	7.4
LPC2-1	0-4	470	8.1	160	1.29	17	14	2600	1100	84	0.20K	16	280
LPC2-2	4-8	5800	3.5	180	0.25	15	8.9	21000	1300	21	0.15K	13	66
LPC2-1B	0-4	6000	2.8	160	0.07	11	7	18000	1000	14	0.15K	7.2	39
LPC2-2B	4-8	4700	2.9	170	0.04	13	7.6	22000	1600	14	0.11K	8.5	42
LPC3-1	0-4	5700	5.6	200	4.54	25	27	30000	1000	150	0.29K	20	480
LPC3-2	4-8	7900	8.5	190	3.96	23	26	31000	730	140	0.29K	20	510
LPC3-3	8-12	3300	3.5	91	0.91	6.6	5.2	13000	180	34	0.15K	5.1	140
LPC3-1A	0-4	4400	6	180	2.73	20	23	29000	1200	100	0.23K	22	410
LPC3-2A	4-8	5200	3.3	99	2.25	12	15	17000	490	70	0.17K	11	250
LPC3-3A	8-12	15000	7.4	220	1.31	29	28	37000	900	110	0.26K	23	450
LPC3-4A	12-16	13000	7.6	250	1.95	32	31	39000	910	120	0.29K	26	570
LPC4-1	0-4	3700	3.4	99	1.43	10	7.3	15000	500	56	0.16K	9.2	170
LPC4-2	4-8	5100	2.9	130	0.43	11	6.6	18000	1400	23	0.13K	10	85
LPC5-1	0-4	26000	5.9	99	2.26	13	13	26000	310	99	1.06	9.5	490
LPC5-2	4-8	7500	12	150	2.43	17	12	63000	1100	190	1.01	17	1100
LPC5-3	8-12	20000	56	200	25	47	33	22-0000	2900	1500	0.66	28	6600
LPC5-4	12-16	5300	16	79	4.49	15	7.1	52000	870	260	0.12K	9.9	1300
LPC5-5	16-20	6200	2.4	87	0.21	5.2	3.9	7300	96	20	0.15K	6.7	53
LPC5-6	20-24	5600	2.6	73	0.17	4.3	3.7	7000	110	16	0.15K	6.8	48

Table 9 (Cont.)
Sediment Core Metal Data

Caddo Lake Sediment Core Data													
STATION	DEPTH	TOC	AS	BA	CD	CR	CU	FE	MN	PB	HG	NI	ZN
CLC1-2	0-3	6500	4.8	290	0.16	22	17	23000	250	22	0.32K	24	83
CLC1-1	3-6	5100	0.6	240	0.09	11	13	11000	120	17	0.17K	11	33
CLC2-1	0-4	5300	5.7	140	0.35	9.9	5.7	23000	700	19	0.18	13	79
CLC2-2	4-8	5000	1.6	160	0.42	12	7.2	14000	370	12	0.14K	7.5	30
CLC3-1	0-4	6500	4.7	260	0.27	19	13	41000	740	29	0.34K	22	110
CLC3-2	4-8	5400	4.6	310	0.13	25	15	33000	660	23	0.24K	31	83
CLC3-3	8-12	4100	1.3	290	0.09	24	19	20000	450	17	0.18K	14	62
CLC4-1	0-4	4100	0.4K	52	0.4K	3.1	1.7K	3600	23	4.7	0.13K	2.9	7.6
JB1-1	0-4	5400	0.9	170	0.05K	9.9	4.6	7000	310	14	0.15K	3.5K	15
JB1-2	4-8	6300	0.4K	120	0.04K	9.4	2.7	6100	140	9.6	0.14K	3.0K	12
CL1-1	0-4	9400	0.8	27	0.04K	4.1	1.8K	4000	67	3.6	0.13K	3.4	16
CL1-2	4-8	8600	2.6	220	0.18	15	5.6	19000	350	16	0.19K	13	73
CL1-3	8-12	7500	2.5	170	0.08	14	6.3	12000	300	13	0.21K	7.8	43
CL1-4	12-16	27000	3.5	230	0.18	21	12	16000	460	22	0.23K	15	63
CLC6A-1	0-8	6200	4.1	260	0.11	30	18	35000	770	17	0.23K	29	76
CLC6A-2	8-16	8400	2.9	260	0.17	22	15	30000	860	16	0.42	26	63
CLC6A-3	16-24	5500	6.2	340	0.23	20	16	39000	960	28	0.27K	26	91
CLC6A-4	24-32	10000	5.1	350	0.31	24	19	48000	1000	31	0.24K	29	110
CLC6A-5	32-40	10077	10	350	1.23	26	44	50000	1200	48	0.43K	35	150
CLC6-1	0-4	4300	9.6	290	0.19	17	17	25000	620	23	0.33K	29	80
CLC6-2	4-8	12000	7.6	260	0.17	22	20	25000	520	20	0.35	34	86
CLC6-3	8-12	12000	2.9	230	0.23	18	23	12000	320	18	0.23K	19	62
CLC6-4	12-16	18000	2.5	310	0.33	27	24	19000	240	20	0.20K	24	110
CLL1-1	0-4	16000	0.9	230	0.28	11	16	8000	360	17	0.19K	9.2	34
CLL1-2	4-8	5800	1	250	0.17	12	18	7400	230	18	0.20K	9.2	32
CLL1-3	8-12	12000	0.6K	300	0.29	14	26	7700	230	19	0.16K	10	18
CLL1-4	12-16	17000	5.6	300	0.27	16	17	16000	430	27	0.32K	21	93

Units: mg/kg
Depth is in inches
K represents values reported as less than detection the detection limit

Priority Pollutants

35. The 119 priority pollutants that were analyzed in the sediments are divided into two groups, BNA and VOA compounds. The priority pollutants are listed in Table 3. Analysis of the first eight sediment samples reported only trace amounts of BNA's, below EPA contract laboratory quality control detection limits. The BNA's reported were n-nitrosodimethyl amine (BCB4), di-ethyl phthalate (BCB1, BCB4, and TMB5), di-butyl phthalate (LP4, LP5, BCB1, BCB4, CL4, C16, and TMB5), and bis(2-ethylhexyl) phthalate (BCB1, BCB4, and TMB5). Phthalates are general laboratory contaminants and sample contamination is suspected in these samples. Quality control method blanks analyzed with the phthalates also reported trace levels, further suggesting possible laboratory contamination. These detections were reported in Lake O' The Pines, Big Cypress Bayou, Caddo Lake, and Twelvemile Bayou. No detectable or trace amounts of the VOA compounds were reported in any of the eight sediment samples.

36. Based on the questionable levels of BNA's, the remaining 24 sediment samples were analyzed for the BNA priority pollutants. Because no VOA's were detected in the first eight samples, VOA analyses were not performed. This second analysis of BNA's indicated trace amounts of the phthalates and PAH's. Di-butyl phthalate and bis(2-ethylhexyl) phthalate both were reported in trace amounts at several stations throughout the project area. Quality control method blanks run with these analyses also reported trace amounts, indicating that these levels were suspect. In addition, di-n-octyl phthalate at station BCB2 and 4-methyl phenol at stations LP4 and BCB5 were reported below the Contract Required Quantitation Limit (CRQL). The PAH's identified at trace levels were pyrene and fluoranthene in Caddo Lake at station CL7.

37. Because of the questionable levels of PAH's reported in the June 1991 series of sediment analysis and local concerns over some sampling stations, four additional sediment samples were collected in October 1991. These stations were LP5A in Lake O' The Pines, LCB1 in Little Cypress Bayou, and CL8 and CL6A in Caddo Lake. These sediments were analyzed for BNA's, VOA's, PCB's, pesticides, and heavy metals. The results of the heavy metals have previously been discussed. Analyses of these sediments did not report any BNA's above the CRQL's. Di-butyl phthalates were reported below the CRQL at stations LP5A, CL8, and CL6A. Bis (2-ethylhexyl) phthalate was reported below the CRQL in Little Cypress Bayou at station LCB1. Trace amounts of several PAH's were reported in Lake O' The Pines and Caddo Lake. Station LP5A reported the most number of PAH's. These were anthracene, naphthalene, fluorene, phenanthrene, fluoranthene,

pyrene, chrysene, benzo(a) anthracene, benzo(b) fluroanthrcene, benzo(k) fluoranthene, benzo(a) pyrene, indeno(1,2,3,c,d) pyrene, and benzo(g,h,i) perylene. Station CL6A reported trace levels of phenanthrene, fluoranthene, and pyrene. Of the VOA compounds, toluene (0.39 mg/kg) was reported above the CRQL's in Caddo Lake at station CL8. Acetone was reported at station CLC6A in Caddo Lake (0.86 mg/kg). Acetone was also reported in the method blanks, suggesting possible laboratory contamination. VOA compounds reported below the CRQL's were chloroform (CLC6A); toluene (LP5A); ethyl benzene (LCB1); acetone (LCB1, CL8, LP5A, and CL6A); 2-butanone (CL8, LP5A, and CL6A); and total xylenes (CL8 and CL6A). Based on the reported levels of PAH's, core samples were collected in the upper portion of Lake O' The Pines and mid-lake in Caddo Lake.

Sediment Core Data

38. The last round of sediment samples indicated that the headwaters of Lake O' The Pines at station LP5A and in Caddo Lake near stations CL6A and CL8 still had questionable levels of PAH's. Sediment cores were collected in Lake O' The Pines and in Caddo Lake in August 1992 and analyzed for PAH's. Table 10 lists the PAH results of the core samples. The core in Caddo Lake at station CL6A was approximately 20 inches in depth and was separated into five 4-inch segments. The top 4-inch segment was labeled CL6A-1, and the bottom segment was labeled CL6A-5. No PAH's were reported in any of the Caddo Lake core segments. PAH's were reported, however, in Lake O' The Pines at station LCP5 and LCP3. The core taken at station LCP5 was approximately 24 inches in depth and was segmented into six 4-inch segments. The top 4-inch segment was labeled LPC5-1, and the bottom segment was labeled LPC5-6. PAH's were detected above the CRQL in the first 12 inches of the LPC5 core. The last 12 inches reported trace levels of PAH's. Trace amounts of PAH's were reported at station LPC3, which is approximately 0.5 mile downstream of LPC5. No PAH's were reported at the other stations LPC2 and LPC4 which are approximately 0.25 and 1 mile downstream of LPC5, respectively. These data clearly show that PAH's are present in the sediments in the most upstream reaches of Lake O' The Pines and may exist for at least a 0.5 mile downstream of the Lone Star Boat Ramp. PAH's, which are known to be carcinogenic in laboratory animals, are formed by incomplete combustion of organic compounds in the presence of insufficient oxygen (AWWA, 1990). They are extremely insoluble in water and are usually associated with particulates in the water column (AWWA, 1990). Because PAH's have been detected in the upper portion of Lake O' The Pines, Tier III testing would be required to evaluate the toxicity of these sediments.

TABLE 10
RESULTS OF PAH ANALYSIS OF SEDIMENT CORES

PAH'S (mg/kg)	LPC5-1	LPC5-2	LPC5-3	LPC5-4	LPC5-5	LPC5-6	ER-L	ER-M
Depth in inches	0-4	4-8	8-12	12-16	16-20	20-24		
Naphthalene	0.37J	0.07J	0.84J	0.09J	<1.0	<0.9		
Acenaphthene	0.05J	<1.2	0.16J	<1.0	<1.0	<0.9		
Fluorene	0.14J	0.16J	0.59J	0.08J	<1.0	<0.9		
Phenanthrene	0.98J	0.64J	2.5J	0.34J	<1.0	<0.9	0.225	1.380
Anthracene	0.55J	0.30J	1.3J	0.16J	<1.0	<0.9	0.085	0.960
Fluoranthene	4.2	2.9	15	0.75J	0.08J	0.05J	0.600	3.600
Pyrene	4.9	3.3	17	0.92J	0.08J	0.04J	0.350	2.200
Chrysene	2.6	1.1J	7.7	0.35J	<1.0	<0.9	0.400	2.800
Benzo(a) Anthracene	2.1	0.86J	7.4	0.23J	<1.0	<0.9	0.230	1.600
Benzo(b) Fluoranthene	2.7	0.66J	6.2	0.13J	<1.0	<0.9		
Benzo(k) Fluoranthene	0.95J	0.41J	3.6	0.11J	<1.0	<0.9		
Benzo(a) Pyrene	1.8	0.39J	5.5	0.09J	<1.0	<0.9		
Indeno(1,2,3,C,D) Pyrene	1.2	0.14J	5.6	<1.0	<1.0	<0.9		
Benzo(g,h,i) Perylene	1.1J	0.11J	4.8	<1.0	<1.0	<0.9		
	LPC1-1	LPC2-1B	LPC3-1A	LPC4-1	LPC4-2			
Depth in Inches	0-4	0-4	0-4	0-4	4-8			
Naphthalene	<0.81	<0.94	<1.7	<1.0	<0.90			
Acenaphthene	<0.81	<0.94	<1.7	<1.0	<0.90			
Fluorene	<0.81	<0.94	<1.7	<1.0	<0.90			
Phenanthrene	<0.81	<0.94	0.09J	<1.0	<0.90		0.225	1.380
Anthracene	<0.81	<0.94	<1.7	<1.0	<0.90		0.085	0.960
Fluoranthene	<0.81	<0.94	0.19J	<1.0	<0.90		0.600	3.600
Pyrene	<0.81	<0.94	0.26J	<1.0	<0.90		0.350	2.200
Chrysene	<0.81	<0.94	0.17J	<1.0	<0.90		0.400	2.800
Benzo(a) Anthracene	<0.81	<0.94	0.07J	<1.0	<0.90		0.230	1.600
Benzo(b) Fluoranthene	<0.81	<0.94	<1.7	<1.0	<0.90			
Benzo(k) Fluoranthene	<0.81	<0.94	<1.7	<1.0	<0.90			
Benzo(a) Pyrene	<0.81	<0.94	<1.7	<1.0	<0.90			
Indeno(1,2,3,C,D) Pyrene	<0.81	<0.94	<1.7	<1.0	<0.90			
Benzo(g,h,i) Perylene	<0.81	<0.94	<1.7	<1.0	<0.90			

J- Indicates concentrations below EPA contract laboratory quality control detection limits.

TABLE 10 (Cont)
RESULTS OF PAH ANALYSIS OF SEDIMENT CORES

	CL6A-1	CL6A-2	CL6A-3	CL6A-4	CL6A-5		ER-L	ER-M
Depth in Inches	0-4	4-8	8-12	12-16	16-20			
Naphthalene	<1.5	<1.4	<1.8	<2.0	<3.0			
Acenaphthene	<1.5	<1.4	<1.8	<2.0	<3.0			
Fluorene	<1.5	<1.4	<1.8	<2.0	<3.0			
Phenanthrene	<1.5	<1.4	<1.8	<2.0	<3.0		0.225	1.380
Anthracene	<1.5	<1.4	<1.8	<2.0	<3.0		0.085	0.960
Fluoranthene	<1.5	<1.4	<1.8	<2.0	<3.0		0.600	3.600
Pyrene	<1.5	<1.4	<1.8	<2.0	<3.0		0.350	2.200
Chrysene	<1.5	<1.4	<1.8	<2.0	<3.0		0.400	2.800
Benzo(a) Anthracene	<1.5	<1.4	<1.8	<2.0	<3.0		0.230	1.600
Benzo(b) Fluoranthene	<1.5	<1.4	<1.8	<2.0	<3.0			
Benzo(k) Fluoranthene	<1.5	<1.4	<1.8	<2.0	<3.0			
Benzo(a) Pyrene	<1.5	<1.4	<1.8	<2.0	<3.0			
Indeno(1,2,3,C,D) Pyrene	<1.5	<1.4	<1.8	<2.0	<3.0			
Benzo(g,h,i) Perylene	<1.5	<1.4	<1.8	<2.0	<3.0			

J- Indicates concentrations below EPA contract laboratory quality control detection limits.

PCB's

39. Although there were no detections of PCB's in the eight surface sediment samples that were screened initially, all surface sediment samples were analyzed for PCB's because of the past reports of PCB's reported in Caddo Lake. These analyses never reported any detections of PCB's. Core samples collected in Caddo Lake in August 1992 were also analyzed for PCB's. There were no detections of even trace amounts of PCB's in any surface or core sediment samples collected during the study.

Pesticides

40. Of the pesticides analyzed in the original eight samples, p'p'DDE, p'p'DDT, and heptachlor epoxide were the only ones detected. Only heptachlor epoxide and p'p'DDE were reported above EPA contract laboratory quality control detection limits (CRQL). The only time p'p'DDE was detected was in Twelvemile Bayou at station TMB3 (0.029 mg/kg) and heptachlor epoxide was only detected in Lake O' The Pines at station LP5 (0.21 mg/kg). Trace amounts, levels reported below CRQL values, of p'p'DDT were

reported in Lake O' The Pines and Twelvemile Bayou at stations LP4 and TMB3, respectively. Analysis of the remaining 24 sediment samples reported only trace amounts of p'p'DDT at station CL2 in Caddo Lake. Pesticide analysis of the four sediment samples collected in October 1991, reported only chlordane (0.073 mg/kg) in Little Cypress Bayou at station LCB1. Due to the low number of reported detectable quantities of pesticides and the lack of multiple pesticides being reported at any one station, there is little reason to believe that sediments are contaminated with pesticides.

Explosives

41. Seventeen sediment samples were analyzed for explosives. Of these, nine were collected in Caddo Lake, four in Twelvemile Bayou, two in Big Cypress Bayou, and two in Lake O' The Pines. It was anticipated that if explosives were present they would be found in Caddo Lake or Twelvemile Bayou. Samples collected in Lake O' The Pines and Big Cypress Bayou were used as background control as they were not likely to be contaminated with explosives. No explosives were reported in any of the samples.

ELUTRIATE TEST RESULTS

42. Due to results of the bulk sediment testing (Tier IIa) Tier IIb testing was performed at six sites. Four sites in upper Lake O' The Pines and two sites in Caddo Lake. A total of six elutriate tests were performed on the bottom sediments to determine if any of the contaminants identified in bulk sediment analysis would likely be released into the water during dredging operations. The elutriate test provides a conservative estimate of what is likely to be released during dredging. The test does not take into account a mixing zone or any dilution that occurs once the dredge material is discharged into open water. The elutriate data shown in Table 11 indicates that water concentrations of iron and manganese exceeded secondary drinking water criteria at every station. Lead exceeded the drinking water criteria at every station except station CLC6A. Copper and zinc exceeded the FWC criteria at all six stations. Barium, which is released from oil and gas drilling mud, exceeded its criteria for drinking water in Lake O' The Pines at station LPC2 and in Caddo Lake at stations CLC6 and CLC6A. Due to the high levels of heavy metals reported by the elutriate tests, water column bioassays would have to be performed to further evaluate the effects that may occur to aquatic life.

TABLE 11
ELUTRIATE RESULTS

Metal Data		AS	CD	CR	CU	PB	HG	NI	AG	ZN	BA	FE	MN
Criteria (μg/L)		**50**	**10**	**50**	**12[f]**	**50**	**2**	**160[f]**	**50**	**110[f]**	**1000**	**300[c]**	**50[c]**
LPC1	W (μg/L)	3.0K	0.3K	13K	17K	3.1	0.2K	23K	9.0K	54.0	73.0	1800	190
	S (mg/kg)	0.80	0.04	3.80	2.60	3.38	0.11	2.95	1.10	11.60	32.25	5125	67.8
	E (μg/L)	6.6	0.35	10K	**20.3**	**65.6**		12.3	1.0K	**162.7**	374.3	**38767**	**1527**
LPC2	W (μg/L)	3.0K	0.3K	13K	17K	2.0	0.2K	23K	9.0K	40.0	66.0	1100	130
	S (mg/kg)	5.80	0.77	16.0	11.45	525	0.18	14.5	1.5	173.0	170	11800	1200
	E (μg/L)	29.1	0.61	22.7	**72.0**	**300**		25.3	1.0K	**459.7**	**1374**	**125067**	**4947**
LPC3	W (μg/L)	3.0K	0.3K	13K	31	6.9	0.5	23K	9K	100	65.0	1400	150
	S (mg/kg)	6.08	2.06	23.25	24.25	100.0	0.00	20.50	2.30	420	187.3	3500	875
	E (μg/L)	9.2	1.3	10.0K	**20.3**	**271.3**		15.3	1.0K	**491**	432.7	**32933**	**1887**
LPC5	W (μg/L)	3K	0.3K	13K	14.0	3.0	0.2K	23K	9.0K	54.0	70.0	1600	220
	S (mg/kg)	15.8	5.76	16.9	12.1	347.5	0.53	12.98	1.72	1599	114.7	62550	897.7
	E (μg/L)	19.5	2.2	10K	**21.7**	**275**		17.7	1.0K	**862**	797	**47167**	**1264**
CLC6	W (μg/L)	3.0K	0.3K	13K	14K	2.0K	0.2K	23K	9K	23.0	42.0	840	100
	S (mg/kg)	5.67	0.41	24.40	22.4	28.3	0.30	26.5	2.45	84.5	312.0	40400	958
	E (μg/L)	6.8	0.54	12.3	**33.7**	**58.4**		23.7	1.0K	**258.3**	**2170**	**87367**	**5997**
CLC6A	W (μg/L)	3.0K	0.3K	13K	14K	2.0K	0.2K	23K	9.0K	20K	47.0	550	100
	S (mg/kg)	6.70	0.2	0.20	19.0	28.0	0.32	29.0	2.7	98.0	272.5	20250	425
	E (μg/L)	7.3	0.3	10K	**16.3**	**32.4**		12.7	1.0K	84.7	**1011**	**46467**	**3690**

Criteria
W Concentration in water column prior to disturbance.
S Concentration in sediment prior to disturbance.
E Concentration in water column after disturbance.

43. Both Caddo Lake and Lake O' The Pines are used for public water supplies. The elutriate test results indicate that the concentrations of some heavy metals may exceed the MCL's in the immediate vicinity of a dredge. Trace amounts were also detected (below detection limits) at station LPC3. The PAH concentrations detected at LPC5 exceeded ER-L and ER-M levels indicating that this station is considered highly contaminated with PAH's.

WATER QUALITY STUDY SUMMARY

44. The routine and intensive water quality surveys did not detect any major problems concerning water quality. Based on these surveys and past studies the surface water quality in the study area is good. The intensive sediment survey found high levels of heavy metals, particularly lead and zinc, in the sediments of both of the lakes within the study area. The high levels of heavy metals were localized to the upper mile of Lake O' The Pines and the central area of Caddo Lake. The elutriate tests indicated that there is the potential for the release of several heavy metals in excess of their respective MCL's in the immediate vicinity of a dredge. The highest levels of PAH's and heavy metals in Lake O' The Pines are found in sediments 8 to 12 inches below the sediment-water surface. Because these contaminated sediments are buried, they should not pose any problems to aquatic life.

DESCRIPTION OF DREDGING ALTERNATIVES

DREDGING ALTERNATIVES

45. The extension of the Red River Waterway from Shreveport, Louisiana, to Daingerfield, Texas, would require the excavation of approximately 76 miles of channel. The dredging alternatives involve using barge or land-based dragline or floating hydraulic dredge. The ability to use these two dredge types is dependent on the size, width, and depth of the existing water areas. Each option is limited by the physical dimensions of the lakes and rivers and the physical limitations of the dredge. For example, Twelevemile Bayou, Caddo Lake, and Lake O' The Pines are all sufficiently deep and wide enough to use either a floating hydraulic dredge or a floating dragline dredge. Big Cypress Bayou may be deep enough in the segment below Jefferson, but it may not be either deep or wide enough to facilitate a hydraulic dredge or a floating dragline equipment in the segment above Jefferson. Therefore, it may be necessary to use land-based dragline equipment to perform channel construction in Big Cypress Bayou within that segment.

46. Construction of the navigation channel would require the disposal of the excavated material in either open water, upland, or upland containment areas. Section 102 of the National Environmental Policy Act requires that alternatives to proposed actions be developed whenever the proposed action could significantly affect the quality of the human environment. For the purpose of this water quality evaluation, the following alternatives have been considered:

a. No Work

b. Dragline dredging with open water disposal

c. Dragline dredging with upland disposal

d. Hydraulic dredging with open water disposal

e. Hydraulic dredging with contained upland disposal

NO WORK ALTERNATIVE

47. Under the no work alternative, there would be no channel improvements in the Shreveport to Daingerfield Reach Waterway Project.

DRAGLINE DREDGING ALTERNATIVES

48. Dragline refers to a method of channel excavation that uses a large bucket or clamshell to remove sediment from the river (see Figure 2). The bucket is suspended from the end of a long boom enabling it to be swung into position. The operator makes repeated cuts into the channel bottom until the desired widths and bottom elevations are achieved. The sediments can either be placed into barges and removed from the area or placed in open water disposal areas forming small islands or berms parallel to the channel.

49. When using dragline dredges, resuspension of sediments occurs throughout the water column in the following manner:

a. From the impact, penetration, and removal of the bucket from the bottom.

b. During hoisting of the bucket from the bottom to the surface, material erodes from the top of the bucket.

c. After the bucket clears the water surface, sediment is lost through rapid drainage and slumping of material heaped above the bucket rim (McLellan, et al., 1989).

50. The rate of material lost is influenced by the condition of the bucket, the hoisting speed, and the properties of the sediment. Even under ideal conditions, losses of loose and fine sediments invariably occur. Special buckets may be considered if the bucket dredge is considered for use in dredging contaminated sediments. The size of the resulting sediment plume is dependent on instream velocities, water depth, material size, bucket condition, and operator skill.

HYDRAULIC DREDGING ALTERNATIVES

51. Hydraulic dredging refers to a method of a channel excavation in which a floating barge supports a cutterhead assembly. The cutterhead and suction pipe are mounted at the end of a ladder and submerged to the desired depth (see Figure 3). The cutterhead sweeps across the channel bottom while pumps force the water-sediment slurry through a floating pipeline to be disposed in open water or in an upland containment area. There are physical limitations to consider when utilizing a hydraulic dredge. Debris such as logs and stumps cannot be removed by the cutterhead and must be removed by physical means. Floating hydraulic dredges have limited applicability where water depths are less than or equal to the draft of the dredge.

52. Resuspension of sediments by a hydraulic dredge is dependent upon the equipment setup and operating techniques. Sediment resuspension characteristics of the cutterhead may be the most sensitive of any dredge type to changes in operating technique (USCE, 1989). Thickness of cut, depth of water over cutter, rate of swing, cutter rotation rate, and suction pressure all affect sediment resuspension rates. In deep water, hydraulic dredges have the potential to resuspend less sediment than dragline dredges. However, when dredging in shallow water where the diameter of the cutterhead is nearly equal to river depth, the advantages of hydraulic dredges are not as great. Hydraulically dredged material is either disposed in open water or pumped into contained upland disposal areas.

53. The impacts to water quality resulting from dredging operations within the Shreveport to Daingerfield Reach of the Red River Waterway Project were evaluated using a national comprehensive testing strategy supported by the Corps (EEDP-04-08). This strategy consists of an optional Tiered testing approach. Each successive tier is based on a "reason to believe" that a potential for unacceptable adverse effects may exist.

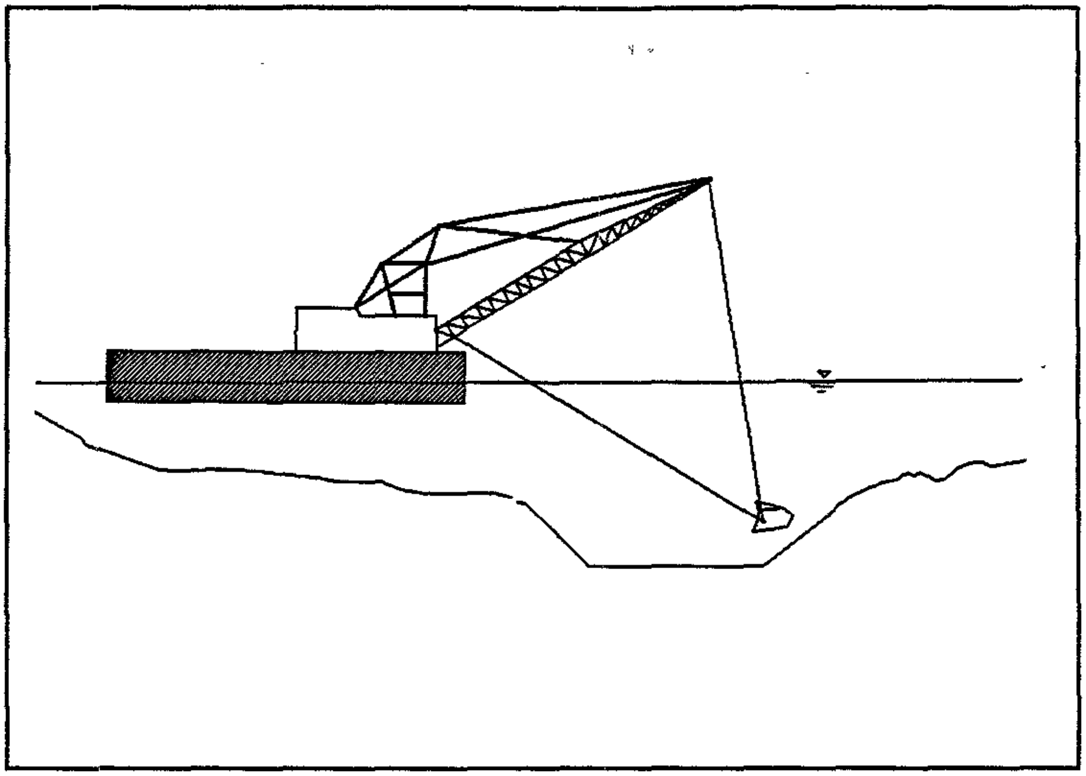


Figure 2 Floating Dragline Dredge

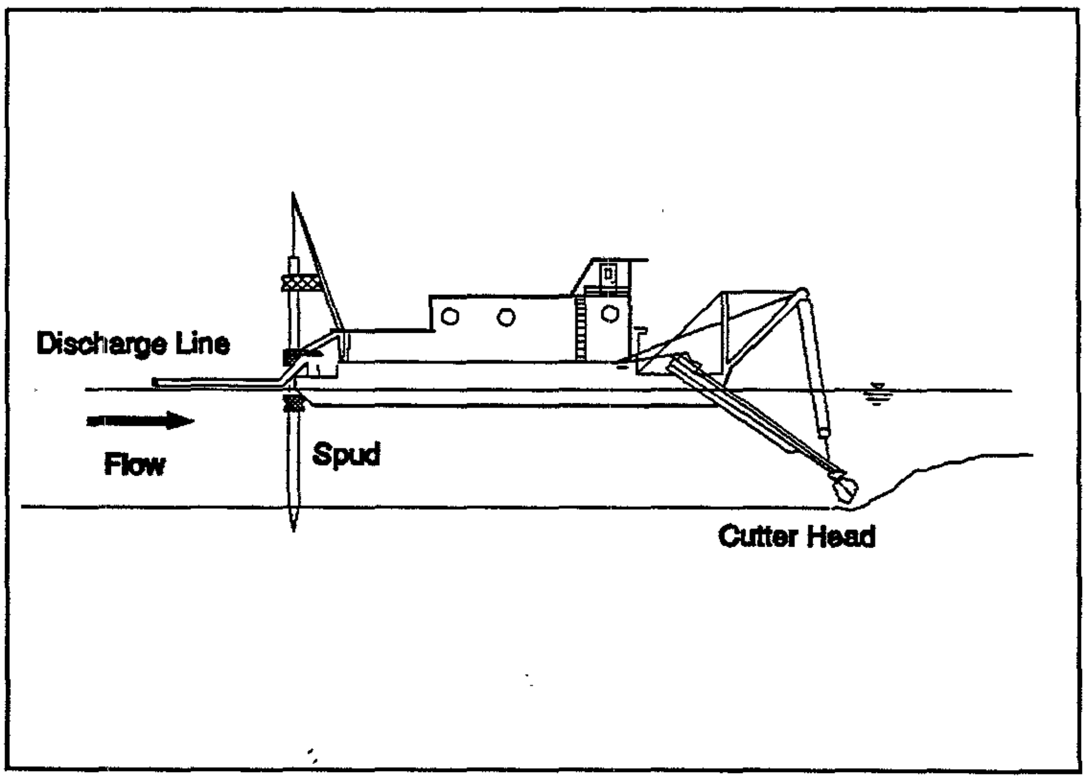


Figure 3 Hydraulic Dredge

WATER QUALITY IMPACTS OF THE DREDGING ALTERNATIVES

54. The impacts to water quality resulting from dredging operations are similar for both dragline and hydraulic dredging methods. The major impacts to water quality resulting from dredging by either dragline or hydraulic methods include increases in suspended solids, increases in turbidity, decreases in DO, release of nutrients, and the resuspension of toxic materials. The magnitude of the impacts to water quality will be dependent on the nature of the material to be dredged, the dredging method selected, and the type of disposal method employed. Impacts to water quality resulting from the various dredging alternatives have been divided into two sections, dragline and hydraulic dredging alternatives. In addition, the direct and indirect impacts to water quality for the two dredging alternatives are discussed independently.

WATER QUALITY IMPACTS OF THE NO WORK ALTERNATIVE

55. Since the no work alternative assumes that there would not be any channel dredging or channel improvements, there would be no direct impacts on the water quality in this basin.

WATER QUALITY IMPACTS ASSOCIATED WITH DRAGLINE DREDGING ALTERNATIVES

56. Impacts to water quality resulting from dragline dredging operations are separated into direct and indirect impacts. Direct impacts to water quality are impacts resulting from the physical aspects of dredging operations. Indirect impacts to water quality include both chemical and biological impacts resulting in response to dredging activities.

Direct Impacts of Dragline Dredging

57. Table 12 summarizes the potential direct impacts resulting from dragline dredging operations. These direct impacts to water quality tend to be immediate and short term in duration. The physical process of removing sediments from the channel resuspends sediment, strips away existing aquatic habitat, and buries or kills invertebrates. Net effects of this activity include increases in water turbidities and lowering and shifting of invertebrate species composition, diversity, and biomass to bottom-dwelling types.

TABLE 12
POTENTIAL DIRECT IMPACTS OF CHANNEL DREDGING

Activity	Impact	Net Effect
A. Channel Excavation	1. Resuspends Sediments	a. increases turbidity b. resuspends toxic substances
	2. Removes aquatic habitat	a. shifts invertebrate species composition, diversity and biomass to botttom-dwelling types b. decreases invertebrate drift c. alerts fish population to non-game species
	3. Buries, injuries, kills biota	a. lowers species richness, diversity, and biomass
B. Removal of Bank Vegetation Using Landbased Equipment	1. Eliminates buffering and stability benefits of bank vegetation	a. increase runoff, erosion and pollution b. increases light intensity c. raises water temperature d. decreases cover e. reduces contribution of organic matter to energy budget f. increase primary productivity
	2. Reduces riparian habitat	a. reduces richness and diversity of river dependent species
C. Machinery Operation	1. Leads to oil and fuel leaks	a. causes localized contamination

58. With the use of a land-based dragline dredge, the removal of trees and bank vegetation would be required to provide access for the maintenance and operation of the dragline. With the removal of bank vegetation, soil erosion will increase until bank vegetation is reestablished and construction is completed. Runoff will contain higher levels of suspended solids. Nutrients which are normally contained by bank vegetation, will be released into the surface water. Although an indirect impact, this increase in nutrients will increase the productivity of aquatic plants.

59. With the use of a floating dragline dredge, the removal of bank vegetation would not be required where the channel width is acceptable. The increase in suspended solids resulting from a floating dragline dredge would be dependent only on the amount of dredged material being removed and the disposal method employed, open water or upland disposal.

60. Either land-based or floating dragline dredging operations will resuspend sediments, particularly silts and clays, which will result in increased turbidities. The effects of increased turbidities include some or all of the following: decreased light penetration, elevated water temperatures, a shift to free-floating algae, lowered DO, impaired predator growth, and reduced fish spawns. Under minor increases in turbidity, fish and invertebrates would experience clogging and irritation of gills (see Table 13). Large increases in suspended sediments could lead to more severe gill irritation, disease, and possibly death. These more severe impacts tend to occur in small closed systems. Where possible, fish will avoid the affected area by moving away from the dredging operations.

61. Another direct impact is potential increases in the availability of toxic pollutants. Dredging activities will disturb sediments which can be contaminated with high levels of heavy metals and/or organic pollutants. During dredging and open water disposal, these sediments can become temporarily suspended and move downstream before resettling. During resuspension, toxic chemicals could enter the aqueous phase and become bioavailable.

Indirect Impacts of Dragline Dredging

62. Indirect impacts of channel dredging on riverine systems can be extensive and long term. They include the loss of stream habitat, long term increases in turbidity due to losses of stream bank vegetative cover, reductions in DO, and increases in temperatures. A summary of possible indirect impacts is listed in Table 14.

TABLE 13
WATER QUALITY DEGRADATION
FROM ELEVATED TURBIDITY LEVELS

Biochemical	a. Resuspension and possible release of toxic substances b. Lowers dissolved oxygen
Physical	a. Decreases light penetration. b. Increases water temperatures.
Biological	a. Algal species shift from attached to free-floating because of decreases in light availability, and the shift and scouring of substrate. b. Low turbidity increases clogging and irritation of fish and invertebrate gills. c. High turbidity increases severe gill clogging, irritation, disease, and possible death to fish and invertebrates. d. Silted sediments results in reduced spawns or suffocated eggs of species utilizing bottom material for egg deposition. e. Predator species' ability to search out prey is decreased, which impairs predator growth and survival.

TABLE 14
COMPREHENSIVE LISTING OF POSSIBLE
INDIRECT IMPACTS OF DREDGING ON WATER QUALITY

Activity	Impact	Net Effect
A. Channel Modifications	1. cause stream channel instabilities including erosion in some stretches and deposition in others	a. increases turbidity b. silts over spawning and recruitment areas
	2. raise flow velocities and increase bed load movement	a. decreases fish and invertebrate habitat b. causes loss of organic materials
	3. homogenize channel flow and reduce diversity of depths and velocities	a. lower macro-invertebrate and fish diversity, richness, and biomass--more ubiquitous species
	4. increase sediment transport out of the tributaries (i.e., rejuvenation)	a. raises bed load and turbidity b. silts over spawning and recruitment areas
	5. decrease out-of-bank flooding events and duration	a. degradation of water quality by increased nutrient retention
	6. reduce biomass and richness of insectivorous game fish	a. causes fish community shift to benthic feeders and piscivores
B. Removal of On-Bank Vegetation	1. increase bank erosion	a. increases bed load and turbidity
	2. leads to higher out-of-bank flow velocities	a. increase bed load and turbidity
	3. increases primary productivity (i.e.,phytoplankton)	a. causes a localized diurnal fluctuation in dissolved oxygen
C. Placement of Dredge Spoils on Bank	1. results in bank erosion during out-of-bank flow events	a. increases bed load and turbidity

* Not all of these are likely to be observed on a single dredging project.

WATER QUALITY IMPACTS ASSOCIATED WITH HYDRAULIC DREDGING ALTERNATIVES

63. Impacts to water quality resulting from hydraulic dredging operations are similar to those resulting from dragline dredging. These include both direct and indirect impacts.

Direct Impacts of Hydraulic Dredging

64. The direct impacts resulting from hydraulic dredging are similar to the direct impacts mentioned for dragline dredging and include those previously mentioned in Table 12. These direct impacts to water quality tend to be immediate and short term in duration. The physical process of removing sediments from the channel resuspends sediment, strips away existing aquatic habitat, and buries or kills invertebrates. Net effects of this activity include increases in water turbidities and a lowering and shifting of invertebrate species composition, diversity, and biomass to bottom-dwelling types.

65. Hydraulic dredging operations within the lakes would not require the removal of bank vegetation. Some bank vegetation would be removed if a hydraulic dredge was selected for channel construction in Big Cypress Bayou between Caddo Lake and Jefferson, Texas. The amount of land clearing required for utilizing an upland containment area would be determined by the size of the containment area. When using open water disposal, the increases in suspended solids will be dependent on the amount and nature of the material to be moved. The resuspension of sediments, particularly silts and clays, will result in increased turbidities, and the effects that are listed in Table 13. The effects of increased turbidities include decreased light penetration, elevated water temperatures, a shift to free-floating algae, lowered DO, impaired predator growth, and reduced fish spawns. Under minor increases in turbidity, fish and invertebrates would experience clogging and irritation of gills. Large increases in suspended sediments would lead to more severe gill irritation, disease, and possibly death. These more severe impacts tend to occur in closed systems, and whenever possible, fish tend to avoid areas of high turbidity.

Indirect Impacts of Hydraulic Dredging

66. Indirect impacts of hydraulic dredging on water quality can be extensive and tend to be longer term. Indirect impacts include the loss of stream habitat, reductions in DO, increases in temperatures, and the release of toxic substances from the sediments. A summary of the indirect impacts is listed in Table 14.

67. The increases in turbidity resulting from dredging operations may increase water temperatures. With increases in suspended solids, more particles would be present to absorb solar radiation and help raise water temperatures. The increases in water temperatures in lakes cause density currents to occur. It is likely that any increases in temperatures will be short term and localized since the increases in suspended solids would occur only during dredging operations.

WATER QUALITY IMPACTS ASSOCIATED WITH OPEN WATER DISPOSAL

68. The Clean Water Act provides guidelines in evaluating dredged material (40 Code of Federal Regulations, part 230). These guidelines indicate that open water disposal would be allowed if the dredged material is "substantially similar" to that of the material at the disposal site. Open water disposal would be allowed when it can be shown that unacceptable concentrations of contaminants would not be transported beyond the boundaries of the mixing zone. During open water disposal, impacts to water quality would be expected to occur. These impacts are similar to those described for dredging operations and would consist of both direct and indirect impacts.

Direct Impacts

69. Direct impacts to water quality resulting from open water disposal tend to be immediate and short term in duration. These impacts would be similar to those described previously, and they are listed in Tables 12 and 13. The physical process of disposing sediments into the water column resuspends sediment, increases turbidities, reduces DO, releases excess nutrients, and resuspends toxic contaminants into the water column. When the dredged material settles out of suspension, it can bury or kill benthic invertebrates.

Indirect Impacts

70. Indirect impacts to water quality resulting from open water disposal include some or all of the following: increases in turbidity, decreases in DO, and increases in water temperatures. These potential impacts are listed in Table 14.

WATER QUALITY IMPACTS ASSOCIATED WITH CONTAINED UPLAND DISPOSAL

71. An upland disposal area is a sedimentation basin which retains the hydraulic dredge discharge. The retention time of the containment area is determined from settling characteristics

of the sediments and the quality of water desired. Effluent from the containment area may contain high levels of suspended solids, nutrients, heavy metals, and other chemical contaminants. Impacts to water quality resulting from the use of upland containment areas include both direct and indirect impacts.

Direct Impacts

72. Direct impacts to water quality resulting from upland disposal area tend to be immediate and short term in duration (Tables 12 and 13). Effluent from the containment areas can contain high levels of suspended solids resulting in increases in water turbidities. Release of toxic materials within the containment area may subsequently be released into the receiving water.

Indirect Impacts

73. Indirect impacts to water quality resulting from upland disposal areas include increases in turbidity, decreases in DO, increases in water temperatures, release of nutrients, and the resuspension of toxic contaminants (Table 14). In addition, when dredging is completed and the containment area is drained, the pH of the soil can decrease which increases the potential for the leaching of heavy metals. After draining, these areas will be exposed to natural weathering processes. Runoff from storm events may leach contaminants from the containment area into surface or groundwater.

QUANTIFICATION OF IMPACTS

74. The quantification of impacts to water quality resulting from channel construction are difficult to analyze. The extent of these impacts depend on the nature of the material to be dredged, the type of construction method, and disposal option utilized. The most likely impacts to water quality resulting from the proposed channel construction include increases in turbidity, increases in temperature, decreases in DO, the release of toxic substances, the leaching of contaminants, and spillage of fuel and oils. The data collected during this study as well as past dredging experiences and related studies were used to quantify these likely impacts.

75. Increases in turbidity will result directly from either dragline or hydraulic dredging operations. The extent of these increases will vary depending on the dredging method used and type of disposal employed. Extremely fine grained materials like clays and silts will be resuspended very rapidly during the dredging process. Since the settling velocities of these particles are very low, they tend to stay in suspension for longer

periods than the coarser-grain particles which settle fairly quickly. A turbidity plume model was used to estimate the length of the turbidity plume resulting from the dredging operations. The length of the plume is dependent on the particle size of the dredged material, the flow velocity in the stream or lake, and the water depth. Results of the turbidity plume model indicated that the longest plumes would not exceed 1,000 feet in Lake O' The Pines and Caddo Lake. Big Cypress Bayou and Twelvemile Bayou, which contain mainly sand sized particles, had smaller estimated plume lengths (less than 200 feet). Based on the model results, impacts to water quality resulting from turbidity would be negligible in Big Cypress Bayou and Twelvemile Bayou. Model results indicate that turbidity levels in Lake O' The Pines and Caddo Lake resulting from dredging activities would range from 800 NTU's near the dredge or in open water disposal areas to less than 50 NTU's 1,000 feet away. With the use of silt curtains in Lake O' The Pines and Caddo Lake, these impacts would be reduced.

76. Studies by the Vicksburg District in 1992 and 1993 showed that daily increases in temperatures within containment areas averaged less than 1 degree C. The temperature increases downstream of a dredged material containment area effluent was less than 0.3 degrees C. Based on past experience, temperature increases due to elevated turbidities may average more than 1 degree C in the vicinity of the dredge or the containment area effluent return but should be less than 1 degree C after mixing. The temperature increases would be restricted to the mixing zone where higher turbidity will occur. These localized increases may induce lateral mixing due to localized temperature differentials.

77. The reduction of DO levels resulting from dredging activities may occur due to the resuspension of sediments rich in organic matter. In addition, increased water temperatures or the oxidation of reduced metals, such as iron and manganese, may contribute to the decrease in DO. It has been reported that during open water disposal operations, surface DO concentrations of 8 to 9 mg/L could be depressed by 2 to 3 mg/L during disposal operations (Herbich, 1992). The amount that the DO will decrease is dependent on the depth and settling rates of the suspended sediments. Due to dilution, settling of sediments, and natural reaeration, DO usually increases with increasing distances from the discharge point. The suspended sediments will begin settling immediately once they are resuspended. The highest concentration of suspended sediment will occur in the vicinity of the dredge. It is likely that any depressions in DO resulting from dredging operations will be localized to areas around the dredge and the discharge point.

78. Although there are reported considerable drops in DO in containment areas, when these flows are returned to the source lake or stream, only minor decreases in DO (< 0.3 mg/L) have been reported (USACE, 1993). The most likely reason that decreases in DO downstream of containment areas are minimal is due to the fact that the return flows from the containment areas are generally small compared to the flows in the receiving stream. Thus the receiving stream is not significantly impacted by the containment area discharge.

79. To evaluate the potential release of contaminants resulting from dredging operations, elutriate tests were performed on sediments collected in Lake O' The Pines and Caddo Lake. The elutriate test was developed by the EPA and Corps as a method to predict what the water quality conditions may be during dredging and disposal operations. This test involves mixing approximately 20 percent sediment by volume with water from the dredging site for 30 minutes. Compressed air is used to keep the sample completely mixed. After 30 minutes, the sample is allowed to settle under quiescent conditions. The sample is then filtered, and the filtrate is analyzed for the chemicals of interest. Results of the test are then compared to appropriate criteria to evaluate potential problems. Since this test does not take into consideration any type of dilution which occurs during dredging operations, the test gives a conservative estimate of the concentrations which are likely to be released into the water column in the immediate vicinity of the dredge or within the open water disposal area. Reported studies on elutriate testing have shown that zinc, iron, nitrate, copper, lead, cadmium, and phosphate, as well as a variety of chlorinated hydrocarbon pesticides, were not released during standard elutriate testing as described above (Lee et al, 1978).

80. In contrast to past studies, elutriate tests performed on sediments collected from Lake O' The Pines and Caddo Lake indicated that heavy metals would be expected to be released into the water column. The test results indicated that lead and barium would be released in excess of safe drinking water criteria. Copper and zinc concentrations were found in excess of the criteria for the protection of freshwater aquatic life. In addition, iron and manganese were found in excess of EPA criteria for the safe consumption of water and fish.

81. Although the release of heavy metals into the water column during dredging is of great concern, the elutriate test predicts only what is expected to be released from a hydraulic dredge discharge. Once mixing and dilution of the dredge discharge with the receiving water occurs, the potential for any toxic effects to aquatic life will be reduced. During disposal operations, anaerobic sediments will be mixed with aerated surface water.

When these sediments become oxygenated, the majority of the heavy metals will form oxides. In particular, reduced forms of iron and manganese, which are slightly more soluble than the other metals, will form oxides. Iron and manganese oxides are insoluble and will begin to coagulate and precipitate. These precipitates have a strong affinity for other heavy metals and effectively sorb or remove the less soluble metal oxides of cadmium, copper, chromium, lead, and zinc from the water column (DMRP, 1978). This scavenging effect of heavy metals by the iron precipitates generally reduces the concentrations of heavy metals which may be released into the water column.

82. Elutriate analysis for PAH's were not performed because prior to August 1992, PAH's had only been detected in trace amounts in the upper end of Lake O' The Pines. Two of the core samples collected at the same time as the material for the elutriate samples did have detectable quantities of PAH's; therefore, further elutriate testing for PAH's would be needed if studies are to continue.

83. The sediments found throughout the project area predominantly contain high levels of organic material as indicated by high concentrations of TOC. Studies conducted by the EPA have indicated that potentially toxic, nonpolar organic chemicals such as chlorinated hydrocarbon pesticides, PCB's, and PAH's, which can be highly toxic to aquatic life, tend to bind to the organic matter through sorption reactions in the sediments (Herbirch, 1992). Since these contaminants usually stay bound to the particulate matter, they will settle out of suspension and be removed from the water column. Herbirch also reports that contaminants attached to particulate matter are typically not available to aquatic life, including benthic and epibenthic forms. With the exception of PAH's, this study did not identify any priority pollutants including pesticides, PCB's, or explosives to be of any concern in the study area. PAH's were found in the sediments within the upstream reach of Lake O' The Pines and in trace amounts within a Caddo Lake sediment sample. If elutriate testing indicates the release of PAH's, the Tiered testing approach would recommend water column toxicity tests for PAH's. The Tiered testing approach does not indicate the need for any further testing of other priority pollutants.

84. It is not possible to estimate the potential of leaching of contaminants from containment areas based on the analyses conducted to date. Toxicity testing using the toxicity characteristic leaching procedure is recommended. With the elevated levels of heavy metals, it is likely that the heavy metals would, over time, be leached from the containment areas during storm events and natural weathering conditions. The potential for leaching of

contaminants from upland disposal areas is a concern and needs to be evaluated further if upland disposal methods are to be considered.

85. An additional direct impact of the dredging alternative is leaking fuel, oils, and other pollutants that may accidently be spilled into the water during construction. Although they cannot be quantified, some leaks invariably occur during all extended construction projects. The extent of these adverse impacts should be localized around the project areas. However, the potential for larger leaks and spills does exist.

RECOMMENDATIONS TO AVOID OR MINIMIZE THE IMPACTS

86. Impacts to water quality will result from the construction of the navigation channel as mentioned previously. These include increases in turbidity, increases in suspended solids, and the resuspension of contaminated sediments. The magnitude of these impacts will depend on the construction method selected and disposal option utilized. Although the impacts discussed previously are unavoidable, certain techniques can be considered to eliminate or minimize the extent of these impacts. The siting of the channel away from areas where the sediments are known to contain elevated levels of heavy metals and poly aromatic hydrocarbons should be considered. It is likely that the channel could be realigned in the upper portion of Lake O' The Pines where PAH's have been reported. This would avoid disturbing the area with elevated levels of heavy metals and PAH's.

87. Silt curtains could be employed in Lake O' The Pines and Caddo Lake to reduce the length of turbidity plumes and suspended solids concentrations resulting from dredging operations. Silt curtains provide a barrier which extends from the water surface to the bottom surface. The barrier prevents turbid water from spreading either by dispersion or by current flow. Placement of silt curtains upstream and downstream of the dredging site within the two lakes would minimize the impacts to the lakes. In addition, silt curtains should be placed around in lake disposal sites to reduce the area of impact. With the use of silt curtains in Lake O' The Pines and Caddo Lake, the extent of the increase in suspended solids and resulting turbidity plumes will be significantly reduced.

CONCLUSIONS AND RECOMMENDATIONS OF WATER QUALITY STUDY

88. Based on the findings of this study, some impacts to water quality would result from the construction of the proposed navigational channel. The predominant impacts include: increases in suspended solids, increases in turbidity, and

releases of heavy metals. These impacts would be short term and persist until construction is completed. Release of heavy metals would be anticipated based on elutriate test results. The metals (barium, copper, lead, zinc, iron and manganese) would be most likely released in excess of drinking water criteria. These metals would likely be reduced to acceptable levels after passage through a reasonable mixing zone.

89. Where sediments have been shown to be substantially similar from those in selected disposal areas, open water disposal would be recommended for the dredged material. Since open water disposal returns the dredged material to the environment similar to which it was taken, open water disposal would likely result in the least long-term impacts to water quality and the aquatic environment. Presently, the use of upland disposal areas is discouraged due to concern of contaminants leaching into surface and ground water.

REFERENCES

American Public Health Association, 1989. Standard Methods for the Examination of Water and Wastewater, 17th ed., Washington, DC.

American Water Works Association, 1990. Water Quality and Treatment, 4th ed., McGraw-Hill, Inc., New York.

Barnard, William D., 1978, "Prediction and Control of Dredged Material Dispersion Around Dredging and Open-Water Pipeline Disposal Operations," Dredged Material Research Program, Technical Report DS-78-13, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS

Barnard, William D., 1978, "Treatment of Contaminated Dredged Material," Dredged Material Research Program, Technical Report DS-78-14, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS

Black and Veatch, 1983, "Executive Summary Long Range Water Supply for Shreveport, Louisiana, Black and Veatch, Dallas, Texas

Bower, H.J.M., 1966, Trace Elements in Biochemistry, Department of Chemistry, The University, Reading, England, Academic Press London

Brannon, James M., 1978, "Evaluation of Dredged Material Pollution Potential," Dredged Material Research Program, Technical Report DS-78-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS

Brannon, James M., Englev, R., Rose, J., Hunt, P., and Smith, I., 1976, "Distribution of Manganese, Nickel, Zinc, Cadmium, and Arsenic in Sediments and in the Standard Elutriate," Miscellaneous paper D-76-18, Dredged Material Research Program, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS

Brannon, James, Plumb, Jr., R, and Smith, I., 1978, "Long-Term Release of Contaminants From Dredged Material," Dredged Material Research Program, Technical Report, D-78-49, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS

Burks, Sterling, and Englev, R., 1978, "Water Quality Impacts of Aquatic Dredged Material Disposal (Laboratory Investigation)," Dredged Material Research Program, Technical Report DS-78-4, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS

Cusack, Thomas M., 1984, "A Study of the Benthic Macroinvertebrate Community Structure of Caddo lake, Texas and Louisiana and Possible Effects of Offshore Oil," M.S. Thesis, Stephen F. Austin State University, Nacogdoches, Texas

Espey, Houston and Associates, Inc. 1991, "Red River Waterway Tributary Lakes Project Environmental Assessment," U.S. Army Corps of Engineers, Vicksburg District, Vicksburg, MS

Ford, Thornton, Norton and Associates, LTD, 1984, "Caddo Lake Enlargement Study Water Quality Analysis of Proposed Off-Channel Storage Reservoir," U.S. Army Corps of Engineers, Vicksburg District, Vicksburg, MS

Hartung, August A., 1983, "Physicochemical Limnology of Caddo Lake, Texas and Louisiana," M.S. Thesis, Stephen F. Austin State University, Nacogdoches, Texas

Herbich, John, B., Handbook of Dredging Engineering, McGraw Hill, Inc., New York, 1992.

JBF Scientific Corporation, 1978, "An Analysis of the Functional Capabilities and Performance of Silt Curtains," Dredged Material Research Program, Technical Report D-78-39, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS

Lee, G. F., Jones, R. A., Saleh, F. Y., Mariani, G. M., Homer, D. H., Butler, J. S., and Bandyopadhyay, P., Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open Water Disposal of Dredged Sediment and Environmental Impact of Open Water Dredged Materials Disposal, Vol. II: Data Report, Technical Report D-78-45, U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS, 1978.

Lucas, G., 1988. Water Quality Characteristics of Delta Lakes with Special Emphasis on the Water Quality of Lake Washington, Freshwater Fisheries Report Number 69, MS. Dept. of Wildlife Conservation, Jackson, MS.

National Oceanic and Atmospheric Administration, 1990. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program, NTIS # PB91-172288 Springfield, VA.

Niemi, Gerald T., DeVore, P., Detenbeck, N., Taylor, D., Lima, A., and Pastov, J., 1990, "Overview of Case Studies on Recovery of Aquatic Systems from Disturbance," Environmental Research Laboratory Office of Research and Development, U.S. Environmental Protection Agency, Duluth, MN

Rubenstein, N.I., Lores, E., and Gregory, N., 1983, "Accumulation of PCB's, Mercury, and Cadmium by Nevels, Cirens, Mercenaria Mercenaria, and Palaemonetes pugio from Contaminated Harbor Sediments," Technical Report D-83-4, prepared by U.S. Environmental Protection Agency, Gulf Breeze, FL, for the U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS

TDWR, 1982, "Pesticide and PCB Concentrations in Texas-Water, Sediment, and Fish Tissue," Texas Department of Water Resources Report N. 264, Austin, TX

Texas Water Quality Board, 1977, "Intensive Surface Water Monitoring Survey for Segment 0401, Caddo Lake," Report No. IMS50, Texas Water Quality Board, Austin, TX

USACE - Fort Worth District, 1983, "Biological Assessment - Impacts of Dredging on Endangered Species at Caddo Lake," USACE-Ft. Worth District, Fort Worth, TX

USACE - Ft. Worth District, 1988, "Water Quality Report Lake O' The Pines, Big Cypress Bayou, Red River Basin, Texas," USACE Ft. Worth District, Fort Worth, TX

USACE - Vicksburg District, 1985, "Caddo Lake Enlargement Study -Water Quality Appendix," USACE Vicksburg District, Vicksburg, MS

USACE - Vicksburg District, 1992, "Final Supplemental EIS Upper Steele Bayou Basin," USACE Vicksburg District, Vicksburg, MS.

USACE - Vicksburg District, 1993, "Draft Supplemental EIS Upper Yazoo River Projects," USACE Vicksburg District, Vicksburg, MS.

USEPA, 1992, "Interim Guidance on Interpretation and Implementation of Aquatic Life Criteria for Metals," Office of Science and Technology, Health and Ecological Criteria Division, U.S. Environmental Protection Agency, Washington, DC

U.S. Environmental Protection Agency, 1986. Quality Criteria for Water 1986, EPA 440/5-86-001. Office of Water Regulations and Standards, Washington, DC.

Venneman, Timothy E., 1984, "The Zooplankton Community of Caddo Lake Texas and Louisiana, A Lake with Numerous Offshore Oil Wells," M.S. Thesis, Stephen F. Austin State University, Nacogdoches, TX .

ATTACHMENT A

SAMPLING AND ANALYTICAL METHODS

Water Quality Sampling
Field and Analytical Methods

All water and sediment samples were collected using guidelines and procedures described by Standard Methods and the National Handbook of Recommended Methods for Water Data Acquisition. In situ measurements of temperature, dissolved oxygen, pH, and specific conductance were conducted with a Martek water quality instrument (Martek Mark 17, Martek Instruments, Inc, Irvine, CA). Calibration of the Martek 17 was conducted daily following manufacturer's guidelines (Martek, 1990).

Sample collection for water quality analyses was conducted with a 2 liter Kemmer bottle which was rinsed with sample water at each site prior to sample collection. Samples were collected approximately 1 foot above the bottom sediment. Aliquot of the sample were placed into containers and appropriately preserved for various types of analysis. Nutrient samples were placed in 500 ml high density polyethylene wide mouth bottles. Approximately 1 ml of sulfuric acid was then added to lower the pH below 2. Samples analyzed for heavy metals were placed in 500 ml high density polyethylene wide mouth bottles. Approximately 1 ml of nitric acid was then added to lower the pH below 2. Samples analyzed for pesticides, PCB's, BNA, and VOA's were placed in specially cleaned 1 liter amber glass jars. Once the sample containers had been filled and the appropriate acid if necessary was added the container was stored on ice until it could be delivered to the laboratory.

Sediment samples were collected using a petite Ponar dredge. At least three sediment samples were collected at each site and placed in a stainless steel or teflon bucket. The sediments were thoroughly mixed and large plant material was removed. The composite sample was then placed into three 250 ml (certified clean) wide mouth glass jars and stored on ice. One sediment core (CLP5) was collected using a Wildco hand core sediment sampler. This produced a 15 centimeter core. The core sample was thoroughly mixed and placed into a 250 ml specially cleaned wide mouth glass jar. The remaining cores samples were collected using an in-house fabricated coring device constructed out of pvc pipe similar to that described by Cooper, et. al, 1991. This coring device allowed deeper cores to be collected. The core samples were then separated into at least 2 inch segments, placed in 250 ml certified clean wide mouth glass jars and stored on ice.

Samples were kept on ice until delivery to the Waterways Experimental Station's Analytical Laboratory Group (ALG) in Vicksburg, MS. All samples were analyzed by the ALG or one of their contract laboratories following the ALG's quality assurance and quality control program which is described in their internal document; Quality Assurance for Environmental Chemical Analyses, 29 October 1991.

Analytical Methods

In Situ Parameters
Dissolved oxygen, temperature, pH, and specific conductivity measurements were made using a Martek Mark 17 water quality data logger and probe. Turbidity measurements were made using a Hach Model 16800 Portalab Turbidimeter.

Water temperature
Method: Thermistor thermometer.
Detection limit: 0.1 °C.
Calibration: National Bureau of Standards certified thermometer.

Dissolved oxygen
Method: Membrane electrode
Detection Limit: 0.1 mg/l.
Calibration: Air calibration.

pH
Method: Electrometric
Detection Limit: 0.1 pH unit.
Calibration: Buffer solutions of pH 4 and 7.

Specific conductance
Method: Electormetric.
Detection Limit: 1 μs/cm.
Calibration: Standard solutions of know conductivity. All readings were corrected for temperature to 25 °C.

Turbidity
Method: Nephelometric.
Detection limit: 1 NTU.
Calibration: Formazin solutions of known NTU values.
Hach Model 16800 Portalab Turbidimeter
Reference: Hach Corp. 1984.

Solids and Ions
Total suspended solids
Sample preservation: Held in dark at 4 °C.
Method: EPA 160.3 (Gravimetric).
Detection limit: 0.001 grams.

Total dissolved solids
Sample preservation: Held in dark at 4 °C.
Method: EPA 160.1 (Gravimetric).
Detection limit: 0.001 grams.
Reference: APHA 1989.

Calcium, Potassium, Sodium
Sample preservation: Sample held in dark at 4 °C.
Method: EPA 200.7

Sulfate
Sample preservation: Sample held in dark at 4 °C.
Method: EPA 375.2

Chloride
Sample preservation: Sample held in dark at 4 °C.
Method: EPA 325.2

Hardness
Sample preservation: HNO_3 to pH <2, held in dark at 4 °C.
Method: EPA 130.1

Alkalinity
Sample preservation: Held in dark at 4 °C.
Method: EPA 310.2

Nutrients

Total organic carbon
Sample preservation: H_2SO_4 to pH <2, held in dark at 4 °C.
Method: Standard Methods 505C.

Total Kjeldahl nitrogen
Sample preservation: H_2SO_4 to pH <2, held in dark at 4 °C.
Method: EPA 351.2

Ammonia nitrogen
Sample preservation: H_2SO_4 to pH <2, held in dark at 4 °C.
Method: EPA 350.1

Nitrate-nitrite nitrogen
Sample preservation: H_2SO_4 to pH <2, held in dark at 4 °C.
Method: EPA 353.2

Total phosphorous
Sample preservation: H_2SO_4 to pH <2, held in dark at 4 °C.
Method: EPA 365.4

Total dissolved phosphorous
Sample preservation: H_2SO_4 to pH <2, held in dark at 4 °C.
Method: EPA 365.4

Metals

Total metals: arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, zinc.
Sample preservation: HNO_3 to pH <2, held in dark at 4 °C.
Method: EPA 200.7

Mercury
Sample preservation: HNO_3 to pH <2, held in dark at 4 °C.
Method: EPA 245.1

Pesticides
Sample preservation: Sample was placed in an amber glass bottle and held in dark at 4 °C.
Method: SW-846 method 8080 and 8140.

PCB's
Sample preservation: Sample was placed in an amber glass bottle and held in dark at 4 °C.
Method: SW-846 method 8080

Priority Pollutants

BNA priority pollutants
Sample preservation: Sample was placed in an amber glass bottle and held in dark at 4 °C.
Method: SW-846 method 8270

VOA priority pollutants
Sample preservation: Sample was placed in an amber glass bottle and held in dark at 4 °C.
Method: SW-846 method 8260.

PAH's
Sample preservation: Sample was placed in an amber glass bottle and held in dark at 4 °C.
Method: SW-846 method 9100

Explosives

GMX, RDX, TNB, BNB, Tetryl, TNT (2,4,6), 2,4 DNT, 2,5 DNT
Sample preservation: Sample was placed in an amber glass bottle and held in dark at 4 °C.
Method: SW-846 method 8330

Oil and Grease

Total oil and grease
Sample preservation: H_2SO_4 to pH <2, held in dark at 4 °C.
Method: EPA 413.2 (Spectrophotometric, infrared)

Total recoverable petroleum hydrocarbons
Sample preservation: H_2SO_4 to pH <2, held in dark at 4 °C.
Method: EPA 418.1 (Spectrophotometric, infrared)

SEDIMENT SAMPLES

Sediment samples were placed in specially clean glass jars and stored on ice. Sediment samples were extracted using SW-846 and APHA Standard methods.

Nutrients

Total Kjeldahl nitrogen
Sample preservation: Held in dark at 4 °C.
Method: EPA 351.2.

Ammonia nitrogen
Sample preservation: Held in dark at 4 °C.
Method: EPA 350.1

Nitrate-nitrite nitrogen
Sample preservation: Held in dark at 4 °C.
Method: EPA 353.2

Total phosphorous
Sample preservation: Held in dark at 4 °C.
Method: EPA 365.4

Metals

Total metals: arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, zinc.

Sample preservation: Held in dark at 4 °C.
Method: EPA 245.5
Detection limit: 0.2ug/l.

Mercury
Sample preservation: Held in dark at 4 °C.
Method: EPA 245.5

Pesticides
Sample preservation: Held in dark at 4 °C.
Method: SW-846 method 8080 and 8140

PCB's
Sample preservation: Held in dark at 4 °C.
Method: SW-846 method 8080

Priority Pollutants

BNA priority pollutants
Sample preservation: Held in dark at 4 °C.
Method: SW-846 method 8270

VOA priority pollutants
Sample preservation: Held in dark at 4 °C.
Method: SW-846 method 8260

PAH'S
Sample preservation: Held in dark at 4 °C.
Method: SW-846 method 9100

Explosives

GMX, RDX, TNB, BNB, Tetryl, TNT (2,4,6), 2,4 DNT, 2,5 DNT
Sample preservation: Held in dark at 4 °C.
Method: SW-846 method 8330

Oil and Grease

Total oil and grease
Sample preservation: Held in dark at 4 °C.
Method: EPA 413.2

Total recoverable petroleum hydrocarbons
Sample preservation: Held in dark at 4 °C.
Method: EPA 418.1

Particle size distribution
Particle size distribution was determined on each sediment using the method of Day (1956) as modified by Patrick (1958). The particle size fractions determined were clay (<2 μm), silt (2 to 50 μm), and sand (>50 μm).

References

1. American Public Health Association, Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989. 1015 Fifteenth Street NW, Washington, DC 20005.

2. ASTM, 1990 Annual Book of ASTM Standards, Water and Environmental Technology, Vol 11.01 and 11.02, 1987. 1916 Race Street, Philadelphia, PA 19103.

3. Cooper, Charles, M. Frank R. Schiebe and J. C. Ritchie, An Inexpensive Sampler for Obtaining Bulk Sediment Cores, U. S. Department of Agriculture, 1991. Agricultural Research Service, Oxford, MS 39655.

4. Federal Register, "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act", Vol 49, No. 209, Friday, October 27, 1984.

5. Hach Company, Portalab Model 16800 Turbidimeter Instruction Manual, 1984. Hach Company P.O. Box 389, Loveland CO 80539.

6. Martek Instruments Inc., Mark 17 Water Quality Monitor Operation Manual, 1990. Martek Instruments, Inc. 17302 Daimler St., Irvine CA 92714.

7. Palermo, Michael R. Development of a Modified Elutriate Test for Estimating the Quality of Effluent from Confined Dredged Material Disposal Areas, Technical Report D-86-4, August 1986. Department of the Army Waterways Experiment Station, Corps of Engineers, P. O. Box 631, Vicksburg, MS 39180.

8. Plumb, Russell H., Jr. Procedures for Handling and Chemical Analysis of Sediment and Water Analysis, EPA/CE-81-1 May 1981. Environmental Laboratory, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS 39180.

9. U. S. Department of Interior, National Handbook of Recommended Methods for Water Data Acquisition. U. S. Geological Survey, Office of Water Data Coordination, 1977, Reston, VA 22092.

10. U. S. Environmental Protection Agency, Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March 1979 and EPA 600/4-82-055 December 1982. Environmental Monitoring and Support Laboratory, Cincinnati, OH 45268.

11. U. S. Environmental Protection Agency, Chemistry Laboratory Manual for Bottom Sediments and Elutriate Testing, March 1979. Region V Central Regional Laboratory, 536 Clark Street, Chicago, IL 60605.

12. U. S. Environmental Protection Agency, Manual of Analytical Methods for the Analysis of Pesticides in Humans and Environmental Samples, EPA-600/8-80-038, June 1980. Health Effects Research Laboratory, Research Triangle Park, NC 27711.

13. U. S. Environmental Protection Agency, Test Methods for Evaluating Solid Waste, SW-846 Third Edition, November 1986 with December 1988 revisions. Office of Solid Waste and Emergency Response, Washington, DC 20460.

ATTACHMENT B

WATER QUALITY AND SEDIMENT QUALITY DATA

Routine Water Quality Data
Collected by the
USGS

	DATE	TEMP	DO	PH	COND	ALK	TURB	COLOR	BOD	NH3	NO-2	TKN	NO2+NO3	ORG.-N	TP	TDP	TSS	TDS	COLIFOR	FECAL	STREP
LOP-1	01-Aug-91	30.0	8.7	8.2	341	59	3.9		3.1	0.030	0.020	0.60	0.400	0.57	0.090	0.010	4	209		28	
(07345600)	20-Aug-91	29.0	9.9	8.1	97	65	2.5		3.9	0.050	0.050	1.00	1.500	0.95	0.080	0.020		268		66000	1000k
	04-Sep-91	29.0	8.9	7.4	427	68	2.5		3.9	0.020	0.030	0.60	1.200	0.58	0.090	0.020	4	248		220K	20K
	16-Oct-91	21.0	11.4	8.6	303	45	5.7		2.6	0.010	0.010	0.70	0.290	0.69	0.040	0.010K	3	179		30	4K
	22-Nov-91	13.5	6.9	6.3	114	16	16		1.3	0.050	0.010K	0.50	0.150	0.45	0.130	0.070	120	89	950	1200	6000K
	19-Dec-91	10.5	8.4	6.1	175	25	7		0.2	0.030	0.010K	0.50	0.220	0.47	0.070	0.020	2	105	520E	90	140
	22-Jan-92	7.0	11.7	6.5	169	19	12		1.3	0.020	0.010	0.40	0.430	0.38	0.070	0.020	8	104	740	790K	380
	13-Feb-92	13.0	9.0	6.7	149	17	27		1	0.040	0.010K	0.60	0.260	0.56	0.100	0.020	9	108	2200	2500	2900
	19-Mar-92	17.0	6.5	6.7	159	25	7		0.6	0.010	0.010K	0.40	0.150	0.39	0.050	0.010K	8	110	220	310E	150
	24-Apr-92	19.5	5.7	6.7	176	21	22		0.8	0.110	0.030	0.60	0.760	0.49	0.160	0.050	11	105	310	390	460
	13-May-92	23.0	5.3	6.6	198	24	42		1.4	0.080	0.030	0.60	1.900	0.52	0.130	0.070	11	142	2200	3000	2400
	18-Jun-92	27.0	3.9	6.4	163	26	18		1.9	0.080	0.010	0.70	0.46	0.62	0.17	0.06	18	126	54	85	190
	avg	20.0	8.0	7.0	206	34	14		1.8	0.044	0.016	0.60	0.643	0.56	0.10	0.030	18	149	834	6110	602
	max	30.0	11.7	8.6	427	68	42		3.9	0.110	0.050	1.00	1.900	0.95	0.17	0.070	120	268	2200	66000	2900
	min	7.0	3.9	6.1	97	16	3		0.2	0.010	0.000	0.40	0.150	0.38	0.04	0.000	2	89	0	0	0

	DATE	TEMP	DO	PH	COND	ALK	TURB	COLOR	BOD	NH3	NO-2	TKN	NO2+NO3	ORG.-N	TP	TDP	TSS	TDS	COLIFOR	FECAL	STREP
LOP-2	01-Aug-91	30.0	8.4	6.8	106	11	2		2.3	0.030	0.010K	0.80	0.050K	0.77	0.090	0.030	3	56		42K	
(07345700)	20-Aug-91	31.0	7.1	6.8	97	11	14		2.5	0.090	0.020	0.90	0.140	0.81	0.120	0.020		55		250	1000k
	04-Sep-91	31.0	9.0	7.9	108	7	1.5		3.1	0.040	0.010K	0.70	0.064	0.66	0.080	0.020	2	52		120	1K
	18-Oct-91	20.5	7.8	6.6	102	8	4.1		2.0	0.010K	0.010K	0.40	0.050K	0.4	0.040	0.020	1K	71			590
	21-Nov-91	15.0	8.4	6.5	157	22	4.5		0.1	0.070	0.010	0.50	0.500	0.43	0.050	0.030	18	108	18K	19K	200
	18-Dec-91	11.0	8.6	6.0	152	18	7.6		0.2	0.020	0.010K	0.60	0.097	0.58	0.070	0.060	4	113	40K	39K	5K
	22-Jan-92	6.0	12.8	6.5	181	22	6.2		1.2	0.010	0.010K	0.40	0.360	0.39	0.050	0.040	4	107	8K	18K	4K
	13-Feb-92	12.0	10.6	7.2	173	19	5.2		0.8	0.020	0.010K	0.50	0.310	0.48	0.060	0.010	11	106	4K	5K	55
	18-Mar-92	17.5	8.4	6.7	126	19	9.5		0.9	0.020	0.010K	0.40	0.050K	0.38	0.060	0.010K	1K	92	14K	17K	270
	22-Apr-92	23.0	9.7	8.3	179	21	4.1		2.1	0.020	0.010K	0.70	0.300	0.68	0.060	0.010	43	129	2k	71	140
	13-May-92	24.0	8.3	6.9	150	14	3.1		1.7	0.020	0.010K	0.40	0.050K	0.38	0.010	0.010K	1K	108	6K	15K	48
	18-Jun-92	29.5	5.7	6.4	131	13	1.9		1.1	0.05	0.010K	0.60	0.050K		0.050	0.030	14	95	2k	2k	20k
	avg	20.9	8.7	6.9	139	15	5		1.5	0.033	0.003	0.58	0.148	0.54	0.06	0.023	9	91	0	40	118
	max	31.0	12.8	8.3	181	22	14		3.1	0.090	0.020	0.90	0.500	0.81	0.12	0.060	43	129	0	250	590
	min	6.0	5.7	6.0	97	7	2		0.1	0.000	0.000	0.40	0.000	0.38	0.01	0.000	0	52	0	0	0

	DATE	TEMP	DO	PH	COND	ALK	TURB	COLOR	BOD	NH3	NO-2	TKN	NO2+NO3	ORG.-N	TP	TDP	TSS	TDS	COLIFOR	FECAL	STREP
LOP-3	31-Jul-91	31.5	8.3	7.9	88	10	3.3		1.2	0.030	0.010	0.300	0.050K	0.27	0.030	0.010K	4	62		20K	
(07345890)	20-Aug-91	32.0	8.5	8.0	102	12	1		2.8	0.090	0.020	0.600	0.050K	0.51	0.030	0.010K		68		220	17000K
	04-Sep-91	27.0	4.2	6.3	104	13	0.8		0.8	0.030	0.010K	0.400	0.052	0.37	0.020	0.010K	14	69		4K	91
	17-Oct-91	23.0	7.7	6.5	86	12	1.7		1.7	0.050	0.030	0.500	0.067	0.45	0.020	0.010K	1K	67			23K
	22-Nov-91	14.5	9.2	6.2	78	12	1.8		0.3	0.060	0.010K	0.300	0.110	0.24	0.010K	0.010K	1	56	20K	8K	36
	19-Dec-91	12.0	8.1	6.1	84	8	2.9		0.1	0.070	0.010K	0.400	0.094	0.33	0.020	0.010K	4	78	120	1k	22K
	22-Jan-92	9.0	13.1	6.2	100	8	3.1		1.0	0.040	0.010K	0.400	0.170	0.36	0.030	0.010K	1	61	2K	1K	2k
	13-Feb-92	11.0	10.6	6.6	107	8	4		0.5	0.030	0.010K	0.400	0.190	0.37	0.020	0.020	10	96	1k	5K	220K
	18-Mar-92	16.5	9.7	6.9	113	11	2.5		0.6	0.010	0.010K	0.400	0.110	0.39	0.020	0.010K	1K	82	1K	1k	13K
	23-Apr-92	22.5	9.1	7.5	118	13	1.5		1.1	0.010K	0.010K	0.400	0.050K	0.4	0.010	0.010	1K	78	2K	8K	14K
	12-May-92	24.5	8.4	6.9	120	12	1.1		1.1	0.030	0.010K	0.200	0.050K	0.17	0.010K	0.010K	1K	91	5K	5K	38K
	17-Jun-92	30.0	7.6	7.8	113	14	0.7		0.5	0.02	0.010K	0.400	0.050K	0.38	0.020	0.010K	1K	78	5K	3K	52
	avg	21.1	8.7	6.9	101	11	2		1.0	0.038	0.005	0.39	0.066	0.35	0.02	0.003	3	74	15	20	16
	max	32.0	13.1	8.0	120	14	4		2.8	0.090	0.030	0.60	0.190	0.51	0.03	0.020	14	96	120	220	91
	min	9.0	4.2	6.1	78	8	1		0.1	0.000	0.000	0.20	0.000	0.17	0.00	0.000	0	56	0	0	0

	DATE	TEMP	DO	PH	COND	ALK	TURB	COLOR	BOD	NH3	NO-2	TKN	NO2+NO3	ORG.-N	TP	TDP	TSS	TDS	COLIFOR	FECAL	STREP
BCB-1	01-Aug-91	27	6.7	6.8	105	25	3.6		1.5	0.220	0.010K	0.70	0.050K		0.040	0.020	4	78		28	
(07346000)	20-Aug-91	26.5	6.8	6.8	125	26.0	3.5		1.7	0.320	0.010	0.90	0.050K		0.040	0.020		85		66000	1000k
	04-Sep-91	27.0	6.7	6.2	117	21.0	2.6		1.2	0.240	0.010K	0.60	0.050K		0.040	0.010	1K	74		220K	20K
	17-Oct-91	22.0	5.2	6.2	91	14.0	1.4		1.3	0.180	0.030	0.60	0.190		0.050	0.020	1K	67			250
	22-Nov-91	14.5	10.9	6.5	79	12.0	1.5		0.2	0.040	0.010K	0.40	0.099		0.010	0.010	5	65	450	40	160
	19-Dec-91	12.5	11.1	6.0	84	8.4	2.7		0.0	0.080	0.010K	0.50	0.095		0.030	0.010K	1	66	300	2K	35K
	22-Jan-92	11.0	11.4	6.3	105	8.3	3.5		1.0	0.050	0.010K	0.40	0.170		0.030	0.030	4	62	2k	8K	10K
	13-Feb-92	11.0	12.6	6.8	107	9.0	4.0		0.6	0.020	0.010K	0.50	0.190		0.040	0.010	8	80	1k	1k	38K
	19-Mar-92	16.0	11.0	6.8	115	11.0	3.0		0.5	0.010	0.010K	0.40	0.110		0.020	0.010K	1K	91	1k	2k	10K
	23-Apr-92	20.0	9.4	6.8	118	13.0	1.8		1.6	0.020	0.010K	0.50	0.050K		0.020		1K	80	5K	47	250
	13-May-92	22.0	6.9	6.5	120	16.0	2.3		0.7	0.160	0.010K	0.50	0.050K		0.010K	0.010K	1	75	14K	32K	200
	17-Jun-92	26.0	7.3	6.4	118	14.0	1.9		1.6	0.050	0.010K	0.40	0.060		0.030	0.010	1	82	5K	12K	100k
	avg	19.6	8.8	6.5	107	15	3		1.0	0.116	0.003	0.53	0.076	ERR	0.03	0.012	2	75	94	6010	78
	max	27.0	12.6	6.8	125	26	4		1.7	0.320	0.030	0.90	0.190	ERR	0.05	0.030	8	91	450	66000	250
	min	11.0	5.2	6.0	79	8	1		0.0	0.010	0.000	0.40	0.000	ERR	0.00	0.000	0	62	0	0	0

	DATE	TEMP	DO	PH	COND	ALK	TURB	COLOR	BOD	NH3	NO-2	TKN	NO2+NO3	ORG.-N	TP	TDP	TSS	TDS	COLIFOR	FECAL	STREP
BCB-2	31-Jul-91	29.5	8.0	7.0	119	16	4.2		2.2	0.010K	0.010K	0.60	0.050K		0.050	0.020	8	81		260	
(07346085)	20-Aug-91	29.0	8.5	7.0	108	16	3.5		2	0.070	0.020	0.70	0.050K		0.060	0.020		83		53000K	53000K
	04-Sep-91	27.0	6.2	6.1	77	7	12		2.1	0.050	0.010	0.50	0.130		0.090	0.020	4	42		1K	75K
	17-Oct-91	19.5	7.7	6.5	85	14	2.8		1.6	0.010	0.010K	0.30	0.050K		0.020	0.010K	1.0K	69		28K	240K
	22-Nov-91	15.0	5.6	6.2	92	11	14		0.7	0.010	0.010K	0.30	0.050K		0.050	0.030	11	71	970	850	3200
	19-Dec-91	10.5	8.4	5.8	79	9.4	6.1		0.1	0.030	0.010K	0.40	0.050K		0.040	0.020	8	73	59	60	52
	22-Jan-92	7.0	11.9	6.0	88	8.2	7.3		1.1	0.020	0.010K	0.30	0.120		0.040	0.020	1K	51	87	120	120
	13-Feb-92	12.5	8.7	6.4	76	9.1	17		0.9	0.030	0.010	0.50	0.089		0.050	0.030	16	57	400K	300K	3600K
	19-Mar-92	16.5	7.3	6.3	85	11	9.4		0.5	0.020	0.010K	0.50	0.050K		0.060	0.010K	1K	81	220	240K	380
	23-Apr-92	22.5	5.2	6.4	102	15	9.6		1.0	0.090	0.020	0.40	0.260		0.060		1	78	86	79	130
	13-May-92	21.5	7.4	6.7	96	15	8.5		0.9	0.020	0.010K	0.30	0.110		0.040	0.020	8	77		42	20K
	17-Jun-92	27.0	4.9	6.2	96	14	8.2		1.7	0.060	0.010K	0.5	0.120		0.060	0.030	6	83	40	43	130
	avg	19.8	7.5	6.4	92	12	9		1.2	0.034	0.005	0.44	0.069	ERR	0.05	0.019	6	71	209	121	365
	max	29.5	11.9	7.0	119	16	17		2.2	0.090	0.020	0.70	0.260	ERR	0.09	0.030	16	83	970	850	3200
	min	7.0	4.9	5.8	76	7	3		0.1	0.000	0.000	0.30	0.000	ERR	0.02	0.000	0	42	0	0	0

	DATE	TEMP	DO	PH	COND	ALK	TURB	COLOR	BOD	NH3	NO-2	TKN	NO2+NO3	ORG.-N	TP	TDP	TSS	TDS	COLIFOR	FECAL	STREP
CL-1	31-Jul-91	30.0	7.3	6.7	100	19			3.6	0.010	0.010K	1.10	0.03		0.030	0.030	12	68	80K	40	16K
(07346280)	21-Aug-91	31.5	6.9	6.8	96	21	6.1	20	3.3	0.030	0.010K	0.93	0.03		0.070	0.020	18	69	40K	20K	65
	11-Sep-91	32.0	7.9	7.6	107	20	8.8	20	5.9	0.010	0.010K	1.10	0.02K		0.050	0.020	8	65	90K	70K	40K
	16-Oct-91	23.5	9.3	7.1	106	21	5.7	20	5.4	0.020	0.010	1.10	0.02K		0.080	0.010K	4	68	1000	690K	140
	21-Nov-91	12.0	9.8	6.5	98	13	11	30	2.6	0.010	0.010	0.56	0.02		0.050	0.010	2	69	320		120
	19-Dec-91	12.0	10.7	6.6	74	9	16	40	2.7	0.020	0.010	0.57	0.03		0.040	0.010K	18	60			32K
	23-Jan-92	8.0	9.6	6.2	104	9	10	50	0	0.010K	0.010K	0.50	0.04		0.050	0.030	48	72	50K	4K	12K
	13-Feb-92	12.0	10.0	6.5	94	8	10	40	0.8	0.020	0.010K	0.40	0.05K			0.010K	18	58	130K	96	12K
	19-Mar-92	17.0	8.5	6.7	94	11	8.5	50	1	0.010	0.010	0.63	0.03		0.080	0.060	2	60	160K	80K	85K
	21-Apr-92	20.0	8.6	7.0	114	13	7.1	20	1.2	0.010K	0.010K	0.50	0.02K		0.040	0.020	10	66	70K	20K	20K
	28-May-91	25.0	6.8	6.1	120	13	9.5	15	2.1	0.090	0.010	0.42	0.04		0.060	0.050	22	74	70K	55K	70K
	18-Jun-91	30.0	7.0	6.8	109	16	5	20	3.4	0.020	0.010	0.68	0.02K		0.050	0.020	4	73	60K	40K	20K
	avg	21.1	8.5	6.7	101	12	19	16	2.7	0.020	0.005	0.71	0.018	ERR	0.055	0.022	14	67	120	14	27
	max	32.0	10.7	7.6	120	21	50	50	5.9	0.090	0.010	1.10	0.040	ERR	0.080	0.060	48	74	1000	96	140
	min	8.0	6.8	6.1	74	5	5	0	0.0	0.000	0.000	0.40	0.000	ERR	0.030	0.000	2	58	0	0	0

	DATE	TEMP	DO	PH	COND	ALK	TURB	COLOR	BOD	NH3	NO-2	TKN	NO2+NO3	ORG.-N	TP	TDP	TSS	TDS	COLIFOR	FECAL	STREP
CL-2	31-Jul-91	30.0	7.6	6.8	105	21			3.3	0.020	0.010K		0.020			0.010	19	64	70K	16K	30K
(07346310)	21-Aug-91	32.5	9.7	7.1	96	19	4.5	15	6.9	0.010	0.010K	1.10	0.020K		0.060	0.010	7	66	12K	5K	10K
	11-Sep-91	29.5	7.9	7.3	106	20	9	20	5.5	0.020	0.010K	1.20	0.020K		0.120	0.070	20	63	120K	35K	43K
	16-Oct-91	22.0	9.3	7.0	106	19	9.1	20	5.4	0.010	0.010	1.10	0.020K		0.080	0.010K	13	63	240K	30K	140
	21-Nov-91	12.0	10.5	6.0	98	14	10	20	2.1	0.010	0.010	0.55	0.020K		0.050	0.010K	1K	66	740		50K
	19-Dec-91	12.0	11.7	6.6	78	9	17	60	2.8	0.020	0.010	0.44	0.100		0.020	0.010K	14	71			68K
	23-Jan-92	8.0	10.4	6.3	105	9	10	50	0.9	0.010K	0.010K	0.56	0.040		0.060	0.030	6	70	200K	12K	4K
	13-Feb-92	15.0	10.3	6.5	98	9	11	40	1.1	0.040	0.010K	0.30	0.180			0.010K	8	68	240	240	68K
	19-Mar-92	16.0	9.0	6.7	87	10	8.6	50	0.8	0.010	0.010	0.69	0.030		0.080	0.050	8	70	40K	10K	30K
	21-Apr-92	21.0	8.9	6.9	114	14	5	20	1.2	0.010K	0.010K	0.60	0.020		0.040	0.020	22	70	140	35K	25K
	28-May-91	16.0	8.0	5.9	119	12	9.7	20	2.4	0.090	0.010K	0.42	0.060		0.020K	0.020	12	72	180K	30K	63K
	18-Jun-91	30.0	6.7	6.7	109	17	3.5	15	3.1	0.020	0.010	0.70	0.020K		0.040	0.020	10	73	50K	15K	35K
	avg	20.3	9.2	6.7	102	14	9		3.0	0.021	0.004	0.70	0.038	ERR	0.06	0.019	11.6	68	102	24	12
	max	32.5	11.7	7.3	119	21	17		6.9	0.090	0.010	1.20	0.180	ERR	0.12	0.070	22	73	740	240	140
	min	8.0	6.7	5.9	78	9	4		0.8	0.000	0.000	0.30	0.000	ERR	0.00	0.000	0	63	0	0	0

	DATE	TEMP	DO	PH	COND	ALK	TURB	COLOR	BOD	NH3	NO-2	TKN	NO2+NO3	ORG.-N	TP	TDP	TSS	TDS	COLIFOR	FECAL	STREP
TMB-1	31-Jul-91	29.5	7.0	7.1	273	51			3.2	0.020	0.010	0.80	0.080		0.060	0.030	31	150	220K	18K	38K
(07347950)	21-Aug-91	30.5	7.5	7.0	189	37	9.9	15	3.3	0.050	0.010	0.88	0.070		0.060	0.010	26	123	50K	28K	100
	11-Sep-91	29.5	7.2	6.8	142	26	14	20	4.5	0.020	0.010K	1.10	0.020K		0.090	0.010	27	85	230	30K	110
	16-Oct-91	22.0	9.3	7.3	220	43	8.4	20	4.2	0.040	0.010	1.30	0.030		0.080	0.030	13	134	220	20K	160
	21-Nov-91	12.0	9.3	7.4	128	24	90	80	2.7	0.040	0.040	0.75	0.120		0.270	0.110	84	86	460		55K
	19-Dec-91	12.0	11.6	7.1	98	13	20	50	3.0	0.030	0.010	0.45	0.040		0.020	0.010K	6	80			40K
	23-Jan-92	8.0	10.6	6.9	144	14	13	50	0.7	0.010	0.010	0.55	0.050		0.060	0.050	4	84	1700K	32K	670
	13-Feb-92	12.0	10.0	6.7	121	17	90	80	0.9	0.050	0.040	0.50	0.054			0.020	84	72	5000		1100
	19-Mar-92	16.0	8.6	6.6	97	13	14	50	0.9	0.020	0.010	0.67	0.040		0.090	0.060	34	70	300K	140K	440
	21-Apr-92	21.0	9.3	7.0	191	27	13	30	2.1	0.010	0.010K	0.57	0.020		0.070	0.020	34	110	220K	100	55K
	28-May-91	24.0	7.7	6.2	170	27	10	15	2.5	0.090	0.010	0.73	0.140		0.080	0.020	26	118	690	55K	200
	18-Jun-91	30.0	6.5	6.9	136	24	9	15	3.1	0.020	0.010	0.72	0.020K		0.050	0.020	12	84	160K	60K	240K
	avg	20.5	8.7	6.9	159	26	26		2.6	0.033	0.013	0.75	0.054	ERR	0.08	0.032	31.8	100	600	11	232
	max	30.5	11.6	7.4	273	51	90		4.5	0.090	0.040	1.30	0.140	ERR	0.27	0.110	84	150	5000	100	1100
	min	8.0	6.5	6.2	97	13	8		0.7	0.010	0.000	0.45	0.000	ERR	0.02	0.000	4	70	0	0	0

	DATE	TEMP	DO	PH	COND	ALK	TURB	COLOR	BOD	NH3	NO-2	TKN	NO2+NO3	ORG.-N	TP	TDP	TSS	TDS	COLIFOR	FECAL	STREP
TMB-2	31-Jul-91	28.0	7.8	7.4	377	59	13	20	4.2	0.010K	0.010K	1.00	0.050K		0.060	0.010K	22	210	120	14K	
(07348000)	21-Aug-91	31.5		6.7	233	41	11	15		0.020	0.010	0.80	0.090		0.070	0.010	27	148	52	18K	
	11-Sep-91	29.5	7.2	7.1	146	29	19	30	4.1	0.010	0.010	1.00	0.020K		0.090	0.010	43	86	230	40K	
	16-Oct-91	21.5	8.8	7.1	259	43	10	20	4.5	0.030	0.010	0.60	0.068		0.080	0.010	30	162	220	30K	
	21-Nov-91	12.0	9.5	6.3	131	25	110	100	4.1	0.050	0.050	0.57	0.130		0.310	0.110	128	93			
	19-Dec-91	12.0	11.0	6.7	123	14	21	50	2	0.020	0.010	0.52	0.040		0.040	0.010K	22	81			
	23-Jan-92	8.0	10.2	6.5	153	15	18	50	0.2	0.020	0.010	0.50	0.050K		0.070	0.020	2	98	1800	40K	
	13-Feb-92	12.5	10.2	7.1	137	10	85	100	1.1	0.070	0.050	0.40	0.070			0.020	134	86		3900	
	19-Mar-92	12.5	8.8	6.7	100	14	15	50	1.2	0.020	0.010	0.62	0.040		0.100	0.050	2	72	400K	200K	
	21-Apr-92	20.0	8.2	7.4	193	30	10	20	0.8	0.040	0.010	0.60	0.050K		0.020	0.010K	4	124		45K	
	28-May-92	24.0	7.3	6.4	183	31	10	20	2.5	0.080	0.010	0.76	0.380			0.040	20	120	780	30K	
	18-Jun-92	30.0	6.5	6.5	144	23	5	20	2.9	0.020	0.010	0.83	0.020K		0.060	0.010	18	91	280K	60K	
	16-Jul-92	30.0	7.4	6.4	93	14	6	20	3.3	0.030	0.010	0.70	0.050K		0.030	0.010K		62	180K	20K	
	avg	20.3	8.6	6.7	158	24	27		2.4	0.034	0.017	0.66	0.068	ERR	0.09	0.023	39.1	102	385	390	
	max	31.5	11.0	7.4	259	43	110		4.5	0.080	0.050	1.00	0.380	ERR	0.31	0.110	134	162	1800	3900	
	min	8.0	6.5	6.3	93	10	5		0.2	0.010	0.010	0.40	0.000	ERR	0.02	0.000	2	62	0	0	

Intensive Water Quality Data
Collected by
U.S. Army Corps of Engineers
Vicksburg District

General Water Quality Parameters
Water Samples - Units are in mg/l

STATION	DATE	TKN	TP	NO3-N	NH3-N	SO-4	TOC	TSS	TS	CL	HARD
LP1	24-Jun-91	0.634	0.086	0.031	0.014	13.6	8.1	56	.	9.68	26.4
LP1	01-Oct-91	0.630	<0.050	<0.020	0.190	11.7	4.1	4	86	9.90	19.8
LP2	24-Jun-91	0.751	0.051	<0.010	0.022	13.1	6.6	10	.	9.68	38.6
LP3	24-Jun-91	0.93	0.075	<0.010	0.187	10.8	4.5	48	.	8.06	28.4
LP4	24-Jun-91	0.636	0.084	0.014	<0.010	13.3	4.5	12	.	9.42	26.4
LP5	25-Jun-91	0.648	0.088	0.110	0.064	24.5	3.2	18	.	12.2	50.8
LP5A	01-Oct-91	0.587	0.073	0.489	<0.020	38.2	2.8	10	186	16.8	69.2
LP6	24-Jun-91	0.843	0.160	<0.010	0.091	16.5	3.2	68	.	29.3	42.6
BCB1	25-Jun-91	0.566	<0.050	<0.010	0.029	12.9	3.1	10	.	10.1	24.4
BCB2	25-Jun-91	0.302	0.088	0.010	0.035	13.4	2.9	10	.	9.09	26.4
BCB3	25-Jun-91	0.54	<0.050	0.023	0.068	13.6	2.4	16	.	9.48	28.4
BCB4	26-Jun-91	0.52	<0.050	0.056	0.056	13.4	6.3	28	.	9.63	30.5
BCB5	26-Jun-91	0.496	<0.050	0.059	0.083	12.8	3.1	18	.	9.65	28.4
BCB6	26-Jun-91	0.506	<0.050	0.098	<0.010	13.2	2.6	14	.	9.67	24.4
CL1	26-Jun-91	0.490	<0.050	0.097	0.022	13.0	1.6	16	.	9.78	24.4
CL2	26-Jun-91	0.356	<0.050	0.101	0.043	13.0	1.5	18	.	9.76	28.4
CL3	26-Jun-91	0.582	0.061	0.084	0.037	13.3	1.6	14	.	9.13	26.4
CL4	27-Jun-91	0.609	0.055	0.034	0.053	12.4	1.6	16	.	8.2	24.4
CL5	27-Jun-91	0.485	<0.050	0.026	<0.010	10.1	<1.0	14	.	8.26	22.3
CL6	27-Jun-91	0.523	0.055	<0.01	0.04	10.1	4.4	18	.	9.48	30.5
CL7	27-Jun-91	0.657	<0.050	0.027	<0.010	9.00	2	26	.	8.79	22.3
CL7	02-Oct-91	0.722	0.095	0.089	<0.020	9.5	5.2	9	103	14.0	21.8
CL8	02-Oct-91	2.05	0.206	<0.020	<0.020	10.5	8.2	15	109	11.4	18.8
TMB1	28-Jun-91	1.53	<0.050	0.108	0.021	.	10.4	10.4	.	.	.
TMB2	28-Jun-91	0.525	<0.050	0.023	0.011	.	7.8	7.8	.	.	.
TMB3	28-Jun-91	0.740	<0.050	0.122	0.104	14.0	1.1	24	.	193	225
TMB4	28-Jun-91	0.544	<0.050	<0.010	<0.010	9.52	<1.0	44	.	12.3	32.5
TMB5	28-Jun-91	0.641	<0.050	<0.010	0.012	9.60	<1.0	42	.	12.8	38.6
LCB1	02-Oct-91	0.425	0.142	0.108	<0.020	11.5	5.1	7	124	14.9	20.6
BB1	03-Oct-91	0.747	0.100	0.075	<0.020	15.0	3.8	38	465	126.0	196

STATION	DATE	ALKALINTY	O&G	TRPH	CA	MG	K	NA
LP1	24-Jun-91	17.1	<0.6	<0.6	.	.	.	.
LP1	01-Oct-91	10.0	.	.	.	.	.	.
LP2	24-Jun-91	21.1	<0.6	<0.6	.	.	.	.
LP3	24-Jun-91	17.6	.	.	.	.	.	.
LP4	24-Jun-91	15.2	.	.	.	.	.	.
LP5	25-Jun-91	20.6	<0.6	<0.6	15.0	3.94	3.6	10.1
LP5A	01-Oct-91	34.2	.	.	.	.	.	.
LP6	24-Jun-91	18.6	.	.	.	.	.	.
BCB1	25-Jun-91	16.9	.	.	.	.	.	.
BCB2	25-Jun-91	18.1	.	.	.	.	.	.
BCB3	25-Jun-91	17.5	<0.6	<0.6	5.47	2.82	2.76	7.85
BCB4	26-Jun-91	16.8	.	.	.	.	.	.
BCB5	26-Jun-91	16.1	.	.	.	.	.	.
CL1	26-Jun-91	15.7	.	.	.	.	.	.
CL2	26-Jun-91	16.6	<0.6	<0.6	.	.	.	.
CL3	26-Jun-91	16.5	.	.	4.78	2.44	2.8	7.53
CL4	27-Jun-91	17	<0.6	<0.6	.	.	.	.
CL5	27-Jun-91	16.0	.	.	4.92	2.44	2.5	6.62
CL6	27-Jun-91	16.6	<0.6	<0.6	4.85	2.28	2.53	6.50
BCB6	26-Jun-91	15.9	.	.	.	.	.	.
CL7	27-Jun-91	16.1	<0.6	<0.6	.	.	.	.
CL7	02-Oct-91	20.9	<0.6	.	.	.	.	.
CL8	02-Oct-91	16.6	.	.	.	.	.	.
TMB1	28-Jun-91		.	.	.	.	.	.
TMB2	28-Jun-91		.	.	.	.	.	.
TMB3	28-Jun-91	72.8	<0.6	<0.6	.	.	.	.
TMB4	28-Jun-91	18.2	.	.	.	.	.	.
TMB5	28-Jun-91	17.9	<0.6	<0.6	.	.	.	.
BLANK	28-Jun-91		<0.5	<0.5	.	.	.	.
LCB1	02-Oct-91	19.3	<1.0	.	.	.	.	.
BB1	03-Oct-91	146	.	.	41.2	18.2	3.00	3.00

Metals Data Collected in Surface Water
Water Samples - Units are in mg/l

STATION	DATE	AS	CD	CR	CU	PB	HG	NI	ZN	BA	FE	MN
LP1	24-Jun-91	<0.005	0.0002	<0.001	0.010	<0.001	0.0004	0.003	0.052	0.068	1.05	0.372
LP1	01-Oct-91	0.023	<0.0001	<0.005	0.141	0.028	0.0007	<0.005	0.214	0.04	0.163	0.451
LP2	24-Jun-91	<0.005	0.0004	<0.001	0.006	<0.001	<0.0002	<0.001	0.026	0.057	0.310	0.190
LP3	24-Jun-91	<0.005	0.0002	<0.001	<0.0010	<0.001	<0.0002	<0.001	<0.008	0.104	2.33	1.88
LP4	24-Jun-91	<0.005	0.0004	<0.001	0.046	<0.001	0.0005	<0.001	0.160	0.048	0.410	0.302
LP5	25-Jun-91	<0.005	0.0003	<0.001	<0.0010	<0.001	<0.0002	<0.001	0.018	0.071	1.21	0.284
LP5A	01-Oct-91	0.131	<0.0001	<0.005	0.005	0.005	<0.0002	<0.005	0.031	0.052	0.631	0.120
LP6	24-Jun-91	<0.005	0.0006	<0.001	0.044	<0.001	<0.0002	<0.001	0.178	0.086	3.22	0.525
BCB1	25-Jun-91	<0.005	0.0002	<0.001	0.0022	<0.001	<0.0002	<0.001	0.012	0.063	0.322	0.598
BCB2	25-Jun-91	<0.005	0.0003	<0.001	<0.0010	<0.001	<0.0002	<0.001	<0.008	0.064	0.380	0.657
BCB3	25-Jun-91	<0.005	0.0003	<0.001	<0.0010	<0.001	[illegible]0002	<0.001	<0.008	0.066	0.463	0.597
BCB4	26-Jun-91	<0.005	0.0005	<0.001	0.022	0.0070	<0.0002	<0.001	0.073	0.065	0.915	0.477
BCB5	26-Jun-91	<0.005	0.0003	<0.001	0.0087	0.0030	<0.0002	<0.001	0.037	0.060	1.41	0.246
BCB6	26-Jun-91	<0.005	0.0003	<0.001	0.0050	0.0010	<0.0002	<0.001	0.024	0.061	1.31	0.217
TMB1	28-Jun-91	<0.005	0.0031	0.0013	0.3080	0.0020	<0.0002	0.004	0.068	0.077	1.31	0.178
TMB2	28-Jun-91	<0.005	0.0003	<0.001	0.0012	0.0010	<0.0002	<0.001	<0.008	0.069	1.13	0.147
TMB3	28-Jun-91	<0.005	0.0003	<0.001	0.058	0.0060	0.0005	<0.001	0.119	0.276	0.697	0.441
TMB4	28-Jun-91	<0.005	0.0044	<0.001	0.0011	0.0010	<0.0002	<0.001	<0.008	0.067	1.05	0.132
TMB5	28-Jun-91	<0.005	0.0003	<0.001	0.006	0.0020	0.0002	<0.001	0.015	0.072	1.20	0.212
CL1	26-Jun-91	<0.005	0.0003	<0.001	<0.0010	0.0010	<0.0002	<0.001	<0.008	0.058	1.18	0.170
CL2	26-Jun-91	<0.005	0.0002	<0.001	0.0063	0.0020	<0.0002	0.001	0.024	0.058	1.23	0.191
CL3	26-Jun-91	0.005	0.00016	<0.001	0.0053	0.0019	<0.0002	<0.001	0.021	0.059	1.18	0.177
CL4	27-Jun-91	0.005	0.00015	<0.001	0.0011	<0.001	<0.0002	<0.001	0.009	0.076	2.27	0.806
CL5	27-Jun-91	0.005	0.00015	<0.001	0.0018	0.0011	<0.0002	<0.001	<0.008	0.060	1.45	0.231
CL6	27-Jun-91	0.006	0.00011	<0.001	<0.0010	<0.001	<0.0002	<0.001	<0.008	0.066	1.67	0.457
CL7	27-Jun-91	<0.005	0.00013	<0.001	0.0013	<0.001	<0.0002	<0.001	<0.008	0.063	1.19	0.201
CL7	02-Oct-91	0.027	<0.0001	<0.005	0.006	0.005	<0.0002	<0.005	0.036	0.049	0.38	0.246
CL8	02-Oct-91	0.006	<0.0001	<0.005	<0.005	0.001	<0.0002	<0.005	<0.005	0.017	0.266	0.037
LCB1	02-Oct-91	0.02	<0.0001	<0.005	0.028	0.007	<0.0002	<0.005	0.142	0.050	1.97	0.154
BB1	03-Oct-91	0.027	<0.0001	<0.005	<0.005	0.003	<0.0002	<0.005	<0.005	0.239	0.623	0.406
CL1-1	14-Aug-92	<0.003	0.0004	<0.013	<0.014	<0.0020	<0.0002	<0.023	<0.020	0.2500	2.700	1.000
CL-JB1	14-Aug-92	<0.003	<0.0003	<0.013	<0.014	<0.0020	<0.0002	<0.023	0.0370	0.0560	3.800	1.200
CLL1	14-Aug-92	<0.003	<0.0003	<0.013	<0.014	<0.0020	<0.0002	<0.023	<0.020	0.0600	1.200	0.790
CLC6	14-Aug-92	<0.003	<0.0003	<0.013	<0.014	<0.0020	<0.0002	<0.023	0.0230	0.0420	0.840	0.100
CLC6A	14-Aug-92	<0.003	<0.0003	<0.013	<0.014	<0.0020	<0.0002	<0.023	<0.020	0.0470	0.550	0.100
CL-C1	14-Aug-92	<0.003	0.0004	<0.013	<0.014	<0.0020	<0.0002	<0.023	<0.020	0.0420	1.200	0.120
CL-C2	12-Aug-92	<0.003	<0.0003	<0.013	0.017	0.0046	0.0006	<0.023	0.19	0.048	1.000	0.170
CL-C3	12-Aug-92	<0.003	<0.0003	<0.013	<0.017	<0.0020	0.0002	<0.023	0.042	0.042	0.720	0.160
CL-C4	12-Aug-92	<0.003	<0.0003	<0.013	<0.017	<0.0020	<0.0002	<0.023	<0.020	0.056	3.700	0.910
LP-C1	13-Aug-92	<0.003	<0.0003	<0.013	<0.017	0.0031	<0.0002	<0.023	0.054	0.073	1.800	0.190
LP-C2	13-Aug-92	<0.003	<0.0003	<0.013	<0.017	0.002	<0.0002	<0.023	0.0400	0.0660	1.100	0.130
LP-C3	13-Aug-92	<0.003	<0.0003	<0.013	0.031	0.0069	0.0005	<0.023	0.1000	0.0650	1.400	0.150
LP-C4	13-Aug-92	<0.003	<0.0003	<0.013	<0.014	0.0023	<0.0002	<0.023	0.0320	0.0680	1.100	0.150
LP-C5	13-Aug-92	<0.003	<0.0003	<0.013	<0.014	0.003	<0.0002	<0.023	0.0540	0.0700	1.600	0.220
BCB-1	13-Aug-92	<0.003	<0.0003	<0.013	<0.014	<0.0020	<0.0002	<0.023	<0.020	0.0600	1.100	0.870

AS - Arsenic
CD - Cadmium
CR - Chromium
CU - Copper
PB - Lead
HG - Mercury
NI - Nickel
ZN - Zinc
BA - Barium
FE - Iron
MN - Manganese

Results of BNA Priority Pollutants Collected in Surface Water
Water Samples - Units are in mg/l

STATION	DATE	PHENOL	2ClPHEN	2NIPHE	24DMePHE	24DClPHE	4Cl3MePH	246TClPH	24DNPH	4NPHE	2M46DNP
LP1	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
LP2	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
LP3	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
LP4	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
LP5	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
LP6	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BCB1	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BCB2	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BCB3	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BCB4	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BCB5	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BCB6	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
CL1	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
CL2	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
CL3	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
CL4	27-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
CL5	27-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
CL6	27-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
CL7	27-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
TMB3	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
TMB4	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
TMB5	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
TMB1	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
TMB2	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BLANK #1		<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BLANK #2		<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BLANK #3		<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BLANK #4		<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
LP5A	01-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
LCB1	02-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
CL8	02-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
CL7	02-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	<0.050
BLANK		<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.050	<0.050	0.050K

STATION	DATE	PClPHE	BENZOAC	2MEPHE	4MEPHE	245TClPH	BZLAL	NNDMEAM	BClIPrE	NNDNPAM	NITROBEN
LP1	24-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
LP2	24-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
LP3	24-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
LP4	25-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
LP5	25-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
LP6	24-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BCB1	25-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BCB2	25-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BCB3	25-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BCB4	26-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BCB5	26-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BCB6	26-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
CL1	26-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
CL2	26-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
CL3	26-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010

ION	DATE	PClPHE	BENZOAC	2MEPHE	4MEPHE	245TClPH	BZLAL	NNDMEAM	BClIPrE	NNDNPAM	NITROBEN
CL4	27-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
CL5	27-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
CL6	27-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
CL7	27-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
TMB3	28-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
TMB4	28-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
TMB5	28-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
TMB1	28-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
TMB2	28-Jun-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BLANK #1		<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BLANK #2		<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BLANK #3		<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BLANK #4		<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
LP5A	01-Oct-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
LCB1	02-Oct-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
CL8	02-Oct-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
CL7	02-Oct-91	<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
BLANK		<0.050	<0.050	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010

STATION	DATE	ISOPHOR	BClEtoME	26DNTOL	24DNTOL	12DPHYD	BENZIDI	33DClBEZ	BClEtE	13DClB	14DClB
LP1	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
LP2	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
LP3	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
LP4	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
LP5	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
LP6	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BCB1	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BCB2	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BCB3	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BCB4	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BCB5	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BCB6	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
CL1	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
CL2	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
CL3	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
CL4	27-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
CL5	27-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
CL6	27-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
CL7	27-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
TMB3	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
TMB4	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
TMB5	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
TMB1	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
TMB2	28-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BLANK #1		<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BLANK #2		<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BLANK #3		<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BLANK #4		<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
LP5A	01-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
LCB1	02-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
CL8	02-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
CL7	02-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010
BLANK		<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.020	<0.010	<0.010	<0.010

STATION	DATE	12DClB	HClETA	124TClB	NAPHTH	HClBU	HClCYPD	2ClNAPH	ACENAY	DMePHTH	ACENAP
LP1	24-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP2	24-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP3	24-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP4	25-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP5	25-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP6	24-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB1	25-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB2	25-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB3	25-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB4	26-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB5	26-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB6	26-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL1	26-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL2	26-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL3	26-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL4	27-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL5	27-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL6	27-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL7	27-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
TMB3	28-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
TMB4	28-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
TMB5	28-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
TMB1	28-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
TMB2	28-Jun-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK #1		0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK #2		0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK #3		0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK #4		0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP5A	01-Oct-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LCB1	02-Oct-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL8	02-Oct-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL7	02-Oct-91	0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK		0.010K	0.010K	0.010K	0.010K	<0.010	<0.010	<0.010	<0.010	1.0000	<0.010

STATION	DATE	FLUORE	DEtPHTH	4ClPHPHE	NNDPHAM	4BrPHET	HClBEN	PHENAN	ANTRAC	DBuPHTH	FLANTHE
LP1	24-Jun-91	<0.010	0.0012J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP2	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP3	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP4	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP5	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP6	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB1	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB2	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB3	25-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB4	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB5	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BCB6	26-Jun-91	<0.010	0.019	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0019 J	<0.010
CL1	26-Jun-91	<0.010	0.029	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0024	<0.010
CL2	26-Jun-91	<0.010	0.028	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0023 J	<0.010
CL3	26-Jun-91	<0.010	0.027	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0023 J	<0.010
CL4	27-Jun-91	<0.010	0.027	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0024 J	<0.010
CL5	27-Jun-91	<0.010	0.022	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0022 J	<0.010
CL6	27-Jun-91	<0.010	0.020	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0020 J	<0.010
CL7	27-Jun-91	<0.010	0.0050 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
TMB3	28-Jun-91	<0.010	0.0071 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0011 J	<0.010
TMB4	28-Jun-91	<0.010	0.0081 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0011 J	<0.010
TMB5	28-Jun-91	<0.010	0.0079 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0012 J	<0.010
TMB1	28-Jun-91	<0.010	0.0062 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
TMB2	28-Jun-91	<0.010	0.0065 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK #1		<0.010	0.0029 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

TION	DATE	FLUORE	DEtPHTH	4ClPHPHE	NNDPHAM	4BrPHET	HClBEN	PHENAN	ANTRAC	DBuPHTH	FLANTHE
BLANK #2		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0012 J	<0.010
BLANK #3		<0.010	0.018	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0015 J	<0.010
BLANK #4		<0.010	0.0059 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0011 J	<0.010
LP5A	01-Oct-91	<0.010	0.0022 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LCB1	02-Oct-91	<0.010	0.0015 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL8	02-Oct-91	<0.010	0.0011 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL7	02-Oct-91	<0.010	0.001 J	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK		<0.010	0.019	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

STATION	DATE	PYRENE	BuBePHTH	CHRYSE	BAANTHR	B2EHPH	DNOcPHT	BBFLANT	BKFLANT	BAPYRE	I123PYR
LP1	24-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0013J	<0.010	<0.010	<0.010	<0.010	<0.010
LP2	24-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LP3	24-Jun-91	<0.010	0.0044 J	<0.010	<0.010	0.0010J	<0.010	<0.010	<0.010	<0.010	<0.010
LP4	25-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0018J	<0.010	<0.010	<0.010	<0.010	<0.010
LP5	25-Jun-91	<0.010	0.0064 J	<0.010	<0.010	0.0035J	<0.010	<0.010	<0.010	<0.010	<0.010
LP6	24-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0020J	<0.010	<0.010	<0.010	<0.010	<0.010
BCB1	25-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0011J	<0.010	<0.010	<0.010	<0.010	<0.010
BCB2	25-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0031J	<0.010	<0.010	<0.010	<0.010	<0.010
BCB3	25-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0019J	<0.010	<0.010	<0.010	<0.010	<0.010
BCB4	26-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0014J	<0.010	<0.010	<0.010	<0.010	<0.010
BCB5	26-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0019J	<0.010	<0.010	<0.010	<0.010	<0.010
BCB6	26-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0031J	<0.010	<0.010	<0.010	<0.010	<0.010
CL1	26-Jun-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL2	26-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0015J	<0.010	<0.010	<0.010	<0.010	<0.010
CL3	26-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0050J	<0.010	<0.010	<0.010	<0.010	<0.010
CL4	27-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0025J	<0.010	<0.010	<0.010	<0.010	<0.010
CL5	27-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0070J	<0.010	<0.010	<0.010	<0.010	<0.010
CL6	27-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0052J	<0.010	<0.010	<0.010	<0.010	<0.010
CL7	27-Jun-91	<0.010	0.0045 J	<0.010	<0.010	0.0055J	0.0026 J	<0.010	<0.010	<0.010	<0.010
TMB3	28-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0019J	<0.010	<0.010	<0.010	<0.010	<0.010
TMB4	28-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0024J	<0.010	<0.010	<0.010	<0.010	<0.010
TMB5	28-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0048J	<0.010	<0.010	<0.010	<0.010	<0.010
TMB1	28-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0026J	<0.010	<0.010	<0.010	<0.010	<0.010
TMB2	28-Jun-91	<0.010	<0.010	<0.010	<0.010	0.0019J	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK #1		<0.010	<0.010	<0.010	<0.010	0.0014J	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK #2		<0.010	<0.010	<0.010	<0.010	0.0021J	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK #3		<0.010	<0.010	<0.010	<0.010	0.0064J	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK #4		<0.010	<0.010	<0.010	<0.010	0.0023J	<0.010	<0.010	<0.010	<0.010	<0.010
LP5A	01-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
LCB1	02-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL8	02-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
CL7	02-Oct-91	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
BLANK		<0.010	<0.010	<0.010	<0.010	0.001J	<0.010	<0.010	<0.010	<0.010	<0.010

STATION	DATE	DBAHANT	B-GHI-PY	ANILINE	4ClANIL	DBENZOFU	2MeNAPH	2NANIL	3NANIL	4NANIL
LP1	24-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
LP2	24-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
LP3	24-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
LP4	25-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
LP5	25-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
LP6	24-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BCB1	25-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BCB2	25-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BCB3	25-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BCB4	26-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BCB5	26-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BCB6	26-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
CL1	26-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
CL2	26-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
CL3	26-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050

STATION	DATE	DBAHANT	B-GHI-PY	ANILINE	4ClANIL	DBENZOFU	2MeNAPH	2NANIL	3NANIL	4NANIL
CL4	27-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
CL5	27-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
CL6	27-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
CL7	27-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
TMB3	28-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
TMB4	28-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
TMB5	28-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
TMB1	28-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
TMB2	28-Jun-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BLANK #1		<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BLANK #2		<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BLANK #3		<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BLANK #4		<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
LP5A	01-Oct-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
LCB1	02-Oct-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
CL8	02-Oct-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
CL7	02-Oct-91	<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050
BLANK		<0.010	<0.010	<0.020	<0.020	<0.010	<0.010	<0.050	<0.050	<0.050

* - J values are reported concentrations below EPA quality control contract laboratory detection limits.

Results of VOA Priority Pollutants Collected in Surface Water Water Samples - Units are in mg/l

STATION	DATE	ClMETH	BRMETH	VNLCL	CLETHA	MECL	DCLETE11	DCLETA11	T-DCLETE
LP1	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP2	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP3	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP4	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP5	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP6	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB1	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB2	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB3	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB4	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB5	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB6	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL1	26-Jun-91	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CL2	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL3	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL4	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL5	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL6	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL7	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB1	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB2	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB3	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB4	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB5	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BLANK	01-Jul-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LCB1	02-Oct-91	<0.010	<0.010	<0.010	<0.010	0.0079	<0.005	<0.005	<0.005
CL7	02-Oct-91	<0.010	<0.010	<0.010	<0.010	0.0031	<0.005	<0.005	<0.005
CL8	02-Oct-91	<0.010	<0.010	<0.010	<0.010	0.0053	<0.005	<0.005	<0.005
BLANK	31-Oct-91	<0.010	<0.010	<0.010	<0.010	0.019	<0.005	<0.005	<0.005

STATION	DATE	C-DCLETE	CHCL3	DCLETA12	TCA111	CCL4	BRDCLME	DCLPR12	T13CLPRE
LP1	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP2	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP3	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP4	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP5	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP6	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB1	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB2	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB3	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB4	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB5	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB6	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL1	26-Jun-91	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CL2	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL3	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL4	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL5	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL6	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL7	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB1	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB2	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB3	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB4	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB5	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BLANK	01-Jul-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LCB1	02-Oct-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL7	02-Oct-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL8	02-Oct-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BLANK	31-Oct-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

STATION	DATE	TCE	DBRCLME	C13CLPRE	TCA112	BENZENE	CHBR3	TCLA1122	TECLETE
LP1	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP2	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP3	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP4	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP5	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LP6	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB1	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB2	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB3	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB4	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB5	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BCB6	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL1	26-Jun-91	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CL2	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL3	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL4	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

STATION	DATE	TCE	DBRCLME	C13CLPRE	TCA112	BENZENE	CHBR3	TCLA1122	TECLETE
CL5	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL6	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL7	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB1	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB2	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB3	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB4	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TMB5	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BLANK	01-Jul-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LCB1	02-Oct-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL7	02-Oct-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CL8	02-Oct-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BLANK	31-Oct-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

STATION	DATE	TOLUENE	CLBEN	ETBEN	ACETONE	BUTANO	CS2	HEXANO2	ME2PE4
LP1	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
LP2	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
LP3	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
LP4	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
LP5	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
LP6	24-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
BCB1	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
BCB2	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
BCB3	25-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
BCB4	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
BCB5	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
BCB6	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
CL1	26-Jun-91	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.005
CL2	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
CL3	26-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
CL4	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
CL5	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
CL6	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
CL7	27-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
TMB1	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
TMB2	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
TMB3	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
TMB4	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
TMB5	28-Jun-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
BLANK	01-Jul-91	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1	<0.005
LCB1	02-Oct-91	<0.005	<0.005	<0.005	<0.100	<0.100	<0.005	<0.050	<0.050
CL7	02-Oct-91	<0.005	<0.005	<0.005	<0.100	<0.100	<0.005	<0.050	<0.050
CL8	02-Oct-91	<0.005	<0.005	<0.005	<0.100	<0.100	<0.005	<0.050	<0.050
BLANK	31-Oct-91	<0.005	<0.005	<0.005	<0.100	<0.100	<0.005	<0.050	<0.050

STATION	DATE	STYRENE	VNACETA	T-XYLENE
LP1	24-Jun-91	<0.005	<0.005	<0.005
LP2	24-Jun-91	<0.005	<0.005	<0.005
LP3	24-Jun-91	<0.005	<0.005	<0.005
LP4	24-Jun-91	<0.005	<0.005	<0.005
LP5	25-Jun-91	<0.005	<0.005	<0.005
LP6	24-Jun-91	<0.005	<0.005	<0.005
BCB1	25-Jun-91	<0.005	<0.005	<0.005
BCB2	25-Jun-91	<0.005	<0.005	<0.005
BCB3	25-Jun-91	<0.005	<0.005	<0.005
BCB4	26-Jun-91	<0.005	<0.005	<0.005
BCB5	26-Jun-91	<0.005	<0.005	<0.005
BCB6	26-Jun-91	<0.005	<0.005	<0.005
CL1	26-Jun-91	<0.005	<0.005	<0.005
CL2	26-Jun-91	<0.005	<0.005	<0.005
CL3	26-Jun-91	<0.005	<0.005	<0.005
CL4	27-Jun-91	<0.005	<0.005	<0.005
CL5	27-Jun-91	<0.005	<0.005	<0.005
CL6	27-Jun-91	<0.005	<0.005	<0.005
CL7	27-Jun-91	<0.005	<0.005	<0.005
TMB1	28-Jun-91	<0.005	<0.005	<0.005
TMB2	28-Jun-91	<0.005	<0.005	<0.005
TMB3	28-Jun-91	<0.005	<0.005	<0.005
TMB4	28-Jun-91	<0.005	<0.005	<0.005
TMB5	28-Jun-91	<0.005	<0.005	<0.005
BLANK	01-Jul-91	<0.005	<0.005	<0.005
LCB1	02-Oct-91	<0.005	<0.050	<0.005
CL7	02-Oct-91	<0.005	<0.050	<0.005
CL8	02-Oct-91	<0.005	<0.050	<0.005
BLANK	31-Oct-91	<0.005	<0.050	<0.005

* - J values are reported concentrations below EPA quality control contract laboratory detection limits.

Pesticide and PCB Analysis of Surface Water Samples
Units are in mg/l

STATION	DATE	ALDRIN	A-BHC	B-BHC	G-BHC	D-BHC	PPDDD	PPDDE	PPDDT	HPTCL	DIELDRIN
LP1	24-Jun-91	<0.000040	<0.000030	<0.000060	<0.000040	<0.000090	<0.00011	<0.000040	<0.00012	<0.000030	<0.000020
LP2	24-Jun-91	<0.000044	<0.000033	<0.000067	<0.000044	<0.000100	<0.00012	<0.000044	<0.00013	<0.000033	<0.000022
LP3	24-Jun-91	<0.000040	<0.000030	<0.000060	<0.000040	<0.000090	<0.00011	<0.000040	<0.00012	<0.000030	<0.000020
LP4	25-Jun-91	<0.000039	<0.000029	<0.000058	<0.000039	<0.000087	<0.00011	<0.000039	<0.00012	<0.000029	<0.000019
LP5	25-Jun-91	<0.000039	<0.000029	<0.000058	<0.000039	<0.000087	<0.00011	<0.000039	<0.00012	<0.000029	<0.000019
LP6	24-Jun-91	<0.000041	<0.000031	<0.000061	<0.000041	<0.000092	<0.00011	<0.000041	<0.00012	<0.000031	<0.000020
BCB1	25-Jun-91	<0.000042	<0.000031	<0.000063	<0.000042	<0.000094	<0.00011	<0.000042	<0.00013	<0.000031	<0.000021
BCB2	25-Jun-91	<0.000038	<0.000029	<0.000058	<0.000038	<0.000087	<0.00011	<0.000038	<0.00012	<0.000029	<0.000019
BCB3	25-Jun-91	<0.000038	<0.000029	<0.000058	<0.000038	<0.000087	<0.00011	<0.000038	<0.00012	<0.000029	<0.000019
BCB4	26-Jun-91	<0.000040	<0.000030	<0.000059	<0.000040	<0.000089	<0.00011	<0.000040	<0.00012	<0.000030	<0.000020
BCB5	26-Jun-91	<0.000039	<0.000029	<0.000059	<0.000039	<0.000088	<0.00011	<0.000039	<0.00012	<0.000029	<0.000020
BCB6	26-Jun-91	<0.000038	<0.000029	<0.000058	<0.000038	<0.000087	<0.00011	<0.000038	<0.00012	<0.000029	<0.000019
CL1	26-Jun-91	<0.000039	<0.000029	<0.000059	<0.000039	<0.000088	<0.00011	<0.000039	<0.00012	<0.000029	<0.000020
CL2	26-Jun-91	<0.000038	<0.000029	<0.000058	<0.000038	<0.000087	<0.00011	<0.000038	<0.00012	<0.000029	<0.000019
CL3	26-Jun-91	<0.000040	<0.000030	<0.000061	<0.000040	<0.000091	<0.00011	<0.000040	<0.00012	<0.000030	<0.000020
CL4	27-Jun-91	<0.000039	<0.000029	<0.000059	<0.000039	<0.000088	<0.00011	<0.000039	<0.00012	<0.000029	<0.000020
CL5	27-Jun-91	<0.000039	<0.000029	<0.000059	<0.000039	<0.000088	<0.00011	<0.000039	<0.00012	<0.000029	<0.000020
CL6	27-Jun-91	<0.000039	<0.000029	<0.000059	<0.000039	<0.000088	<0.00011	<0.000039	<0.00012	<0.000029	<0.000020
CL7	27-Jun-91	<0.000039	<0.000029	<0.000059	<0.000039	<0.000088	<0.00011	<0.000039	<0.00012	<0.000029	<0.000020
TMB3	28-Jun-91	<0.000042	<0.000031	<0.000063	<0.000042	<0.000094	<0.00011	<0.000042	<0.00013	<0.000031	<0.000021
TMB4	28-Jun-91	<0.000040	<0.000030	<0.000060	<0.000040	<0.000090	<0.00011	<0.000040	<0.00012	<0.000030	<0.000020
TMB5	28-Jun-91	<0.000039	<0.000029	<0.000058	<0.000039	<0.000087	<0.00011	<0.000039	<0.00012	<0.000029	<0.000019
BLANK #1	01-Jul-91	<0.000040	<0.000030	<0.000060	<0.000040	<0.000090	<0.00011	<0.000040	<0.00012	<0.000030	<0.000020
BLANK #2	01-Jul-91	<0.000040	<0.000030	<0.000060	<0.000040	<0.000090	<0.00011	<0.000040	<0.00012	<0.000030	<0.000020
LCB1	02-Oct-91	<0.000039	<0.000029	<0.000059	<0.000039	<0.000088	<0.00011	<0.000039	<0.00012	<0.000029	<0.000020
CL8	02-Oct-91	<0.000039	<0.000029	<0.000059	<0.000039	<0.000087	<0.00011	<0.000039	<0.00012	<0.000029	<0.000020
CL7	02-Oct-91	<0.000039	<0.000029	<0.000059	<0.000039	<0.000090	<0.00011	<0.000039	<0.00012	0.000005 J	<0.000020
BLANK	31-Oct-91	<0.000040	<0.000030	<0.000060	<0.000040	<0.000090	<0.00011	<0.000040	<0.00012	<0.000030	<0.000020

STATION	DATE	ENDOI	ENDOII	ENDOSU	ENDRIN	HPTCLE	METOXYCL	CLORDANE	TOXAPHEN	ENDRKETN	ENDALD
LP1	24-Jun-91	<0.00014	<0.000040	<0.00066	<0.000060	<0.00083	<0.0018	<0.0007	<0.0024	<0.00011	
LP2	24-Jun-91	<0.00016	<0.000044	<0.00073	<0.000067	<0.00092	<0.0020	<0.0007	<0.0027	<0.00012	
LP3	24-Jun-91	<0.00014	<0.000040	<0.00066	<0.000060	<0.00083	<0.0018	<0.0007	<0.0024	<0.00011	
LP4	24-Jun-91	<0.00014	<0.000039	<0.00064	<0.000058	<0.00081	<0.0017	<0.0006	<0.0023	<0.00011	
LP5	25-Jun-91	<0.00014	<0.000039	<0.00064	<0.000058	<0.00081	<0.0017	<0.0006	<0.0023	<0.00011	
LP6	24-Jun-91	<0.00014	<0.000041	<0.00067	<0.000061	<0.00085	<0.0018	<0.0007	<0.0024	<0.00011	
BCB1	25-Jun-91	<0.00015	<0.000042	<0.00069	<0.000063	<0.00086	<0.0018	<0.0007	<0.0025	<0.00011	
BCB2	25-Jun-91	<0.00013	<0.000038	<0.00063	<0.000058	<0.00080	<0.0017	<0.0006	<0.0023	<0.00011	
BCB3	25-Jun-91	<0.00013	<0.000038	<0.00063	<0.000058	<0.00080	<0.0017	<0.0006	<0.0023	<0.00011	
BCB4	26-Jun-91	<0.00014	<0.000040	<0.00065	<0.000059	<0.00082	<0.0017	<0.0007	<0.0024	<0.00011	
BCB5	26-Jun-91	<0.00014	<0.000039	<0.00065	<0.000059	<0.00081	<0.0017	<0.0006	<0.0024	<0.00011	
BCB6	26-Jun-91	<0.00013	<0.000038	<0.00063	<0.000058	<0.00080	<0.0017	<0.0006	<0.0023	<0.00011	
CL1	26-Jun-91	<0.00014	<0.000039	<0.00065	<0.000059	<0.00081	<0.0017	<0.0006	<0.0024	<0.00011	
CL2	26-Jun-91	<0.00013	<0.000038	<0.00063	<0.000058	<0.00080	<0.0017	<0.0006	<0.0023	<0.00011	
CL3	26-Jun-91	<0.00014	<0.000040	<0.00067	<0.000061	<0.00084	<0.0018	<0.0007	<0.0024	<0.00011	
CL4	27-Jun-91	<0.00014	<0.000039	<0.00065	<0.000059	<0.00081	<0.0017	<0.0006	<0.0024	<0.00011	
CL5	27-Jun-91	<0.00014	<0.000039	<0.00065	<0.000059	<0.00081	<0.0017	<0.0006	<0.0024	<0.00011	
CL6	27-Jun-91	<0.00014	<0.000039	<0.00065	<0.000059	<0.00081	<0.0017	<0.0006	<0.0024	<0.00011	
CL7	27-Jun-91	<0.00014	<0.000039	<0.00065	<0.000059	<0.00081	<0.0017	<0.0006	<0.0024	<0.00011	
TMB3	28-Jun-91	<0.00015	<0.000042	<0.00069	<0.000063	<0.00086	<0.0018	<0.0007	<0.0025	<0.00011	
TMB4	28-Jun-91	<0.00014	<0.000040	<0.00066	<0.000060	<0.00083	<0.0018	<0.0007	<0.0024	<0.00011	
TMB5	28-Jun-91	<0.00014	<0.000039	<0.00064	<0.000058	<0.00081	<0.0018	<0.0006	<0.0023	<0.00011	
BLANK #1	01-Jul-91	<0.00014	<0.000040	<0.00066	<0.000060	<0.00083	<0.0018	<0.0007	<0.0024	<0.00011	
BLANK #2	01-Jul-91	<0.00014	<0.000040	<0.00066	<0.000060	<0.00083	<0.0018	<0.0007	<0.0024	<0.00011	
LCB1	02-Oct-91	<0.00014	<0.000039	<0.00065	<0.000059	<0.00081	<0.0017	<0.0007	<0.0024	<0.00011	<0.00023
CL8	02-Oct-91	<0.00014	<0.000039	<0.00063	<0.000059	<0.00081	<0.0017	<0.0007	<0.0024	<0.00011	<0.00023
CL7	02-Oct-91	<0.00014	<0.000039	<0.00066	<0.000059	<0.00083	<0.0018	<0.0007	<0.0024	<0.00011	<0.00023
BLANK	31-Oct-91	<0.00014	<0.000040	<0.00066	<0.000060	<0.00083	<0.0018	<0.0007	<0.0024	<0.00011	<0.00023

STATION	DATE	PCB-1016	PCB-1221	PCB-1232	PCB-1242	PCB-1248	PCB-1254	PCB-1260
LP1	24-Jun-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
LP2	24-Jun-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0014	<0.0014
LP3	24-Jun-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
LP4	24-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
LP5	25-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
LP6	24-Jun-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
BCB1	25-Jun-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0014	<0.0014
BCB2	25-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0012	<0.0012
BCB3	25-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0012	<0.0012
BCB4	26-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
BCB5	26-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
BCB6	26-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0012	<0.0012
CL1	26-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
CL2	26-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0012	<0.0012
CL3	26-Jun-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
CL4	27-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
CL5	27-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
CL6	27-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
CL7	27-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
TMB3	28-Jun-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0014	<0.0014
TMB4	28-Jun-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
TMB5	28-Jun-91	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0013	<0.0013
BLANK #1	01-Jul-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
BLANK #2	01-Jul-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
LCB1	02-Oct-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
CL8	02-Oct-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
CL7	02-Oct-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013
BLANK	31-Oct-91	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	<0.0013	<0.0013

Explosive Analyses of Surface Water Samples
Units are in mg/l

STATION	DATE	HMX	RDX	TNT	DNB	TETRYL	TNT	2,4-DNT	2,6-DNT
LP1	24-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
LP5	25-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
BCB3	25-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
CL6	27-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
CL7	27-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
CL4	27-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
CL5	27-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
CL1	26-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
CL2	26-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
CL3	26-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
TMB1	28-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
TMB2	28-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
TMB3	28-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
TMB4	28-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
TMB5	28-Jun-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
BLANK		<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
CL8	02-Oct-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
CL7	02-Oct-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020
BLANK	31-Oct-91	<0.020	<0.020	<0.020	<0.020	<0.050	<0.020	<0.020	<0.020

Intensive Sediment Quality Data
Collected by
U.S. Army Corps of Engineers
Vicksburg District

Sediment Particle Size

STATION	DATE	TOC	%SAND	%SILT	%CLAY	%FINES
LP1	24-Jun-91	10159				
LP2	24-Jun-91	12363	0.0	60.7	39.3	
LP3	24-Jun-91	12453	16.8	64.3	18.9	
LP4	25-Jun-91	3207	68.4	23.1	8.5	
LP5	25-Jun-91	21975	7.8	0.0	0.0	92.2
LP6	24-Jun-91	4495	66.2			33.8
BCB1	25-Jun-91	2417	80.2	12.4	7.4	
BCB2	25-Jun-91	2456	89.4	6.5	4.1	
BCB3	25-Jun-91	4340	76.6			23.4
BCB4	26-Jun-91	5651	66.2	17.8	16.0	
BCB5	26-Jun-91	13191	28.8			71.2
CL1	26-Jun-91	11473	56.2			43.8
CL2	26-Jun-91	7402	60.0			40.0
CL3	26-Jun-91	12446	67.6	14.7	17.7	
CL4	27-Jun-91	39440	0.0	55.9	44.1	
CL5	27-Jun-91	33232	0.0			100.0
CL6	27-Jun-91	29072	0.0	56.3	43.7	
CL7	27-Jun-91	11560	38.2			61.8
TMB1	28-Jun-91	4724	87.6	7.0	5.4	
TMB2	28-Jun-91	5551	11.4	32.9	55.7	
TMB3	28-Jun-91	11463	13.2	36.3	50.5	
TMB4	28-Jun-91	6071	20.6	49.9	29.5	
TMB5	28-Jun-91	1849	76.0	12.8	11.2	
BCB6	26-Jun-91	1520	72.4	19.2	8.4	
CLP5	27-Jun-91	10403				
LP4S	02-Oct-91	2767	66.2			33.8

Sediment Analyses of Metals
Units are in mg/kg

STATION	DATE	TOC	AS	CD	CR	CU	PB	HG	NI	ZN	BA	FE	MN
LP6	24-Jun-91	4495	1.39	<0.400	7.20	4.00	10.0	<0.100	3.60	31.1	12.5	9100	702
LP5	25-Jun-91	21975	8.30	4.20	40.8	32.9	126	0.210	28.8	484	237	41500	1280
LP5A	01-Oct-91	11297	6.80	1.00	14.5	10.5	87.3	0.405	11.4	396	97.6	30500	480
CLP5	27-Jun-91	10403	7.19	5.50	36.0	35.8	170	0.294	27.8	568	244	47900	861
LP4	25-Jun-91	3207	1.73	<0.400	4.40	1.50	7.50	<0.100	3.30	30.7	49.1	6860	316
LP3	24-Jun-91	12453	5.16	0.500	12.4	6.70	23.3	<0.100	10.3	59.8	127	16700	521
LP2	24-Jun-91	12363	11.76	2.30	25.0	11.9	41.3	<0.100	18.3	95.1	211	45000	1160
LP1	24-Jun-91	10159	5.0	0.600	17.8	9.50	26.7	<0.100	12.5	63.3	161	20800	940
LP4S	01-Oct-91	2767	2.60	<0.10	1.80	0.60	10.7	<0.100	5.70	61.0	348	22800	364
BCB1	25-Jun-91	2417	0.85	<0.400	3.70	<0.500	5.50	<0.100	0.600	8.90	30.8	4870	162
BCB2	25-Jun-91	2456	<0.8	<0.400	2.50	<0.500	2.30	<0.100	0.900	4.80	15.6	2750	262
BCB3	25-Jun-91	4340	<0.8	<0.400	3.50	<0.900	4.60	<0.100	1.30	8.20	24.8	2720	159
BCB4	26-Jun-91	5651	0.96	<0.400	6.40	2.00	5.70	<0.100	3.00	17.7	43.3	7580	203
BCB5	26-Jun-91	13191	3.10	<0.900	16.6	5.70	18.0	<0.100	12.8	62.9	157	19900	543
BCB6	26-Jun-91	1520	<0.8	<0.400	4.30	1.10	7.50	<0.100	3.20	16.7	35.0	6130	70.9
LCB1	02-Oct-91	10528	1.40	<0.01	0.50	0.500	23.6	<0.100	<0.50	<0.60	<1.0	21300.00	<0.50
CL1	26-Jun-91	11473	2.22	<0.400	9.10	2.90	12.6	<0.100	6.80	50.8	81.7	13600.0	291.0
CL2	26-Jun-91	7402	1.25	<0.600	7.60	2.30	10.1	<0.100	5.40	38.5	64.3	10400.0	254.0
CL3	26-Jun-91	12446	1.27	0.500	8.40	4.00	8.20	<0.100	6.90	35.6	72.5	8310.0	158.0
CL4	27-Jun-91	39440	6.62	1.60	27.8	15.1	58.9	0.174	27.3	128	146	36200	446
CL5	27-Jun-91	33232	11.24	1.90	25.6	16.4	44.5	0.262	39.3	139	290	45100	1160
CL6	27-Jun-91	29072	5.41	1.90	25.8	14.4	38.7	0.130	27.9	108	258	52100	633
CL6A	02-Oct-91	9679	5.80	0.48	36.5	37.1	45.5	0.122	34.1	160	329	53700	12400
CL7	27-Jun-91	11560	2.60	0.600	13.1	11.8	15.7	<0.100	12.6	48.1	123	18300	411
CL8	02-Oct-91	5899	4.00	<0.01	14.7	10.8	25.1	<0.100	22.0	84.9	157	17600	258
TMB1	28-Jun-91	4724	1.77	<0.400	4.70	1.80	5.40	<0.100	4.50	11.3	45.1	5820	152
TMB2	28-Jun-91	5551	1.65	0.600	17.8	8.80	14.6	<0.100	17.5	45.9	311	19400	576
TMB3	28-Jun-91	11463	1.73	0.600	19.3	9.20	15.1	<0.100	18.1	47.7	328	18200	591
TMB4	28-Jun-91	6071	3.67	0.600	18.7	9.20	25.3	<0.100	16.6	45.3	162	20500	513
TMB5	28-Jun-91	1849	0.92	<0.400	5.30	1.70	5.70	<0.100	4.30	11.7	60.3	6640	93.0

Sediment Analyses of BNA Priority Pollutants
Units are in mg/kg

STATION	DATE	PHENOL	2ClPHEN	2NIPHE	24DMEPHE	24DClPHE	4CL3MEPH	246TClPH	24DNPH	4NPHE	2M46DNPH	PClPHE	BENZOAC	2MEPHE
LP4	25-Jun-91	<5.1	<5.1	<5.1	<5.1	<5.1	<10.2	<5.1	<25.5	<25.5	<25.5	<25.5	<25.5	<5.1
LP5	25-Jun-91	<13.1	<13.1	<13.1	<13.1	<13.1	<26.2	<13.1	<65.5	<65.5	<65.5	<65.5	<65.5	<13.1
BCB1	25-Jun-91	<0.85	<0.85	<0.85	<0.85	<0.85	<1.70	<0.85	<4.25	<4.25	<4.25	<4.25	<4.25	<0.85
BCB4	26-Jun-91	<0.89	<0.89	<0.89	<0.89	<0.89	<1.78	<0.89	<4.45	<4.45	<4.45	<4.45	<4.45	<0.89
CL4	27-Jun-91	<16.0	<16.0	<16.0	<16.0	<16.0	<32.0	<16.0	<80.0	<80.0	<80.0	<80.0	<80.0	<16.0
CL6	27-Jun-91	<13.0	<13.0	<13.0	<13.0	<13.0	<26.0	<13.0	<65.0	<65.0	<65.0	<65.0	<65.0	<13.0
TMB3	28-Jun-91	<6.9	<6.9	<6.9	<6.9	<6.9	<13.8	<6.9	<34.5	<34.5	<34.5	<34.5	<34.5	<6.9
TMB5	28-Jun-91	<1.4	<1.4	<1.4	<1.4	<1.4	<2.8	<1.4	<7.0	<7.0	<7.0	<7.0	<7.0	<1.4
BLANK #1		<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<0.67	<3.3	<3.3	<3.3	<3.3	<3.3	<0.67
BLANK #2		<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<0.67	<3.3	<3.3	<3.3	<3.3	<3.3	<0.67
LP1	24-Jun-91	<1.9	<1.9	<1.9	<1.9	<1.9	<3.8	<1.9	<9.5	<9.5	<9.5	<9.5	<9.5	<1.9
LP2	24-Jun-91	<2.6	<2.6	<2.6	<2.6	<2.6	<5.2	<2.6	<13.0	<13.0	<13.0	<13.0	<13.0	<2.6
LP3	24-Jun-91	<1.8	<1.8	<1.8	<1.8	<1.8	<3.6	<1.8	<9.0	<9.0	<9.0	<9.0	<9.0	<1.8
LP6	24-Jun-91	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0
BCB2	25-Jun-91	<0.82	<0.82	<0.82	<0.82	<0.82	<1.6	<0.82	<4.6	<4.6	<4.6	<4.6	<4.6	<0.82
BCB3	25-Jun-91	<0.82	<0.82	<0.82	<0.82	<0.82	<1.6	<0.82	<4.6	<4.6	<4.6	<4.6	<4.6	<0.82
BCB5	26-Jun-91	<1.3	<1.3	<1.3	<1.3	<1.3	<2.6	<1.3	<6.5	<6.5	<6.5	<6.5	<6.5	<1.3
BCB6	26-Jun-91	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0
CL1	26-Jun-91	<1.1	<1.1	<1.1	<1.1	<1.1	<2.2	<1.1	<5.5	<5.5	<5.5	<5.5	<5.5	<1.1
CL2	26-Jun-91	<1.1	<1.1	<1.1	<1.1	<1.1	<2.2	<1.1	<5.5	<5.5	<5.5	<5.5	<5.5	<1.1
CL3	26-Jun-91	<1.1	<1.1	<1.1	<1.1	<1.1	<2.2	<1.1	<5.5	<5.5	<5.5	<5.5	<5.5	<1.1
CL5	27-Jun-91	<1.8	<1.8	<1.8	<1.8	<1.8	<3.6	<1.8	<9.0	<9.0	<9.0	<9.0	<9.0	<1.8
CL7	27-Jun-91	<1.4	<1.4	<1.4	<1.4	<1.4	<2.8	<1.4	<7.0	<7.0	<7.0	<7.0	<7.0	<1.4
TMB1	28-Jun-91	<0.80	<0.80	<0.80	<0.80	<0.80	<1.6	<0.80	<4.0	<4.0	<4.0	<4.0	<4.0	<0.8
TMB2	28-Jun-91	<0.80	<0.80	<0.80	<0.80	<0.80	<1.6	<0.80	<4.0	<4.0	<4.0	<4.0	<4.0	<0.8
TMB4	28-Jun-91	<0.80	<0.80	<0.80	<0.80	<0.80	<1.6	<0.80	<4.0	<4.0	<4.0	<4.0	<4.0	<0.8
BLANK #1		<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<0.67	<3.3	<3.3	<3.3	<3.3	<3.3	<0.67
BLANK #2		<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<0.67	<3.3	<3.3	<3.3	<3.3	<3.3	<0.67
BLANK #3		<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<0.67	<3.3	<3.3	<3.3	<3.3	<3.3	<0.67
LCB1	02-Oct-91	<1.1	<1.1	<1.1	<1.1	<1.1	<2.2	<1.1	<5.5	<5.5	<5.5	<5.5	<5.5	<1.1
CL8	02-Oct-91	<2.4	<2.4	<2.4	<2.4	<2.4	<4.8	<2.4	<12.0	<12.0	<12.0	<12.0	<12.0	<2.4
LP5A	01-Oct-91	<1.1	<1.1	<1.1	<1.1	<1.1	<2.2	<1.1	<5.5	<5.5	<5.5	<5.5	<5.5	<1.1
CL6A	02-Oct-91	<3.2	<3.2	<3.2	<3.2	<3.2	<6.4	<3.2	<16.0	<16.0	<16.0	<16	<16	<3.2
BLANK		<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<0.67	<3.3	<3.3	<3.3	<3.3	<3.3	<0.67

STATION	DATE	4MEPHE	245TClPH	BZLAL	NNDMEAM	BCLIPRE	NNDNPAM	NITROBEN	ISOPHOR	BCLETOME	26DNTOL	24DNTOL	12DPHYD	BENZIDI
LP4	25-Jun-91	<5.1	<5.1	<10.2	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<25.5
LP5	25-Jun-91	<13.1	<13.1	<26.2	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<65.5
BCB1	25-Jun-91	<0.85	<0.85	<1.7	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<4.25
BCB4	26-Jun-91	<0.89	<0.89	<1.78	0.073 J	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<4.45
CL4	27-Jun-91	<16.0	<16.0	<32	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<80.0
CL6	27-Jun-91	<13.0	<13.0	<26	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<65.0
TMB3	28-Jun-91	<6.9	<6.9	<13.8	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<34.5
TMB5	28-Jun-91	<1.4	<1.4	<2.8	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<7.0
BLANK #1		<0.67	<0.67	<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<3.3
BLANK #2		<0.67	<0.67	<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<3.3
LP1	24-Jun-91	<1.9	<1.9	<3.8	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<9.5
LP2	24-Jun-91	<2.6	<2.6	<5.2	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<13.0
LP3	24-Jun-91	<1.8	<1.8	<3.6	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<9.0
LP6	24-Jun-91	0.26 J	<1.0	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0
BCB2	25-Jun-91	<0.82	<0.82	<1.6	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<4.6
BCB3	25-Jun-91	<0.82	<0.82	<1.6	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<4.6
BCB5	26-Jun-91	1.2 J	<1.3	<2.6	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<6.5
BCB6	26-Jun-91	<1.0	<1.0	<2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0
CL1	26-Jun-91	<1.1	<1.1	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<5.5
CL2	26-Jun-91	<1.1	<1.1	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<5.5
CL3	26-Jun-91	<1.1	<1.1	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<5.5
CL5	27-Jun-91	<1.8	<1.8	<3.6	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<9.0
CL7	27-Jun-91	<1.4	<1.4	<2.8	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<7.0

STATION	DATE	4MEPHE	245TCLPH	BZLAL	NNDMEAM	BCLIPRE	NNDNPAM	NITROBEN	ISOPHOR	BCLETOME	26DNTOL	24DNTOL	12DPHYD	BENZIDI
TMB1	28-Jun-91	<0.8	<0.8	<1.6	<0.8	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<4.0
TMB2	28-Jun-91	<0.8	<0.8	<1.6	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<4.0
TMB4	28-Jun-91	<0.8	<0.8	<1.6	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<4.0
BLANK #1		<0.67	<0.67	<1.3	<0.67	<0.67	<0.67	<0.67	0.064 J	<0.67	<0.67	<0.67	<0.67	<3.3
BLANK #2		<0.67	<0.67	<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<3.3
BLANK #3		<0.67	<0.67	<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<3.3
LCB1	02-Oct-91	<1.1	<1.1	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<5.5
CL8	02-Oct-91	0.14 J	<2.4	<4.8	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<12.0
LP5A	01-Oct-91	<1.1	<1.1	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<5.5
CL6A	02-Oct-91	<3.2	<3.2	<6.4	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<16.0
BLANK		<0.67	<0.67	<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<3.3

STATION	DATE	33DCLBEZ	BCLETE	13DCLB	14DCLB	12DCLB	HCLETA	124TCLB	NAPHTH	HCLBU	HCLCYPD	2CLNAPH	ACENAY	DMEPHTH
LP4	25-Jun-91	<10.2	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1
LP5	25-Jun-91	<26.2	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1
BCB1	25-Jun-91	<1.7	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85
BCB4	26-Jun-91	<1.78	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89
CL4	27-Jun-91	<32.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0
CL6	27-Jun-91	<26.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0
TMB3	28-Jun-91	<13.8	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9
TMB5	28-Jun-91	<2.8	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
BLANK #1		<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67
BLANK #2		<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67
LP1	24-Jun-91	<3.8	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9
LP2	24-Jun-91	<5.2	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
LP3	24-Jun-91	<3.6	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
LP6	24-Jun-91	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BCB2	25-Jun-91	<1.6	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82
BCB3	25-Jun-91	<1.6	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82
BCB5	26-Jun-91	<2.6	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
BCB6	26-Jun-91	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
CL1	26-Jun-91	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
CL2	26-Jun-91	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
CL3	26-Jun-91	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
CL5	27-Jun-91	<3.6	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<[illegible].8	<1.8	<1.8
CL7	27-Jun-91	<2.8	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
TMB1	28-Jun-91	<1.6	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.30	<0.80	<0.80
TMB2	28-Jun-91	<1.6	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80
TMB4	28-Jun-91	<1.6	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80
BLANK #1		<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67
BLANK #2		<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67
BLANK #3		<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67
LCB1	02-Oct-91	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
CL8	02-Oct-91	<4.8	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4
LP5A	01-Oct-91	<2.2	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	0.16 J	<1.1	<1.1	<1.1	<1.1	<1.1
CL6A	02-Oct-91	<6.4	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2
BLANK		<1.3	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67

STATION	DATE	ACENAP	FLUORE	DETPHTH	4CLPHPHE	NNDPHAM	4BRPHET	HCLBEN	PHENAN	ANTRAC	DBUPHTH	FLANTHE	PYRENE	BUBEPHTH
LP4	25-Jun-91	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	0.28 J	<5.1	<5.1	<5.1
LP5	25-Jun-91	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	0.84 J	<13.1	<13.1	<13.1
BCB1	25-Jun-91	<0.85	<0.85	<.432	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	0.107 J	<0.85	<0.85	<0.85
BCB4	26-Jun-91	<0.89	<0.89	<.06	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	0.16 J	<0.89	<0.89	<0.89
CL4	27-Jun-91	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	0.70 J	<16.0	<16.0	<16.0
CL6	27-Jun-91	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	0.70 J	<13.0	<13.0	<13.0
TMB3	28-Jun-91	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9
TMB5	28-Jun-91	<1.4	<1.4	<.06	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	0.15 J	<1.4	<1.4	<1.4
BLANK #1		<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	0.0019 J	<0.67	<0.67	<0.67
BLANK #2		<0.67	<0.67	<.22	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	0.078 J	<0.67	<0.67	<0.67
LP1	24-Jun-91	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	0.09 J	<1.9	<1.9	<1.9
LP2	24-Jun-91	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
LP3	24-Jun-91	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	0.17 J	<1.8	<1.8	<1.8

STA	DATE	ACENAP	FLUORE	DETPHTH	4CLPHPHE	NNDPHAM	4BRPHET	HCLBEN	PHENAN	ANTRAC	DBUPHTH	FLANTHE	PYRENE	BUBEPHTH
LP6	24-Jun-91	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.06 J	<1.0	<1.0	<1.0
BCB2	25-Jun-91	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	0.09 J	<0.82	<0.82	<0.82
BCB3	25-Jun-91	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	0.12 J	<0.82	<0.82	<0.82
BCB5	26-Jun-91	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	0.27 J	<1.3	<1.3	<1.3
BCB6	26-Jun-91	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.45 J	<1.0	<1.1	<1
CL1	26-Jun-91	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	0.07 J	<1.1	<1.1	<1.1
CL2	26-Jun-91	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
CL3	26-Jun-91	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
CL5	27-Jun-91	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
CL7	27-Jun-91	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	0.23 J	0.43 J	0.17 J
TMB1	28-Jun-91	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80
TMB2	28-Jun-91	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80
TMB4	28-Jun-91	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80
BLANK #1		<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<.33	<0.67	<0.67	<0.67
BLANK #2		<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<.04	<0.67	<0.67	<0.67
BLANK #3		<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67
LCB1	02-Oct-91	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	0.12 J	<1.1	<1.1	<.25
CL8	02-Oct-91	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	0.02 J	<2.4	0.48 J	<2.4	<2.4	<2.4
LP5A	01-Oct-91	<1.1	0.03 J	<1.1	<1.1	<1.1	<1.1	<1.1	0.25 J	<.12	0.23 J	0.5[illegible] J	0.53 J	<1.1
CL6A	02-Oct-91	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	0.08 J	<3.2	0.41 J	0.095 J	0.12 J	<3.2
BLANK		<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	0.11 J	<0.67	<0.67	<0.67

STATION	DATE	CHRYSE	BAANTHR	B2EHPH	DNOCPHT	BBFLANT	BKFLANT	BAPYRE	I123PYR	DBAHANT	B-GHI-PY	ANILINE	4CLANIL	DBENZOFU
LP4	25-Jun-91	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<10.2	<10.2	<5.1
LP5	25-Jun-91	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<26.2	<26.2	<13.1
BCB1	25-Jun-91	<0.85	<0.85	0.198 J	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<1.7	<1.7	<0.85
BCB4	26-Jun-91	<0.89	<0.89	0.20 J	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<1.78	<1.78	<0.89
CL4	27-Jun-91	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<16.0	<32.0	<32.0	<16.0
CL6	27-Jun-91	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<26.0	<26.0	<13.0
TMB3	28-Jun-91	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<13.8	<13.8	<6.9
TMB5	28-Jun-91	<1.4	<1.4	0.97 J	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<2.8	<2.8	<1.4
BLANK #1		<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<1.3	<0.67
BLANK #2		<0.67	<0.67	0.30 J	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<1.3	<0.67
LP1	24-Jun-91	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<3.8	<3.8	<1.9
LP2	24-Jun-91	<2.6	<2.6	0.19 J	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<5.2	<5.2	<2.6
LP3	24-Jun-91	<1.8	<1.8	0.19 J	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<3.6	<3.6	<1.8
LP6	24-Jun-91	<1.0	<1.0	0.32 J	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0
BCB2	25-Jun-91	<0.82	<0.82	4.5 J	0.56 J	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<1.6	<1.6	<0.82
BCB3	25-Jun-91	<0.82	<0.82	1.5 J	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<0.82	<1.6	<1.6	<0.82
BCB5	26-Jun-91	<1.3	<1.3	0.15 J	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<2.6	<2.6	<1.3
BCB6	26-Jun-91	<1.0	<1.0	0.30 J	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0
CL1	26-Jun-91	<1.1	<1.1	0.15 J	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<2.2	<2.2	<1.1
CL2	26-Jun-91	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<2.2	<2.2	<1.1
CL3	26-Jun-91	<1.1	<1.1	0.13 J	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<2.2	<2.2	<1.1
CL5	27-Jun-91	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<3.6	<3.6	<1.8
CL7	27-Jun-91	<.17	<1.4	0.44 J	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<2.8	<2.8	<1.4
TMB1	28-Jun-91	<0.80	<0.80	0.04 J	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<1.6	<1.6	<0.80
TMB2	28-Jun-91	<0.80	<0.80	0.08 J	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<1.6	<1.6	<0.80
TMB4	28-Jun-91	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<1.6	<1.6	<0.80
BLANK #1		<0.67	<0.67	0.12 J	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<1.3	<0.67
BLANK #2		<0.67	<0.67	0.09 J	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<1.3	<0.67
BLANK #3		<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<1.3	<0.67
LCB1	02-Oct-91	<1.1	<1.1	0.14 J	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<2.2	<2.2	<1.1
CL8	02-Oct-91	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<4.8	<4.8	<2.4
LP5A	01-Oct-91	0.64 J	0.49 J	<1.1	<1.1	0.56 J	0.43 J	0.44 J	0.39 J	<1.1	0.32 J	<2.2	<2.2	<1.1
CL6A	02-Oct-91	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<6.4	<6.4	<3.2
BLANK		<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<1.3	<1.3	<0.67

STATION	DATE	2MENAPH	2NANIL	3NANIL	4NANIL
LP4	25-Jun-91	<5.1	<25.5	<25.5	<25.5
LP5	25-Jun-91	<13.1	<65.5	<65.5	<65.5
BCB1	25-Jun-91	<0.85	<4.25	<4.25	<4.25
BCB4	26-Jun-91	<0.89	<4.45	<4.45	<4.45
CL4	27-Jun-91	<16.0	<80.0	<80.0	<80.0
CL6	27-Jun-91	<13.0	<65.0	<65.0	<65.0
TMB3	28-Jun-91	<6.9	<34.5	<34.5	<34.5
TMB5	28-Jun-91	<1.4	<7.0	<7.0	<7.0
BLANK #1		<0.67	<3.3	<3.3	<3.3
BLANK #2		<0.67	<3.3	<3.3	<3.3
LP1	24-Jun-91	<1.9	<9.5	<9.5	<9.5
LP2	24-Jun-91	<2.6	<13.0	<13.0	<13.0
LP3	24-Jun-91	<1.8	<9.0	<9.0	<9.0
LP6	24-Jun-91	<1.0	<5.0	<5.0	<5.0
BCB2	25-Jun-91	<0.82	<4.6	<4.6	<4.6
BCB3	25-Jun-91	<0.82	<4.6	<4.6	<4.6
BCB5	26-Jun-91	<1.3	<6.5	<6.5	<6.5
BCB6	26-Jun-91	<1.0	<5.0	<5.0	<5.0
CL1	26-Jun-91	<1.1	<5.5	<5.5	<5.5
CL2	26-Jun-91	<1.1	<5.5	<5.5	<5.5
CL3	26-Jun-91	<1.1	<5.5	<5.5	<5.5
CL5	27-Jun-91	<1.8	<9.0	<9.0	<9.0
CL7	27-Jun-91	<1.4	<7.0	<7.0	<7.0
TMB1	28-Jun-91	<0.80	<4.0	<4.0	<4.0
TMB2	28-Jun-91	<0.80	<4.0	<4.0	<4.0
TMB4	28-Jun-91	<0.80	<4.0	<4.0	<4.0
BLANK #1		<0.67	<3.3	<3.3	<3.3
BLANK #2		<0.67	<3.3	<3.3	<3.3
BLANK #3		<0.67	<3.3	<3.3	<3.3
LCB1	02-Oct-91	<1.1	<5.5	<5.5	<5.5
CL8	02-Oct-91	<2.4	<12.0	<12.0	<12.0
LP5A	01-Oct-91	<1.1	<5.5	<5.5	<5.5
CL6A	02-Oct-91	<3.2	<16.0	<16.0	<16.0
BLANK		<0.67	<3.3	<3.3	<3.3

Sediment Analyses of VOA Priority Pollutants
Units are in mg/kg

STATION	DATE	CLMETH	BRMETH	VNLCL	CLETHA	MECL	11DCLETE	11DCLETA	T-DCLETE	C-DCLETE	CHCL3	12DCLETA	TCA111
LP4	24-Jun-91	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009
LP5	25-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022
BCB1	26-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
BCB4	26-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
CL4	27-Jun-91	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034
CL6	27-Jun-91	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
TMB3	28-Jun-91	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012
TMB5	28-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
BLANK		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LCB1	02-Oct-91	<0.017	<0.017	<0.017	<0.017	0.032	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085
CL8	02-Oct-91	<0.042	<0.042	<0.042	<0.042	0.022	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021
LP5A	01-Oct-91	<0.016	<0.016	<0.016	<0.016	0.013	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082
CL6A	01-Oct-91	<0.054	<0.054	<0.054	<0.054	0.19	<0.027	<0.027	<0.027	<0.027	0.013J	<0.027	<0.027
BLANK #1		<0.010	<0.010	<0.010	<0.010	0.019	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BLANK #2		<0.010	<0.010	<0.010	<0.010	0.0018J	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

STATION	DATE	CCL4	BRDCLME	DClPR12	T-13CLPRE	TCE	DBRCLME	C13ClPRE	112TCA	BENZENE	CHBr3	1122TClA	TEClETE
LP4	24-Jun-91	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009
LP5	25-Jun-91	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022
BCB1	26-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
BCB4	26-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
CL4	27-Jun-91	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034
CL6	27-Jun-91	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
TMB3	28-Jun-91	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012
TMB5	28-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
BLANK		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LCB1	02-Oct-91	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085	<0.0085
CL8	02-Oct-91	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021
LP5A	01-Oct-91	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082
CL6A	01-Oct-91	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027
BLANK #1		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
BLANK #2		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

STATION	DATE	TOLUENE	ClBEN	ETBEN	ACETONE	BUTANO	CS2	2HEXANO	4Me2PE	STYRENE	VNACETA	T-XYLENE
LP4	24-Jun-91	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.180	<0.009	<0.009	<0.009	<0.009
LP5	25-Jun-91	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.430	<0.022	<0.022	<0.022	<0.022
BCB1	26-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.140	<0.007	<0.007	<0.007	<0.007
BCB4	26-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.140	<0.007	<0.007	<0.007	<0.007
CL4	27-Jun-91	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.670	<0.030	<0.030	<0.030	<0.030
CL6	27-Jun-91	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.400	<0.040	<0.040	<0.040	<0.040
TMB3	28-Jun-91	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.230	<0.012	<0.012	<0.012	<0.012
TMB5	28-Jun-91	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.130	<0.007	<0.007	<0.007	<0.007
BLANK		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.100	<0.005	<0.005	<0.005	<0.005
LCB1	02-Oct-91	<0.0085	<0.0085	0.0046J	0.11J	<0.170	<0.0085	<0.085	<0.085	<0.0085	<0.085	0.026
CL8	02-Oct-91	0.39	<0.021	<0.021	0.28J	0.12J	<0.021	<0.21	<0.021	<0.021	<0.021	0.0061J
LP5A	01-Oct-91	0.0016J	<0.0082	<0.0082	0.13J	0.015J	<0.0082	<0.082	<0.0082	<0.0082	<0.0082	<0.0082
CL6A	01-Oct-91	<0.027	<0.027	<0.027	0.87	0.059J	<0.027	<0.27	<0.027	<0.027	<0.027	0.0053J
BLANK #1		<0.005	<0.005	<0.005	0.0086J	<0.10	<0.005	<0.050	<0.005	<0.005	<0.005	<0.005
BLANK #2		<0.005	<0.005	<0.005	0.0086J	<0.10	<0.005	<0.050	<0.005	<0.005	<0.005	<0.005

Sediment Analyses of Pesticides
Units are in mg/kg

STATION	DATE	ALDRIN	A-BHC	B-BHC	G-BHC	D-BHC	PPDDD	PPDDE	PPDDT	HPTCL	DIELDRIN	ENDOI	ENDOII
LP1	24-Jun-91	<0.0027	<0.0020	<0.0040	<0.0027	<0.0060	<0.0073	<0.0027	<0.0080	<0.0020	<0.0013	<0.0093	<0.0027
LP2	24-Jun-91	<0.0025	<0.0018	<0.0037	<0.0025	<0.0055	<0.0068	<0.0025	<0.0074	<0.0018	<0.0012	<0.0086	<0.0025
LP3	24-Jun-91	<0.0025	<0.0019	<0.0038	<0.0025	<0.0057	<0.0070	<0.0025	<0.0076	<0.0019	<0.0013	<0.0089	<0.0025
LP6	24-Jun-91	<0.0026	<0.0020	<0.0040	<0.0026	<0.0059	<0.0073	<0.0026	<0.0079	<0.0020	<0.0013	<0.0092	<0.0026
BCB2	25-Jun-91	<0.0025	<0.0019	<0.0038	<0.0025	<0.0057	<0.0070	<0.0025	<0.0076	<0.0019	<0.0013	<0.0089	<0.0025
BCB3	25-Jun-91	<0.0025	<0.0019	<0.0038	<0.0025	<0.0057	<0.0069	<0.0025	<0.0075	<0.0019	<0.0013	<0.0088	<0.0025
BCB5	26-Jun-91	<0.0026	<0.0019	<0.0039	<0.0026	<0.0058	<0.0071	<0.0026	<0.0078	<0.0019	<0.0013	<0.0091	<0.0026
BCB6	26-Jun-91	<0.0027	<0.0020	<0.0040	<0.0027	<0.0060	<0.0074	<0.0027	<0.0080	<0.0020	<0.0013	<0.0094	<0.0027
CL1	26-Jun-91	<0.0025	<0.0019	<0.0038	<0.0025	<0.0057	<0.0070	<0.0025	<0.0076	<0.0019	<0.0013	<0.0089	<0.0025
CL2	26-Jun-91	<0.0027	<0.0020	<0.0040	<0.0027	<0.0060	<0.0073	<0.0027	0.0019 J	<0.0020	<0.0013	<0.0093	<0.0027
CL3	26-Jun-91	<0.0025	<0.0020	<0.0040	<0.0027	<0.0060	<0.0073	<0.0027	<0.0080	<0.0020	<0.0013	<0.0093	<0.0027
CL5	27-Jun-91	<0.0025	<0.0019	<0.0038	<0.0025	<0.0057	<0.0070	<0.0025	<0.0076	<0.0026	<0.0013	<0.0089	<0.0025
CL7	27-Jun-91	<0.0027	<0.0020	<0.0040	<0.0027	<0.0060	<0.0074	<0.0027	<0.0080	<0.0020	<0.0013	<0.0094	<0.0027
TMB1	28-Jun-91	<0.0026	<0.0020	<0.0040	<0.0026	<0.0060	<0.0073	<0.0026	<0.0079	<0.0020	<0.0013	<0.0093	<0.0026
TMB2	28-Jun-91	<0.0027	<0.0020	<0.0040	<0.0027	<0.0060	<0.0073	<0.0027	<0.0080	<0.0020	<0.0013	<0.0093	<0.0027
TMB4	28-Jun-91	<0.0026	<0.0020	<0.0039	<0.0026	<0.0059	<0.0072	<0.0026	<0.0079	<0.0020	<0.0013	<0.0092	<0.0026
BLANK#1		<0.0027	<0.0020	<0.0040	<0.0027	<0.0060	<0.0074	<0.0027	<0.0080	<0.0020	<0.0013	<0.0094	<0.0027
BLANK#2		<0.0027	<0.0020	<0.0040	<0.0027	<0.0060	<0.0074	<0.0027	<0.0080	<0.0020	<0.0013	<0.0094	<0.0027
LP4	24-Jun-91	<0.0041	<0.0031	<0.0062	<0.0041	<0.0093	<0.0011	<0.0041	0.0015 J	<0.0031	<0.0021	<0.014	<0.0041
LP5	25-Jun-91	<0.010	<0.0076	<0.015	<0.010	<0.023	<0.028	<0.010	<0.030	<0.0076	<0.0050	<0.035	<0.010
BCB1	25-Jun-91	<0.0034	<0.0026	<0.0051	<0.0034	<0.0077	<0.0094	<0.0034	<0.010	<0.0026	<0.0017	<0.012	<0.0034
BCB4	26-Jun-91	<0.0036	<0.0027	<0.0054	<0.0036	<0.0081	<0.0099	<0.0036	<0.011	<0.0027	<0.0018	<0.013	<0.0036
CL4	27-Jun-91	<0.013	<0.0098	<0.020	<0.013	<0.029	<0.036	<0.013	<0.039	<0.0098	<0.0065	<0.046	<0.013
CL6	27-Jun-91	<0.011	<0.0083	<0.017	<0.011	<0.025	<0.030	<0.011	<0.033	<0.0083	<0.0055	<0.034	<0.011
TMB3	28-Jun-91	<0.0056	<0.0042	<0.0084	<0.0056	<0.013	<0.015	<0.029	0.0027 J	<0.0042	<0.0028	<0.020	<0.0056
TMB5	28-Jun-91	<0.0057	<0.0043	<0.0086	<0.0057	<0.013	<0.016	<0.0057	<0.017	<0.0043	<0.0029	<0.020	<0.0057
BLANK		<0.0027	<0.0020	<0.0040	<0.0027	<0.0060	<0.0074	<0.0027	<0.0080	<0.0020	<0.0013	<0.0094	<0.0027
LCB1	02-Oct-91	<0.0045	<0.0034	<0.0067	<0.0045	<0.010	<0.012	<0.0045	<0.013	<0.0034	<0.0022	<0.016	<0.0054
CL8	02-Oct-91	<0.0099	<0.0074	<0.015	<0.0099	<0.022	<0.027	<0.0099	<0.030	<0.0074	<0.0050	<0.035	<0.0099
LP5A	02-Oct-91	<0.0045	<0.0034	<0.0067	<0.0045	<0.010	<0.012	<0.0045	<0.013	<0.0034	<0.0022	<0.016	<0.0045
CL6A	02-Oct-91	<0.013	<0.0097	<0.019	<0.013	<0.026	<0.035	<0.013	<0.039	<0.0097	<0.0064	<0.045	<0.013
BLANK		<0.0027	<0.0020	<0.0040	<0.0027	<0.0066	<0.0074	<0.0027	<0.0080	<0.0020	<0.0013	<0.0094	<0.0027

STATION	DATE	ENDOSU	ENDRIN	HPTCLE	METOXYCL	CLORDANE	TOXAPHEN	PCB-1016	PCB-1221	PCB-1232	PCB-1242	PCB-1248	PCB-1254
LP1	24-Jun-91	<0.044	<0.0040	<0.056	<0.12	<0.043	<0.16	<0.043	<0.043	<0.043	<0.043	<0.043	<0.086
LP2	24-Jun-91	<0.041	<0.0037	<0.051	<0.11	<0.040	<0.15	<0.040	<0.040	<0.040	<0.040	<0.040	<0.080
LP3	24-Jun-91	<0.042	<0.0038	<0.053	<0.11	<0.041	<0.15	<0.041	<0.041	<0.041	<0.041	<0.041	<0.082
LP6	24-Jun-91	<0.044	<0.0040	<0.055	<0.12	<0.043	<0.16	<0.043	<0.043	<0.043	<0.043	<0.043	<0.086
BCB2	25-Jun-91	<0.042	<0.0038	<0.053	<0.11	<0.041	<0.15	<0.041	<0.041	<0.041	<0.041	<0.041	<0.082
BCB3	25-Jun-91	<0.042	<0.0038	<0.052	<0.11	<0.041	<0.15	<0.041	<0.041	<0.041	<0.041	<0.041	<0.082
BCB5	26-Jun-91	<0.043	<0.0039	<0.054	<0.11	<0.042	<0.16	<0.043	<0.043	<0.043	<0.043	<0.043	<0.084
BCB6	26-Jun-91	<0.044	<0.0040	<0.056	<0.12	<0.044	<0.16	<0.043	<0.043	<0.043	<0.043	<0.043	<0.087
CL1	26-Jun-91	<0.042	<0.0038	<0.053	<0.11	<0.041	<0.15	<0.040	<0.040	<0.040	<0.040	<0.040	<0.082
CL2	26-Jun-91	<0.044	<0.0040	<0.055	<0.12	<0.043	<0.15	<0.041	<0.041	<0.041	<0.041	<0.041	<0.087
CL3	26-Jun-91	<0.044	<0.0040	<0.055	<0.12	<0.043	<0.16	<0.043	<0.043	<0.043	<0.043	<0.043	<0.087
CL5	27-Jun-91	<0.042	<0.0038	<0.053	<0.11	<0.041	<0.15	<0.041	<0.041	<0.041	<0.041	<0.041	<0.083
CL7	27-Jun-91	<0.044	<0.0040	<0.056	<0.12	<0.044	<0.15	<0.041	<0.041	<0.041	<0.041	<0.041	<0.087
TMB1	28-Jun-91	<0.044	<0.0040	<0.055	<0.12	<0.043	<0.16	<0.042	<0.042	<0.042	<0.042	<0.042	<0.086
TMB2	28-Jun-91	<0.044	<0.0040	<0.055	<0.12	<0.043	<0.15	<0.041	<0.041	<0.041	<0.041	<0.041	<0.086
TMB4	28-Jun-91	<0.043	<0.0039	<0.54	<0.12	<0.043	<0.16	<0.043	<0.043	<0.043	<0.043	<0.043	<0.085
BLANK#1		<0.044	<0.0040	<0.056	<0.12	<0.044	<0.15	<0.041	<0.041	<0.041	<0.041	<0.041	<0.087
BLANK#2		<0.044	<0.0040	<0.056	<0.12	<0.044	<0.16	<0.044	<0.044	<0.044	<0.044	<0.044	<0.087

ST/ N	DATE	ENDOSU	ENDRIN	HPTCLE	METOXYCL	CLORDANE	TOXAPHEN	PCB-1016	PCB-1221	PCB-1232	PCB-1242	PCB-1248	PCB-1254
LP4	24-Jun-91	<0.068	<0.0062	<0.086	<0.18	<0.067	<0.25	<0.067	<0.067	<0.067	<0.067	<0.067	<0.13
LP5	25-Jun-91	<0.17	<0.015	0.21	<0.44	<0.16	<0.60	<0.16	<0.16	<0.16	<0.16	<0.16	<0.33
BCB1	25-Jun-91	<0.056	<0.0051	<0.71	<0.15	<0.056	<0.21	<0.056	<0.056	<0.056	<0.056	<0.056	<0.11
BCB4	26-Jun-91	<0.059	<0.0054	<0.074	<0.16	<0.058	<0.22	<0.058	<0.058	<0.058	<0.058	<0.058	<0.12
CL4	27-Jun-91	<0.22	<0.020	<0.27	<0.57	<0.21	<0.78	<0.21	<0.21	<0.21	<0.21	<0.21	<0.42
CL6	27-Jun-91	<0.18	<0.017	<0.23	<0.48	<0.18	<0.66	<0.18	<0.18	<0.18	<0.18	<0.18	<0.36
TMB3	28-Jun-91	<0.093	<0.0084	<0.12	<0.25	<0.091	<0.34	<0.091	<0.091	<0.091	<0.091	<0.091	<0.18
TMB5	28-Jun-91	<0.094	<0.0086	<0.12	<0.25	<0.093	<0.34	<0.093	<0.093	<0.093	<0.093	<0.093	<0.19
BLANK		<0.044	<0.0040	<0.056	<0.12	<0.044	<0.16	<0.044	<0.044	<0.044	<0.044	<0.044	<0.087
LCB1	02-Oct-91	<0.074	<0.0067	<0.093	<0.20	0.073	<0.27	<0.073	<0.073	<0.073	<0.073	<0.073	<0.15
CL8	02-Oct-91	<0.16	<0.015	<0.21	<0.44	<0.16	<0.59	<0.16	<0.16	<0.16	<0.16	<0.16	<0.32
LP5A	02-Oct-91	<0.074	<0.0067	<0.093	<0.20	<0.073	<0.27	<0.73	<0.73	<0.73	<0.73	<0.073	<0.15
CL6A	02-Oct-91	<0.21	<0.019	<0.27	<0.57	<0.21	<0.77	<0.21	<0.21	<0.21	<0.21	<0.21	<0.42
BLANK	31-Oct-91	<0.044	<0.0040	<0.056	<0.12	<0.044	<0.16	<0.044	<0.044	<0.044	<0.044	<0.044	<0.087

STATION	DATE	PCB-1260	T-PCB	ENDRKETN	ENDALD
LP1	24-Jun-91	<0.086	<0.086	<0.0073	.
LP2	24-Jun-91	<0.080	<0.080	<0.0068	.
LP3	24-Jun-91	<0.082	<0.082	<0.0070	.
LP6	24-Jun-91	<0.086	<0.086	<0.0073	.
BCB2	25-Jun-91	<0.082	<0.082	<0.0070	.
BCB3	25-Jun-91	<0.082	<0.082	<0.0069	.
BCB5	26-Jun-91	<0.084	<0.084	<0.0071	.
BCB6	26-Jun-91	<0.087	<0.087	<0.0074	.
CL1	26-Jun-91	<0.082	<0.082	<0.0070	.
CL2	26-Jun-91	<0.087	<0.087	<0.0073	.
CL3	26-Jun-91	<0.087	<0.087	<0.0073	.
CL5	27-Jun-91	<0.083	<0.083	<0.0070	.
CL7	27-Jun-91	<0.087	<0.087	<0.0074	.
TMB1	28-Jun-91	<0.086	<0.086	<0.0073	.
TMB2	28-Jun-91	<0.086	<0.086	<0.0073	.
TMB4	28-Jun-91	<0.085	<0.085	<0.0072	.
BLANK#1		<0.087	<0.087	<0.0074	.
BLANK#2		<0.087	<0.087	<0.0074	.
LP4	24-Jun-91	<0.13	.	<0.028	.
LP5	25-Jun-91	<0.33	.	<0.028	.
BCB1	25-Jun-91	<0.11	.	<0.0094	.
BCB4	26-Jun-91	<0.12	.	<0.017	.
CL4	27-Jun-91	<0.42	.	<0.036	.
CL6	27-Jun-91	<0.36	.	<0.030	.
TMB3	28-Jun-91	<0.18	.	<0.015	.
TMB5	28-Jun-91	<0.19	.	<0.016	.
BLANK		<0.087	.	<0.0074	.
LCB1	02-Oct-91	<0.15	.	<0.012	<0.026
CL8	02-Oct-91	<0.32	.	<0.027	<0.057
LP5A	02-Oct-91	<0.15	.	<0.012	<0.026
CL6A	02-Oct-91	<0.42	.	<0.035	<0.074
BLANK	31-Oct-91	<0.087	.	<0.087	<0.015

Sediment Analyses of Explosives
Units are in mg/kg

	DATE	HMX	RDX	TNB	DNB	TETRYL	TNT	2,4-DNT	2,6-DNT
CL1	26-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
CL2	26-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
CL3	26-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
CL4	27-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
CL5	27-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
CL6	27-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
CL7	27-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
TMB1	28-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
TMB2	28-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
TMB3	28-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
TMB4	28-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
TMB5	28-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
LP5	25-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
BCB3	25-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
LP1	24-Jun-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
BLANK		<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
CL8	02-Oct-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
CL6A	02-Oct-91	<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26
BLANK		<2.2	<1.0	<0.25	<0.25	<0.65	<0.25	<0.25	<0.26

**Intensive Sediment Core Data
Collected by
U.S. Army Corps of Engineers
Vicksburg District**

Metal Analyses of Sediment Cores
Units are in mg/kg

Depth in inches

STATION	DATE	DEPTH	TOC	AS	CD	CR	CU	PB	HG	NI	AG	ZN	AL	BA	CO	FE	MN	TKN	TP	COD
LPC1-1	13-Aug-92	0-4	1000	1	0.04K	4.4	2.8	3.4	0.11K	3.1	1.1K	14	3900	37	2.4	6100	110	11	5.3	520K
LPC1-2	13-Aug-92	4-8	450	0.9	0.04K	5.3	2.8	3.9	0.11K	2.9K	1.1K	14	4300	38	1.8	6300	82	11	5.5	550K
LPC1-3	13-Aug-92	8-12	1000	0.9	0.04K	3.3	2.4	3.5	0.11K	2.9K	1.1K	11	2700	33	1.5	5200	53	11	5.3	530K
LPC1-4	13-Aug-92	12-16	470	0.4	0.04K	2.2	2.4	2.7	0.11K	2.9K	1.1K	7.4	1500	21	1.4K	2900	26	7	3.4	550K
LPC2-1	13-Aug-92	0-4	5800	8.1	1.29	17	14	84	0.20K	16	1.7K	280	13000	160	20	2600	1100	120	35	5800
LPC2-2	13-Aug-92	4-8	6000	3.5	0.25	15	8.9	21	0.15K	13	1.3K	66	17000	180	16	21000	1300	86	22	6000
LPC2-1B	13-Aug-92	0-4	6000	2.8	0.07	11	7	14	0.15K	7.2	1.3K	39	11000	160	15	18000	1000	43	18	4300
LPC2-2B	13-Aug-92	4-8	4700	2.9	0.04	13	7.6	14	0.11K	8.5	1.2K	42	13000	170	23	22000	1600	53	18	2600
LPC3-1	13-Aug-92	0-4	5700	5.6	4.54	25	27	150	0.29K	20	2.7K	480	13000	200	23	30000	1000	200	78	49000
LPC3-2	13-Aug-92	4-8	7900	8.5	3.96	23	26	140	0.29K	20	2.7K	510	14000	190	19	31000	730	200	72	50000
LPC3-3	13-Aug-92	8-12	3300	3.5	0.91	6.6	5.2	34	0.15K	5.1	1.3K	140	5200	91	4.3	13000	180	61	23	15000
LPC3-1A	13-Aug-92	0-4	4400	6	2.73	20	23	100	0.23K	22	2.6K	410	8100	180	26	29000	1200	210	94	42000
LPC3-2A	13-Aug-92	4-8	5200	3.3	2.25	12	15	70	0.17K	11	1.5K	250	6300	99	10	17000	490	140	36	22000
LPC3-3A	13-Aug-92	8-12	15000	7.4	1.31	29	28	110	0.26K	23	2.5K	450	16000	220	22	37000	900	310	91	43000
LPC3-4A	13-Aug-92	12-16	13000	7.6	1.95	32	31	120	0.29K	26	2.6	570	17000	250	22	39000	910	170	100	29000
LPC4-1	13-Aug-92	0-4	3700	3.4	1.43	10	7.3	56	0.16K	9.2	1.4K	170	7700	99	8.1	15000	500	90	28	19000
LPC4-2	13-Aug-92	4-8	5100	2.9	0.43	11	6.6	23	0.13K	10	1.2K	85	11000	130	12	18000	1400	59	22	8400
LPC5-1	13-Aug-92	0-4	26000	5.9	2.26	13	13	99	1.06	9.5	1.2K	490	6500	99	8.7	26000	310	59	30	27000
LPC5-2	13-Aug-92	4-8	7500	12	2.43	17	12	190	1.01	17	2.2	1100	7700	150	14	63000	1100	130	37	25000
LPC5-3	13-Aug-92	8-12	20000	56	25	47	33	1500	0.66	28	2.9	6600	19000	200	19	220000	2900	69	51	27000
LPC5-4	13-Aug-92	12-16	5300	16	4.49	15	7.1	260	0.12K	9.9	1.3K	1300	8400	79	7.4	52000	870	43	21	22000
LPC5-5	13-Aug-92	16-20	6200	2.4	0.21	5.2	3.9	20	0.15K	6.7	1.3K	53	4000	87	8.6	7300	96	49	10	18000
LPC5-6	13-Aug-92	20-24	5600	2.6	0.17	4.3	3.7	16	0.15K	6.8	1.4K	48	2900	73	9.6	7000	110	120	12	17000

Table 1 (cont.)
Core Data (mg/kg)

STATION	DATE	DEPTH	TOC	AS	CD	CR	CU	PB	HG	NI	AG	ZN	AL	BA	CO	FE	MN	TKN	TP	COD
CLC1-2	12-Aug-92	0-3	6500	4.8	0.16	22	17	22	0.32K	24	2.8K	83	20000	290	19	23000	250	138.8	26.5	150
CLC1-1	12-Aug-92	3-6	5100	0.6	0.09	11	13	17	0.17K	11	1.6K	33	12000	240	5.3	11000	120	55	13.9	94
CLC2-1	12-Aug-92	0-4	5300	5.7	0.35	9.9	5.7	19	0.18	13	1.9K	79	8800	140	19	23000	700	63.7	35.5	170
CLC2-2	12-Aug-92	4-8	5000	1.6	0.42	12	7.2	12	0.14K	7.5	1.3K	30	12000	160	5.3	14000	370	24.1	8.8	20
CLC3-1	12-Aug-92	0-4	6500	4.7	0.27	19	13	29	0.34K	22	3.0K	110	15000	260	19	41000	740	159.9	42.9	180
CLC3-2	12-Aug-92	4-8	5400	4.6	0.13	25	15	23	0.24K	31	2.4K	83	22000	310	26	33000	660	90.8	31.1	160
CLC3-3	12-Aug-92	8-12	4100	1.3	0.09	24	19	17	0.18K	14	1.7K	62	23000	290	12	20000	450	28.7	18.9	56
CLC4-1	12-Aug-92	0-4	4100	0.4K	0.4K	3.1	1.7K	4.7	0.13K	2.9	1.1K	7.6	1900	52	1.4K	3600	23	8.1	2.4	20
JB1-1	14-Aug-92	0-4	5400	0.9	0.05K	9.9	4.6	14	0.15K	3.5K	1.2K	15	11000	170	2.7	7000	310	17.9	5	42
JB1-2	14-Aug-92	4-8	6300	0.4K	0.04K	9.4	2.7	9.6	0.14K	3.0K	1.2K	12	10000	120	1.5K	6100	140	14	4	45
CL1-1	14-Aug-92	0-4	9400	0.8	0.04K	4.1	1.8K	3.6	0.13K	3.4	1.2K	16	2400	27	2.9	4000	67	25.1	4.2	45
CL1-2	14-Aug-92	4-8	8600	2.6	0.18	15	5.6	16	0.19K	13	1.7K	73	13000	220	15	19000	350	74.4	33.7	94
CL1-3	14-Aug-92	8-12	7500	2.5	0.08	14	6.3	13	0.21K	7.8	1.8K	43	11000	170	6.6	12000	300	81.1	19.2	170
CL1-4	14-Aug-92	12-16	27000	3.5	0.18	21	12	22	0.23K	15	2.1K	63	21000	230	8.8	16000	460	70.7	16.1	160
CLC6A-1	14-Aug-92	0-8	6200	4.1	0.11	30	18	17	0.23K	29	2.1K	76	23000	260	16	35000	770	69	47.6	47
CLC6A-2	14-Aug-92	8-16	8400	2.9	0.17	22	15	16	0.42	26	1.9K	63	17000	260	16	30000	860	68.5	42.3	97
CLC6A-3	14-Aug-92	16-24	5500	6.2	0.23	20	16	28	0.27K	26	2.6K	91	15000	340	18	39000	960	117.9	44.3	150
CLC6A-4	14-Aug-92	24-32	10000	5.1	0.31	24	19	31	0.24K	29	2.8K	110	21000	350	19	48000	1000	102.4	58.2	130
CLC6A-5	14-Aug-92	32-40		10	1.23	26	44	48	0.43K	35	4.1K	150	22000	350	22	50000	1200	232.8	46.4	140
CLC6-1	14-Aug-92	0-4	4300	9.6	0.19	17	17	23	0.33K	29	2.9K	80	11000	290	19	25000	620	137	27.8	160
CLC6-2	14-Aug-92	4-8	12000	7.6	0.17	22	20	20	0.35	34	3.1K	86	17000	260	18	25000	520	64.1	30	74
CLC6-3	14-Aug-92	8-12	12000	2.9	0.23	18	23	18	0.23K	19	2.1K	62	13000	230	7.4	12000	320	55.5	21.6	73
CLC6-4	14-Aug-92	12-16	18000							24	1.7K	110	25000	310	10	19000	240	27.3	20.5	24
CLL1-1	14-Aug-92	0-4	16000	0.9	0.28	11	16	17	0.19K	9.2	1.7K	34	12000	230	5.3	8000	360	44.1	11.5	86
CLL1-2	14-Aug-92	4-8	5800	1	0.17	12	18	18	0.20K	9.2	1.8K	32	11000	250	6.4	7400	230	93.7	16.3	130
CLL1-3	14-Aug-92	8-12	12000	0.6K	0.29	14	26	19	0.16K	10	1.8K	18	12000	300	5	7700	230	30.3	22.3	52
CLL1-4	14-Aug-92	12-16	17000	5.6	0.27	16	17	27	0.32K	21	2.8K	93	12000	300	24	16000	430	111.8	61.2	170

PCB Analysis of Sediment Cores
Units are in mg/kg

STATION	DATE	DEPTH	PCB-1016	PCB-1221	PCB-1232	PCB-1242	PCB-1248	PCB-12254	PCB-1260
CLC1-2	12-Aug-92	0-3	0.105K	0.210K	0.105K	0.105K	0.105K	0.105K	0.105K
CLC1-1	12-Aug-92	3-6	0.057K	0.120K	0.057K	0.057K	0.057K	0.057K	0.057K
CLC2-1	12-Aug-92	0-4	0.071K	0.140K	0.071K	0.071K	0.071K	0.071K	0.071K
CLC2-2	12-Aug-92	4-8	0.047K	0.096K	0.047K	0.047K	0.047K	0.047K	0.047K
CLC3-1	12-Aug-92	0-4	0.113K	0.230K	0.113K	0.113K	0.113K	0.113K	0.113K
CLC3-2	12-Aug-92	4-8	0.091K	0.190K	0.091K	0.091K	0.091K	0.091K	0.091K
CLC3-3	12-Aug-92	8-12	0.064K	0.130K	0.064K	0.064K	0.064K	0.064K	0.064K
CLC4-1	12-Aug-92	0-4	0.042K	0.085K	0.042K	0.042K	0.042K	0.042K	0.042K
JB1-1	14-Aug-92	0-4	0.051K	0.103K	0.051K	0.051K	0.051K	0.051K	0.051K
JB1-2	14-Aug-92	4-8	0.045K	0.092K	0.045K	0.045K	0.045K	0.045K	0.045K
CL1-1	14-Aug-92	0-4	0.044K	0.089K	0.044K	0.044K	0.044K	0.044K	0.044K
CL1-2	14-Aug-92	4-8	0.062K	0.130K	0.062K	0.062K	0.062K	0.062K	0.062K
CL1-3	14-Aug-92	8-12	0.068K	0.140K	0.068K	0.068K	0.068K	0.068K	0.068K
CL1-4	14-Aug-92	12-16	0.076K	0.150K	0.076K	0.076K	0.076K	0.076K	0.076K
CLC6A-1	14-Aug-92	0-8	0.075K	0.150K	0.075K	0.075K	0.075K	0.075K	0.075K
CLC6A-2	14-Aug-92	8-16	0.071K	0.140K	0.071K	0.071K	0.071K	0.071K	0.071K
CLC6A-3	14-Aug-92	16-24	0.097K	0.200K	0.097K	0.097K	0.097K	0.097K	0.097K
CLC6A-4	14-Aug-92	24-32	0.100K	0.200K	0.100K	0.100K	0.100K	0.100K	0.100K
CLC6A-5	14-Aug-92	32-40	0.160K	0.320K	0.160K	0.160K	0.160K	0.160K	0.160K
CLC6-1	14-Aug-92	0-4	0.110K	0.220K	0.110K	0.110K	0.110K	0.110K	0.110K
CLC6-2	14-Aug-92	4-8	0.110K	0.230K	0.110K	0.110K	0.110K	0.110K	0.110K
CLC6-3	14-Aug-92	8-12	0.077K	0.160K	0.077K	0.077K	0.077K	0.077K	0.077K
CLC6-4	14-Aug-92	12-16	0.067K	0.130K	0.067K	0.067K	0.067K	0.067K	0.067K
CLL1-1	14-Aug-92	0-4	0.063K	0.130K	0.063K	0.063K	0.063K	0.063K	0.063K
CLL1-2	14-Aug-92	4-8	0.065K	0.130K	0.065K	0.065K	0.065K	0.065K	0.065K
CLL1-3	14-Aug-92	8-12	0.065K	0.130K	0.065K	0.065K	0.065K	0.065K	0.065K
CLL1-4	14-Aug-92	12-16	0.100K	0.210K	0.100K	0.100K	0.100K	0.100K	0.100K

PAH Analysis of Sediment Cores
Units are in mg/kg

	LP5-1	LP5-2	LP5-3	LP5-4	LP5-5	LP5-6	LPC1-1	LPC2-1B
Naphthalene	0.37J	0.07J	0.84J	0.09J	<1.0	<0.9	<0.81	<0.94
Acenaphthene	0.05J	<1.2	0.16J	<1.0	<1.0	<0.9	<0.81	<0.94
Fluorene	0.14J	0.16J	0.59J	0.08J	<1.0	<0.9	<0.81	<0.94
Phenanthrene	0.98J	0.64J	2.5J	0.34J	<1.0	<0.9	<0.81	<0.94
Anthracene	0.55J	0.30J	1.3J	0.16J	<1.0	<0.9	<0.81	<0.94
Fluoranthene	4.2	2.9	15	0.75J	0.08J	0.05J	<0.81	<0.94
Pyrene	4.9	3.3	17	0.92J	0.08J	0.04J	<0.81	<0.94
Chrysene	2.6	1.1J	7.7	0.35J	<1.0	<0.9	<0.81	<0.94
Benzo(a) Anthracene	2.1	0.86J	7.4	0.23J	<1.0	<0.9	<0.81	<0.94
Benzo(b) Fluoranthene	2.7	0.66J	6.2	0.13J	<1.0	<0.9	<0.81	<0.94
Benzo(k) Fluoranthene	0.95J	0.41J	3.6	0.11J	<1.0	<0.9	<0.81	<0.94
Benzo(a) Pyrene	1.8	0.39J	5.5	0.09J	<1.0	<0.9	<0.81	<0.94
Indeno(1,2,3,C,D) Pyrene	1.2	0.14J	5.6	<1.0	<1.0	<0.9	<0.81	<0.94
Benzo(g,h,i) Perylene	1.1J	0.11J	4.8	<1.0	<1.0	<0.9	<0.81	<0.94

Red River Waterway Project
Shreveport, LA, to Daingerfield, TX, Reach
Reevaluation Study In-Progress Review

APPENDIX 2
GROUND-WATER RESOURCES

RED RIVER WATERWAY PROJECT
SHREVEPORT, LA, TO DAINGERFIELD, TX, REACH
REEVALUATION STUDY IN-PROGRESS REVIEW

APPENDIX 2
GROUND-WATER RESOURCES

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APPENDIX 2
GROUND-WATER RESOURCES

INTRODUCTION

1. The purpose of the ground-water study is to identify preproject baseline ground-water conditions and predict potential project-induced ground-water impacts in the study area. The ground-water study is similar in scope to that performed on the lower Red River Waterway and is a cooperative effort involving the U.S. Army Corps of Engineers, Vicksburg District; U.S. Geological Survey (USGS), and the U.S. Department of Agriculture, Soil Conservation Service (SCS). The responsibilities of the respective agencies are as follows:

a. The Vicksburg District served as the project sponsor providing funding and coordinating the work effort of USGS and SCS. The Vicksburg District installed, maintained, and monitored data from the ground-water well network.

b. USGS measured water levels in the monitoring wells and piezometers quarterly. They also performed water quality analyses on samples from selected wells on an annual basis. All data were incorporated into the Ground Water Site Inventory data base for access by the Vicksburg District and SCS.

c. SCS evaluated the effects that changes in ground-water levels caused by the project would have on agricultural crops, pasture lands, and woodlands in the project vicinity. SCS established crop, woodland, and pasture observation plots throughout the project area to determine preproject baseline conditions. The SCS also provided guidance and field supervision for installation of the shallow piezometer network. These piezometers were designed to record the water table fluctuation in the upper portions of the alluvial aquifer.

METHOD OF STUDY

2. An observational approach was taken for the ground-water study. It was decided that no predictive digital modeling would be appropriate for this study because boundary conditions (i.e., lock and dam sites, channel alignments) were not adequately known at this time and would likely change in the future. A program designed to establish existing ground-water conditions and its

relationship to existing surface water levels, agriculture, and pasture and woodland areas was developed. The investigative program consisted of four major components. These components included geologic mapping, ground-water monitoring, water level and water quality analyses, and crop/pasture/woodland observations.

GEOLOGIC MAPPING

3. The Vicksburg District contracted with U.S. Army Corps of Engineers, Waterways Experiment Station (WES), Vicksburg, Mississippi, to develop a series of geologic maps for the project area. These maps can be found in the WES Technical Report (GL-92-1) dated February 1992 which has previously been placed in the local depositories. The geologic maps show the different patterns of alluvium and Tertiary formation which have been deposited or outcrop throughout the proposed project reach. The maps also describe the different lithologies associated with these units as well as characterizing the environments of deposition for the recent alluvium. The report gives a general overview of the geohydrology that can be expected from the different subsurface groups and formations. Cross-sections have also been included which show the association and varying thicknesses for the topstratum and substratum alluvium as well as the depths to the upper boundaries for the Tertiary formations which subcrop beneath the overlying sediment.

GROUND-WATER MONITORING

4. The Vicksburg District installed a series of monitoring wells and piezometers at the 27 sites shown on Figure 1. The fieldwork was started in June and was completed in August 1991. The site locations were chosen jointly with USGS and SCS and were selected using the following criteria:

a. Proximity to the authorized navigation project.

b. Proximity to areas of potential impact to the existing ground-water regime (i.e., navigation pools, dam sites).

c. Proximity to existing surface water gaging stations.

d. Ease of access.

5. A pilot boring was drilled at each site in order to determine lithology and select the screened interval for the monitoring well. The pilot borings at the proposed lock and dam sites were extended 50 feet into the Tertiary formations underlying the

alluvium to determine the presence of a Tertiary aquifer at the sites. The borings were drilled by the mud rotary method and soil samples were taken on 5-foot intervals with a 2-1/2-inch drive tube sampler.

a. Monitor Wells. A 2-inch PVC monitor well was completed in the alluvial (substratum) aquifer at each site. All wells completed in the alluvial aquifer are designated with the letter "c" on Figure 1. At site 4 (proposed Lock and Dam No. 6 site), a 2-inch well was completed in a Lower Wilcox Tertiary sand stratum that was in direct connection with the alluvial aquifer. No significant Tertiary aquifer was encountered at piezometer site 21 (proposed Lock and Dam No. 7 site). All wells completed in Tertiary aquifers are designated with the letter "d" on Figure 1. Seven existing wells that were drilled by USGS for the Red River Waterway Pool 5 Ground-Water Study were rehabilitated and monitored. These sites are north of Shreveport between the Red River and Twelvemile Bayou. The wells are designated CD-334, 335, 336, 337, 341, 485, and 501, and are shown on Figure 1.

b. Piezometers. A series of 1/2-inch galvanized open standpipe piezometers were installed within the fine grained topstratum (confining unit) that overlies the alluvial aquifer at sites 2, 3, 7, 10, 15, 16, 20, 21, and 25. The top 10 feet of soil was sampled continuously at these sites, and the soils were logged in the field by a soil scientist from SCS. The soil scientist then selected the depths for the shallow piezometers based on soil characteristics. The shallow piezometers are designated by the letters "a" and "b" on Figure 1 with the "a" designation representing piezometers monitoring the upper 3 to 5 feet of soil and "b" designation representing a piezometer monitoring the soil from 5 to 10 feet in depth.

WATER LEVELS AND WATER QUALITY

6. Ground-water levels were measured quarterly in the monitoring wells and piezometers by USGS. The data were input into the USGS Ground Water Site Inventory data base to be readily available to the Corps or SCS. Water quality analyses will be conducted on samples from selected wells annually. The parameters of analysis are summarized in Table 1.

TABLE 1
GROUND-WATER QUALITY PARAMETERS

pH	Calcium
Specific Conductance	Magnesium
Total Dissolved Solids	Sodium
Alkalinity	Potassium
Total Hardness	Fluoride
Total Chlorides	Dissolved Silica
Sulfate	Sodium Adsorption Ratio
	% Sodium

AGRICULTURE OBSERVATION PLOTS

7. SCS established observation plots for agricultural crops, pastureland and woodlands at the sites shown on Figure 1. These plots were established on soils representative of the major soil types found within the project area. The majority of the project area lies within the Western Coastal Plain and seven sites are located on silty soils typically found in upland stream bottoms. Two sites are located on clay soils within the Red River Alluvial Plain. Detailed soil descriptions were recorded at selected piezometer battery locations and recommendations were made with regard to the depth at which shallow piezometers were set.

8. The nine observation plots were installed at varying land surface elevations on soils producing the major crops of the project area: soybeans, forages, and timber. Tree species observed include loblolly and shortleaf pines, willow oak, water oak, white oak, black gum, sweet gum, and bald cypress. Forage species evaluated were common Bermuda grass, Dallis grass, and Pensacola Bahia grass.

9. Piezometers were installed as necessary at each crop observation plot to measure ground-water levels. On forage and row crop plots, tensiometers were installed to measure available soil moisture within the root zone.

10. Data collected from forage and row crops included height of plants, insect damage, general plant condition, management information, available soil moisture, piezometer, and tensiometer readings. On woodland plots, healthy trees of important timber species were selected for observation. Study parameters recorded for each species observed included crown class, tree origin, diameter, age, and height.

11. Forage and soybean observation plots are monitored every 10 days during the growing season (March-October). Woodland observation plots are monitored annually in the dormant season (November-February).

GEOLOGY

12. Physiographically the Shreveport to Daingerfield project area lies in the West Gulf Coastal Plain Province in what is recognized as the East Texas Embayment. This region is typified by low elevations and gradual relief. The study area lies within the Big Cypress Bayou and Red River drainage basins. Here, the ground surface elevations average 175 feet, National Geodetic Vertical Datum (NGVD), with relief varying between 25 to 50 feet, NGVD. Occasional bluffs adjacent to the flood plain levels may result in slightly more relief in some areas.

13. The sediments of the study area are of Quaternary and Tertiary age and represents periods of both fluvial and marine deposition. The environments of deposition for the formations outcropping in the Shreveport to Daingerfield study area range from shallow marine through deltaic and coastal to terrestrial. The Quaternary and Tertiary units forming the outcrop pattern for the study area include from youngest to oldest, alluvial, Sparta (sand), Weches, Queen City (sand), Reklaw and Carrizo (sand) Formations, and the Wilcox Group. The youngest Tertiary outcrop material is found in the northwest, and the oldest Tertiary outcrop material is found in the southeast sections of the project boundaries. This reversal in trend, from younger to older units gulfward is due to the late Cretaceous volcanically originated Sabine uplift. The most important structural features in this area are the East Texas Syncline, Sabine Uplift, and the Rodessa Fault. The East Texas Syncline is a broad structural downwarping which trends generally northeast to southwest and whose axis lies just north of the project area. The Sabine Uplift is a structural high whose northwest flank borders the lower portion of the study reach. Both of these features have effected the dip and thickness of the local strata. Consequently, the geologic units, except the Quaternary deposits, generally dip and thicken northwest toward the axis of the East Texas Basin. The Rodessa Fault which trends northeasterly through Jefferson has caused vertical displacement ranging from 0 to 200 feet in the Tertiary formations in this portion of the project area.

14. The geologic units pertinent to the ground water in the report area range in age from Paleocene to Recent with the principal source of ground water being the geologic units of Eocene age. The geologic units, their thickness, lithology, age,

and water-bearing properties are summarized in Table 2. Units of the Wilcox Group plus the Carrizo (sand), the Reklaw, and the Queen City (sand) Formations form what is locally known as the Cypress Aquifer. This aquifer is the predominate source for water in the study area. Also, in ascending order, above the Queen City (sand) are the Weches (greensand) and the Sparta (sand) which occur only as outliers capping some of the ridges in the project area. These units yield only small amounts of ground water to shallow wells.

15. The alluvium in the Big Cypress and Red River Valleys was deposited by Big Cypress Bayou and the Red River unconformably on an eroded Tertiary surface. The alluvium consists of a fining upward sequence of gravel, sand, silt, and clay. The alluvium in the valley of Big Cypress Bayou ranges from 20 to 50 feet in thickness while along Twelvemile Bayou in the Red River Valley, it thickens from 50 to 70 feet. The basal sand and gravel in the alluvium forms the alluvial aquifer in the study area. Ground water from the alluvial aquifer is not heavily utilized for domestic or agricultural uses in the project area.

POTENTIAL GROUND-WATER IMPACTS

16. Twelvemile and Big Cypress Bayous flow directly on sediments that comprise the alluvial aquifer throughout the project area. The exchange of water between these bayous and the underlying alluvial aquifer is governed by: (a) the degree to which the stream has penetrated the sediments comprising the aquifer, (b) the hydraulic conductivity and thickness of the materials that make up the streambed (hereafter referred to as streambed conductance), and (c) the direction of the hydrostatic gradient; i.e., the difference between the hydrostatic head in the aquifer and the bayous. The direction of the hydraulic gradient is controlled by the hydrostatic heads in the bayous and the aquifer and determines if the bayous gain or lose water. If the head in the bayou is greater than that in the aquifer, the hydraulic gradient is toward the aquifer and the bayou loses water to the aquifer. When the head in the bayou is less than that in the aquifer, the hydraulic gradient is toward the bayou and the bayou gains water from the aquifer. The two aspects of the project that have the potential to affect bayou-aquifer interaction in the study area are (a) dredging the navigation channel which could alter the streambed conductance and (b) changes in flow lines that will result from navigation improvements; i.e., construction of locks and dams.

17. To determine the effects of dredging and navigation improvements, data in the form of stage duration curves, bayou cross sections, and soil borings were compiled and analyzed. Annual stage-duration curves for with- and without-project

Table 2

Geologic Units and Their Water–Bearing Characteristics

SYSTEM	SERIES	GROUP	UNIT	APPROXIMATE MAXIMUM THICKNESS (FT)	CHARACTER OF ROCKS		WATER-BEARING PROPERTIES
Quaternary	Holocene and Pleistocene		Alluvium	60	Sand silt, clay, and some gravel.		Not known to yield water to any wells; probably would yield small quantities of fresh water.
Tertiary	Eocene	Claiborne	Sparta Sand	50	Sand and sandy clay.		Yields small quantities of fresh water to shallow wells locally.
			Weches Formation	60	Glauconite glauconitic clay and sand; secondary deposits of limonite common in outcrop areas.		Yields small quantities of fresh water to wells locally.
			Queen City Sand	400	Sand silt, clay, and some lignite.	CYPRESS AQUIFER	Yields small quantities of fresh water to wells; would yield moderate quantities.
			Reklaw Formation	100	Glauconitic clay, sand, and some lignite; locally may consist largely of sand; commonly contains considerable limonite in outcrop areas.		Yields small quantities of fresh water to wells.
			Carrizo Sand	150	Sand, silt, and clay.		Yields small quantities of fresh water to wells; locally, probably would yield moderate quantities.
		Wilcox		550	Sand, silt, clay, and lignite.		Yields moderate to possibly large quantities of fresh water to wells.
	Paleocene	Midway		800	Calcareous clay and minor amounts of limestone, silt, and glauconitic sand.		Yields no water.

conditions were produced by Hydraulics Branch, Engineering Division, U.S. Army Corps of Engineers. Stage-duration curves were derived from available gages and the locations of the gages and stage-duration curves are presented on Figure 2. Actual stage duration curves are shown on Figures 3 through 9.

18. The soil borings from the installation of 27 piezometers were examined for the purpose of determining the affect of dredging along the project area. These data reveal that the existing river channel is in direct contact with the alluvial aquifer. For the purposes of this report, the study area was divided into the seven reaches. These reaches are described in Table 3.

TABLE 3
SEVEN STUDY REACHES

Twelve Mile Bayou - Soda Lake Area	Mile 17.6 - 22.2
Caddo Lake - Subreach 1	Mile 23.1 - 43.6
Highway 43 To Jefferson - Subreach 1	Mile 51.9 - 64.0
Jefferson to Lake of the Pines - Subreach 1	Mile 70.2 - 73.7
Jefferson to Lake of the Pines - Subreach 2	Mile 73.7 - 77.2
Jefferson to Lake of the Pines - Subreach 3	Mile 77.2 - 80.7
Jefferson to Lake of the Pines - Subreach 4	Mile 80.7 - 84.3

19. The analysis of annual stage-duration curves allows for the evaluation of navigational improvements (locks and dams) between pre- and postproject flow conditions. Data evaluated for the purposes of this report were concerned with the 90 percent exceedance on the stage-duration curves. These conditions are representative of the bayou stages that would be observed at the respective locations 90 percent of the time and do not take into consideration short duration storm events. To accurately evaluate postproject conditions in relation to navigation improvements, it was necessary to subdivide the Jefferson to Lake Of The Pines reach into four subreaches. The subdivision of this reach was due to steep variations in hydraulic gradient over the relatively short channel distance for this portion of the project.

IMPACTS DUE TO DREDGING

20. Construction of the navigation channel by dredging could impact ground-water levels in the alluvial aquifer adjacent to

the project by changing the hydraulic conductivity of the streambed. In general, the alluvial aquifer becomes coarser and, thus, more transmissive with depth. Thus, if the improved navigation channel was significantly deeper than the thalweg of the existing channel, the bayou aquifer connection would be improved allowing a greater flux of water to the bayou from the aquifer or to the aquifer from the bayou depending on the hydraulic gradient.

21. An evaluation of the impact from dredging of the proposed 9-foot navigation channel (without the construction of navigation improvements) was conducted based on numerous cross sections of the existing channel (preproject) and soil borings taken at the 27 piezometer sites. This preconstruction data was compared to the proposed dredged channel improvements and included an overdepth for maintenance. These criteria were applied to the seven reaches identified in Table 3 and the results are discussed below:

a. Twelvemile Bayou. Existing channel bottom elevations in this reach vary between elevation 128 and 137 feet, NGVD, with the average being 133 feet, NGVD. The postproject channel bottom was designed at 133 feet, NGVD. Therefore, dredging of the navigation channel has little or no impact on the streambed conductance in this reach.

b. Caddo Lake. Dredging in Caddo Lake would have no affect on the ground-water surface since sediments in this reach are already saturated and the pool elevation of Caddo lake would remain unchanged.

c. Highway 43 to Jefferson. Existing channel bottom elevations in this reach vary between elevation 129 and 164 feet, NGVD. The postproject channel bottom was designed at 154 feet, NGVD. Although dredging of the navigation channel appears to have little impact on the streambed for much of the lower and intermediate portions of this reach, the upper portion of Big Cypress Bayou would require as much as 10 feet of dredged material to be excavated. Tertiary age sediments are encountered at approximately elevation 152 to 165 feet, NGVD, in the vicinity of Jefferson. This indicates that the proposed channel would cut entirely through the alluvial aquifer and likely into Tertiary age deposits. This would probably result in an increase in streambed conductance for this reach.

d. Jefferson to Lake Of The Pines (Subreach 1). Existing channel bottom elevations in this reach average 164 feet, NGVD. The postproject channel bottom elevations were designed at 173 feet, NGVD; therefore, dredging of the navigation channel would not require the removal of material deeper than the existing thalweg. Because of this, minimal effects to ground water should be observed.

e. Jefferson to Lake Of The Pines (Subreach 2). Existing channel bottom elevations in this reach average 168 feet, NGVD. The postproject channel bottom was designed at 173 feet, NGVD; therefore, dredging of the navigation channel would not require the removal of material deeper than the existing thalweg, and little effects to streambed conductance should be observed.

(f) Jefferson to Lake Of The Pines (Subreach 3). Existing channel bottom elevations in this reach range between 171 and 176 feet, NGVD, and average 173 feet, NGVD. The postproject channel bottom was designed at 173 feet, NGVD; therefore, dredging of the navigation channel would not remove significant quantities of additional material, and potential impacts to streambed conductance would be minimal.

f. Jefferson to Lake Of The Pines (Subreach 4). Existing channel bottom elevations in this reach range between 178 and 181 feet, NGVD, and average 180 feet, NGVD. The postproject channel bottom was designed at 173 feet, NGVD; therefore dredging of the navigation channel would remove approximately 7 feet of material below the existing thalweg resulting in a significant increase in streambed conductance for this reach.

IMPACTS DUE TO CHANGES IN FLOW LINES

22. An evaluation of the impacts on the local ground-water regime due to the impoundment of water associated with the proposed navigation improvements was also conducted based on the annual stage duration curves previously discussed on (Figures 3-9). Pre-and postproject comparisons at the 90 percent exceedance were assessed. This criteria was applied to the seven reaches identified, and the results are discussed below:

a. Twelvemile Bayou. Existing water surface elevations in this reach average 142 feet, NGVD, at the 90 percent exceedance (Figure 3). Postproject water surface elevations are predicted at 145 feet, NGVD. This indicates that the Twelvemile Bayou reach would have a rise in water levels of 3 feet. This would have marginal impacts on the ground water of this reach, causing elevated ground-water surfaces immediately adjacent to the channel for this reach of the project area.

b. Caddo Lake. Existing water surface elevations in this reach would remain unchanged at the 90 percent exceedance, rendering no impact to the ground-water surface elevations during postproject conditions (Figure 4).

c. Highway 43 to Jefferson. Existing water surface elevations in this reach average 168.5 feet, NGVD, at the 90 percent exceedance (Figure 5). Postproject water surface elevations are predicted at 168.5 feet, NGVD. This indicates that the ground-water elevations for this reach would experience no change.

d. Jefferson to Lake Of The Pines (Subreach 1) Existing water surface elevations in this reach average 170 feet, NGVD (Figure 6). Postproject water surface elevations are predicted at 185 feet, NGVD, at the 90 percent exceedance. This indicates a rise in the water surface elevation for this reach of the project of approximately 15 feet, NGVD. A corresponding rise in ground-water levels in the alluvial aquifer adjacent to this reach can also be expected.

(e) Jefferson to Lake Of The Pines (Subreach 2). Existing water surface elevations in this reach average 176.0 feet, NGVD, at the 90 percent exceedance (Figure 7). Postproject water surface elevations are predicted at 185 feet, NGVD, at the 90 percent exceedance. This indicates an inundation of the Cypress Bayou area along this reach of approximately 9 feet. A corresponding rise in local ground-water levels in the alluvial aquifer would also occur in this reach.

e. Jefferson to Lake Of The Pines (Subreach 3). Existing water surface elevations in this reach average 180.2 feet, NGVD, at the 90 percent exceedance (Figure 8). Postproject water surface elevations are predicted at 185 feet, NGVD. This indicates inundation of the Cypress Bayou area adjacent to this reach of approximately 4.8 feet. A corresponding rise in ground water levels can also be anticipated in this reach.

f. Jefferson to Lake Of The Pines (Subreach 4). Existing water surface elevations in this reach average 182.7 feet, NGVD, at the 90 percent exceedance (Figure 9). Postproject water surface elevations are predicted at 185 feet, NGVD. This indicates approximately 2.3 feet of inundation would occur to the area adjoining this portion of Big Cypress Bayou. A corresponding rise in local ground-water levels would also occur in this reach.

SUMMARY OF IMPACTS

23. The effects of dredging alone (without construction of locks and dams) would have significant impacts along two areas of the project. The first is the Highway 43 to Jefferson reach and the second is the upper most reach of Big Cypress Bayou, Jefferson to Lake Of The Pines (Subreach 4). Channel dredging in these reaches would result in significant increases in streambed conductance.

24. Impoundment, the construction of locks and dams would have affects on several reaches of the project. The impacts of inundation vary widely from marginal to severe. Five of the seven reaches or subreaches would be impacted by inundation. These are summarized below:

a. Twelvemile Bayou would be affected by a rise in ground-water levels on an average of 3 feet.

b. Jefferson to Lake Of The Pines Subreach 1 would be affected by a rise in ground-water levels on an average of 15 feet.

c. Jefferson to Lake Of The Pines Subreach 2 would be affected by a rise in ground-water levels on an average of 9 feet.

d. Jefferson to Lake Of The Pines Subreach 3 would be affected by a rise in ground-water levels on an average of 4.8 feet.

e. Jefferson to Lake Of The Pines Subreach 4 would be affected by a rise in ground-water levels on an average of 2.3 feet.

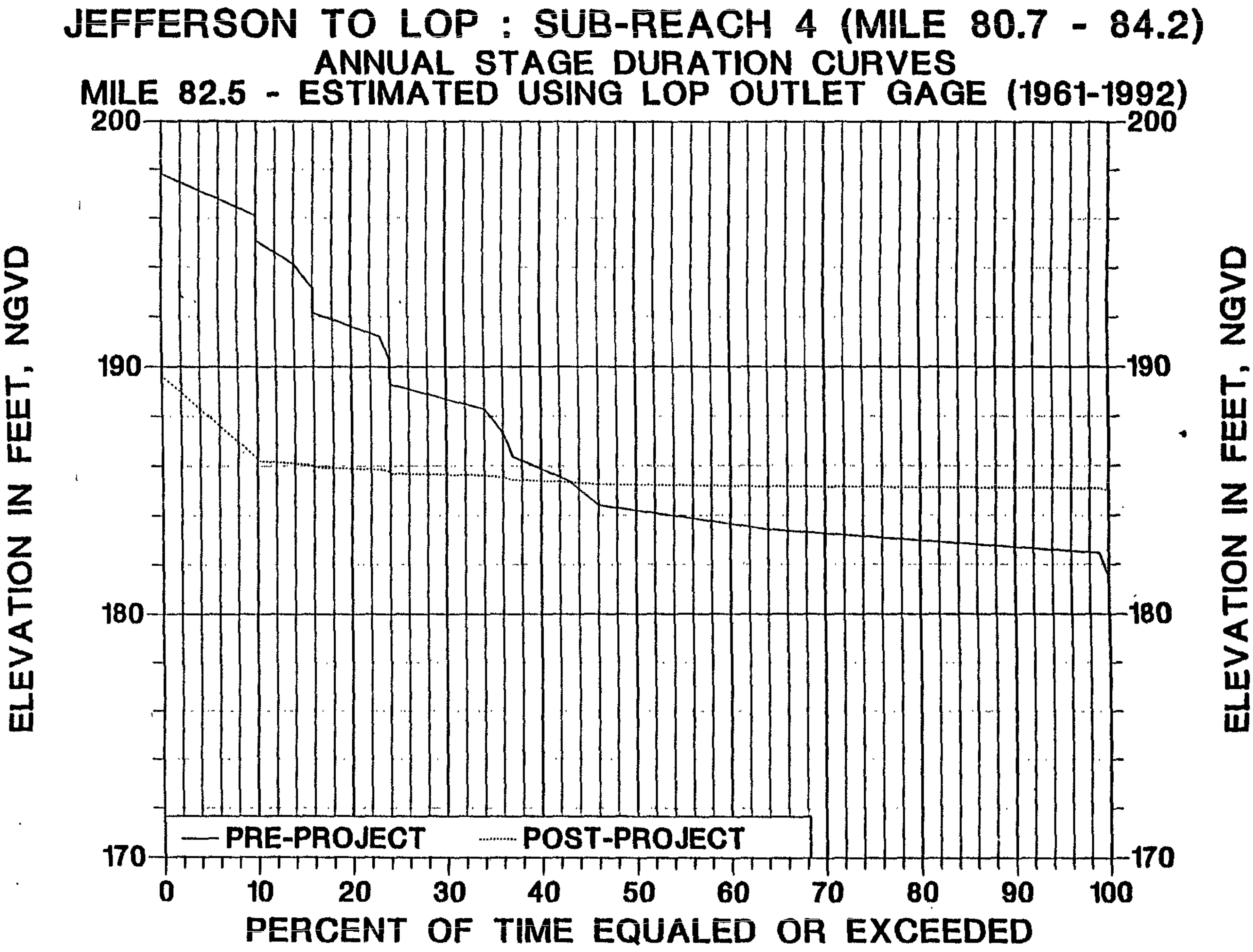

JEFFERSON TO LOP : SUB-REACH 4 (MILE 80.7 - 84.2)
ANNUAL STAGE DURATION CURVES
MILE 82.5 - ESTIMATED USING LOP OUTLET GAGE (1961-1992)
ELEVATION IN FEET, NGVD
200
190
180
170
PRE-PROJECT
POST-PROJECT
0
10
20
30
40
50
60
70
80
90
100
PERCENT OF TIME EQUALED OR EXCEEDED

Figure 9

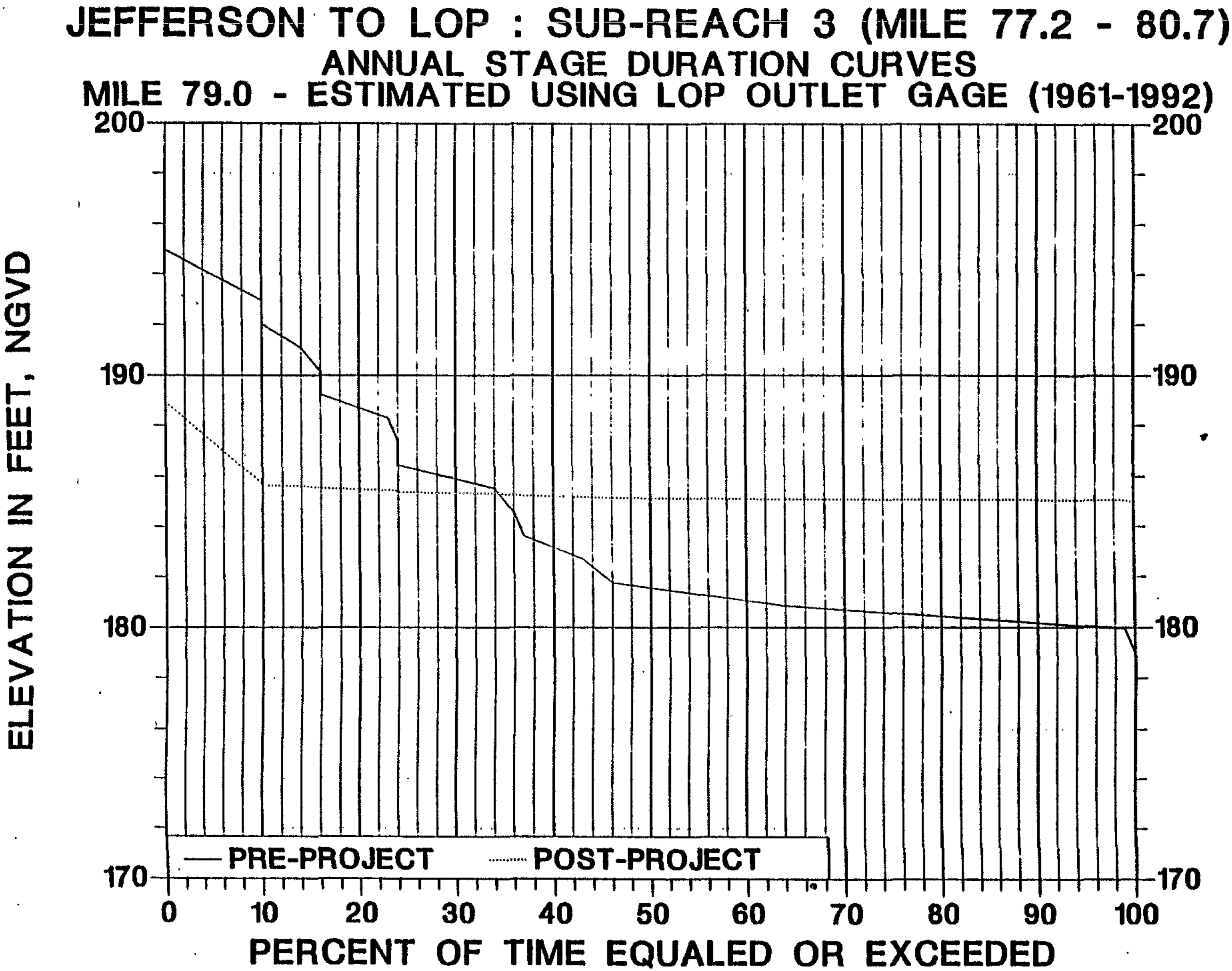

JEFFERSON TO LOP : SUB-REACH 3 (MILE 77.2 - 80.7)
ANNUAL STAGE DURATION CURVES
MILE 79.0 - ESTIMATED USING LOP OUTLET GAGE (1961-1992)
200
190
180
170
0
10
20
30
40
50
60
70
80
90
100
ELEVATION IN FEET, NGVD
PERCENT OF TIME EQUALED OR EXCEEDED
PRE-PROJECT
POST-PROJECT

Figure 8

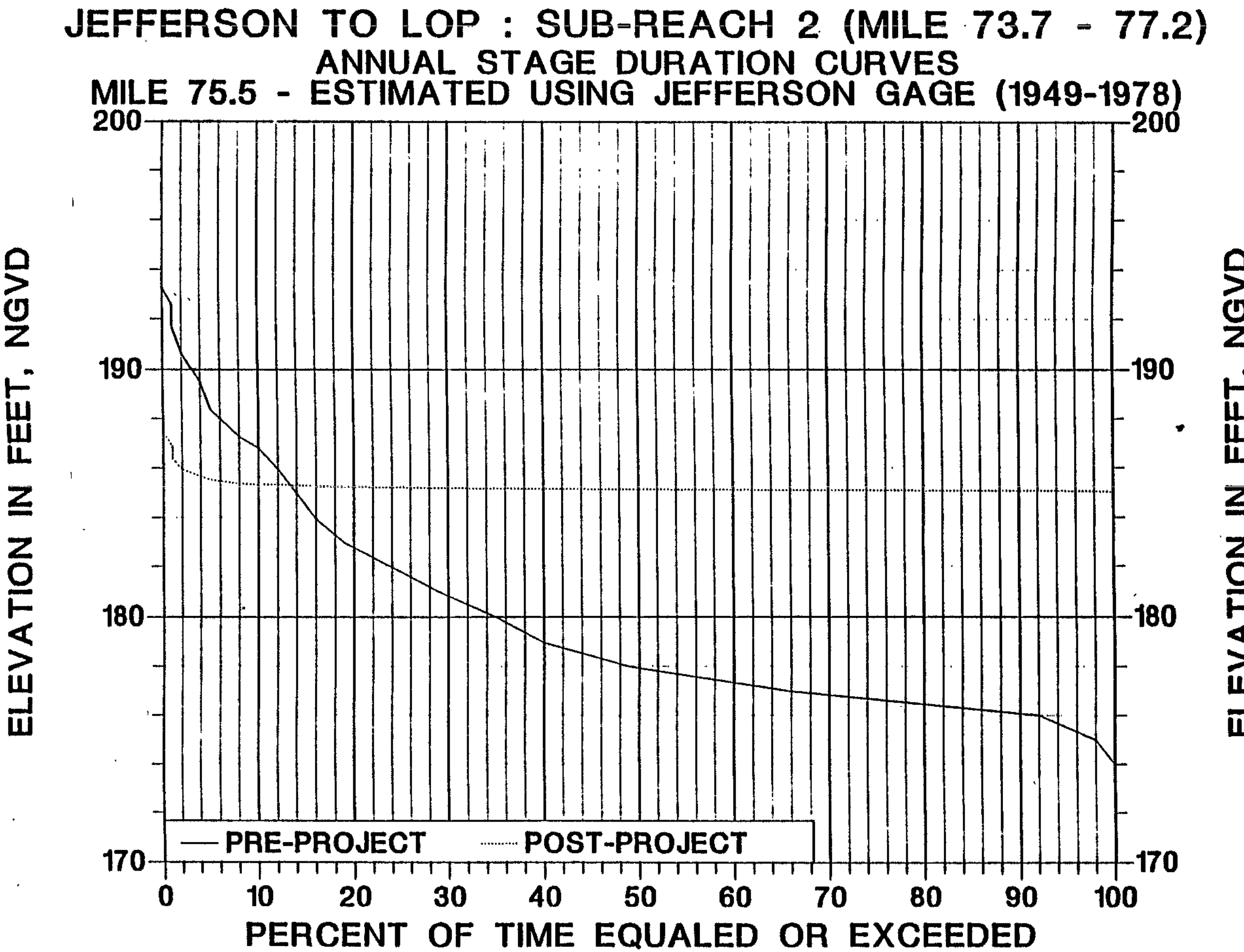

JEFFERSON TO LOP : SUB-REACH 2 (MILE 73.7 - 77.2)
ANNUAL STAGE DURATION CURVES
MILE 75.5 - ESTIMATED USING JEFFERSON GAGE (1949-1978)
ELEVATION IN FEET, NGVD
200
190
180
170
PRE-PROJECT
POST-PROJECT
0
10
20
30
40
50
60
70
80
90
100
PERCENT OF TIME EQUALED OR EXCEEDED

Figure 7

JEFFERSON TO LOP : SUB-REACH 4 (MILE 80.7 - 84.2)
ANNUAL STAGE DURATION CURVES
MILE 82.5 - ESTIMATED USING LOP OUTLET GAGE (1961-1992)

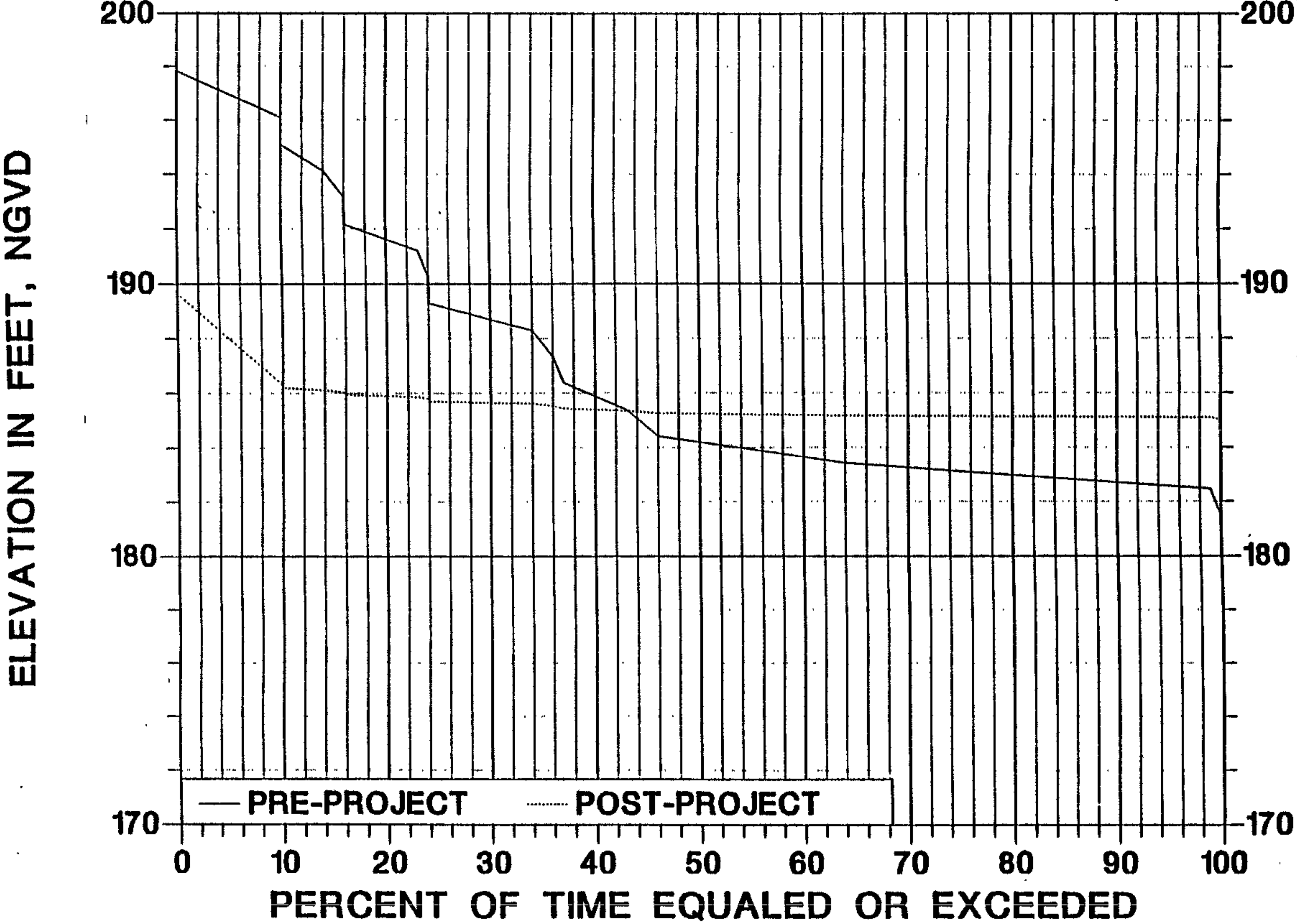


Figure 9

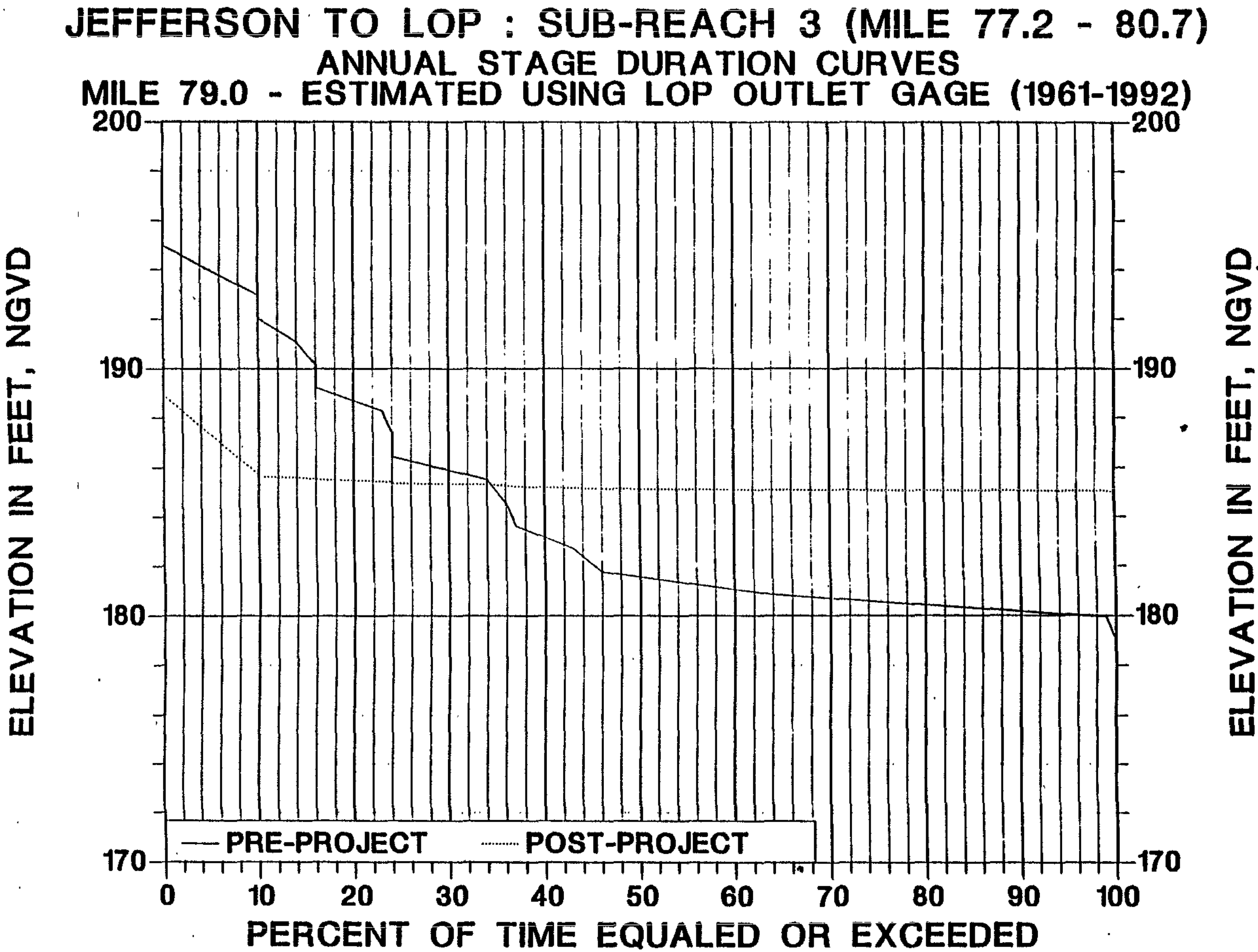

JEFFERSON TO LOP : SUB-REACH 3 (MILE 77.2 - 80.7)
ANNUAL STAGE DURATION CURVES
MILE 79.0 - ESTIMATED USING LOP OUTLET GAGE (1961-1992)
200
190
180
170
ELEVATION IN FEET, NGVD
PRE-PROJECT
POST-PROJECT
0
10
20
30
40
50
60
70
80
90
100
PERCENT OF TIME EQUALED OR EXCEEDED

Figure 8

JEFFERSON TO LOP : SUB-REACH 2 (MILE 73.7 - 77.2)
ANNUAL STAGE DURATION CURVES
MILE 75.5 - ESTIMATED USING JEFFERSON GAGE (1949-1978)

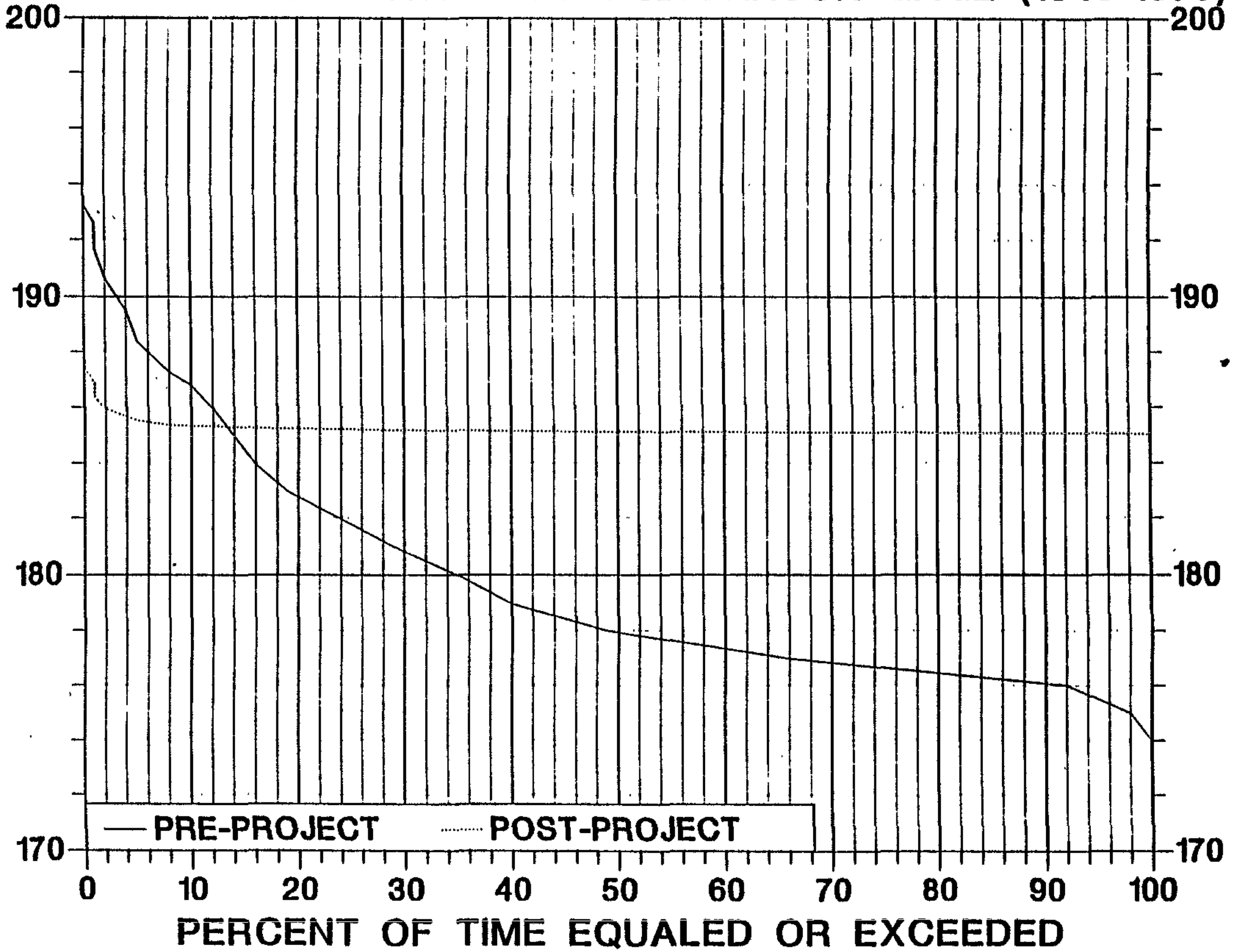
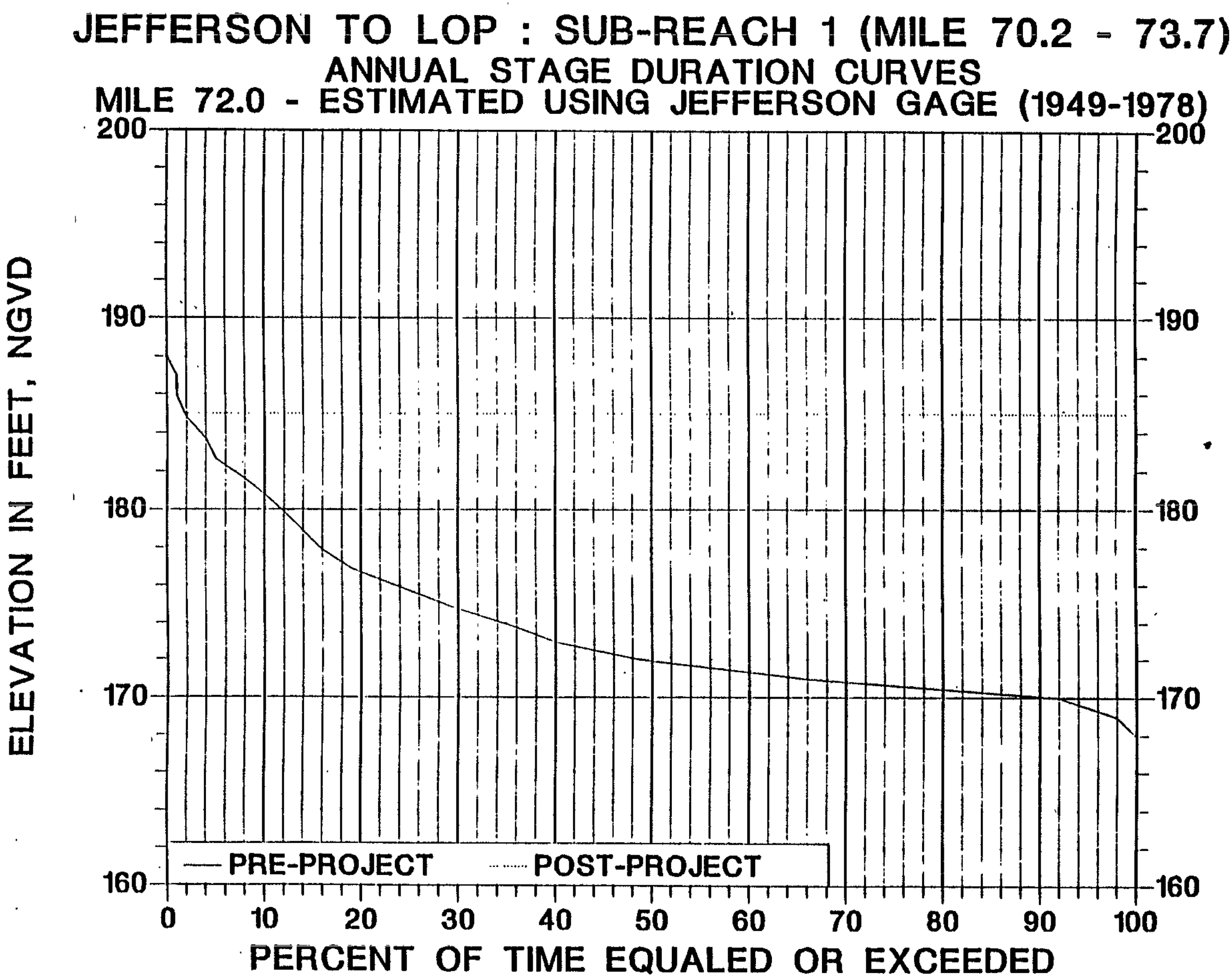


Figure 7



JEFFERSON TO LOP : SUB-REACH 1 (MILE 70.2 - 73.7)
ANNUAL STAGE DURATION CURVES
MILE 72.0 - ESTIMATED USING JEFFERSON GAGE (1949-1978)
ELEVATION IN FEET, NGVD
200
190
180
170
160
PRE-PROJECT
POST-PROJECT
0
10
20
30
40
50
60
70
80
90
100
PERCENT OF TIME EQUALED OR EXCEEDED

Figure 6

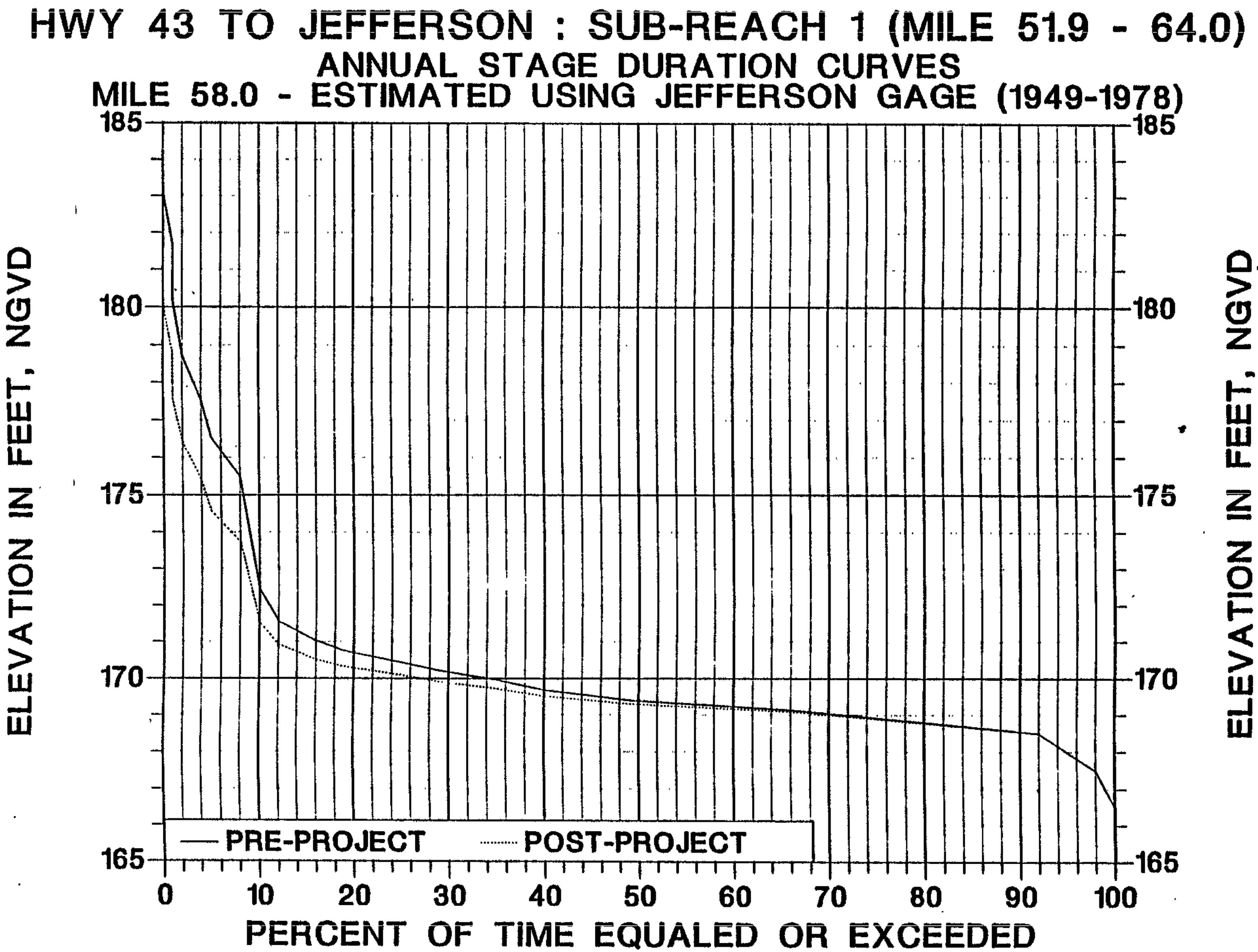

HWY 43 TO JEFFERSON : SUB-REACH 1 (MILE 51.9 - 64.0)
ANNUAL STAGE DURATION CURVES
MILE 58.0 - ESTIMATED USING JEFFERSON GAGE (1949-1978)
ELEVATION IN FEET, NGVD
185
180
175
170
165
PRE-PROJECT
POST-PROJECT
0
10
20
30
40
50
60
70
80
90
100
PERCENT OF TIME EQUALED OR EXCEEDED

Figure 5

CADDO LAKE : SUB-REACH 1 (MILE 23.1 - 43.6)
ANNUAL STAGE DURATION CURVES
MILE 33.4 - ESTIMATED USING MOORINGSPORT GAGE (1963-1992)

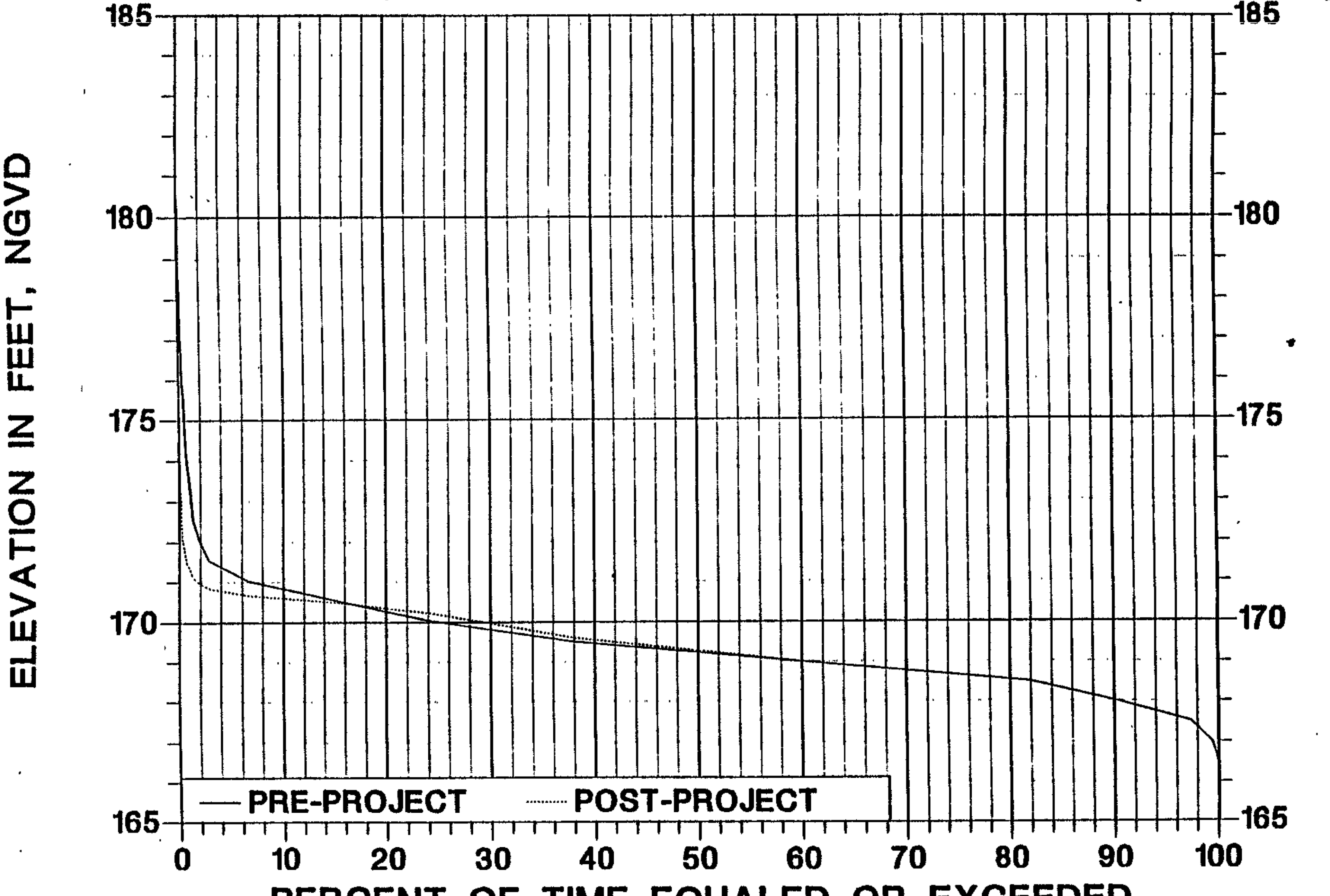


Figure 4

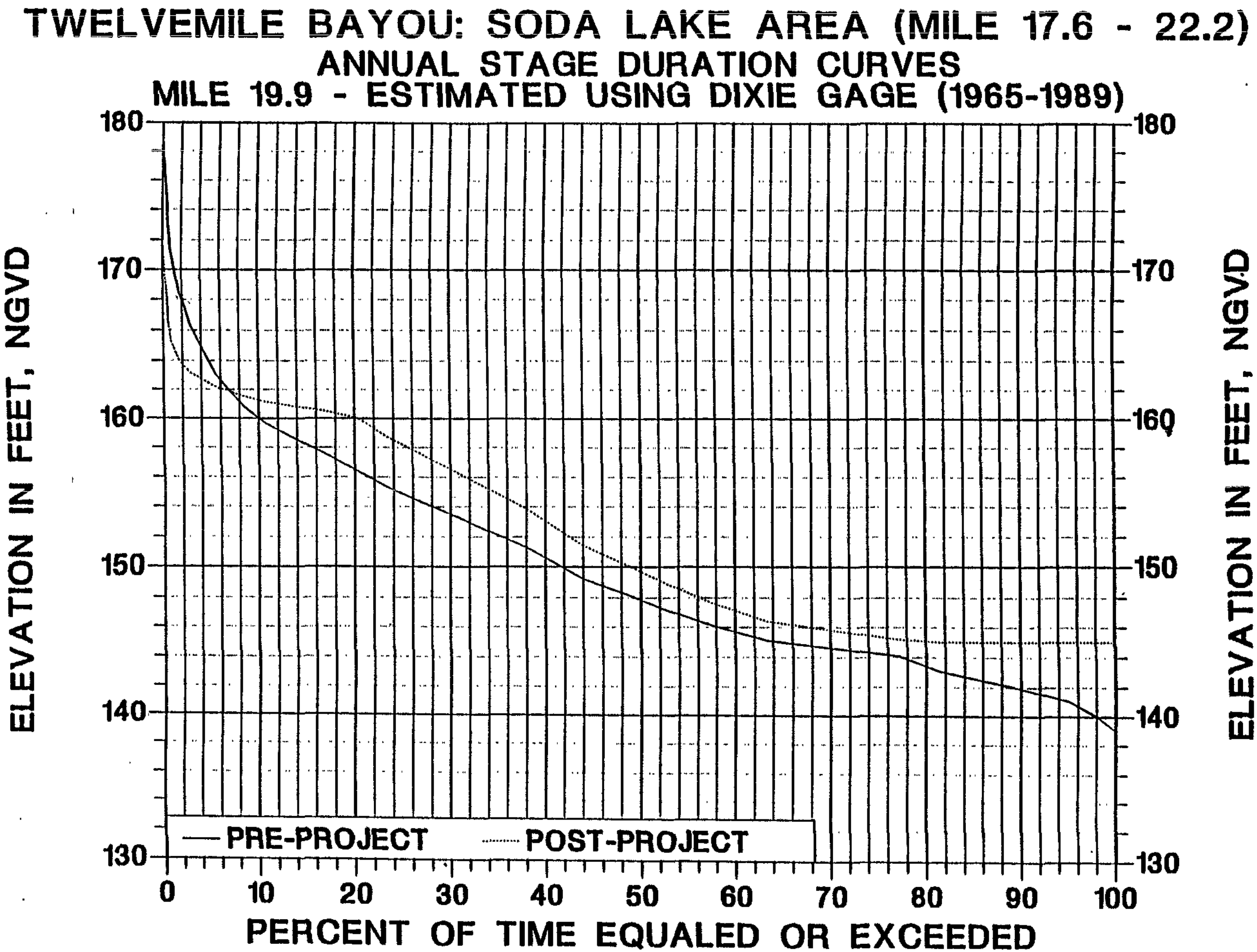

TWELVEMILE BAYOU: SODA LAKE AREA (MILE 17.6 - 22.2)
ANNUAL STAGE DURATION CURVES
MILE 19.9 - ESTIMATED USING DIXIE GAGE (1965-1989)
ELEVATION IN FEET, NGVD
180
170
160
150
140
130
PRE-PROJECT
POST-PROJECT
0
10
20
30
40
50
60
70
80
90
100
PERCENT OF TIME EQUALED OR EXCEEDED

Figure 3

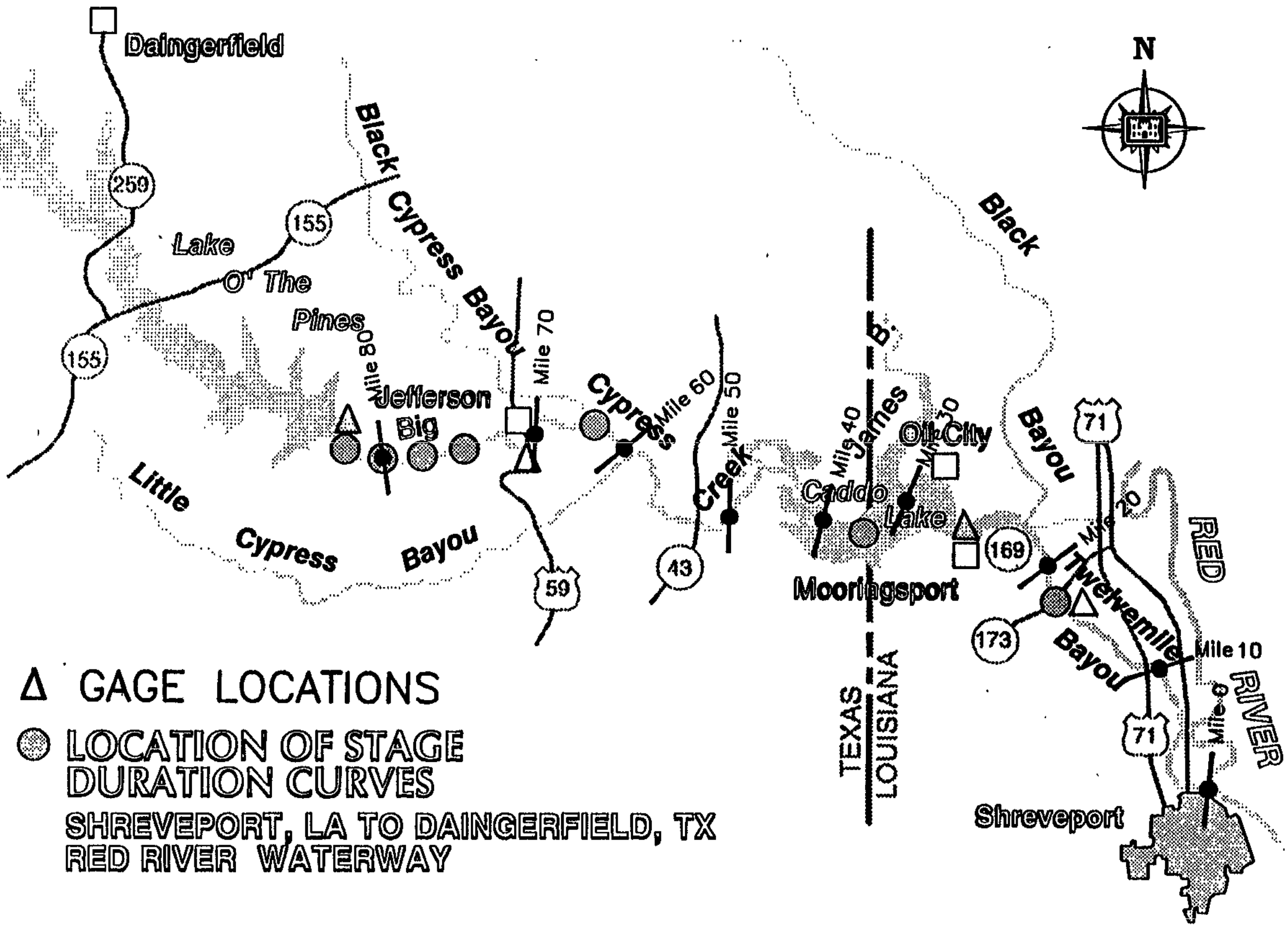

Daingerfield
N
259
155
165
Lake O' The Pines
Black Cypress Bayou
Mile 80
Mile 70
Mile 60
Mile 50
Mile 40
Mile 30
Mile 20
Mile 10
Mile 0
Jefferson
Big Cypress Creek
Little Cypress Bayou
59
43
James B.
Caddo Lake
Oil City
Mooringsport
169
173
71
Black Bayou
Twelvemile Bayou
RED RIVER
TEXAS
LOUISIANA
Shreveport
GAGE LOCATIONS
LOCATION OF STAGE DURATION CURVES
SHREVEPORT, LA TO DAINGERFIELD, TX
RED RIVER WATERWAY

Figure 2

Red River Waterway Project
Shreveport, LA, to Daingerfield, TX, Reach
Reevaluation Study In-Progress Review

APPENDIX 3
WETLAND RESOURCES

RED RIVER WATERWAY PROJECT
SHREVEPORT, LA, TO DAINGERFIELD, TX
REEVALUATION STUDY IN-PROGRESS REVIEW

APPENDIX 3
WETLAND RESOURCES

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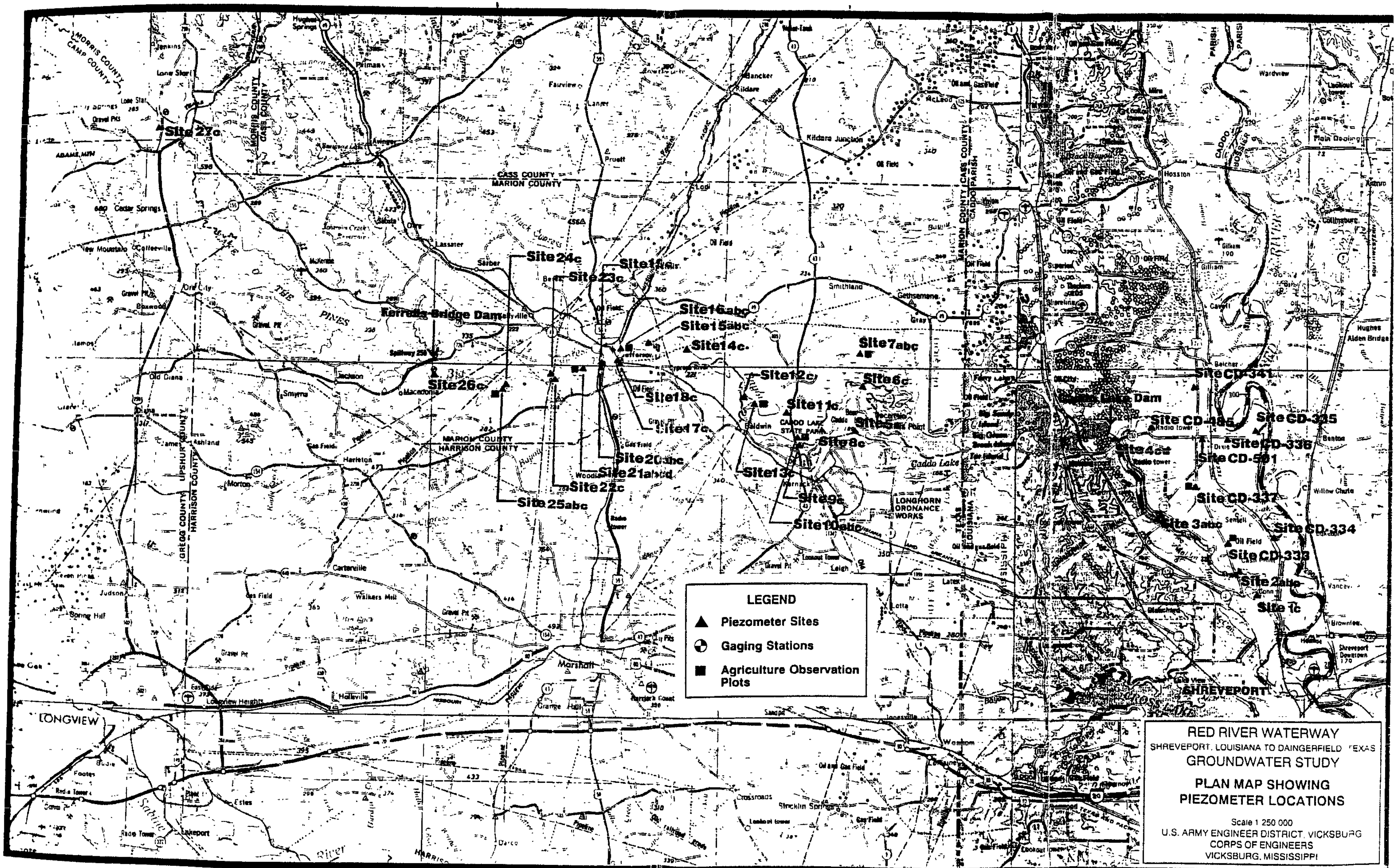

LEGEND
Piezometer Sites
Gaging Stations
Agriculture Observation Plots
RED RIVER WATERWAY
SHREVEPORT, LOUISIANA TO DAINGERFIELD, TEXAS
GROUNDWATER STUDY
PLAN MAP SHOWING PIEZOMETER LOCATIONS
Scale 1 250 000
U.S. ARMY ENGINEER DISTRICT, VICKSBURG
CORPS OF ENGINEERS
VICKSBURG, MISSISSIPPI
Site 27c
Site 24c
Site 23c
Site 16abc
Site 15abc
Site 14c
Site 7abc
Site 12c
Site 6c
Site 26c
Site 18c
Site 11c
Site 17c
Site 8c
Site 20abc
Site 21abcd
Site 22c
Site 13c
Site 25abc
Site 9c
Site 10abc
Site CD-341
Site CD-485
Site CD-335
Site CD-336
Site CD-501
Site 4c
Site CD-337
Site 3abc
Site CD-334
Site CD-333
Site 2abc
Site 1c
Ferrells Bridge Dam
CASS COUNTY
MARION COUNTY
MARION COUNTY
HARRISON COUNTY
MORRIS COUNTY
CAMP COUNTY
GREGG COUNTY
UPSHUR COUNTY
HARRISON COUNTY
CADDO PARISH
LONGHORN ORDNANCE WORKS
Caddo Lake
Marshall
LONGVIEW
SHREVEPORT

Figure 1

RED RIVER WATERWAY PROJECT
SHREVEPORT, LA, TO DAINGERFIELD, TX, REACH
REEVALUATION STUDY IN-PROGRESS REVIEW

APPENDIX 3
WETLAND RESOURCES

INTRODUCTION

1. The purpose of this report is to assess what impacts construction of the four-barge tow, authorized alignment navigation channel would have on the wetlands in the project area. To facilitate the study of the navigation project, the project area was divided into four navigation reaches. They are:

a. Reach 1 - Shreveport to Caddo Lake Dam. Twelvemile Bayou to the existing Caddo Lake Dam. Soda Lake Wildlife Management Area is within this reach.

b. Reach 2 - Caddo Lake Dam to Jefferson, TX. Caddo Lake and Big Cypress Bayou to Jefferson, TX. Caddo Lake State Park is located within this reach.

c. Reach 3 - Jefferson, TX to Ferrells Bridge Dam. Big Cypress Bayou above Jefferson, TX to Ferrells Bridge Dam at Lake O' The Pines.

d. Reach 4 - Lake O' The Pines. Lake O' The Pines reservoir to turning basin near Daingerfield, TX.

2. Project impacts will primarily affect bottom-land hardwood wetlands (BLHW). BLHW may be the most endangered wetland class within the United States. Land development within the southern United States will cause a continuous reduction in timberland area (Alig et al. 1990). Within the Mississippi Alluvial Plain, BLHW acreage is projected to decline from 12 million acres in 1937 to only 4 million acres in 1995 (MacDonald et al. 1979, Clark and Benforado 1981). In Texas, there has been an 18 percent loss of BLHW from 1935-1975 and estimates indicate that only 37 percent of presettlement BLHW currently remain (Frye 1986, Neal and Jemison 1990). The manmade activities which threaten BLHW include clearing for agriculture, flood control projects, transportation corridors, and urbanization. The specific impact types associated with the navigation project include BLHW clearing for the channel right-of-way including lock and dam construction, BLHW modifications caused by dredged material disposal, and BLHW hydrologic regime modifications. The loss of BLHW means the loss of sites for timber production and habitat for fish, terrestrial wildlife and waterfowl. However, BLHW are recognized to perform other important functions. These functions are discussed in several literature reviews and include groundwater recharge and discharge, floodflow alteration, sediment stabilization, sediment and toxicant retention, nutrient removal and transformation, and production export (Mitsch and Gosselink 1986, Erwin 1989, Taylor et al. 1990, Adamus et al. 1991).

3. Project impacts will be discussed with regards to the floodflow alteration, sediment stabilization, sediment and toxicant retention, nutrient removal and transformation and production export wetland functions. The important BLHW functions of fish habitat, terrestrial wildlife habitat and waterfowl habitat are discussed in separate reports. In contrast to the habitat functions, there currently exists no accepted, rapid procedure which quantitatively evaluates the subject functions. Consequently, support is lacking for impact assessments based on the quantitative loss of the subject functions which then can be used to develop compensatory mitigation replacement ratios. The Department of the Army/Environmental Protection Agency Memorandum of Agreement (MOA) will be referenced for guidance during the discussion of mitigation. Acreage estimates of project impacts to the BLHW were provided by the Vicksburg District.

GENERAL WETLAND LAND CLASS DESCRIPTION

4. For the navigation reaches, wetland acreage and locations for each wetland class are shown in Figures 1 to 4. Bottom-land hardwood and cypress-tupelo are the main wetland classes. In general, the tree strata composition of the bottom-land hardwood class includes the moderately flood-tolerant or flood-tolerant oaks species (e.g. water oak, Quercus nigra L.; willow oak, Quercus phellos L.; overcup oak, Quercus lyrata Walt.). The cypress-tupelo class is dominated by baldcypress (Taxodium distichum (L.) Rich.). Tupelo species present include blackgum (Nyssa sylvatica var. biflora (Walt.) Sarg.) and water tupelo (Nyssa aquatica L.). Both wetland classes have the potential to perform the subject functions. Consequently, further discussion will combine the two classes under the general title of BLHW.

DESCRIPTION OF WETLAND FUNCTIONS

FLOODFLOW ALTERATION

5. Floodflow alteration is the ability of a wetland to store surface waters or attenuate floodflow velocities. Vegetation type and density within the BLHW may have a direct influence on floodflows by affecting flood plain roughness (Carter et al. 1979). Mathematical models depict a positive relationship between flood peak attenuation and travel time and flood plain roughness (Fread 1977, Robbins 1977). The forested wetlands along Big Cypress Bayou enhance the roughness factor within the flood plain. Other factors which affect the magnitude the BLHW alter floodflows include the magnitude and duration of storms, amount of upslope runoff, size of the BLHW (above-ground storage capacity), degree of soil saturation (below-ground storage capacity) and position of the BLHW within the watershed (Adamus et al. 1991). For the project area BLHW, opportunities to alter floodflows may be influenced by the timing, amount, and duration of discharge from Lake O' The Pines reservoir.

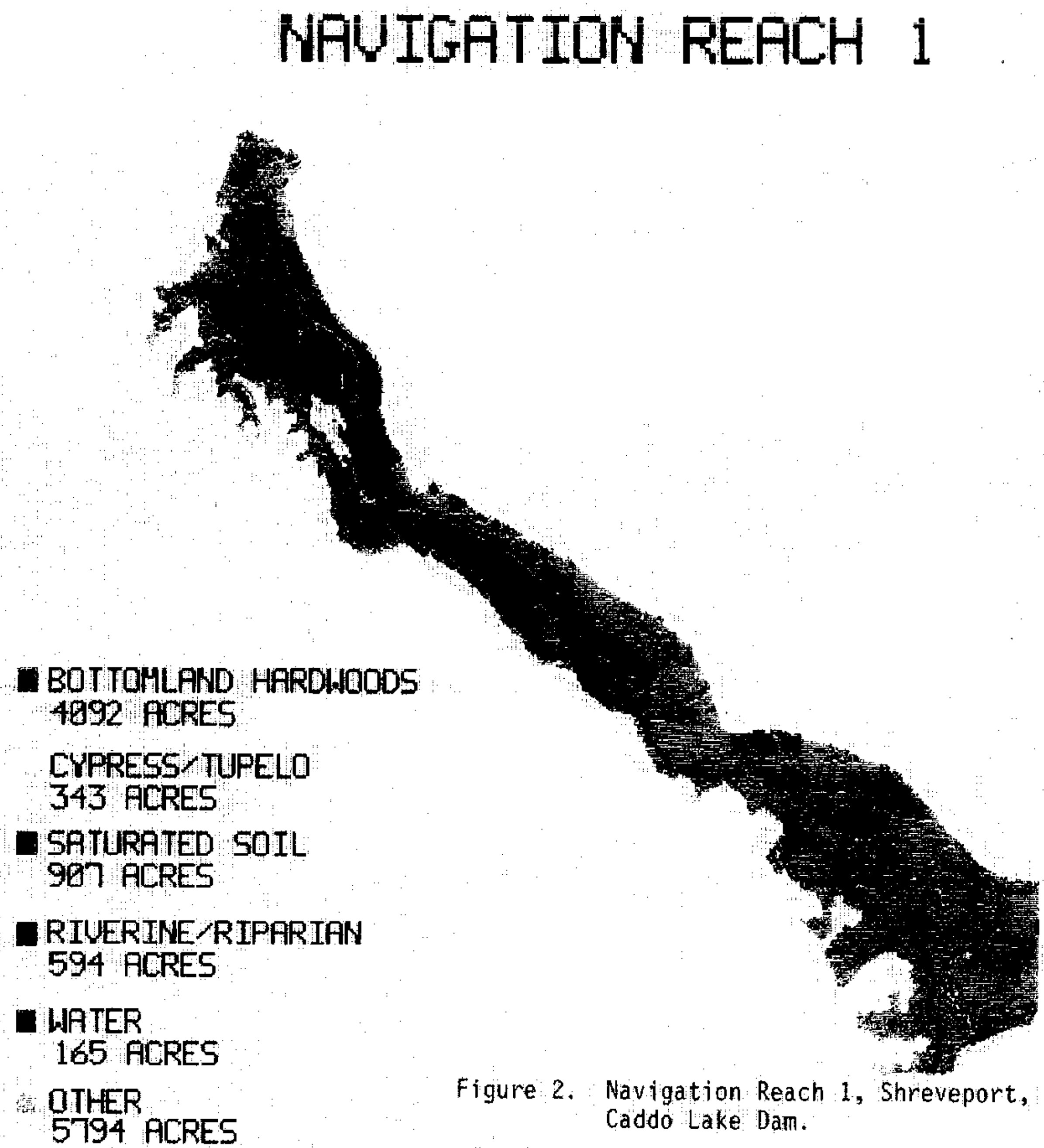


Figure 2. Navigation Reach 1, Shreveport, LA to Caddo Lake Dam.

NAVIGATION REACH 2

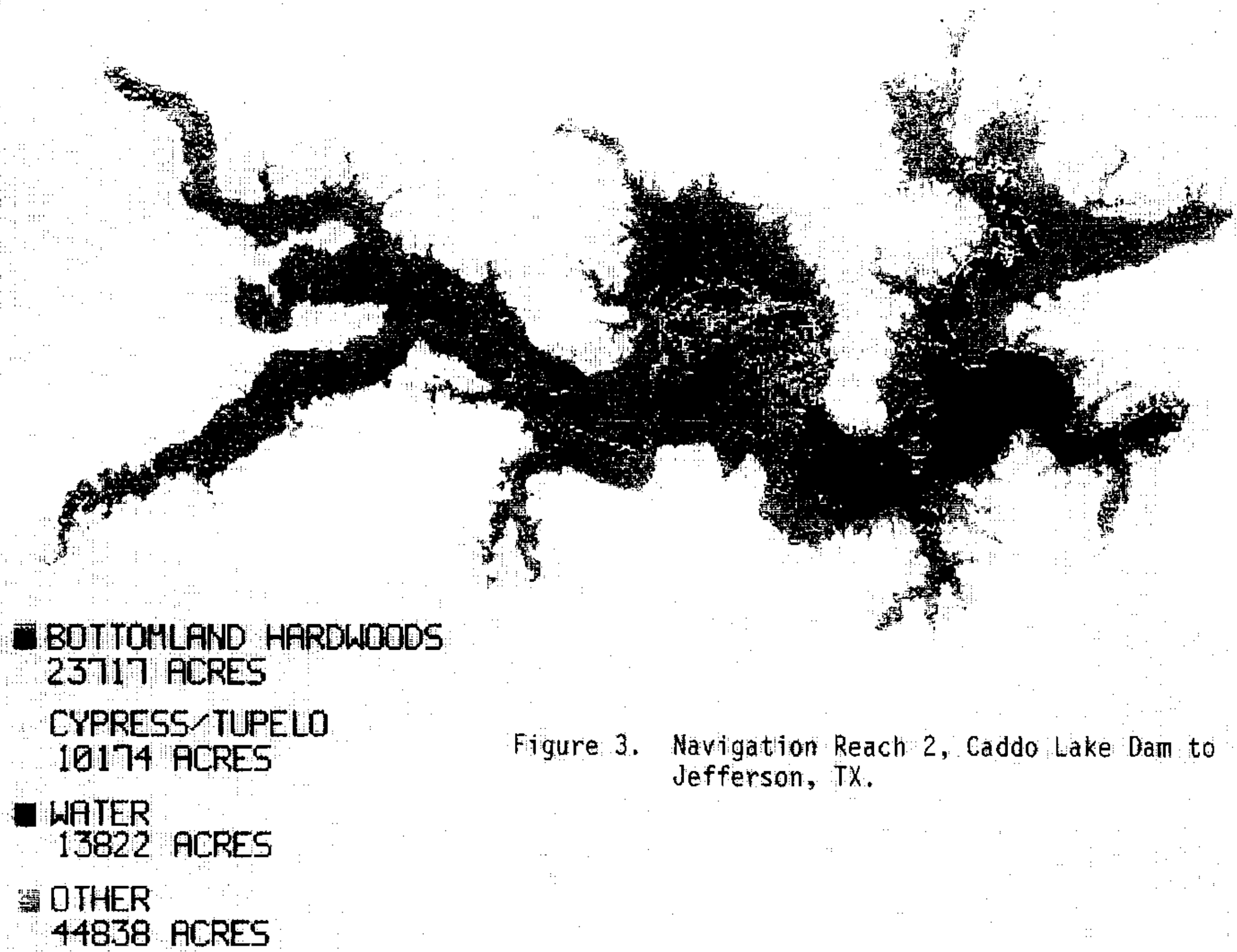


Figure 3. Navigation Reach 2, Caddo Lake Dam to Jefferson, TX.

NAVIGATION REACH 3

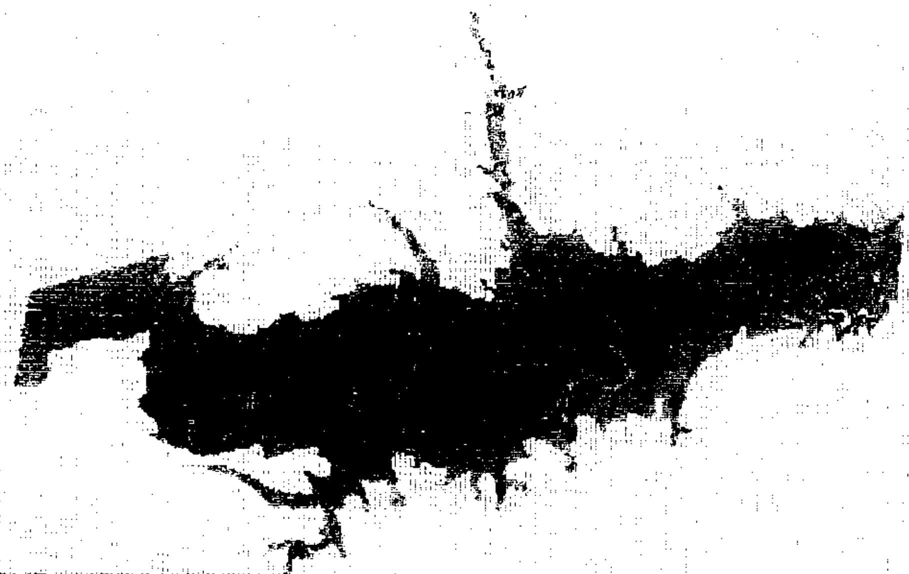
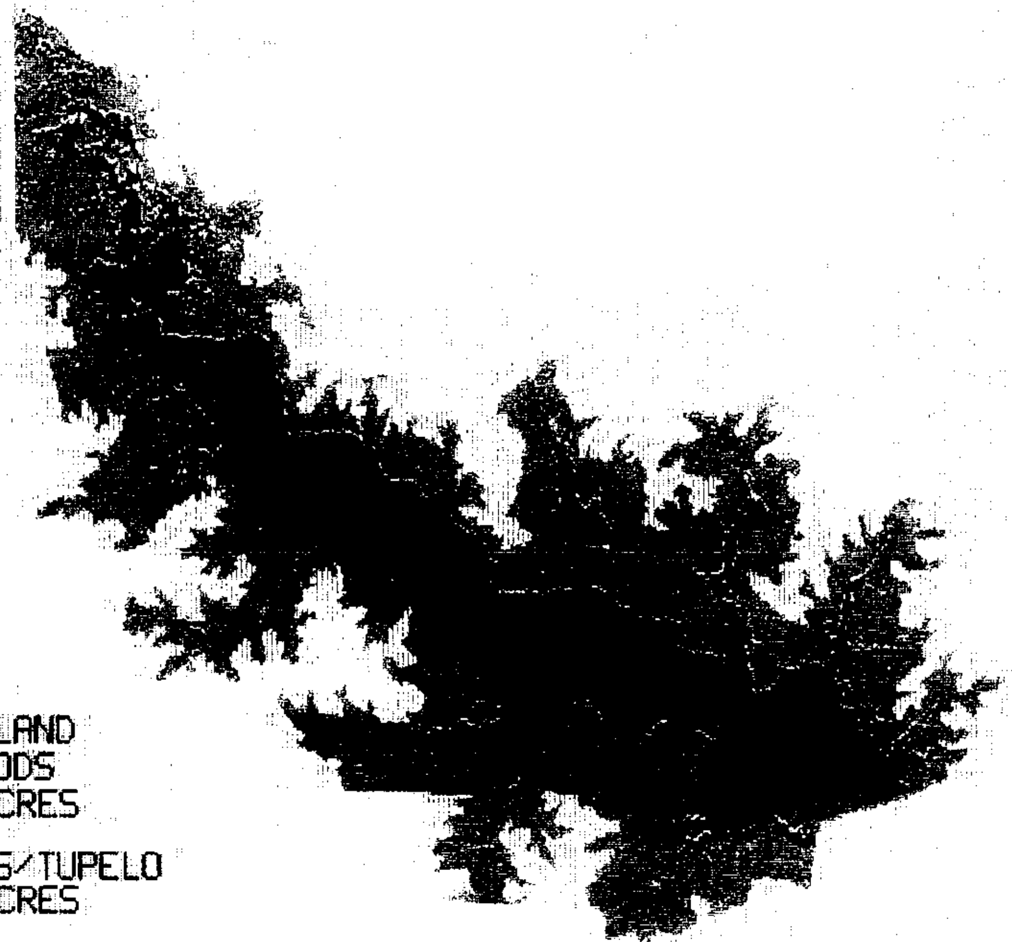


Figure 4. Navigation Reach 3, Jefferson, TX, to Ferrell's Bridge Dam at Lake O' the Pines.

NAVIGATION REACH 4



BOTTOMLAND HARDWOODS
7143 ACRES

CYPRESS/TUPELO
2481 ACRES

WATER
17312 ACRES

OTHER
23909 ACRES

Figure 5. Navigation Reach 4, Lake O' the Pines Reservoir.

SEDIMENT STABILIZATION

6. Sediment stabilization occurs when wetland vegetation is effective in binding soils and dissipating erosive forces. Because trees have a long life span and a spreading root habit, they provide an important mechanism for controlling erosion. Soils are stabilized by binding with the tree root system. The wide, shallow root mats of flood plain trees anchor the soil and prevent loss by scouring (Wharton et al. 1982). In addition, trees control erosion by rain interception and energy dissipation, transpiration and infiltration enhancement (Bailey and Copeland 1961). Forested wetlands protect downstream banks from erosion by reducing throughflow floodwater velocities (Taylor et al. 1990). Soils are also stabilized by the root mats of understory herbaceous and woody plants. The BLHW within the project area stabilize soils because of their overstory and understory component (providing a root mat) and their potential influence in reducing flow velocities.

SEDIMENT AND TOXICANT RETENTION

7. The sediment and toxicant retention function involves the ability of a wetland to physically trap inorganic sediments or toxic chemical substances. Sediments and toxicants may be delivered to the wetlands either by runoff or by overbank flows (Adamus et al. 1991). Sediments in runoff are retained in the BLHW before moving to deeper water and sediments in overbank floodwaters are retained before moving downstream. Vegetation and the gradual slope (or depressions) found in wetlands enhance sedimentation by increasing floodwater detention times (Novotny 1980). The frictional resistance and the obstruction of flow caused by BLHW vegetation aid in the precipitation of sediments (Taylor et al. 1990). Enhanced rates of sedimentation in wetlands correlate with toxicant retention since many of the toxicants are adsorbed to the sediments.

NUTRIENT REMOVAL AND TRANSFORMATION

8. Wetlands which perform the nutrient removal and transformation function can trap and then change inorganic nutrients into other chemical forms. In part, the success a forested area has in removing nutrients is due to the effectiveness in altering water flows. Sediments laden with nutrients are more likely to settle in forested flood plains when floodwater duration is increased and velocity is decreased. Once deposited, the sediments provide a source of mineral nutrition for the BLHW (Farnsworth et al. 1979). The transformation of inorganic nutrient inputs to organic forms (e.g. leaf and branch litter) can support secondary productivity and a detrital-based food-web (Elder 1985). Literature reviews of the biochemical transformations which may occur in wetlands can be found in Mitsch and Gosselink (1986) and Armstrong (1982).

PRODUCTION EXPORT

9. Production export involves the transportation of organic plant material from a wetland to downstream areas. The potential for exporting organic

material from the BLHW is high because of the availability of litter and the exposure of BLHW to periodic overbank flooding. The level at which a BLHW performs the production export function is determined to an extent by the hydrological regime (Taylor et al. 1990). Periodic flooding inputs inorganic and organic nutrients into forested wetlands enhancing primary productivity (Conner and Day 1976, Mitsch and Gosselink 1986). The floodwaters also provide a vehicle for exporting the production downstream in the form of decaying plant material. A positive linear relationship exists between organic carbon export and the amount of runoff from watersheds drained through wetlands (Mulholland and Kuenzler 1979). BLHW with hydrologic regimes characterized by free-flowing water and periodic dry cycles may have enhanced organic matter decomposition and export when compared to sites which are continuously flooded with stagnant water (Conner and Day 1991). The exported organic matter consists of particulate and dissolved forms (Taylor et al. 1990, Mitsch and Gosselink 1986). Some fish and invertebrate species rely entirely or in part on particulate organic matter as a food source (de la Cruz 1979), while dissolved matter is utilized by microorganisms (Correll 1978).

ASSESSMENT OF PROJECT IMPACTS

10. The types of wetland functions and to what extent they are performed can be significantly altered by manmade impacts. Discussions on the effects of manmade impacts to wetland functions can be found in a literature review by Adamus et al. (1991) and specifically for BLHW functions in publications by Gosselink and Lee (1989) and Gosselink et al. (1990). The following discussion on project impacts to BLHW functions borrows from these sources.

11. Constructing the navigation channel and the locks and dam will require clearing a portion of the BLHW within the project area. The loss of vegetation will mean the loss of friction for altering floodflows and a carbon source for production export. Above- and below-ground floodwater storage capacity will be lost because a permanent water-holding channel will cover sites which were periodically dry and available for water storage. Root mats which stabilize the soil will be lost, increasing the chance for bank erosion. Construction of the 4-Barge Tow Authorized Alignment will require clearing 1,119 BLHW acres (Table 3-1).

Table 3-1
Bottom-land hardwood wetland acres cleared during construction of the navigation channel right-of-way and lock and dams for the 4-Barge Tow Authorized Alignment

Navigation Reach	Bottom-land Hardwood Acres Impacted
Shreveport to Caddo Lake Dam	463
Caddo Lake Dam to Jefferson, TX	438
Jefferson, TX to Ferrells Bridge Dam	176
Lake O' The Pines	42
Total	1,119

12. The presence and magnitude of the subject functions are influenced by the BLHW hydrologic regime. The possible scenarios which can affect the hydrologic regime include the improved water conveyance of the channel which may reduce the chance for overbank flooding, the unintentional drainage or permanent inundation of the BLHW adjacent to the channel, and the potential for ground-water interactions.

13. Channel construction will involve the removal of natural meanders and an increase in channel depth and width. Straightening or confining channels decreases the potential for overbank flows preventing floodwater contact with vegetation and unsaturated soils (Belt 1975). Consequently, areas adjacent to modified streams have a reduced potential to alter floodflows. The loss of overbank flooding can result in decreased organic matter export downstream (Klimas 1988, Kuenzler and Craig 1986). Soil erosiveness is enhanced because channelized streams have greater flow velocities and rapid fluctuations in flows (Huish and Pardue 1978, Nunnally and Keller 1979, Stern and Stern 1980). Manmade alterations in stream hydrology have reduced the effectiveness of a Louisiana swamp to perform the nutrient removal and transformation function (Kemp and Day 1974). Snag removal may have indirectly led to the substantial reduction in functional BLHW area by removing wetland hydrology (Harris and Gosselink 1990).

14. The BLHW impact defined as the loss of wetland hydrology caused by channel improvements was based on the number of acres which no longer flood during a 2-year frequency rainfall event. Pre- and postproject stages were compared and used in conjunction with stage-area curves to calculate the BLHW acreage no longer flooded. BLHW within the 2-year frequency flood plain were considered to have wetland hydrology in most years (e.g. flooding 3 out of

5 consecutive years) which increases the probability that the subject functions were being performed. The improved water conveyance of the navigation channel is estimated to remove 2,433 BLHW acres from overbank flooding (Table 3-2).

Table 3-2
Bottom-land hardwood wetland acres estimated to have a negative hydrologic regime modification resulting from construction of the 4-Barge Tow Authorized Alignment navigation channel. Assessment based on a 2-year frequency flood event

Navigation Reach	Bottom-land Hardwood Acres Impacted
Permanent Loss to Overbank Flooding	
Shreveport to Caddo Lake Dam	434
Caddo Lake Dam to Jefferson, TX	1,288
Jefferson, TX to Ferrells Bridge Dam	711
Lake O' The Pines	0
Total	2,433
Permanent Inundation	
Jefferson, TX to Ferrells Bridge Dam	266
Total Hydrologic Impacts	2,699

15. BLHW adjacent to the channel may be inadvertently drained or become permanently inundated or saturated. Where the channel route follows the existing stream, comparisons of the natural topographic elevations (USGS 1:24000 topographic maps) with the pool elevations to be maintained by the lock and dams (Figure 1) suggest that water levels will be confined within the channel. However, widening and deepening the existing stream may alter the hydrologic relationship between the stream, the natural levee, and the backswamp of the flood plain. The risk of hydrologic impact is especially high where the channel deviates from the stream and cuts through existing BLHW. Enhanced drainage of the adjacent BLHW may occur if the pool elevation maintained by the lock and dams is below the elevation of the backswamp swales. For example, the proposed 185-foot pool elevation within Navigation Reach 3 may be 10 feet below the topographic elevation of portions of the BLHW. Enhanced drainage may not totally eliminate the probability that

wetland functions will be performed. The BLHW resource will remain adjacent to the channel. However, the reduced duration of inundation will most likely shift the understory vegetation to less flood-tolerant species. Because of their long lifespan, little change would be expected in the composition of the tree strata.

16. BLHW vegetation has developed morphological and physiological adaptations which ensure survival in a hydrologic regime characterized by alternating dry periods and wet periods. Permanent inundation or soil saturation will result in the eventual mortality of even the most flood-tolerant BLHW tree species. Permanent inundation or soil saturation may occur if the pool elevations are above the BLHW topographic elevations. The loss to wetland functions will compare with that of the BLHW being cleared. Permanent inundation of 266 BLHW acres is anticipated near Lock and Dam No. 7 at Jefferson, TX (Table 3-2).

17. Preliminary information suggests that Big Cypress Bayou has a hydrologic connection with a shallow subsurface aquifer (see Appendix 2). For certain BLHW sites, root zone contact with the aquifer for portions of the year may have a significant influence on plant community composition and the types and rates of below-ground biochemical transformations. The influence the navigation channel will have on the aquifer and subsequently the BLHW depends on the relationship between the channel route, lock and dam location, pool elevation, lithology, and topography of the BLHW. The assessments of project impacts to ground-water hydrology indicate that the increased permanent pool elevation maintained by Lock and Dam No. 7 will significantly increase the ground-water elevations in the Jefferson, TX, to Ferrells Bridge Dam Navigation Reach. Permanent soil saturation may occur in certain locations within the BLHW. As with permanent surface inundation, saturating the soil by raising the level of the aquifer may result in the significant changes in plant community composition or the eventual death of the BLHW stand. Alterations in ground-water hydrology could have a chronic effect on the BLHW which precludes accurately estimating immediate negative impacts.

18. BLHW cleared for dredged material disposal sites will have similar negative effects on wetland functions as clearing for the channel right-of-way. If sites are not cleared, the disposal of dredged material within the BLHW will act as a fill raising the site elevation. The ability of the BLHW to receive or retain floodwaters will be reduced. The hydrologic modification will reduce the opportunity that the floodflow alteration, sediment and toxicant retention and the nutrient removal and transformation functions may be performed. Production export will be reduced because of the decrease in hydrology (delivery system), the understory vegetation will be covered, and the overstory vegetation can be expected to have reduced growth and increased mortality. The shallow root growth habit of the BLHW tree species facilitates the diffusion of oxygen from the atmosphere to the roots. The placement of dredge material over the existing soil can impede oxygen diffusion or at least increase the distance oxygen must diffuse from the atmosphere to the roots. Anaerobic conditions detrimental to tree survival can develop within the root zone. For the 4-Barge Tow Authorized Alignment, dredge disposal will affect a total of 1,404 BLHW acres (Table 3-3). Overall total BLHW impacts resulting from construction of the proposed project will be 5,222 acres (Table 3-4).

Table 3-3
Bottom-land hardwood wetland acres impacted by the disposal of dredged material during construction of the 4-Barge Tow Authorized Alignment navigation channel

Navigation Reach	Bottom-land Hardwood Acres Impacted
Shreveport to Caddo Lake Dam	42
Caddo Lake Dam to Jefferson, TX	610
Jefferson, TX to Ferrells Bridge Dam	752
Lake O' The Pines	0
Total	1,404

Table 3-4
Summary of bottom-land hardwood wetland impacts resulting from construction of the 4-Barge Tow Authorized Alignment navigation channel

Type of Impact	Bottom-land Hardwood Acres Impacted
Channel Right-Of-Way and Lock and Dam Construction	1,119
Hydrologic Regime Modification	
- Permanent Loss of Flooding	2,433
- Permanent Inundation	266
Dredge Disposal Placement	1,404
Grand Total of Impacts	5,222

MITIGATION FOR WETLAND IMPACTS

19. The goal of the Corps, as outlined in the 1990 Water Resources Development Act, is to achieve no overall net loss of the Nation's remaining wetlands. Consequently, the 1990 MOA between the Department of the Army and the Environmental Protection Agency recommends that project impacts to wetlands be avoided if practicable, and mitigation for unavoidable impacts be accomplished by minimizing impacts and finally compensation. Avoidance involves considering practicable alternatives to a project which will not cause harm to the wetland or have other significant negative environmental consequences. Minimizing impacts considers reducing project impacts by design modifications and implementing the project with environmentally sensitive practices. Compensation of unavoidable impacts requires the restoration or creation of wetlands with the objective of replacing the lost wetland functions.

20. The MOA recommends that compensation for wetland impacts requires a 1 to 1 functional replacement. However, when definitive information on wetland functions is not available, a minimum of 1 to 1 acreage replacement is recommended. Definitive (quantitative) information had not been developed for functions such as floodflow alteration, sediment stabilization, sediment and toxicant retention, nutrient removal and transformation and production export for the project area wetlands. At present, no accepted, rapid, on-site evaluation method is available to assign a quantitative value to the magnitude a wetland can perform these particular functions. For a 1 to 1 replacement, mitigation for project impacts would be 5,222 acres (Table 3-4). However, compensation ratios greater than 1 to 1 should be considered. The MOA recommends that mitigation occur on-site (within or adjacent to the project area) and be in-kind (the restoration or creation of BLHW). The mitigation type suggested for the wetland impacts is the on-site restoration of BLHW by the reforestation of frequently flooded agricultural and fallow fields. On-site mitigation will not be possible if restoration sites are not available in the vicinity of the project area. In-kind replacement will be difficult if the sites selected do not have the topographic, edaphic, and hydrologic features comparable to the impacted sites. Because of the topography, diverse vegetation, and complex hydrology (e.g., ground-water interactions), on-site and in-kind replacement of the project area BLHW may prove difficult. The lack of opportunity to replace impacted BLHW on-site and in-kind may require compensation at a greater than 1 to 1 ratio.

Conversion Factors, Non-SI to SI (Metric) Units of Measurement

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	0.405	hectares
feet	0.305	meters
square miles	2.590	square kilometers

Literature Cited

Adamus, P. R., Stockwell, L. T., Clairain, E. J., Jr., Morrow, M. E., Rozas, L. P., and Smith, R. D. 1991. "Wetlands Evaluation Technique (WET); Volume I: Literature Review and Evaluation Rationale," Technical Report WRP-91- , US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Alig, R. J., Hohenstein, W. G., Murray, B. C., and Haight, R. G. 1990. Changes in area of timberland in the United States, 1952-2040, by ownership, forest type, region, and State. Gen. Tech. Rep. SE-64. Asheville, NC. U. S. D. A. Forest Service, Southeastern Forest Experiment Station. 34 pp.

Armstrong, W. 1982. Waterlogged Soils. In: Environment and Plant Ecology. J. R. Etherington, ed. J. Wiley and Sons, New York.

Bailey, R. W. and Copeland, O. L. 1961. Vegetation and engineering structures in flood and erosion control. In: 13th Congress of International Union of Forest Research Organizations. Vienna, Austria. Sept. 10-17, 1961. USDA Intermountain Forest and Range Experiment Station, Ogden, Utah.

Belt, C. B. 1975. The 1973 flood and man's constriction of the Mississippi River. Science 189: 681-684.

Carter, V., Bedinger, M. S., Novitski, R. P. and Wilen, W. O. 1979. Water resources and wetlands. In: Wetlands Functions and values: The State of Our Understanding. P. E. Greeson, J. R. Clark and J. R. Clark, eds. American Water Resources Association, Minneapolis, Minnesota. 344-376.

Clark, J. R. and Benforado, J., eds. 1981. Wetlands of Bottomland Hardwood Forests. Elsevier Science Publishing Co., Amsterdam. 401 pp.

Conner, W. H. and Day, J. W. 1976. Productivity and composition of a baldcypress-water tupelo site and a bottomland hardwood site in a Louisiana swamp. American Journal of Botany 63: 1354-1364.

Conner, W. H. and Day, Jr., J. W. 1991. Leaf litter decomposition in three Louisiana freshwater forested wetland areas with different flooding regimes. Wetlands 11(2): 303-312.

Correll, D. L. 1978. Estuarine productivity. Bioscience 28: 646-650.

de la Cruz, A. 1979. Production and transport of detritus in wetlands. In: Wetland Functions and Values: The State of Our Understanding. P. E. Greeson, J. R. Clark, and J. E. Clark, eds. American Water Resources Association, Minneapolis, Minnesota. 162-174.

Elder, J. F. 1985. Nitrogen and phosphorus speciation and flux in a large florida river wetland system. Water Resources 21: 724-732.

Erwin, K. L. 1989. Wetland evaluation for restoration and creation. In: Wetland Creation and Restoration: The Status of the Science, Vol. II: Perspectives. Kusler, J. A. and Kentula, M. E. eds. EPA/600/3-89/038 October 1989.

Farnsworth, E. G., Nichols, M. C., Vann, C. N., Wolfson, L. G. Bosserman, R. W., Hendrix, P. R., Golley, F. B., and Cooley, J. L. 1979. Impacts of sediments and nutrients on biota in surface waters of the Unites States. US Environmental Protection Agency, Environmental Research Laboratory, Athens, GA. EPA-600/3-79-105.

Fread, D. L. 1977. Flood routing in meandering rivers with flood plains. In: Symposium on Inland Waterways for Navigation, Flood Control, Water Diversions. ASCE, New York. pp. 16-35.

Frye, R. G. 1986. Bottomland hardwoods - current supply, status, habitat quality and future impacts from reservoirs. Pages 24-28 in: C. A. McMahan and R. G. Frye, editors. Texas Parks and Wildlife Department, Austin, Texas. PWD-RP-7100-133-3/87.

Gosselink, J. G. and Lee, L. C. 1989. Cumulative impact assessment in bottomland hardwood forests. Wetlands 9: 83-174.

Gosselink, J. G., Lee, L. C. and Muir, T. A., editors. 1990. Ecological Processes and Cumulative Impacts: Illustrated by Bottomland Hardwood Wetland Ecosystems. Lewis Publishers, Inc., Chelsea, Michigan. 708 pp.

Harris, L. D. and Gosselink, J. G. 1990. Chapter 9: Cumulative Impacts of Bottomland Hardwood Forest Conversion on Hydrology, Water Quality, and Terrestrial Wildlife. In: Ecological Processes and Cumulative Impacts: Illustrated by Bottomland Hardwood Wetland Ecosystems. J. G. Gosselink, L. C. Lee, and T. A. Muir, eds. Lewis Publishers, Inc., Chelsea, Michigan. 708 pp.

Huish, M. T. and Pardue, G. B. 1978. Ecological studies of one channelized and two unchannelized swamp streams in North Carolina. US Fish and Wildlife Service Biological Series Program. FWS/OBS-78/85.

Kemp, G. P. and Day, J. W. 1974. Nutrient dynamics in a Louisiana swamp receiving agricultural runoff. In: Cypress Swamps. K. C. Ewel and H. T. Odums, eds. University of Florida Press, Gainesville, FL. pp. 286-293.

Klimas, C. V. 1987. Baldcypress response to increased water levels, Caddo Lake, Louisiana-Texas. Wetlands 7: 25-37.

Klimas, C. V. 1988. River regulation effects on floodplains hydrology and ecology. In: The Ecology and Management of Wetlands, Vol. 1. D. D. Hook, et al., eds. Timber Press, Portland OR.

˘uenzler, E. J. and Craig, N. J. 1986. Land use and nutrient yields of the Chowan river watershed. In: Watershed Research Perspectives. D. L. Correll, ed. Smithsonian Institution Press, Washington, D.C. 77-107.

MacDonald, P. O., Frayer, W. E. and Clauser, J. K. 1979. Documentation, chronology, and future predictions of bottomland hardwood habitat losses in the Lower Mississippi Alluvial Plain. Vols. 1 and 2. US Fish and Wildlife Service. Jackson, Miss. 133 pp. and 295 pp.

Mitsch, W. J. and Gosselink, J. G. 1986. Wetlands. Van Nostrand Reinhold, New York. 537 pp.

Mulholland, P. J. and Kuenzler, E. J. 1979. Organic carbon export from upland and forested wetland watersheds. Limnology and Oceanography 24: 960-966.

Neal, J. A. and Jemison, E. S. 1990. Chapter 10: The Texas/Oklahoma bottomland hardwood forest protection program. In: Ecological Processes and Cumulative Impacts: Illustrated by Bottomland Hardwood Wetland Ecosystems. J. G. Gosselink, L. C. Lee, and T. A. Muir, eds. Lewis Publishers, Inc., Chelsea, Michigan. 708 pp.

Novotny, V. 1980. Delivery of suspended sediment and pollutants from nonpoint sources during overland flow. Water Resources Bulletin 16: 1057-1065.

Nunnally, N. and Keller, E. 1979. Use of fluvial processes to minimize adverse effects of stream channelization. Water Resources Research Institute Report No. 144. University of North Carolina, Chapel Hill, NC.

Robbins, L. G. 1977. Roughness characteristics of the Lower Mississippi. In: Symposium on Indland Waterways for Navigation, Flood Control, Water Diversions. ASCE, New York. 1209-1228.

Stern, D. H. and Stern, M. S. 1980. Effects of bank stabilization on the physical and chemical characteristics of streams and small river: A synthesis. US Fish and Wildlife Service, Washington D. C. FWS/OBS-80/11.

Taylor, J. R., Cardamone, M. A., and Mitsch, W. J. 1990. Chapter 2: Bottomland Hardwood Forests: Their Functions and Values. In: Ecological Processes and Cumulative Impacts: Illustrated by Bottomland Hardwood Wetland Ecosystems. J. G. Gosselink, L. C. Lee, and T. A. Muir, eds. Lewis Publishers, Inc., Chelsea, Michigan. 708 pp.

USAED, Vicksburg. 1991. Red River Waterway, Shreveport, Louisiana to Daingerfield, Texas. Initial Project Management Plan Navigation Study. U. S. Army Corps of Engineers, Vickburg District.

USAED, Vicksburg. 1992. Waterwise. The Newsletter of the Shreveport to Daingerfield Study, Issue No. 6. U. S. Army Corps of Engineers, Vicksburg District.

Wharton, C. H., Kitchens, W. M., Pendleton, E. C. and Sipe, T. W. 1982. The ecology of bottomland hardwood swamps of the Southeast: A community profile. US Fish and Wildlife Service, Washington, D. C. FWS/OBS-81/37.

APPENDIX

MEMORANDUM OF AGREEMENT BETWEEN THE ENVIRONMENTAL PROTECTION AGENCY AND THE DEPARTMENT OF THE ARMY CONCERNING THE DETERMINATION OF MITIGATION UNDER THE CLEAN WATER ACT SECTION 404(b)(1) GUIDELINES

I. Purpose

The United States Environmental Protection Agency (EPA) and the United States Department of the Army (Army) hereby articulate the policy and procedures to be used in the determination of the type and level of mitigation necessary to demonstrate compliance with the Clean Water Act (CWA) Section 404(b)(1) Guidelines ("Guidelines"). This Memorandum of Agreement (MOA) expresses the explicit intent of the Army and EPA to implement the objective of the CWA to restore and maintain the chemical, physical, and biological integrity of the Nation's waters, including wetlands. This MOA is specifically limited to the Section 404 Regulatory Program and is written to provide guidance for agency field personnel on the type and level of mitigation which demonstrates compliance with requirements in the Guidelines. The policies and procedures discussed herein are consistent with current Section 404 regulatory practices and are provided in response to questions that have been raised about how the Guidelines are implemented. The MOA does not change the substantive requirements of the Guidelines. It is intended to provide guidance regarding the exercise of discretion under the Guidelines.

Although the Guidelines are clearly applicable to all discharges of dredged or fill material, including general permits and Corps of Engineers (Corps) civil works projects, this MOA focuses on standard permits (33 CFR 325.5(b)(1))[1]. This focus is intended solely to reflect the unique procedural aspects associated with the review of standard permits, and does not obviate the need for other regulated activities to comply fully with the Guidelines. EPA and Army will seek to develop supplemental guidance for other regulated activities consistent with the policies and principles established in this document.

This MOA provides guidance to Corps and EPA personnel for implementing the Guidelines and must be adhered to when considering mitigation requirements for standard permit applications. The Corps will use this MOA when making its determination of compliance with the Guidelines with respect to mitigation for standard permit applications. EPA will use this MOA in developing its positions on compliance with the Guidelines for

[1]Standard permits are those individual permits which have been processed through application of the Corps public interest review procedures (33 CFR 325) and EPA's Section 404(b)(1) Guidelines, including public notice and receipt of comments. Standard permits do not include letters of permission, regional permits, nationwide permits, or programmatic permits.

proposed discharges and will reflect this MOA when commenting on standard permit applications.

II. Policy

A. The Council on Environmental Quality (CEQ) has defined mitigation in its regulations at 40 CFR 1508.20 to include: avoiding impacts, minimizing impacts, rectifying impacts, reducing impacts over time, and compensating for impacts. The Guidelines establish environmental criteria which must be met for activities to be permitted under Section 404.[2] The types of mitigation enumerated by CEQ are compatible with the requirements of the Guidelines; however, as a practical matter, they can be combined to form three general types: avoidance, minimization and compensatory mitigation. The remainder of this MOA will speak in terms of these more general types of mitigation.

B. The Clean Water Act and the Guidelines set forth a goal of restoring and maintaining existing aquatic resources. The Corps will strive to avoid adverse impacts and offset unavoidable adverse impacts to existing aquatic resources, and for wetlands, will strive to achieve a goal of no overall net loss of values and functions. In focusing the goal of no overall net loss to wetlands only, EPA and Army have explicitly recognized the special significance of the nation's wetlands resources. This special recognition of wetlands resources does not in any manner diminish the value of other waters of the United States, which are often of high value. All waters of the United States, such as streams, rivers, lakes, etc., will be accorded the full measure of protection under the Guidelines, including the requirements for appropriate and practicable mitigation. The determination of what level of mitigation constitutes "appropriate" mitigation is based solely on the values and functions of the aquatic resource that will be impacted. "Practicable" is defined at Section 230.3(q) of the Guidelines.[3] However, the level of mitigation determined to be appropriate and practicable under Section 230.10(d) may lead to individual permit decisions which do not fully meet this goal because the mitigation measures necessary to meet this goal are not feasible, not practicable, or would accomplish only inconsequential reductions in impacts. Consequently, it is recognized that no net loss of wetlands functions and values may not be achieved in each and every permit action. However, it remains a goal of the Section 404 regulatory program to contribute to the national goal of no overall net loss of the nation's remaining wetlands base. EPA and Army are committed to working with others through the Administration's interagency task force and other avenues to help achieve this national goal.

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[2](except where Section 404(b)(2) applies).

[3]Section 230.3(q) of the Guidelines reads as follows: "The term practicable means available and capable of being done after taking into consideration cost, *existing technology, and logistics in light of overall project purposes*." (Emphasis supplied)

C. In evaluating standard Section 404 permit applications, as a practical matter, information on all facets of a project, including potential mitigation, is typically gathered and reviewed at the same time. The Corps, except as indicated below, first makes a determination that potential impacts have been avoided to the maximum extent practicable; remaining unavoidable impacts will then be mitigated to the extent appropriate and practicable by requiring steps to minimize impacts and, finally, compensate for aquatic resource values. This sequence is considered satisfied where the proposed mitigation is in accordance with specific provisions of a Corps and EPA approved comprehensive plan that ensures compliance with the compensation requirements of the Section 404(b)(1) Guidelines (examples of such comprehensive plans may include Special Area Management Plans, Advance Identification areas (Section 230.80), and State Coastal Zone Management Plans). It may be appropriate to deviate from the sequence when EPA and the Corps agree the proposed discharge is necessary to avoid environmental harm (e.g., to protect a natural aquatic community from saltwater intrusion, chemical contamination, or other deleterious physical or chemical impacts), or EPA and the Corps agree that the proposed discharge can reasonably be expected to result in environmental gain or insignificant environmental losses.

In determining "appropriate and practicable" measures to offset unavoidable impacts, such measures should be appropriate to the scope and degree of those impacts and practicable in terms of cost, existing technology, and logistics in light of overall project purposes. The Corps will give full consideration to the views of the resource agencies when making this determination.

1. Avoidance.[4] Section 230.10(a) allows permit issuance for only the least environmentally damaging practicable alternative.[5] The thrust of this section on alternatives is avoidance of impacts. Section 230.10(a) requires that no discharge shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact to the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences. In addition, Section 230.10(a)(3) sets forth rebuttable presumptions that 1) alternatives for non-water dependent activities that do not involve special aquatic sites[6] are available and 2) alternatives that do not involve special aquatic sites have less adverse impact on the aquatic environment.

[4]Avoidance as used in the Section 404(b)(1) Guidelines and this MOA does not include compensatory mitigation.

[5]It is important to recognize that there are circumstances where the impacts of the project are so significant that even if alternatives are not available, the discharge may not be permitted regardless of the compensatory mitigation proposed (40 CFR 230.10(c)).

[6]Special aquatic sites include sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs and riffle pool complexes.

Compensatory mitigation may not be used as a method to reduce environmental impacts in the evaluation of the least environmentally damaging practicable alternatives for the purposes of requirements under Section 230.10(a).

2. Minimization. Section 230.10(d) states that appropriate and practicable steps to minimize the adverse impacts will be required through project modifications and permit conditions. Subpart H of the Guidelines describes several (but not all) means for minimizing impacts of an activity.

3. Compensatory Mitigation. Appropriate and practicable compensatory mitigation is required for unavoidable adverse impacts which remain after all appropriate and practicable minimization has been required. Compensatory actions (e.g., restoration of existing degraded wetlands or creation of man-made wetlands) should be undertaken, when practicable, in areas adjacent or contiguous to the discharge site (on-site compensatory mitigation). If on-site compensatory mitigation is not practicable, off-site compensatory mitigation should be undertaken in the same geographic area if practicable (i.e., in close physical proximity and, to the extent possible, the same watershed). In determining compensatory mitigation, the functional values lost by the resource to be impacted must be considered. Generally, in-kind compensatory mitigation is preferable to out-of-kind. There is continued uncertainty regarding the success of wetland creation or other habitat development. Therefore, in determining the nature and extent of habitat development of this type, careful consideration should be given to its likelihood of success. Because the likelihood of success is greater and the impacts to potentially valuable uplands are reduced, restoration should be the first option considered.

In the situation where the Corps is evaluating a project where a permit issued by another agency requires compensatory mitigation, the Corps may consider that mitigation as part of the overall application for purposes of public notice, but avoidance and minimization shall still be sought.

Mitigation banking may be an acceptable form of compensatory mitigation under specific criteria designed to ensure an environmentally successful bank. Where a mitigation bank has been approved by EPA and the Corps for purposes of providing compensatory mitigation for specific identified projects, use of that mitigation bank for those particular projects is considered as meeting the objectives of Section II.C.3 of this MOA, regardless of the practicability of other forms of compensatory mitigation. Additional guidance on mitigation banking will be provided. Simple purchase or "preservation" of existing wetlands resources may in only exceptional circumstances be accepted as compensatory mitigation. EPA and Army will develop specific guidance for preservation in the context of compensatory mitigation at a later date.

III. Other Procedures

A. Potential applicants for major projects should be encouraged to arrange preapplication meetings with the Corps and appropriate federal, state or Indian tribal, and local authorities to determine requirements and documentation required for proposed permit evaluations. As a result of such meetings, the applicant often revises a proposal to avoid or minimize adverse impacts after developing an understanding of the Guidelines requirements by which a future Section 404 permit decision will be made, in addition to gaining an understanding of other state or tribal, or local requirements. Compliance with other statutes, requirements and reviews, such as NEPA and the Corps public interest review, may not in and of themselves satisfy the requirements prescribed in the Guidelines.

B. In achieving the goals of the CWA, the Corps will strive to avoid adverse impacts and offset unavoidable adverse impacts to existing aquatic resources. Measures which can accomplish this can be identified only through resource assessments tailored to the site performed by qualified professionals because ecological characteristics of each aquatic site are unique. Functional values should be assessed by applying aquatic site assessment techniques generally recognized by experts in the field and/or the best professional judgment of federal and state agency representatives, provided such assessments fully consider ecological functions included in the Guidelines. The objective of mitigation for unavoidable impacts is to offset environmental losses. Additionally for wetlands, such mitigation should provide, at a minimum, one for one functional replacement (i.e., no net loss of values), with an adequate margin of safety to reflect the expected degree of success associated with the mitigation plan, recognizing that this minimum requirement may not be appropriate and practicable, and thus may not be relevant in all cases, as discussed in Section II.B of this MOA.[7] In the absence of more definitive information on the functions and values of specific wetlands sites, a minimum of 1 to 1 acreage replacement may be used as a reasonable surrogate for no net loss of functions and values. However, this ratio may be greater where the functional values of the area being impacted are demonstrably high and the replacement wetlands are of lower functional value or the likelihood of success of the mitigation project is low. Conversely, the ratio may be less than 1 to 1 for areas where the functional values associated with the

[7]For example, there are certain areas where, due to hydrological conditions, the technology for restoration or creation of wetlands may not be available at present, or may otherwise be impracticable. In addition, avoidance, minimization, and compensatory mitigation may not be practicable where there is a high proportion of land which is wetlands. EPA and Army, at present, are discussing with representatives of the oil industry, the potential for a program of accelerated rehabilitation of abandoned oil facilities on the North Slope to serve as a vehicle for satisfying necessary compensation requirements.

area being impacted are demonstrably low and the likelihood of success associated with the mitigation proposal is high.

C. The Guidelines are the environmental standard for Section 404 permit issuance under the CWA. Aspects of a proposed project may be affected through a determination of requirements needed to comply with the Guidelines to achieve these CWA environmental goals.

D. Monitoring is an important aspect of mitigation, especially in areas of scientific uncertainty. Monitoring should be directed toward determining whether permit conditions are complied with and whether the purpose intended to be served by the condition is actually achieved. Any time it is determined that a permittee is in non-compliance with mitigation requirements of the permit, the Corps will take action in accordance with 33 CFR Part 326. Monitoring should not be required for purposes other than these, although information for other uses may accrue from the monitoring requirements. For projects to be permitted involving mitigation with higher levels of scientific uncertainty, such as some forms of compensatory mitigation, long term monitoring, reporting and potential remedial action should be required. This can be required of the applicant through permit conditions.

E. Mitigation requirements shall be conditions of standard Section 404 permits. Army regulations authorize mitigation requirements to be added as special conditions to an Army permit to satisfy legal requirements (e.g., conditions necessary to satisfy the Guidelines) [33 CFR 325.4(a)]. This ensures legal enforceability of the mitigation conditions and enhances the level of compliance. If the mitigation plan necessary to ensure compliance with the Guidelines is not reasonably implementable or enforceable, the permit shall be denied.

F. Nothing in this document is intended to diminish, modify or otherwise affect the statutory or regulatory authorities of the agencies involved. Furthermore, formal policy guidance on or interpretation of this document shall be issued jointly.

G. This MOA shall take effect on February 7, 1990, and will apply to those completed standard permit applications which are received on or after that date. This MOA may be modified or revoked by agreement of both parties, or revoked by either party alone upon six (6) months written notice.

2/6/90

Robert W. Page (date)
Assistant Secretary of the Army
(Civil Works)

LaJuana S. Wilcher 2/6/90

LaJuana S. Wilcher (date)
Assistant Administrator for Water
U.S. Environmental Protection Agency

Red River Waterway Project
Shreveport, LA, to Daingerfield, TX, Reach
Reevaluation Study In-Progress Review

APPENDIX 4
TERRESTRIAL RESOURCES