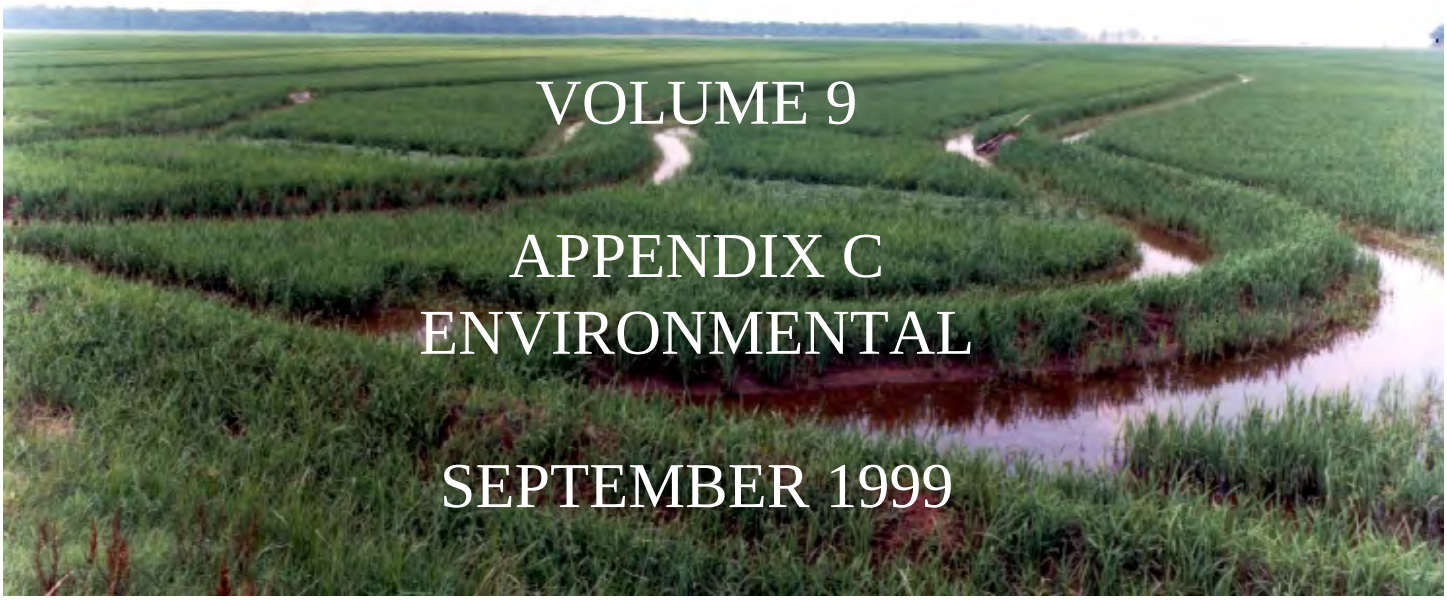
US Army Corps of Engineers
Memphis District
Mississippi River Comission

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY

GRAND PRAIRIE REGION AND BAYOU METO BASIN, ARKANSAS PROJECT

GRAND PRAIRIE AREA DEMONSTRATION PROJECT

GENERAL REEVALUATION REPORT



VOLUME 9

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EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA DEMONSTRATION PROJECT

APPENDIX C - ENVIRONMENTAL

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HABITAT EVALUATION SYSTEM ANALYSIS

SECTION I

GRAND PRAIRIE AREA DEMONSTRATION PROJECT ARKANSAS

HABITAT EVALUATION SYSTEM ANALYSIS

The Habitat Evaluation System (HES), U. S. Army Corps of Engineers (1980), was utilized to determine existing habitat quality, project future habitat quality, quantify future with-project impacts, and calculate mitigation requirements. The HES is based on the fundamental assumption that the diversity and abundance of animal populations are determined by basic abiotic and biotic factors that can be readily quantified. The HES field data collection methodology is based on rating key abiotic and biotic factors of habitat types on a scale of 0 to 1, with 1 representing the maximum value; these habitat ratings are called habitat quality index (HQI) scores.

In order to calculate HQI scores for each significant habitat type, habitat evaluations were conducted at potential impact sites (30 terrestrial plots) by an interagency team comprised of biologists from the Corps of Engineers, Arkansas Game and Fish Commission, U. S. Fish and Wildlife Service, and the Natural Resources Conservation Service. Plot sizes were as prescribed in the standard HES methodology. HQI scores for all evaluation plots are presented in Table 1. A description of the various habitat types is as follows:

Bottomland Hardwood Forest - This palustrine wetland (i.e., wetland dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens) is a broad-leaved deciduous forest that is temporarily or seasonally flooded. These forests of the study area are comprised of various bottomland hardwood associations (excluding baldcypress and tupelo) and total approximately 15,860 acres.

Forested Swamp - This palustrine forest is found on semipermanently and permanently flooded sites within the project area. It is comprised of broad-leaved deciduous and/or needle-leaved deciduous trees. Baldcypress, water tupelo, swamp tupelo and black willow are dominant tree species. Presently, forested swamps occupy approximately 4,071 acres. Note - Although this forest is often considered a bottomland hardwood forest type; it was placed into this separate wetland habitat category because of its tolerance of wetter site conditions.

Scrub/Shrub Swamp - this palustrine wetland is dominated by woody vegetation less than 20 feet tall and occurs on sites that are temporarily, seasonally, semipermanently, and permanently flooded and sites that are intermittently exposed. These areas are comprised of true shrubs, young trees, and shrubs or trees that are small or stunted because of environmental conditions. Most of these wetlands are dominated by buttonbush and/or black willow. Approximately 6,987 acres of scrub/shrub swamp exist in the project area.

Marsh - This category includes both lacustrine and palustrine wetlands. Lacustrine marsh consists of littoral aquatic beds that are semipermanently or permanently flooded and dominated by rooted vascular plants (e.g., pondweeds, water lilies, etc.). Aquatic beds are dominated by plants that grow primarily on or below the water surface. The palustrine marsh consists of aquatic beds that are located on semipermanently and permanently flooded sites and wetlands that are dominated by persistent emergent vegetation (e.g., cattail, sedges, loosestrife). The project area contains approximately 1,370 acres of marsh.

Dead Timber - This category represents areas of dead and dying bottomland hardwood forest. This habitat type is found on sites that have undergone hydrologic changes such as inundation by beaver ponds and impoundments for irrigation purposes. Dead timber exists on sites that are intermittently exposed and semipermanently and permanently flooded. There are only approximately 99 acres of dead timber within the project area.

Upland Hardwood Forest - This hardwood habitat was included in the habitat evaluation because of the unique nature of this resource. Upland forest cover types are oak and oak-hickory associations. Common tree species found within these woodlands include post oak, white oak, southern red oak, northern red oak, water oak, shagbark hickory, mockernut hickory, and bitternut hickory. The project area contains approximately 14,940 acres of upland hardwood forest.

TABLE 1

Habitat Quality Index Values For Terrestrial Wildlife

Habitat Type	Plot Number	HQI Value
UHF	1a	0.76
UHF	1b	0.92
UHF	1c	0.96
UHF	3a	0.72
BLH	3b	0.78
FS	4	0.68
BLH	5	0.79
UHF	6	0.87
UHF	7	0.80
BLH	8	0.77
FS	9	0.71
FS	10	0.72
UHF	16	0.60
UHF	17	0.84
BLH	18	0.97
BLH	19	0.83

BLH	20	0.74
BLH	21	0.78
M	22	0.50
S/S	23	0.71
BLH	26	0.76
BLH	27	0.82
FS	28	0.69
BLH	29a	0.73
BLH	29b	0.79
M	30	0.54
S/S	35a	0.84
BLH	35b	0.80
BLH	36	0.82
UHF	38	0.73

NOTES: UHF = Upland Hardwood Forest
BLH = Bottomland Hardwood Forest
S/S = Scrub/Shrub Swamp
FS = Forested Swamp
M = Marsh

Marsh habitats were evaluated using data forms for the Terrestrial Evaluation of Lakes.

The above plot numbers are not necessarily sequential because plot locations were selected and numbered in the office prior to the actual field work. Then, some plots were eliminated or relocated because land owners denied access or because changes to canal and pipeline alignments were made during the planning process.

HQI scores for each habitat type and changes in habitat type quantity were projected over the 50-year project life of the study for both future with- and without-project conditions. A habitat unit value (HUV) was then derived, as a product of the HQI and habitat type quantity, for each habitat type for future with- and without-project conditions. These HUVs were then annualized, and annualized HUV comparisons were made between future with- and without-project conditions to measure project-induced gains or losses in habitat quality. Table 2 shows the existing and projected habitat values that were used to quantify impacts and determine mitigation requirements.

TABLE 2
HES Analysis

		Without Project			With Project		
Habitat Type	Year	Acres	HQI	HUV	Acres	HQI	HUV
Upland	0	14,940	0.78	11,653.20	14,940	0.78	11,653.20
Hardwoods	10	14,940	0.78	11,653.20	14,816	0.78	11,556.48
	20	14,940	0.78	11,653.20	14,816	0.78	11,556.48
	30	14,940	0.78	11,653.20	14,816	0.78	11,556.48
	50	14,940	0.78	11,653.20	14,816	0.78	11,556.48
			Total HUV	582,660.00		Total HUV	578,307.60
			Annualized HUV	11,653.20		Annualized HUV	11,566.15
Regenerating	0	0		0.00	0		0.00
Upland Hardwoods	10	0		0.00	65	0.34	22.10
	20	0		0.00	65	0.44	28.60
	30	0		0.00	65	0.56	36.40
	50	0		0.00	65	0.70	45.50
			Total HUV	0.00		Total HUV	1,508.00
			Annualized HUV	0.00		Annualized HUV	30.16
Bottomland	0	15,860	0.80	12,688.00	15,860	0.80	12,688.00
Hardwoods	10	15,860	0.80	12,688.00	15,801	0.80	12,640.80
	20	15,860	0.80	12,688.00	15,801	0.80	12,640.80
	30	15,860	0.80	12,688.00	15,801	0.80	12,640.80
	50	15,860	0.80	12,688.00	15,801	0.80	12,640.80
			Total HUV	634,400.00		Total HUV	632,276.00
			Annualized HUV	12,688.00		Annualized HUV	12,645.52
Regenerating	0	0		0.00	0		0.00
Bottomland	10	0		0.00	35	0.34	11.90
Hardwoods	20	0		0.00	35	0.44	15.40
	30	0		0.00	35	0.56	19.60
	50	0		0.00	35	0.70	24.50
			Total HUV	0.00		Total HUV	812.00
			Annualized HUV	0.00		Annualized HUV	16.24
Forested	0	4,071	0.70	2,849.70	4,071	0.70	2,849.70
Swamp	10	4,071	0.70	2,849.70	4,059	0.70	2,841.30
	20	4,071	0.70	2,849.70	4,059	0.70	2,841.30
	30	4,071	0.70	2,849.70	4,059	0.70	2,841.30
	50	4,071	0.70	2,849.70	4,059	0.70	2,841.30
			Total HUV	142,485.00		Total HUV	142,107.00
			Annualized HUV	2,849.70		Annualized HUV	2,842.14
Regenerating	0	0		0.00	0		0.00
Forested	10	0		0.00	5	0.29	1.45
Swamp	20	0		0.00	5	0.38	1.90
	30	0		0.00	5	0.48	2.40
	50	0		0.00	5	0.60	3.00
			Total HUV	0.00		Total HUV	99.50
			Annualized HUV	0.00		Annualized HUV	1.99

TABLE 2 (CONTD.)
HES Analysis

Scrub/Shrub	0	6,987	0.77	5,379.99	6,987	0.77	5,379.99
Swamp	10	6,987	0.77	5,379.99	6,940	0.77	5,343.80
	20	6,987	0.77	5,379.99	6,940	0.77	5,343.80
	30	6,987	0.77	5,379.99	6,940	0.77	5,343.80
	50	6,987	0.77	5,379.99	6,940	0.77	5,343.80
			Total HUV	268,999.50		Total HUV	267,370.95
			Annualized HUV	5,379.99		Annualized HUV	5,347.42
Regenerating	0	0		0.00	0		0.00
Scrub/Shrub	10	0		0.00	17	0.33	5.61
Swamp	20	0		0.00	17	0.42	7.14
	30	0		0.00	17	0.54	9.18
	50	0		0.00	17	0.67	11.39
			Total HUV	0.00		Total HUV	379.10
			Annualized HUV	0.00		Annualized HUV	7.58
Marsh	0	1,370	0.52	712.40	1,370	0.52	712.40
	10	1,370	0.52	712.40	1,367	0.52	710.84
	20	1,370	0.52	712.40	1,367	0.52	710.84
	30	1,370	0.52	712.40	1,367	0.52	710.84
	50	1,370	0.52	712.40	1,367	0.52	710.84
			Total HUV	35,620.00		Total HUV	35,549.80
			Annualized HUV	712.40		Annualized HUV	711.00
Regenerating	0	0		0.00	0		0.00
Hardwoods On	10	0		0.00	28	0.34	9.52
Spoil (Weirs)	20	0		0.00	28	0.40	11.20
	30	0		0.00	28	0.44	12.32
	50	0		0.00	28	0.50	14.00
			Total HUV	0.00		Total HUV	532.00
			Annualized HUV	0.00		Annualized HUV	10.64
Agricultural	0	254,406			254,406		
Land	10	254,406			241,762		
	20	254,406			241,762		
	30	254,406			241,762		
	50	254,406			241,762		
Ag. Land Lost To Project Features					12,683		
Habitat Lost To Project Features					95		
TOTAL AHUV				33,283.29			33,178.84

TOTAL AHUV LOST	WETLANDS AHUV LOST	UPLAND AHUV LOST
104.45	58.20	46.25

SECTION II

MITIGATION AND ENVIRONMENTAL FEATURES

SECTION II

GRAND PRAIRIE AREA DEMONSTRATION PROJECT

MITIGATION AND ENVIRONMENTAL FEATURES

II-01. MITIGATION AND ENVIRONMENTAL FEATURES

This plan describes the mitigation features considered, the screening process, and the mitigation needs associated with the proposed construction of an irrigation water import system. In addition to wetland losses, this plan also addresses construction impacts to upland hardwood forests. This plan specifically relates to activities associated with Section 401 Water Quality Certification.

This plan does not address potential impacts resulting from the construction of on-farm project features (i.e., irrigation reservoirs, water distribution systems, tailwater recovery systems) or subsequent compensatory mitigation. Individual farmers would be required to obtain Section 404(b)(1) permits for any on-farm features constructed in wetlands. The Natural Resources Conservation Service estimates that approximately 200 acres of farmed wetlands would be lost to the construction of on-farm features. Approximately 200 acres of farmed wetlands or prior converted farmland would be acquired and planted in bottomland hardwoods to mitigate this impact. It is important to note that these are only estimates of the on-farm impacts and compensatory mitigation. The actual impacts and required mitigation would be determined as each on-farm plan is completed. The project sponsor would acquire mitigation land for on-farm wetland losses in manageable tracts. Mitigation land acquisition would proceed at the same rate as construction of on-farm features.

II-02. AUTHORITIES/RESPONSIBILITIES

Pursuant to Section 401 of the Federal Water Pollution Control Act, the Memphis District, U. S. Army Corps of Engineers, will apply for state water quality certification with the Arkansas Department of Water Pollution Control and Ecology to construct the water import and delivery systems. It is assumed that all on-farm water distributions systems, conservation features, and reservoirs would be constructed on non-wetland agricultural lands; in order to construct an on-farm project feature in a wetland, a farmer would have to apply for and obtain an individual Section 404 permit from the Corps of Engineers and state water quality certification. The White River Regional Irrigation Water Distribution District (local sponsor) has the authority and capability to furnish mitigation lands for the project recommended in the general reevaluation report (GRR) and in accordance with the terms and conditions of the project cooperation agreement (PCA). All construction would be performed by contracted labor and equipment. Contracts would be administered and inspected by the Corps of Engineers. After project completion, the White River Regional Irrigation Water Distribution District would hold or transfer this property in conformance with the terms of this plan.

II-03. PROJECT DESCRIPTION

Depletion of the alluvial aquifer in eastern Arkansas, due to extensive agricultural water use, prompted the U. S. House of Representatives, Committee on Public Works and Transportation, to adopt a resolution in September 1982 authorizing the Memphis District, Corps of Engineers, to examine the feasibility of agricultural water supply and conservation improvements in the region. The Water Resources Development Act of 1996 reauthorized the Grand Prairie - Bayou Meto Project. The Grand Prairie - Bayou Meto Project was previously authorized by the Flood Control Act of 1950 and deauthorized in 1989 pursuant to Section 1001(b) of WRDA 1986.

The Grand Prairie study area encompasses 362,662 acres and includes significant portions of Prairie and Arkansas Counties and small portions of Monroe and Lonoke Counties. The primary purpose of the reevaluation study is to develop a plan that provides supplemental agricultural water, agricultural water conservation, and groundwater preservation. The selected plan consists of a major pump station and an elaborate water distribution system which utilizes existing channels, new canals, pipelines, and numerous associated hydraulic structures to transfer surface water from the White River to the project area. Water conservation measures, groundwater management strategies, retrofit of existing farm irrigation systems, and new on-farm storage reservoirs are integral parts of the plan.

II-04. RESTORATION FEATURES

Existing resources and project features would be intertwined for environmental mitigation and restoration purposes. *Mitigation* includes impact avoidance, impact minimization, impact rectification, impact reduction or elimination, and impact compensation (ER 1105-2-100, 1989). *Restoration* consists of measures undertaken to return existing fish and wildlife habitat resources to a natural condition (EC 1105-2-206, 1994). The study area includes a region that once contained a vast tallgrass prairie, upland hardwood forests, and an interconnected waterway system comprised of meandering streams and bottomland hardwood forests and forested swamps. This region annually winters large numbers of migratory waterfowl. Major environmental project features would partially restore native prairie vegetation, stream fisheries, and provide waterfowl habitat within the study area.

Prairie Restoration - Since the project area is within a region which historically contained a vast tallgrass prairie, a major environmental project feature would be an attempt to restore native prairie. A unique opportunity exists to establish native prairie vegetation within the rights-of-way of proposed irrigation canals. The proposed canals and levees would permanently take land out of crop production regardless of the rights-of-way management. Since the associated equipment berms represent only a very narrow strip of land to be taken out of production for the sole purpose of prairie restoration, restoration within the berm boundaries places no excessive burden on area farmers. Approximately 184 miles of new canals are being proposed for construction. A restoration plan to establish prairie on canal levees and associated 10-foot berms, located landward of each levee, is currently being developed. The levees and berms would comprise an area totaling approximately 3,000 acres, affording an opportunity to increase substantially the amount of tallgrass prairie within

the project area. Moreover, establishment of prairie along the canal system could serve to "vegetatively" connect many of the existing prairie remnants. Grassland restoration along these narrow strips would, therefore, provide movement "corridors" for many grassland wildlife species.

Waterfowl Habitat - Approximately 17,400 acres of harvested grain fields are currently being flooded for waterfowl each winter in the project area. Under the auspices of the North American Waterfowl Management Plan, a component of the Grand Prairie Area Demonstration Project is being developed to flood additional cropland acreage for waterfowl. Flooding additional cropland for waterfowl foraging habitat has been identified as critical in meeting the habitat requirements of waterfowl in Arkansas (Yaich 1990) as well as the entire Lower Mississippi Valley (Loesch et. al. 1994). The selected plan involves the annual flooding of approximately 38,529 acres of harvested and rolled rice fields from 1 October until 28 February of each year.

Weirs and Additional Water in Receiving Streams - Approximately 120 weirs would be constructed in existing channels and streams at various locations throughout the project area. The primary purpose of these weirs is to impound water for irrigation pumping. However, these weirs with their associated upstream pools and tailwater areas would also significantly improve fishery habitat. Aquatic habitat benefits derived from stream weirs includes provision of structure, increased dissolved oxygen content, food concentration, and depth and current variation. Fish sampling surveys conducted during the summer of 1996 within the study area indicated that existing weirs provided habitat for fishes that were rare or sporadic in occurrence. In fact, white bass and spotted sunfish were found only around existing weirs, and golden topminnow and bantam sunfish were substantially more abundant at weirs than in other reaches (see Appendix C, Section V).

Weirs are usually made of concrete, riprap, or a combination of both and placed in a river or tributary to raise upstream water levels or maintain minimum pool elevations. Therefore, these structures can prevent upstream and downstream movement of fishes. The ability to make spawning runs is crucial to the maintenance of some fish populations (Schnick et al. 1981). However, dominant taxa of the Delta tributaries are not large, migratory species, but rather small habitat generalists that exhibit only localized movement. Localized movement of fishes within the study area streams may not be totally prevented since predicted maximum water depths are one to four feet over the crest elevation of proposed weirs (see Appendix C, Section V).

Extremely low flows occur within most project area streams during the summer because of channelization and withdrawals for irrigation. Therefore, additional water that is being pumped from the White River would obviously improve the habitat quality for fish, especially during the spring and summer months. In fact, the gain in habitat units (HUs) for the receiving streams and existing canals totaled 4,328 HUs per month. However, it is important to note that these streams contain very tolerant species that are only remotely similar to the parent fauna of the White River (see Appendix C, Section V). Therefore, fishery improvement in the receiving streams does not constitute in-kind mitigation. However, this feature does provide stream restoration.

II-05. MITIGATION FEATURES

A *mitigation feature* is best described as an "on - site" established fish and wildlife resources management procedure, activity, or technique that is designed to offset construction and/or associated impacts (ER 1105-2-100). Numerous mitigation features that would partially offset terrestrial and aquatic losses have been incorporated into the project design. The following two features exemplify efforts to reduce impacts.

1. Environmental review of canal/pipeline alignment identified several opportunities to relocate these items into road right-of-ways or open land to minimize habitat losses.

2. Pipeline clearing limits in woodlands were reduced from 50 feet to 25 feet.

II-06. PROJECT IMPACTS

Impacts to bottomland hardwoods, forested swamp, scrub/shrub, and marsh categories are grouped here in a single wetlands category. Impacts associated with the selected alternative also include losses to upland hardwood habitat; impacts to upland hardwood forest would be mitigated in-kind because of major reductions in this forest type over historic conditions. Habitat losses are also identified as being permanent or temporary. All impacts associated with pipeline construction are considered to be temporary and all impacts associated with canal construction are considered to be permanent. A detailed explanation of habitat unit values, acreage impacted, and loss calculations is found in Appendix C, Section I, Habitat Evaluation System Analysis. Permanent and temporary impacts due to project construction are summarized as follows:

Canals and Pipelines

Upland Hardwoods Permanently Impacted by Canals:	54 acres
Upland Hardwoods Temporarily Impacted by Pipelines:	55 acres
Total:	124 acres

Wetlands Permanently Impacted by Canals:	40 acres
Wetlands Temporarily Impacted:	26 acres
Total:	66 acres

Water Retention Weirs

Upland Hardwoods Permanently Impacted:	5 acres
Upland Hardwoods Temporarily Impacted:	10 acres
	Total: 15 acres
Wetlands Permanently Impacted:	24 acres
Wetlands Temporarily Impacted:	31 acres
	Total: 55 acres

In summary, approximately 59 acres of upland hardwoods and 64 acres of wetlands would be permanently impacted. Approximately 65 acres of upland hardwoods and 57 acres of wetlands would be cleared but replanted or allowed to regenerate following construction. The acreage shown for temporary weir impacts includes construction of access roads.

II-07. MITIGATION NEEDS

Mitigation needs for terrestrial habitat losses were calculated using the data generated in the Habitat Evaluation System (HES) analysis. Habitat Quality Index (HQI) values for the various cover types identified during the habitat evaluation process were applied to the acres of uplands and wetlands permanently and temporarily impacted. Losses, in terms of Annualized Habitat Unit Values (AHUVs) were then tabulated in the HES table found in Appendix C, Section I.

Project impacts to 123 acres of wetlands (64 acres permanent and 59 acres temporary) would result in the loss of 58.20 AHUVs. Project impacts to 139 acres of upland hardwoods (59 acres permanent and 65 acres temporary) would cause the loss of 46.25 AHUVs. The total AHUV loss is 104.45. However, compensatory mitigation would have to specifically offset the loss of 58.2 wetland AHUV's and 46.25 upland hardwood AHUV's.

II-08. MITIGATION ALTERNATIVES CONSIDERED

A wide range of mitigation alternatives were considered for mitigating the unavoidable wildlife habitat losses associated with project construction. The categories of habitat losses considered in the formulation of mitigation alternatives were upland hardwoods, bottomland hardwoods, and other wetlands. Some alternatives mitigate more than one category of loss. The Habitat Evaluation System (HES) was used to quantify losses and consequently establish the need for, the amount, and type of mitigation.

Bottomland hardwood and upland hardwood impacts would be the most significant in terms of AHUV's lost. It was determined that upland hardwood losses in the Wattensaw Wildlife Management Area and at other sites would be mitigated in-kind because of their uniqueness to this geographic region. Alternatives considered for mitigation of bottomland hardwood and upland

hardwood losses were: (1) preservation easements to maintain buffer strips along the newly constructed canals, (2) fee title land acquisition within the study area, and (3) development of public land within the study area.

Buffer Strips - Since canal construction would be done from both sides, a 10-foot wide equipment berm would be required on each side of the canal levees. The easements to be obtained for project construction would specify that the right-of-way not be used for agricultural purposes. Therefore, berm and disposal areas not needed for maintenance operations would be allowed to revegetate by natural succession. These berm and spoil strips would provide a continuous tract of hardwoods contiguous to the new canals for their entire length. These wooded strips would help retain the stability of the channel and filter non-point drainage. The continuous woodland strips would also connect large forested tracts within the study area thereby providing wildlife travel corridors.

Fee Title Land Acquisition and Reforestation Within the Study Area - This alternative would provide one or more contiguous blocks of land that would be managed for public use. Wetland and upland habitat losses would be mitigated with the reforestation of cleared land acquisitions. Prior converted farmland and farmed wetlands would be targeted for wetlands restoration sites; it may be necessary to restore hydrology to all or some of the wetlands mitigation sites. Upland mitigation sites would be reforested in selected upland hardwood tree species, and wetlands mitigation sites would be planted in selected bottomland hardwood species. These sites would be managed to provide public use and sustained habitat for game and non-game species.

Development of Public Lands Within the Study Area - Publicly owned land within the study area includes the White River National Wildlife Refuge, Cache River National Wildlife Refuge, and Wattensaw Wildlife Management Area which is owned and managed by the Arkansas Game and Fish Commission. Intensive management of these areas was considered as a potential means for partial mitigation of habitat losses. Management measures such as intensified forest management, planting upland and bottomland hardwoods on the appropriate open lands, food plots, green tree reservoirs, and moist soil units were considered.

II-09. SCREENING OF MITIGATION ALTERNATIVES

The mitigation alternatives described in the preceding paragraphs were evaluated as to their ability to offset the fish and wildlife habitat losses that would result from the construction of the entire import system. Table 1 shows the mitigation alternatives considered, identifies those deleted and those considered in detail, and states the reason for deletion or further consideration. Fee acquisition and subsequent reforestation of privately owned land within the study area was the only alternative retained for further analysis. The paragraphs that follow provide a more detailed description of the process for screening mitigation alternatives.

TABLE 1

SCREENING OF MITIGATION ALTERNATIVES

Alternative	Delete	Retain	Reason
Buffer Strips	X		Contributes to water quality, fishery, wildlife corridors, and channel stability. Mitigation for bottomland hardwoods would be extremely limited because levees would be constructed along much of the right-of-way thereby creating "upland" sites. This alternative does not provide a large, manageable, contiguous block of land. Also, the best use of the acquired right-of-way is for the previously described prairie restoration. This prairie restoration would also contribute to water quality in the adjacent channels. Use of can rights-of way for prairie restoration reforestation is also preferred by the project sponsor.
Reforestation of Fee Title Land Within the Study Area land		X	Provides mitigation in manageable units for upland hardwoods, bottomland hardwoods, and other wetlands. Fee acquisition and subsequent reforestation of privately owned within the study area would provide a net increase in lands that are available for public utilization.
Development of Public Lands Within the Study Area bottomlands, upland hardwood restoration of existing would not provide a net	X		Within the Wattensaw WMA, even extremely intensive management would not produce the needed management credits. There is hardly any cleared bottomland available for bottomland hardwood restoration. Each refuge also contains only a limited amount of prior-converted and/or farmed wetland remaining that has not be restored to bottomland hardwoods. Also, since most of the refuge lands are typical sites would not be available for restoration. Moreover, federal or state property increase in public land.

II-10. COST EFFECTIVE ANALYSIS OF REFORESTATION TECHNIQUES

The cost effectiveness approach was developed to provide a means of examining the costs associated with various methods of habitat restoration and the associated outputs. The thrust of previous analytical methods focused primarily on project costs due, in part, to the absence of an adequate econometric means to estimate the project benefits for environmental outputs in pecuniary terms. The analytical processes involved in these cost analyses are: (1) cost effectiveness analysis to insure the least cost solution is identified for each possible level of environmental output and (2) identification of considerations and needs other than reforestation costs. Four planting methods for reforesting mitigation sites were evaluated.

The resulting benefits and costs associated with reforestation of mitigation lands were used in a cost effectiveness analysis to evaluate various reforestation alternatives in terms of costs per annualized habitat unit value (AHUV). It was assumed that the tree growth rates of regenerating bottomland and upland hardwood forests would be similar; therefore, the same average habitat quality index (HQI) values were used for both upland hardwood and bottomland hardwood sites. Also, the planting costs for both hardwood types would be the same. Numerous planting options that included various treatments such as fertilizer, site preparation, etc., were considered but the selection was narrowed down to the four methods described below.

Acorns, Aerial Seeding - Site would be disced prior to planting. Acorns would be planted by aerial direct seeding at 10 pounds per acre. This method results in fair to poor survival rates. Planting cost is approximately $70.00 per acre.

Acorns, Tractor Plant - Site would be disced prior to planting. Acorns would be planted with a tractor and mechanical planter at a rate of 440 acorns per acre. This method results in fair to poor survival rates. Planting cost is approximately $75.00 per acre.

Seedlings, Tractor Plant - Site would be disced prior to planting. One-year old seedlings would be planted with a tractor and planting machine at a rate of 440 seedlings per acre. This method results in excellent survival rates. Planting cost would be approximately $140.00 per acre.

Seedlings, Hand Plant - Site would be disced prior to planting. One-year old seedlings would be planted by hand at a rate of 440 seedlings per acre. This method results in excellent survival rates. Planting cost would be approximately $180.00 per acre.

In order to determine the mitigation acreage necessary to offset wetland and upland hardwood forest AHUV losses under each reforestation alternative, the following formula was used: mitigation acreage required = AHUVs lost divided by the management potential of each alternative.

The management potential (MP) was calculated for each planting alternative. The formula for calculating the MP is as follows: MP = annualized HQI of land with management minus the

annualized HQI of land without management. "Land without management" is cleared agricultural land, and "land with management" is land that has been reforested. The annualized HQI for cleared land within the study area was determined to be 0.25. The annualized HQI of the managed land would vary with the reforestation technique employed. It was assumed that the growth rates and annualized HQI values of regenerating upland and bottomland hardwoods would be the same. Also, planting costs for both hardwood types would be the same.

The planting cost per acre varies by alternative as presented above. These cost estimates are based on cost figures of actual planting operations on state and federal lands within the Lower Mississippi Valley. The cost per acre includes labor, equipment, and seedlings and/or acorns. The acquisition cost per acre of cleared land was estimated to be $1,104.93. Table 2 displays the required mitigation acreage, planting costs, land costs, and total cost per AHUV for each of the four reforestation alternatives.

TABLE 2
COMPARATIVE PLANTING ALTERNATIVE COSTS

Alternative	Average HQI			Acres Required				
	With Mgmt.	W/out Mgmt.	MP	Bottomland Hdwds.	Upland Hdwds.	Total Planting Costs	Total Land Costs	Total Cost/ AHUV
Acorns, Aerial Seeding	0.41	0.25	0.16	364	289	$45,710	$721,519	$7,345.42
Acorns, Tractor Plant	0.43	0.25	0.18	323	257	$43,500	$640,859	$6,552.02
Seedlings, Tractor Plant	0.49	0.25	0.24	243	193	$61,040	$481,749	$5,196.64
Seedlings, Hand Plant	0.49	0.25	0.24	243	193	$78,480	$481,749	$5,363.61

II-11. SELECTED ALTERNATIVE

It was determined through the cost effective analysis that the mechanical planting of seedlings is the most cost effective ($5,196.64/AHUV) method for reforesting mitigation sites. However, this alternative was not selected as the preferred alternative. The hand planting of seedlings was selected as the preferred planting alternative. Although the hand planting of seedlings is not quite as economical ($5,363.61/AHUV) as planting by mechanical means, hand planting was selected because of the need to randomly distribute seedlings to achieve a more "natural" appearance. Reforestation with a tractor and planter is restricted to the placement of seedlings in rows.

Approximately 243 acres of prior converted wetland or farmed wetland would be acquired to replace wetland AHUV losses and approximately 193 acres of cleared upland property would be purchased to replace the upland hardwood AHUV losses. These bottomland and upland sites would be planted in bottomland and upland hardwood species, respectively. Bottomland hardwood mitigation for the forested swamp, scrub/shrub, and the marsh wetland types does not represent true "in kind" mitigation. However, the AHUV losses within the other wetland categories is quite small; and reforestation of bottomland hardwoods maximizes AHUV gains. Moreover, state and federal resource agencies prefer bottomland hardwood restoration to mitigate the losses in all wetland categories. Many of the tracts to be considered for acquisition would most likely contain cleared wetland restoration sites (i.e., prior converted farmland, farmed wetlands), cleared uplands, and portions that are forested. Tracts would likely be purchased that contain a variety of soils, hydrology, and cover types since efforts would be made to purchase land from "willing sellers" and also to acquire large contiguous tracts of land. This means that the acreage of prior converted cropland and farmed wetlands, cleared uplands, and woodland must be tabulated and tracked as prospective sites are identified and screened.

A detailed planting scheme cannot be prepared until site selection is imminent. However, the following tentative planting recommendations are submitted and may be amended for site specific conditions at a later date. Mitigation tracts would be planted in a variety of bottomland or upland hardwoods to offset upland and wetland losses. Both bottomland and upland mitigation sites would be comprised of cleared agricultural land, and all planting areas would be disced prior to planting. Discing temporarily controls weed competition, reduces rodent cover, facilitates planting and inspection, and stimulates early successional growth of grasses and forbs that are desirable to a variety of wildlife species. The tree planting contract would require a 66% survival rate one year after planting. All trees would be hand planted on 10-foot centers (440 seedlings per acre) with random distribution (not in rows) in order to insure a natural appearance. Also, seedlings would be planted as a mixture of different species. All seedlings would be planted as soon as possible after the mitigation property is acquired, depending on weather conditions and planting season. Seedlings would be planted by contract personnel after approval of a site plan and acquisition of the property. A minimum of four tree species would be planted at each site and no single species shall exceed 30% of the total trees planted on each site. The tree planting contractor shall select four different species from the following lists.

Upland Hardwood Sites	Bottomland Hardwood Sites
Post oak	Nuttall oak
Southern red oak	Overcup oak
White oak	Cherrybark oak
Shagbark hickory	Baldcypress
Black cherry	Green Ash
Black Walnut	Bitter pecan
Scarlet oak	Pin oak
Shingle oak	Water oak

II-12. SITE SELECTION PROCESS

Mitigation of project induced wetland and upland habitat losses would be provided by the project sponsor. Mitigation site selection would be conducted by an interagency team comprised of representatives of the Corps of Engineers, U. S. Fish and Wildlife Service, Natural Resources Conservation Service (NRCS), Arkansas Game and Fish Commission, Arkansas Department of Pollution Control and Ecology, Arkansas Natural Heritage Commission, and the White River Regional Irrigation Water Distribution District (project sponsor). Site selection criteria would include land classifications such as prior converted farmland or farmed wetland, soils, hydrology, proximity to other resources, tract size, and "willing sellers." Top priority would be given to those tracts that meet criteria selected by the interagency team and adjoin an existing state management area, federal refuge and/or similar land unit. Also, every effort would be made to acquire large, contiguous, "manageable" tracts as opposed to small isolated units. One of the first steps in the selection process would be to meet with the NRCS district conservationists to identify prior converted and farmed wetland units within the Grand Prairie study area. After potential sites have been identified on maps and/or aerial photographs; the mitigation team would visit each site and evaluate it's potential based upon the selection criteria.

II-13. MITIGATION SITE PLAN

Since preliminary acquisition agreements have not been reached, a detailed mitigation plan cannot be prepared at this time. However, a detailed site plan that describes access, acreage, soils, hydrology, and vegetation would be prepared and submitted to the Arkansas Department of Water Pollution Control and Ecology and other cooperating agencies as soon as mitigation lands have been identified and a preliminary acquisition agreement has been made. The wetland site plan would be developed in accordance with mitigation guidance found in the multi-agency draft publication *Arkansas Wetland Conservation Plan.* The detailed mitigation plan would also include descriptions of any "improvements" such as plantings and/or hydrologic modifications if needed.

II-14. MANAGEMENT

The selected mitigation tracts would be acquired in fee title by the project sponsor, the White River Regional Irrigation Water Distribution District. These tracts would be managed to provide public use and sustained habitat for game and non-game species.

II-15. MONITORING

Tree plantings would be monitored twice a year for one year to assess survival rates. Plantings would be considered successful if equal to or exceeding 66 % survival. If survival rates fall below 66%, additional plantings would be made to replace the dead stems. In addition, those sites that may require hydrologic modifications would be inspected annually so as to insure that wetland conditions are being maintained.

SECTION III

WATER QUALITY

GROUND WATER INSTITUTE

THE UNIVERSITY OF MEMPHIS

EASTERN ARKANSAS GROUND WATER QUALITY ASSESSMENT

performed by

HERFF COLLEGE OF ENGINEERING
GROUND WATER INSTITUTE

John W. Smith, Ph.D., P.E., DEE
Kandita Horne Waller
Jennifer Redden

for

U. S. Army Corps of Engineers
Memphis District

February 1997

Department of Civil Engineering/Herff College of Engineering/Memphis, Tennessee 38152
A Tennessee Board of Regents Institution
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PREFACE

The Ground Water Institute at the University of Memphis was organized in 1992 as a research/service unit within the Herff College of Engineering with the fundamental mission of performing research for and service to ground water management decision makers. The nucleus of the Institute is a data base of spatially related ground water data accessible through a geographic information system.

The Institute undertakes project oriented research which will contribute to the mission of the Institute and which has adequate academic integrity. As part of the partnering arrangement established between the Memphis District, U. S. Army Corps of Engineers, and The University of Memphis, the Institute has made available to the Memphis District the staff and facilities of the Institute in an analysis of the ground water quality of the Grand Prairie region of Eastern Arkansas.

Funding for this project was provided in part through a contract with the Memphis District of the U. S. Army Corps of Engineers. Facilities and support staff of the Institute were provided by the University. Special appreciation is expressed to the following Institute and/or Civil Engineering personnel: James Outlaw, Research Associate; Sarah Iverson, Merrie Salyers, Jonathan Smith, Undergraduates; and Paul Palazolo, Visiting Professor.

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I. BACKGROUND

The hydrology of the Grand Prairie region of Eastern Arkansas was extensively studied in the decades of the 80's and 90's as water use for irrigation created excessive drawdown of the alluvial aquifer. The ground water problems experienced in the Grand Prairie have also appeared in other areas of Eastern Arkansas in the alluvial aquifer. A water resources demonstration project has been proposed for the Grand Prairie region of Eastern Arkansas which would augment ground water use in the region with surface water diverted from the White River. The preliminary plan of improvement for the Grand Prairie area consists of a major pumping station and a network of new canals, existing channels, pipelines, and associated channel structures to provide intrabasin transfer of the surface water to the ground water depleted areas. Included as an integral part of the plan are: conservation measures, ground water management strategies, on-farm storage reservoirs, and fish/wildlife restoration and management features. A pumping facility located on the White River just North of DeValls Bluff would be utilized to deliver surface water from the White River throughout the project area during peak use periods and for filling storage reservoirs during off-season periods. Conservation practices in the plan include water management of irrigation applications, irrigation pipelines, and tailwater recover systems. Fish and wildlife restoration and management will be an integral part of the system's operation - especially during the off-season.

The Mississippi River Valley alluvial aquifer is a part of the Mississippi Embayment aquifer system in the Gulf of Mexico Coastal Plain. The alluvial aquifer is prolific; ground water withdrawals totaled 7,600 cubic feet per second in 1985, mostly for irrigation of rice, and accounted for nearly 60 percent of all ground water pumpage in the Gulf Coastal area[1]. The alluvial aquifer consists of 60 to 140 feet of sand and gravel of Quaternary Age, grading from gravel at the bottom to fine sand near the top, and underlying 32,000 square miles in parts of Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee. Throughout most of the area, the alluvial aquifer is overlain by the Mississippi River Valley confining unit - 10 to 50 feet of silts, clays, and fine-grained sands. The thickness of the confining unit is highly variable. The underlying beds consist of alternating sands and clays of the Mississippi Embayment aquifer system[1].

The hydrogeology of the Mississippi River Valley alluvial aquifer has been described by Ackerman and others, including the development of a conceptual model for steady-state regional flow analysis. An intensive analysis of the effects of pumping on the Grand Prairie

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[1] Ackerman, D. J., *Hydrology of the Mississippi River Valley Alluvial Aquifer, South-Central United States--A Preliminary Assessment of the Regional Flow System,* Water Resources Investigations Report 88-4028, U.S.G.S., 1989

region of the alluvial aquifer was performed by Waldron[2] for the Memphis District of the U. S. Army Corps of Engineers. The study, which was part of a partnering agreement between the University and the Memphis District, focused on the ground water depletion effects of pumpage from the alluvial aquifer in Eastern Arkansas and the possible effects of the pumpage on the natural environment. Existing as well as projected conditions with the proposed White River diversion project in place were simulated using the U.S.G.S. MODFLOW finite-difference model. While the previous U.S.G.S work[1] was very useful for the Waldron model development, it was a region model which specifically was not to be used for local analyses. Waldron's work expanded the previous U.S.G.S. simulations for this specific region.

The water augmentation project being implemented by the U. S. Army Corps of Engineers would divert sufficient water from the White River to allow a 93 % reduction in ground water withdrawal from the alluvial aquifer. The Waldron study concluded that if agricultural pumpage continued at its current rate, the saturated thickness of the alluvial aquifer in the Grand Prairie region would drop to a point where recharge would not be possible. The predicted time frame for this would be by the year 2050. The White River water augmentation project, implemented by the year 2015, would allow the aquifer to rebound in the Grand Prairie region.

The changes in water quality caused by the commingling of the White River water with the existing surface water bodies and continued limited well water could potentially create problems to the natural environment and the agricultural activities of the region. While Waldron[2] evaluated the impact of the White River diversion on the wetlands, no attempt was made to investigate the changes in water quality. A more comprehensive environmental analysis of the project would include an analysis and assessment of the changes in water quality and the effect of these changes on the natural environment as well as the agricultural activities.

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[2] Waldron, B. A., and Anderson, J. A., *Development of a Ground Water Flow Model with Predictive Solutions for Grand Prairie Project Implementation, Ground Water Institute,* University of Memphis, 1995

II. SCOPE OF STUDIES

The overall objective of this study was to assess the impact on the quality of water used for irrigation when surface water diversion occurs. A necessary part of the study was the evaluation of the sufficiency of existing data to assess the impacts, both positive and negative, of the proposed demonstration project on water quality [both ground water and surface water] and to augment the existing data with field studies where necessary. Specifically, the initial phase of the study was to accumulate existing water quality data and to analyze the sufficiency of the data to make projections of the long-term impact of the surface water usage. The second phase was to execute the necessary field studies to generate additional water quality data necessary to augment the historical data base. The final portion of the study was an analysis of the impact of projected water quality changes on agricultural activity in this region. The expected output of this study would be a summary report of available data, any additional data which was required to complete an environmental evaluation, and a final environmental evaluation of the impact of surface water diversion for ground water augmentation.

III. STUDY PROCEDURE & GENERAL APPROACH

In order to assess adequately the effects of the change in the quality of the water used for agriculture and aquaculture with the proposed demonstration project, several pieces of data had to be developed. The characteristics of the ground water presently used of irrigation and aquaculture as well as the characteristics of the surface water proposed for augmentation need to be defined. The amount of water used both in the present scenario of primary dependence on ground water resources and the proposed project scenario of surface water augmentation has been projected as part of Waldron's work[2]. A limited amount of field verification including discussions with water users in the Grand Prairie region and actual field data collection was incorporated into the study. All of the water quality data were placed in a geographic information system data base for ease of analysis and recall.

The primary source of the existing water quality data for this region was the U. S. EPA STORET data base. A CD-ROM of the STORET data for Eastern Arkansas was obtained from EARTHINFO[3] . This data base included both ground and surface water quality parameter values through 1994.

Several U. S. G. S. reports contain generalizations of ground and surface water quality; however, all of the discrete data were found in the STORET data base. A study which specifically focused on the impact of agricultural practices on ground water quality was performed by Leidy[4] for Lonoke County. The study concluded that the potential for widespread ground water contamination in the study area was low because of the relatively impermeable clay and silt deposits of the alluvial confining unit that overlie the alluvial aquifer in most of, if not all, of the study area. Locally, however, potential contaminants might enter the aquifer from streams incised into and in hydraulic connection with the alluvial aquifer.

The Arkansas Department of Pollution Control and Ecology[5] instituted an on-going ambient "prototype" monitoring program in 1986 to gather background ground water quality data from various aquifers in the state. One of the prototype areas encompasses approximately 90 square miles surrounding the town of Lonoke in central Lonoke County. This prototype was selected because it represented an agricultural community in the Mississippi Delta where pesticide and fertilizer use increases the possibility of ground

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[3] EARTHINFO, EPA STORET 1995, Region 6:2, States AR, LA, EARTHINFO, Inc., Boulder, CO, 1995

[4] Leidy, V. A., and Morris, E. E., *Ground Water Quality and Preliminary Assessment of the Potential for Contamination Beneath Agricultural Lands in Central Lonoke County, Arkansas,* Water Resources Investigations Report 90-4009, U.S.G.S., 1990

[5] Anon,1994 Water Quality Inventory Report, Arkansas Department of Pollution Control & Ecology, 1994

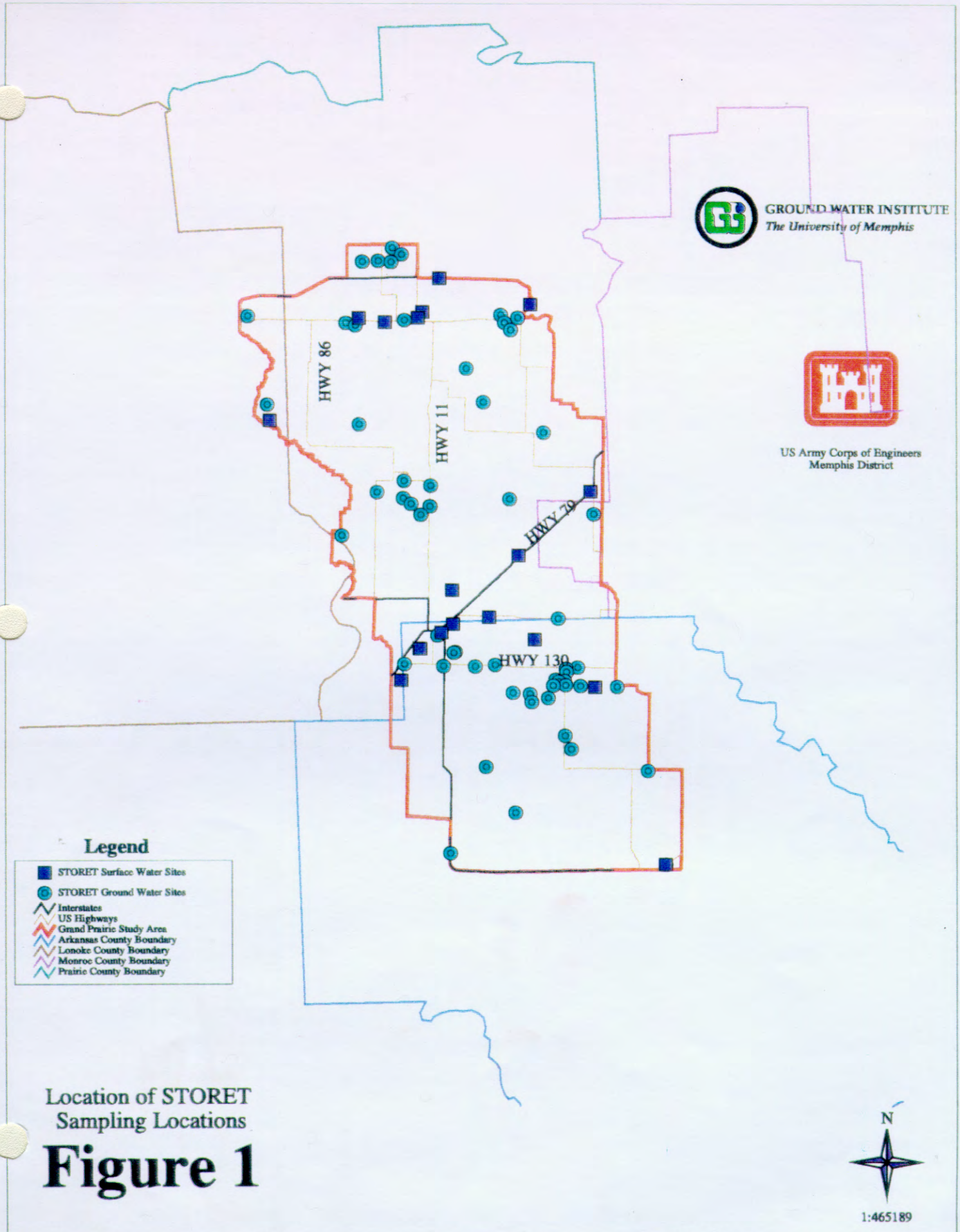
water contamination. The objective of the monitoring program was to determine if agricultural practices in the Lonoke, Arkansas, area have resulted in ground water contamination in the Alluvial aquifer with pesticide residues and nitrates associated with fertilizer application. Results of the first two sampling periods initiated in the late spring and summer of 1988 and 1991 are available. Analysis of the data from the studies did not indicate that the agricultural use of pesticides and fertilizers in this area created elevated levels of nitrates in the ground water. Similarly, pesticide residues were not present in the ground water.

Data defining the surface water quality in the Grand Prairie region were available in the STORET data base[3] and the 1994 water quality inventory published by the ADPCE[5]. The extent of the surface water quality data base is considerably greater than that for the ground water data.

A geographic information system (GIS) data base was created in order to analyze the data and to develop graphical outputs. The GIS coverage developed by Waldron[2] was used to create a basic coverage of each county within the Grand Prairie region complete with major roads and water bodies (streams and open water). The project boundary as defined by the Corps project team in 1995 was used in the data base development. A coverage was also created which contained all of the wells for which data are available in the STORET data base. The location of the wells was determined by the longitude and latitude values in the STORET data base. All of the water quality values in the STORET data base were appended to each well and became part of the GIS data base. Water quality data for the White River were also included in the STORET data base and incorporated into the GIS data base.

IV. ANALYSIS OF EXISTING DATA

As shown in Figure 1, the distribution of wells and surface water sampling locations for which STORET data are available within the Grand Prairie region is not spatially uniform. A compounding problem is that very few of the sites have been sampled over multiple years. A complete listing of the wells and surface water sampling locations in the STORET data base which are within the study region is given in Appendix A. Using the GIS data base, a water quality coverage was created for selected parameters which represented the average value of the specific parameter in the areas where well data were available. The parameters of interest were the conservative, inorganic materials which will remain in the soil and potentially cause a "salting" of the agricultural area and thus decrease agricultural productivity. Selection of these parameters was made following analysis of the historical values for both the ground water and the White River water. These parameters represented those with the greatest difference and thus the greatest impact due to the water diversion project. Coverages for each selected parameter in the region are included in Appendix B. The surface water sampling locations reflect the water quality in the interior drainage systems. One set of data for the White River at DeValls Bluff was included in the data base for reference purposes.



Location of STORET Sampling Locations

Figure 1

V. ASSESSMENT OF EXISTING DATA BASE

One of the unknowns of the water quality study was whether adequate water quality data were available to assess the impact of the surface water diversion project. Existing ground water data exist for the period of 1929 to 1988; however, very few of the ground water sources have been repetitively sampled during this time period. Computer generated average values for each decade indicated that the ground water quality values were not consistent across the decade analysis periods. This could be because of changes in water quality, differences in analytical precision, or simply the lack of repetitive values. Equally sparse were values for surface water within the study area as is evident from an analysis of the figures in Appendix B. Very few sampling sites have been reported in the study area. A wealth of water quality data for the White River exists for the DeValls Bluff sampling location. Potentially toxic organic and inorganic compounds do not appear to be present in the surface water at significantly higher levels than in the presently used ground water.

Because of the variability in the ground water quality data in the STORET data base, reasonable predictions of changes in water quality due to the surface water diversion project required limited field data to confirm the existing water quality data base.

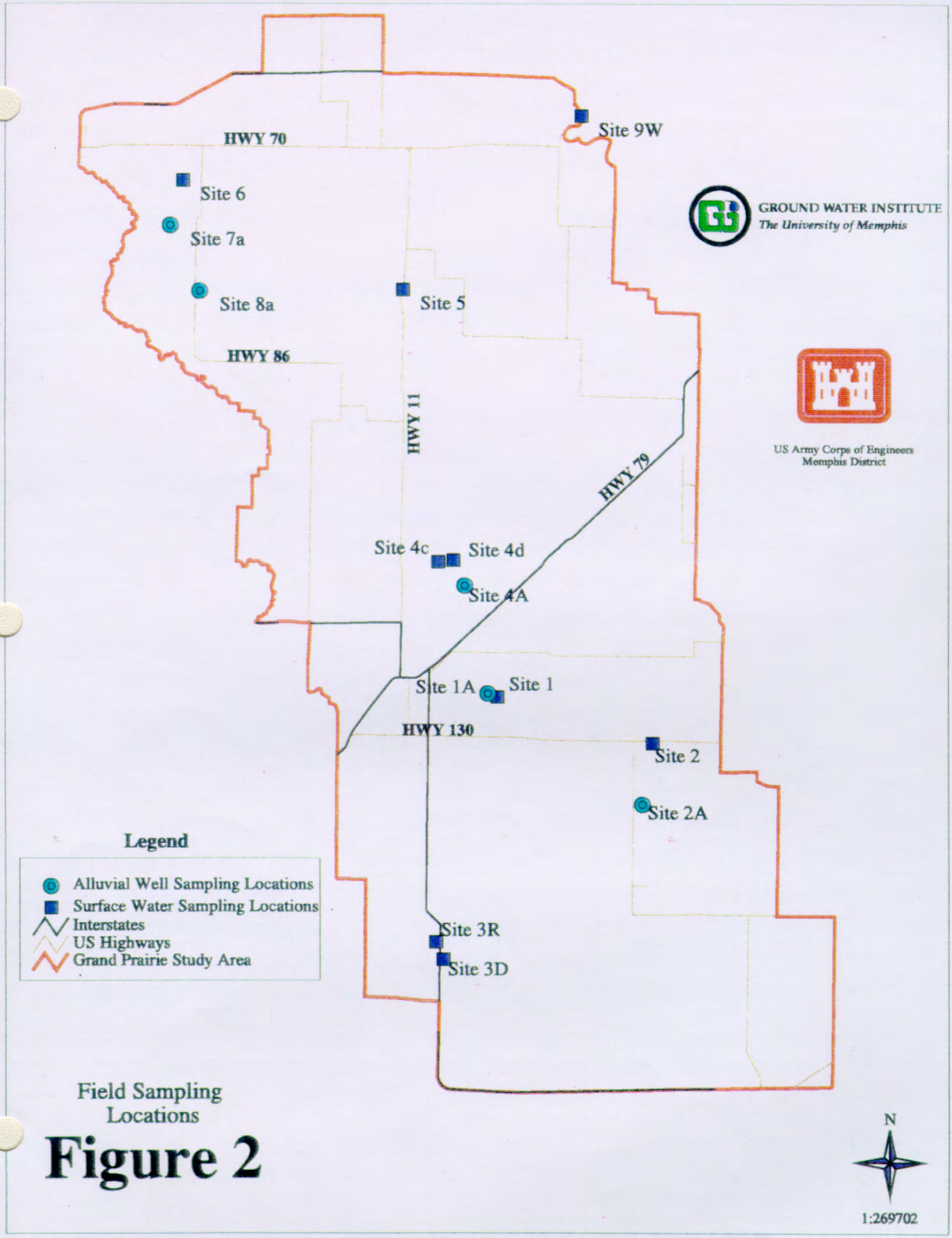
VI. FIELD SAMPLING PROGRAM

Because of the inconsistency of the historical ground water quality values and the limited surface water quality data, a field sampling program was conducted to gather sufficient ground and surface water quality data to confirm the validity of using the historical data base. Surface water reservoirs which are presently used to capture interior surface water drainage as well as tail water recovery systems used at the end of the growing season are prevalent in the study area. Many of the man-made structures also receive ground water from the alluvial wells.

A water quality sampling program using the sites shown in Figure 2 was undertaken to provide quality data for the water which is presently being used for irrigation. These locations were selected with the assistance of Lori Walton of the White River Irrigation District. The alluvial wells were selected in close proximity to the reservoirs to permit sampling at the same time to provide confirmation data for the STORET data. Surface water was sampled in the reservoirs which are used for tail water recovery. Many of the interior drainage ditches were dry during much of the growing season and had limited flow immediately following an intense rain. However, excess irrigation water and water removed from the fields at the end of the growing period filled the ditches and was subsequently pumped into the reservoirs. Thus, from the perspective of the quality of surface water presently used for irrigation, the reservoirs were deemed appropriate for sampling. At the present time, the flow in the interior streams is a mixture of precipitation runoff and irrigation water, with the majority being irrigation water. In most locations within the study area, the irrigation water begins as ground water pumped from the alluvial and Sparta aquifers which runs off the fields or is pumped directly into the reservoirs (Sampling Site 7a for instance).

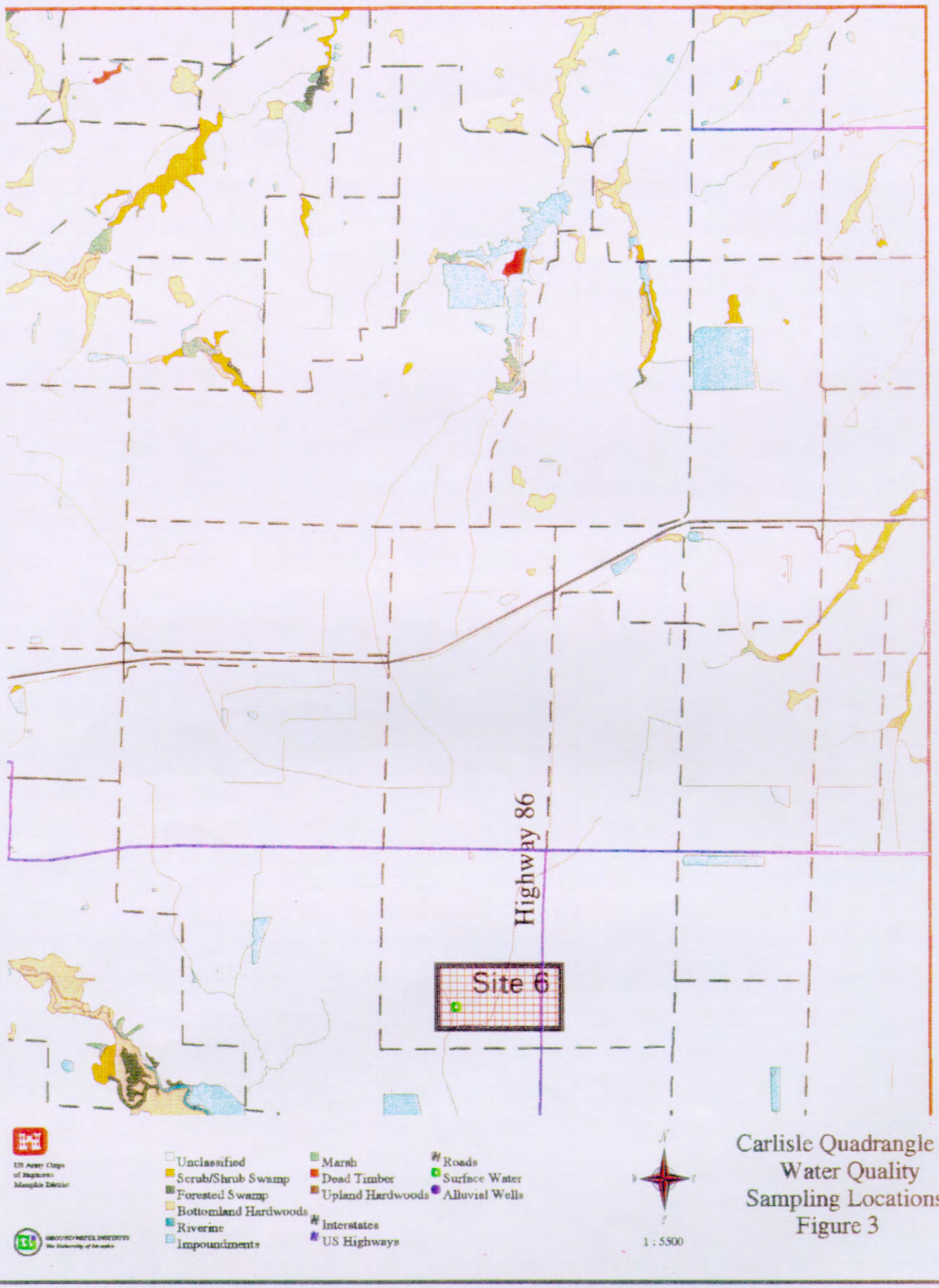
Grab samples from the surface and ground water locations were obtained on an approximate two week frequency from the beginning of the planting period [early May] through the completion of the crop season [late August]. Reservoir samples were obtained from the bank of the reservoir with due care taken to avoid biasing the sample due to wave action. Ground water samples were obtained from the discharge of the operating alluvial wells. The location of the surface and alluvial sampling sites is shown in more detail in Figures 3 through 9.

Each sample was analyzed in the field for temperature, pH, and conductivity. Laboratory analyses were performed for total hardness, calcium hardness, alkalinity, turbidity, color (true and apparent), fecal coliform level, copper, iron, and nitrates. All of the laboratory analyses were performed in the Environmental Engineering laboratory of the University of Memphis.

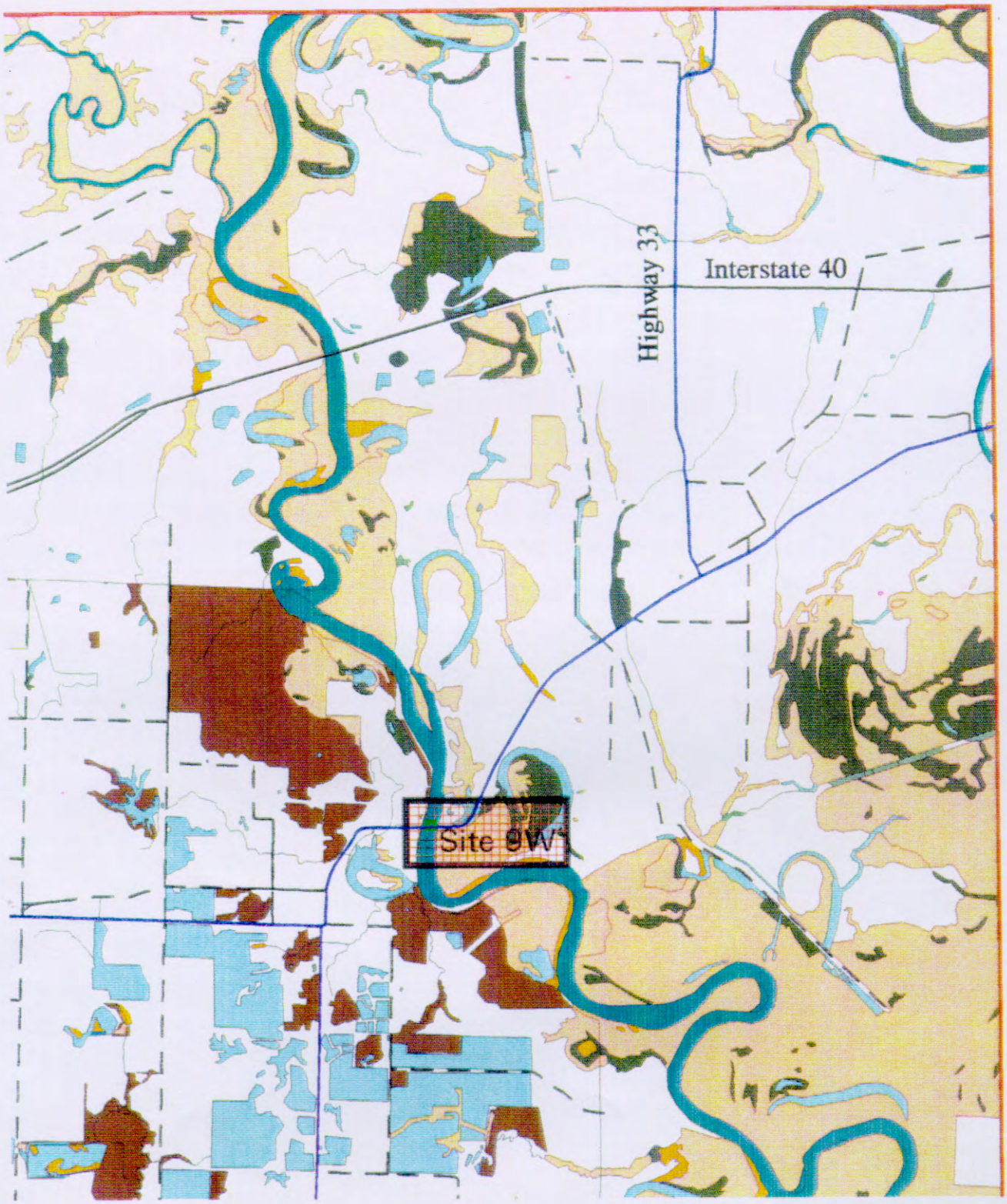


Field Sampling Locations

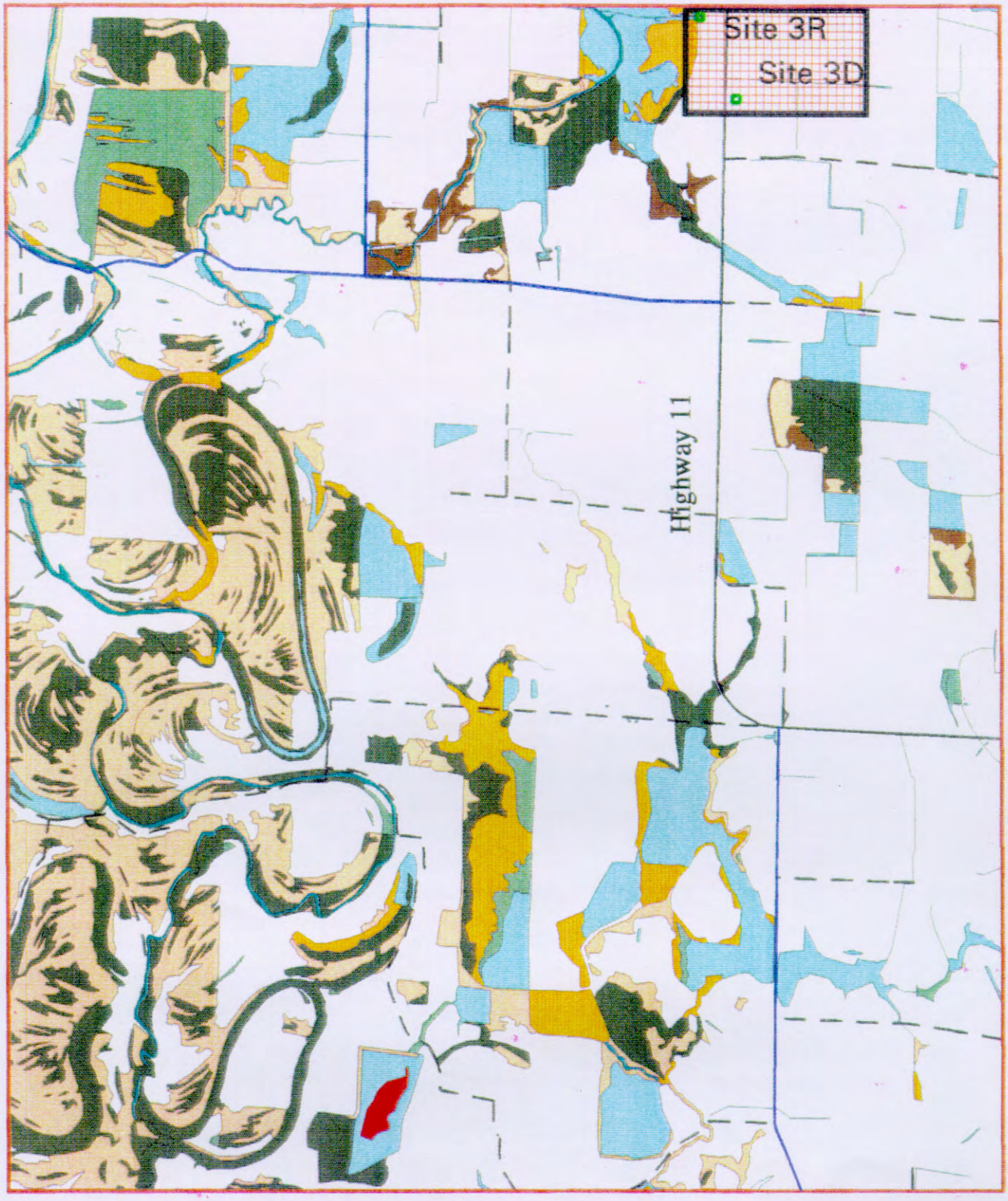
Figure 2



Carlisle Quadrangle
Water Quality
Sampling Locations
Figure 3



DeValls Bluff Quadrangle
Water Quality
Sampling Locations
Figure 4



US Army Corps of Engineers Memphis District

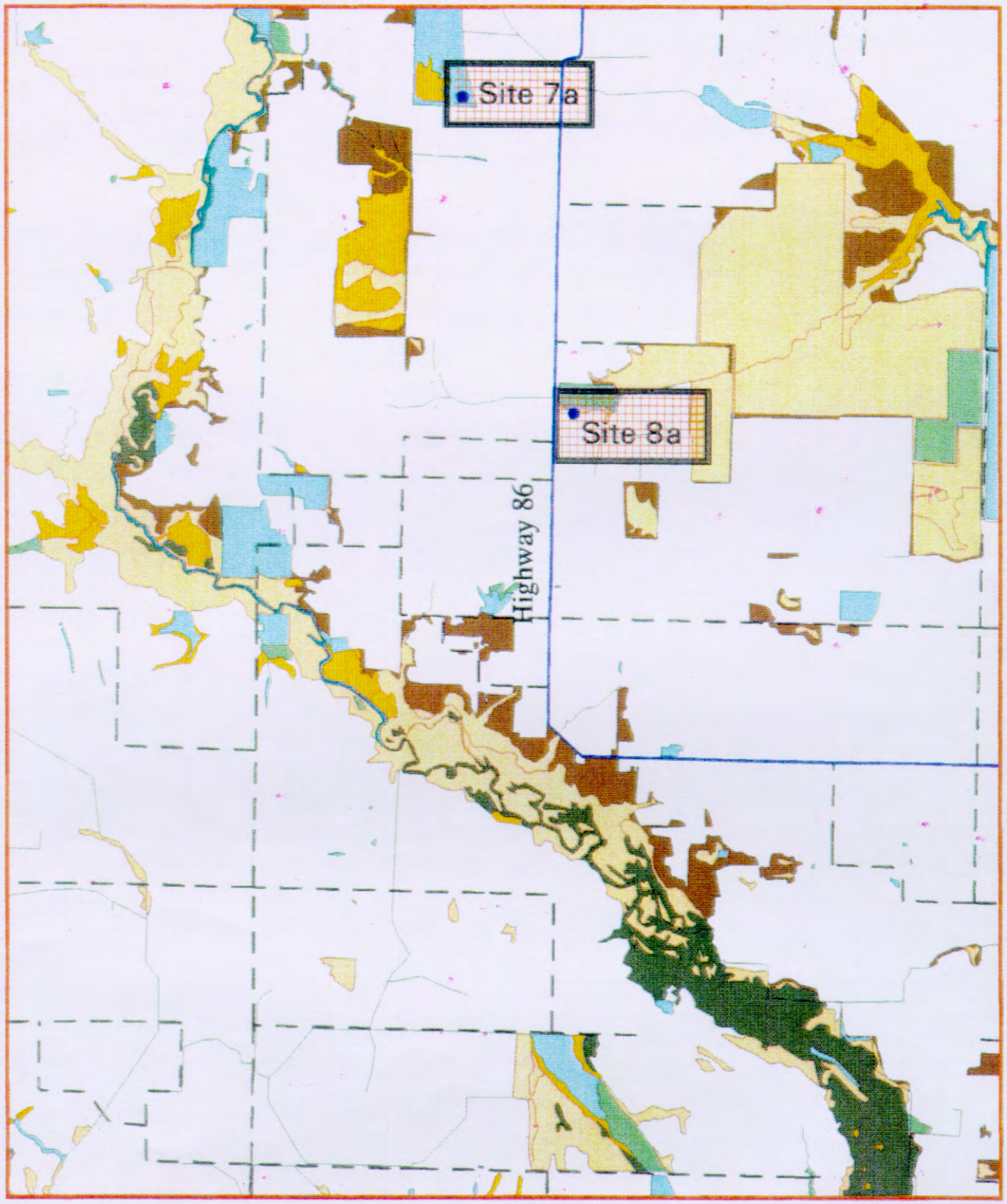
GROUNDWATER INSTITUTE The University of Memphis

Unclassified
Scrub/Shrub Swamp
Forested Swamp
Bottomland Hardwoods
Riverine
Impoundments
Marsh
Dead Timber
Upland Hardwoods
Interstates
US Highways
Roads
Surface Water
Alluvial Wells

N

1 : 5500

Lodges Corner Quadrangle
Water Quality
Sampling Locations
Figure 5



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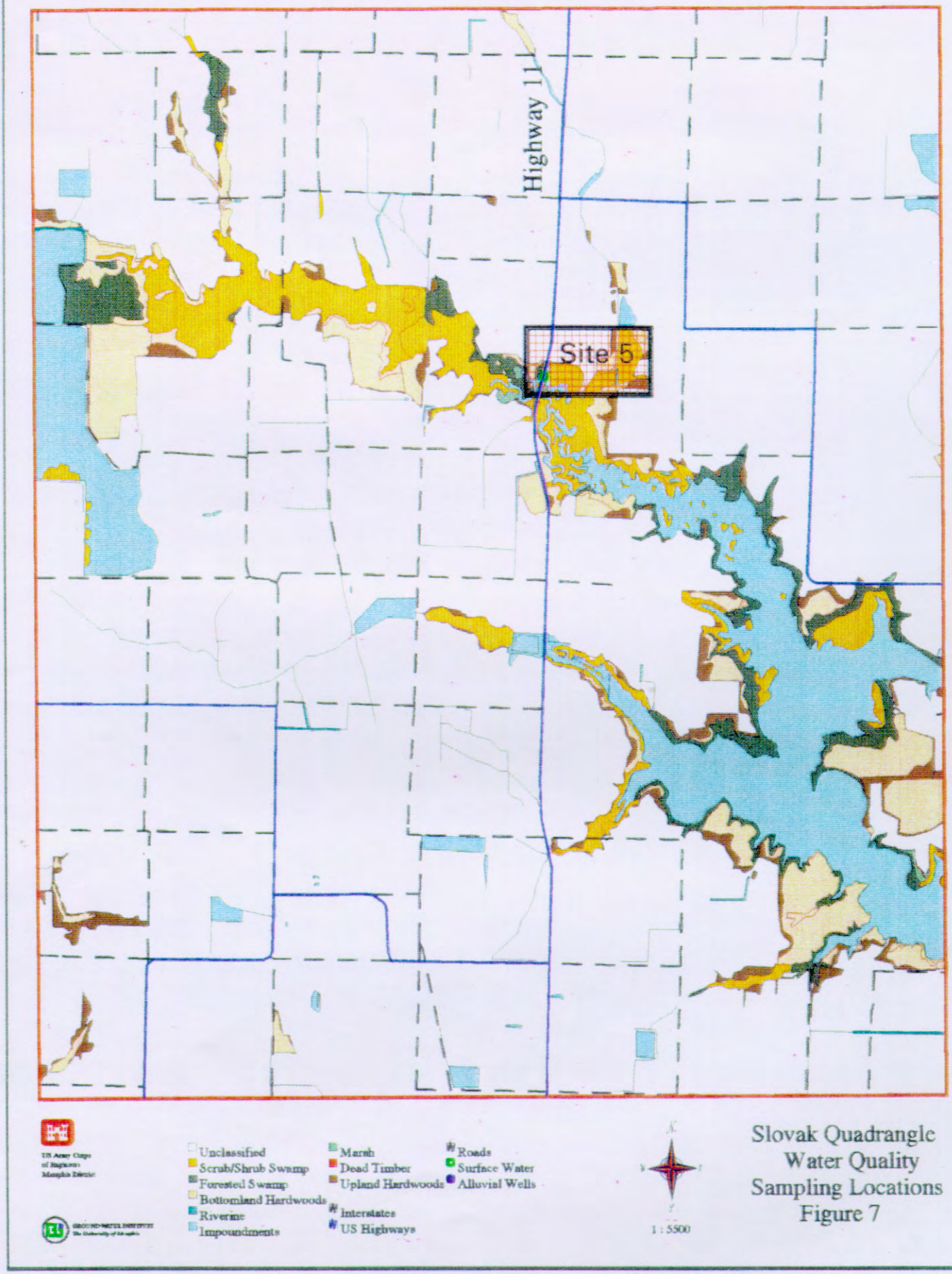
GROUNDWATER INSTITUTE The University of Memphis

Unclassified
Scrub/Shrub Swamp
Forested Swamp
Bottomland Hardwoods
Riverine
Impoundments
Marsh
Dead Timber
Upland Hardwoods
Interstates
US Highways
Roads
Surface Water
Alluvial Wells

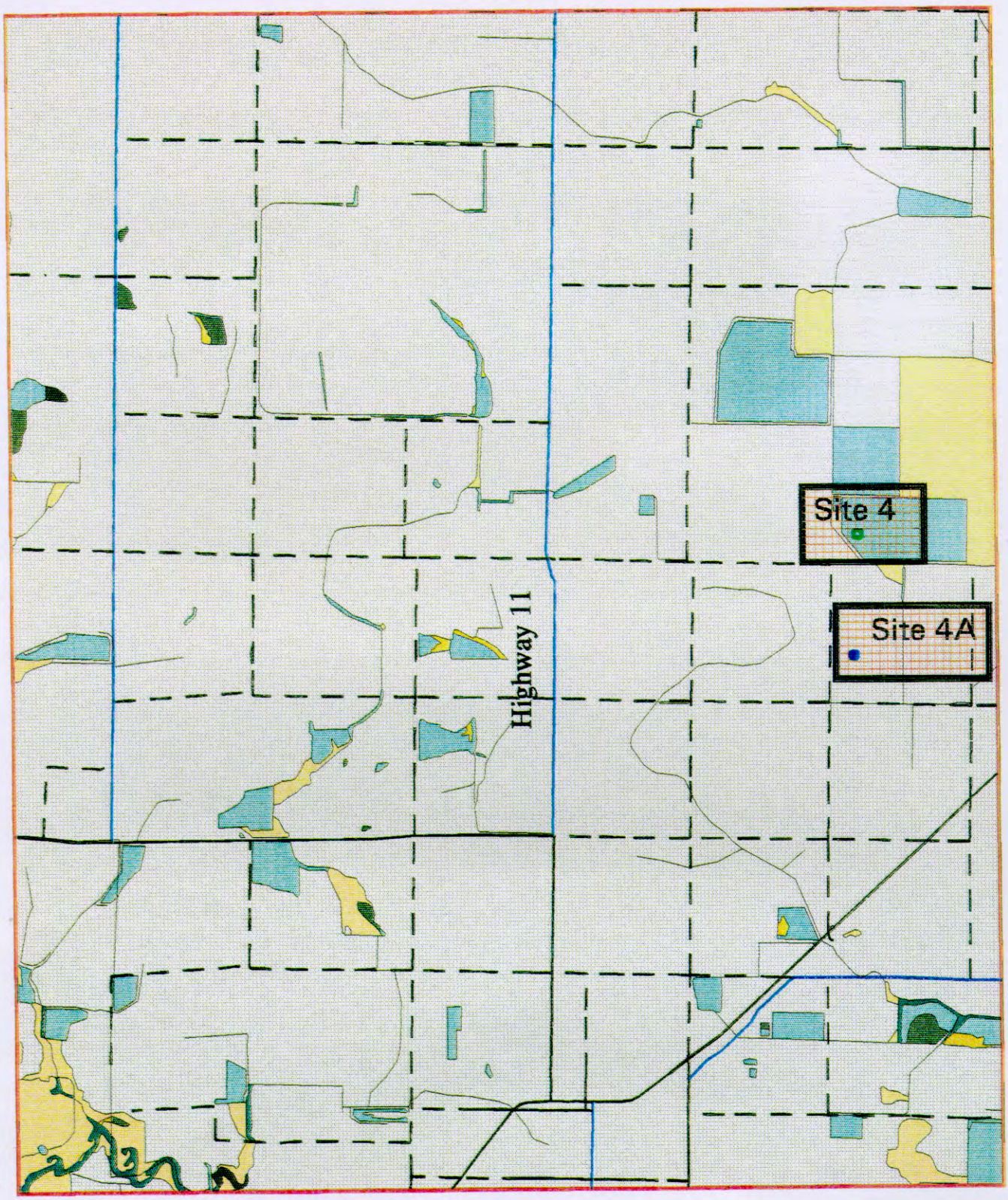
N

1 : 5500

Parkers Corner Quadrangle
Water Quality
Sampling Locations
Figure 6



Slovak Quadrangle
Water Quality
Sampling Locations
Figure 7



US Army Corps of Engineers Memphis District

GROUND-WATER INSTITUTE The University of Memphis

Unclassified
Scrub/Shrub Swamp
Forested Swamp
Bottomland Hardwoods
Riverine
Impoundments

Marsh
Dead Timber
Upland Hardwoods

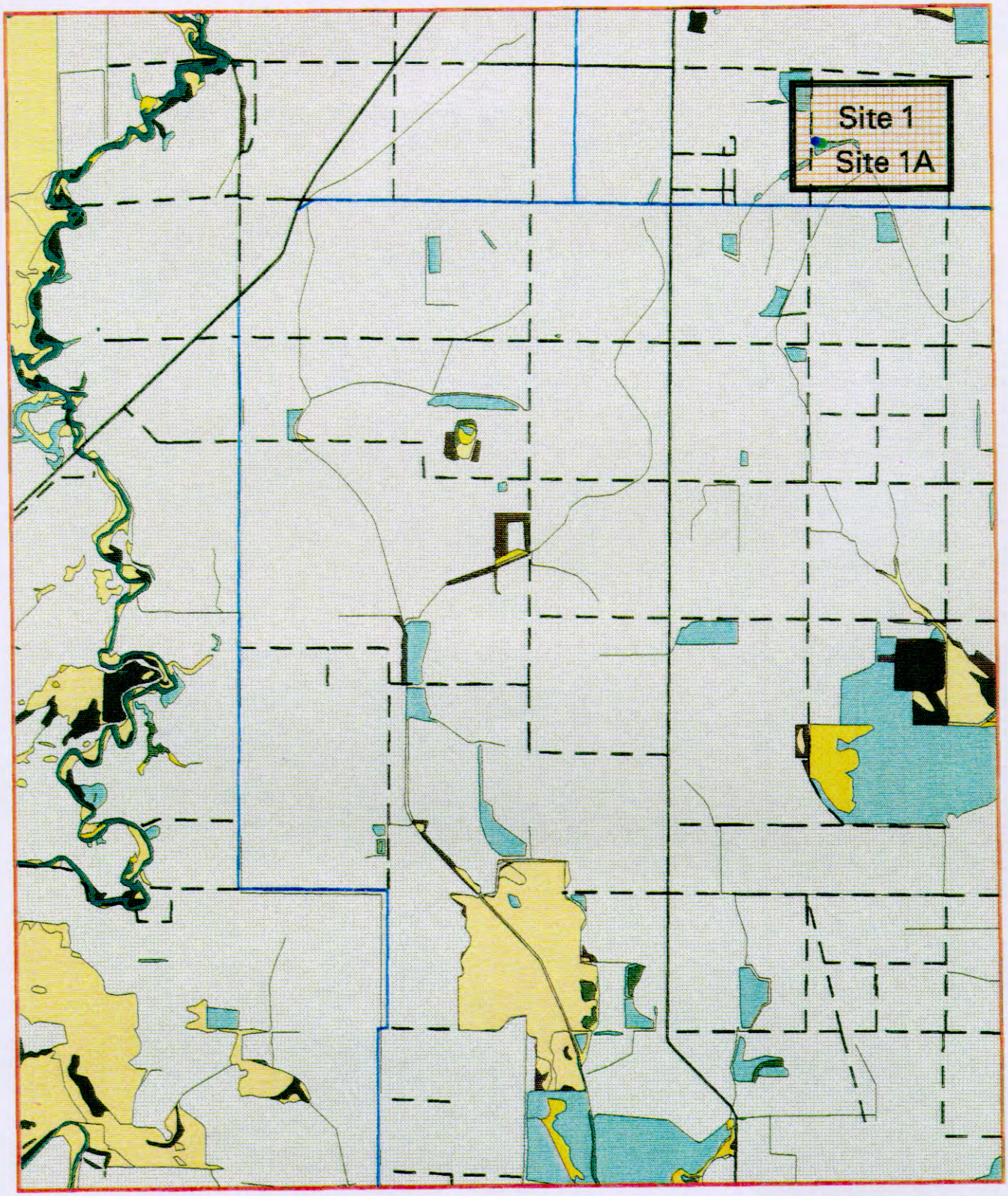
Interstates
US Highways

Roads
Surface Water
Alluvial Wells

N W E S

1 : 5500

Stuttgart North Quadrangle
Water Quality
Sampling Locations
Figure 8



US Army Corps of Engineers Memphis District

GROUNDWATER INSTITUTE The University of Memphis

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Scrub/Shrub Swamp
Forested Swamp
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Riverine
Impoundments

Marsh
Dead Timber
Upland Hardwoods

Interstates
US Highways

Roads
Surface Water
Alluvial Wells

N
W
E
S

1 : 5500

Stuttgart South Quadrangle
Water Quality
Sampling Locations
Figure 9

The surface water sampling locations were as follows:

Reservoir #1: This man-made reservoir is located just East of Stuttgart off of 10th street extended. The reservoir receives flow from both an alluvial well and a tail water recovery system (See Figure 10). The preponderance of water entering the reservoir during the planting/growing season appeared to be well water. The streams surrounding the reservoir varied from stagnant water, no water, to flowing conditions when excess irrigation water was leaving the fields.

Reservoir #2: The second reservoir (Figure 11) is the Walworth Reservoir East of Stuttgart on Highway 153. This is actually two reservoirs with a connecting ditch which flows under the highway. Due to the extremely low water in the reservoir and the obvious contamination from a livestock area, this site was not used for the data verification program.

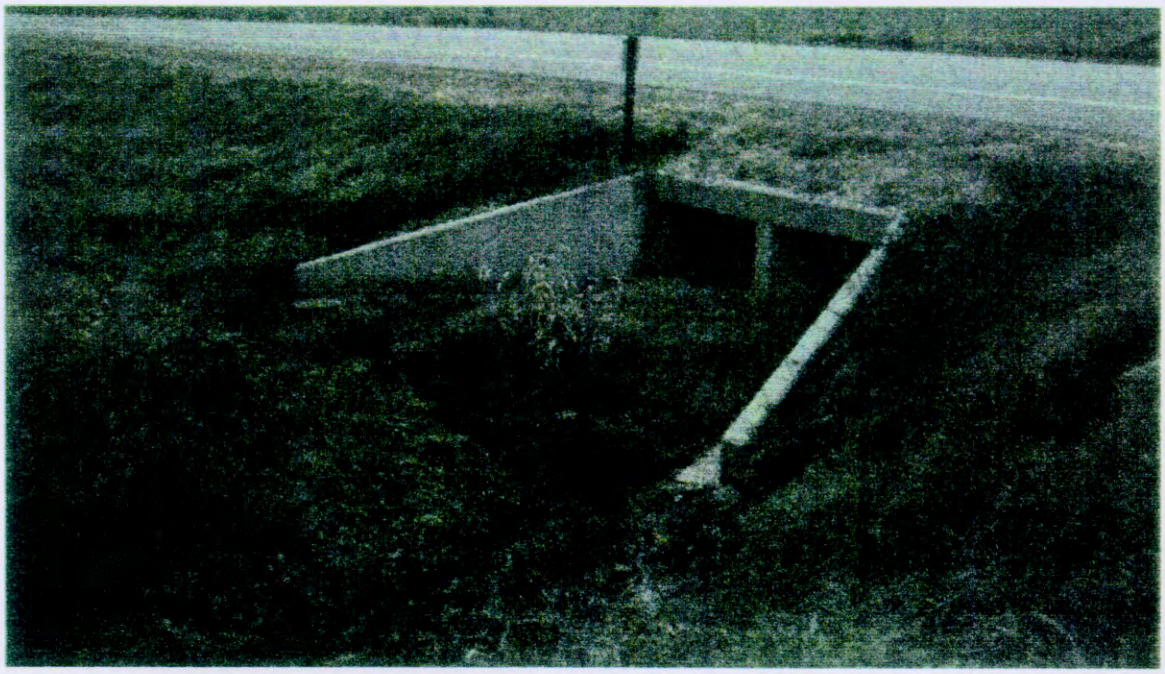
Reservoir #3: Located South of Stuttgart on Highway 165 and identified as "Cox" reservoir on the county road map, the third reservoir is a natural body of water which provided two surface sampling locations. The first, listed as "3R" was in the intake canal of the pump which supplied the irrigation water to the various field. The second, "3D", was from a tail-water recovery ditch flowing into the reservoir. Only two samples were obtained from the tail-water recover ditch due to the lack of flow during the summer months (See Figure 12). The representiveness of the water at Site 3R as "typical" interior surface water is questionable. As mentioned above, the sampling point was a man-made canal used as the sump for the irrigation supply pump and as such was stagnant during part of the sampling period. In addition, the reservoir is in reality a large swamp receiving drainage from as far North as Lonoke. One of the water quality samples was discarded due to the large number of dead fish at the sampling location. Sampling site 3D was typical of the tail water recovery ditches in the study area. Immediately following a heavy precipitation event or at the end of the irrigation period, the ditch would have flowing water. During most of the sampling period, the ditch was dry.

Reservoir #4: The fourth site is known as the "Lost Island" reservoir and is located at the Arkansas/Prairie County line north of Stuttgart just west of Highway 79. Surface water samples were obtained directly from the man-made reservoir which is replenished from a tail-water recovery system (See Figure 13). This reservoir, as with site 3R, is totally replenished from tail

Field Sampling Site 1
Figure 10

Field Sampling Site 2
Figure 11

Field Sampling Site 3 R
Figure 12



Field Sampling Site 3 D
Figure 12 (continued)

Field Sampling Site 4
Figure 13

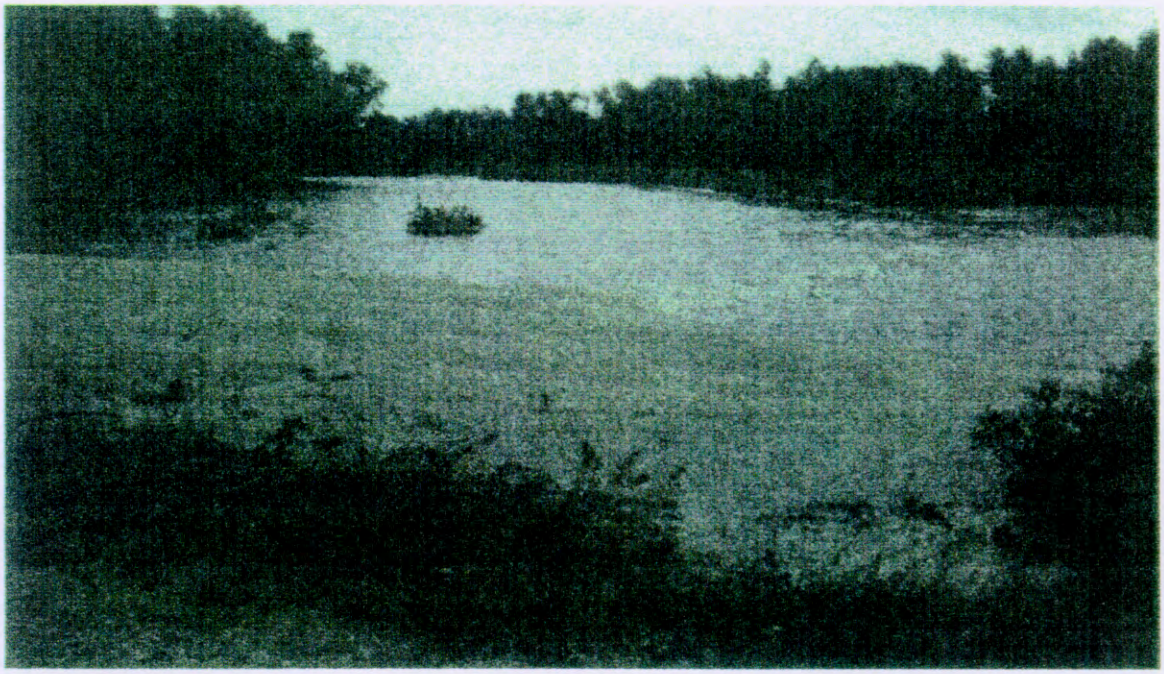
water recovery ditches. The water quality of the reservoir was considered typical of the average water quality in the recovery ditches.

Reservoir #5: The fifth surface water sampling location is where one of the arms of Peckerwood Lakes crosses Highway 11 (See Figure 14). Being on the upper reaches of the lake, sampling point 5 should represent surface water runoff quality of streams in the study area although the water quality was biased by the standing water condition at the sampling site.

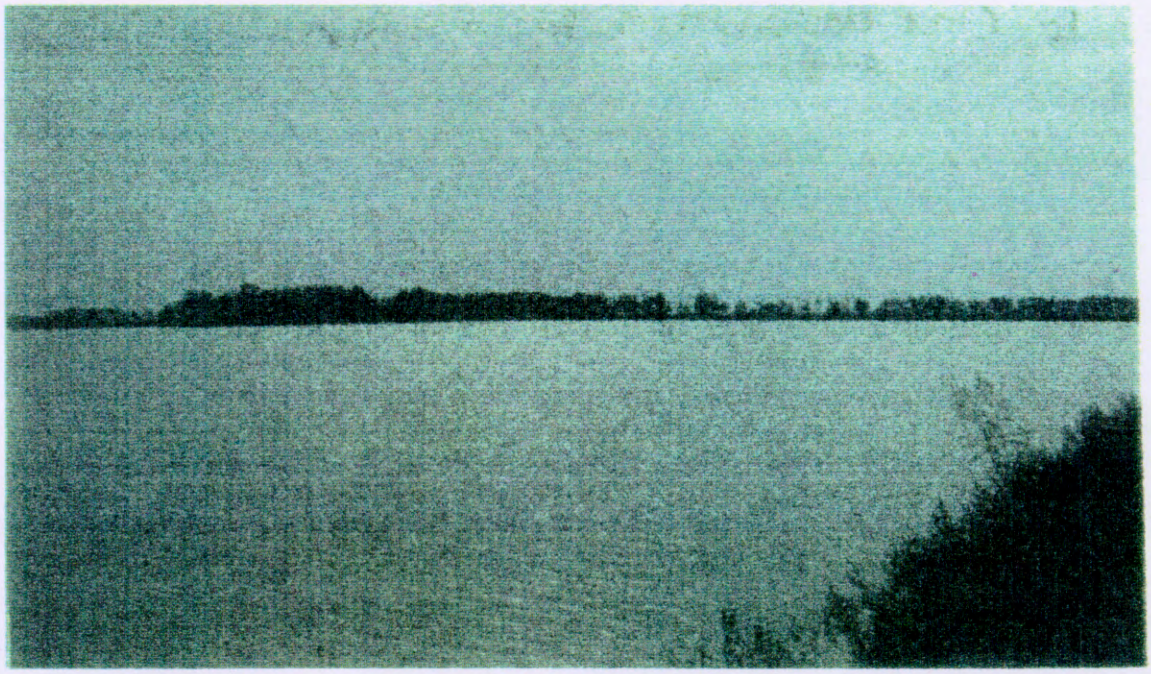
Reservoir #6: A man-made reservoir located West of Highway 86, approximately 1/2 mile South of Highway 70, which received inflow from both a natural stream and a tail-water recovery system was selected as the sixth surface water location (See Figure 15). The natural stream which flowed from the North beside the reservoir was dammed with a lift pump used to pump all of the water from the ditch into the lake. As with the other surface water sampling sites, the majority of the water in the ditch and thus in the reservoir originated as runoff from the irrigated areas.

White River: Several samples were obtained from the White River near DeValls Bluff (see Figure 16) to check the STORET data base for the White River.

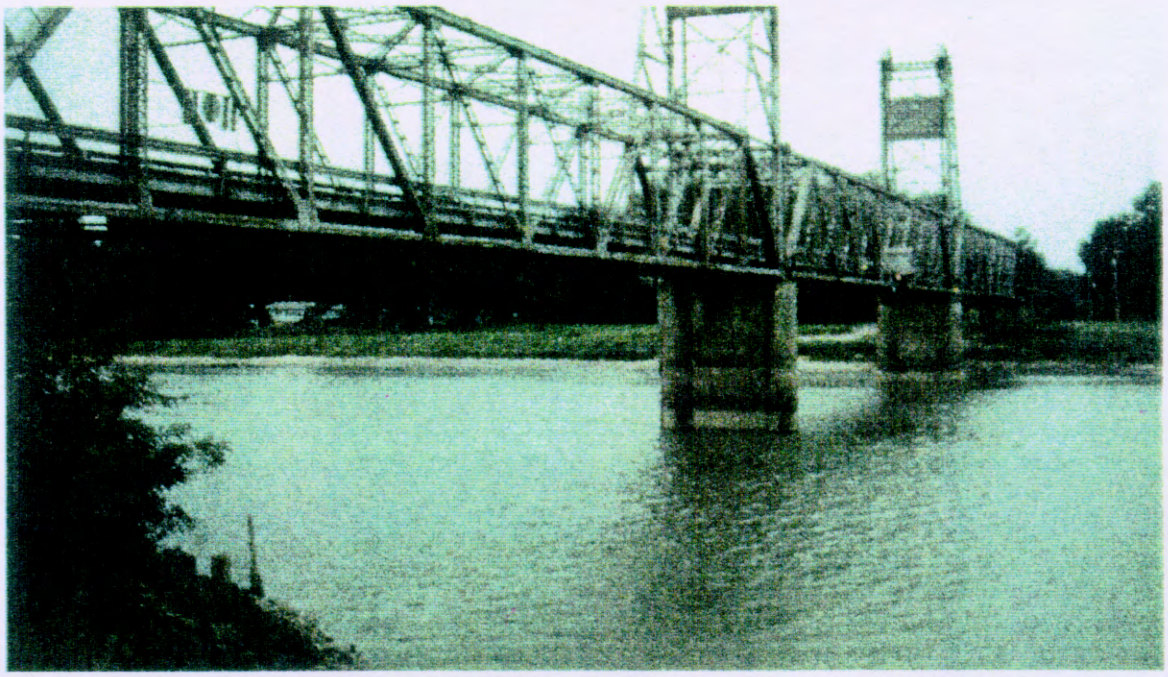
Alluvial wells in the vicinity of reservoirs 1, 2, 4, and 6 were sampled when the surface water samples were obtained. These sampling locations are identified as 1a, 2a, 4a, and 7a. Samples from sites 1a and 7a were obtained from discharge lines from an alluvial well used to fill a storage reservoirs. Samples from the other two alluvial wells were obtained from the discharges in the fields. A typical alluvial well discharge is shown in Figure 17.



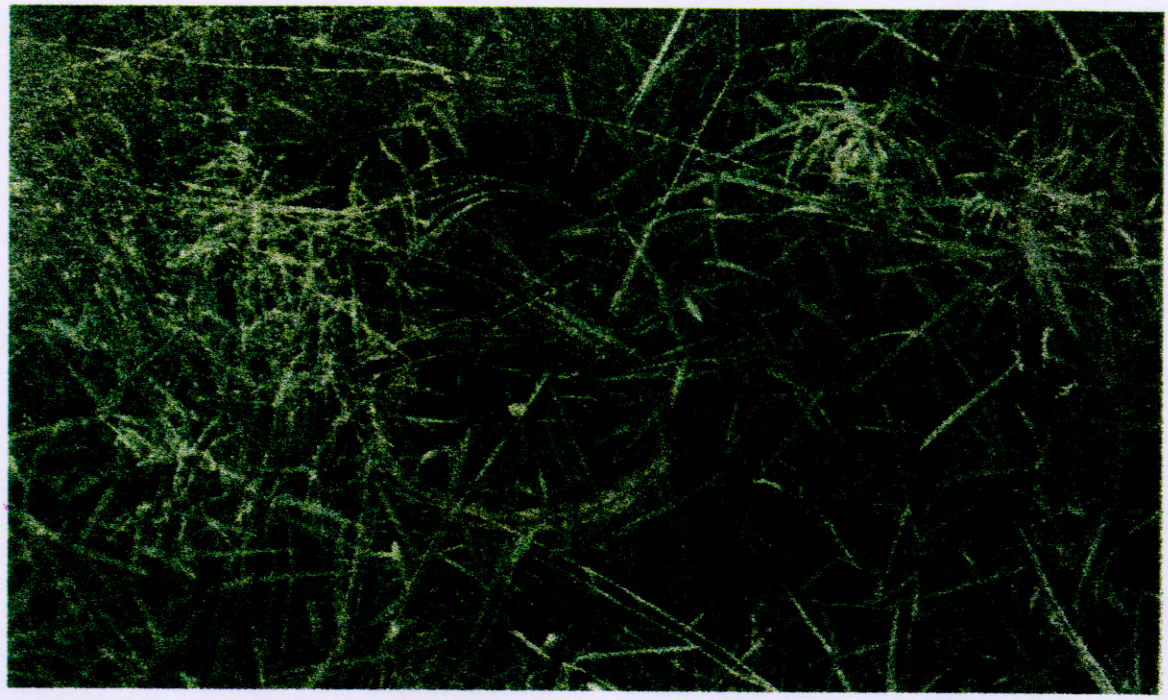
Field Sampling Site 5
Figure 14



Field Sampling Site 6
Figure 15



White River Sampling Site
Figure 16



A typical alluvial well discharge
Figure 17

VII. WATER QUALITY DATA

The water quality data accumulated during the course of this study are summarized in a series of figures on the following pages which indicate the

- average values of the field data collected during the Summer of 1996
- maximum, average, and minimum values of the parameter obtained from the STORET data base for ground water and surface water in the study area
- maximum, average, and minimum values of the parameter for the White River obtained from the STORET data base

Values for the individual parameters are presented on separate graphs in the following figures:

Figure #	Parameter
18	Alkalinity
19	Total Hardness
20	Calcium Hardness
21	Conductivity
22	Copper
23	Iron
24	Nitrate
25	pH
26	Dissolved Solids
27	Suspended Solids
28	Temperature
29	True Color
30	Turbidity

The primary parameters of concern for agriculture are the pH, temperature, dissolved solids, suspended solids, copper, iron, hardness (total and calcium) and alkalinity. Water quality parameters of concern for fish and wildlife maintenance in the waterways and reservoirs were obtained from the Environmental Protection Agency (EPA 440/5-86-001). Quantitative data were specified for temperature, alkalinity, copper, iron, and dissolved solids. The data for each of the parameters are discussed in the following paragraphs.

pH: The pH values (Figure 25) represented the values most consistent with historical data of all of the parameters. The average values for the field data were within the observed maximum and minimum values from the STORET data base. In addition, the historical values for the White River are close to the historical values for the alluvial water and the surface water. The pH

Figure 18 - Alkalinity

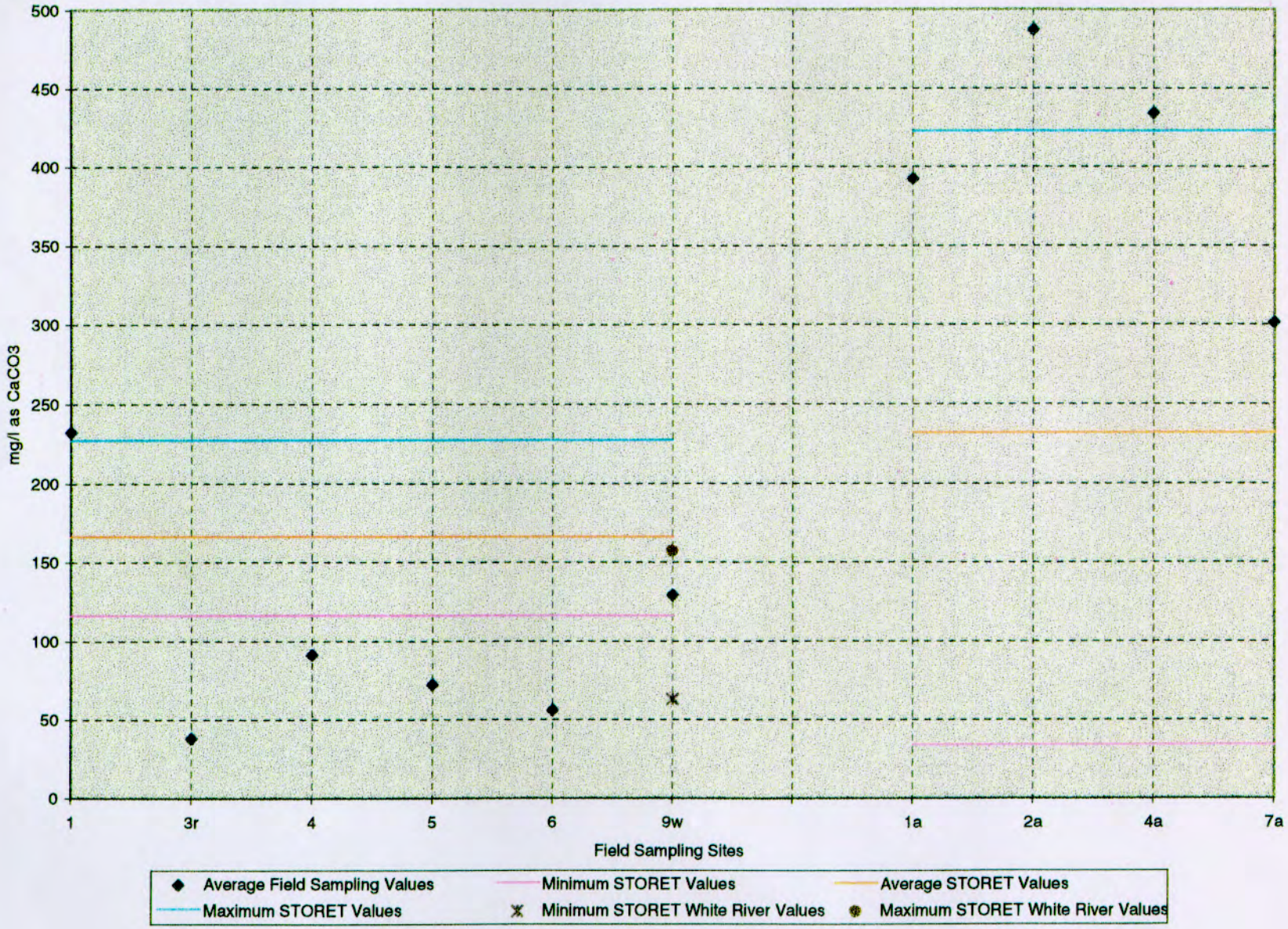


Figure 19 - Total Hardness

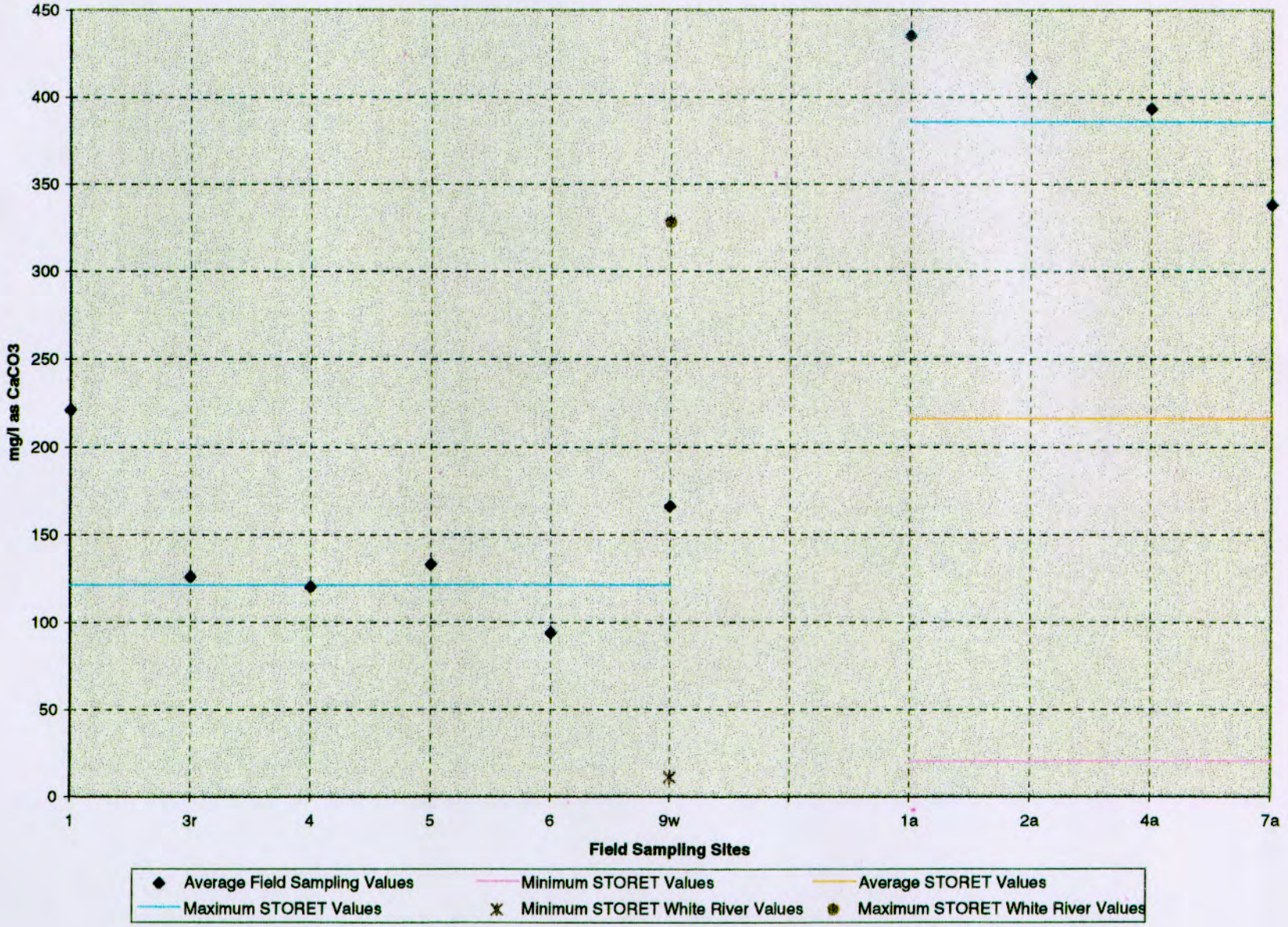


Figure 20 - Calcium Hardness

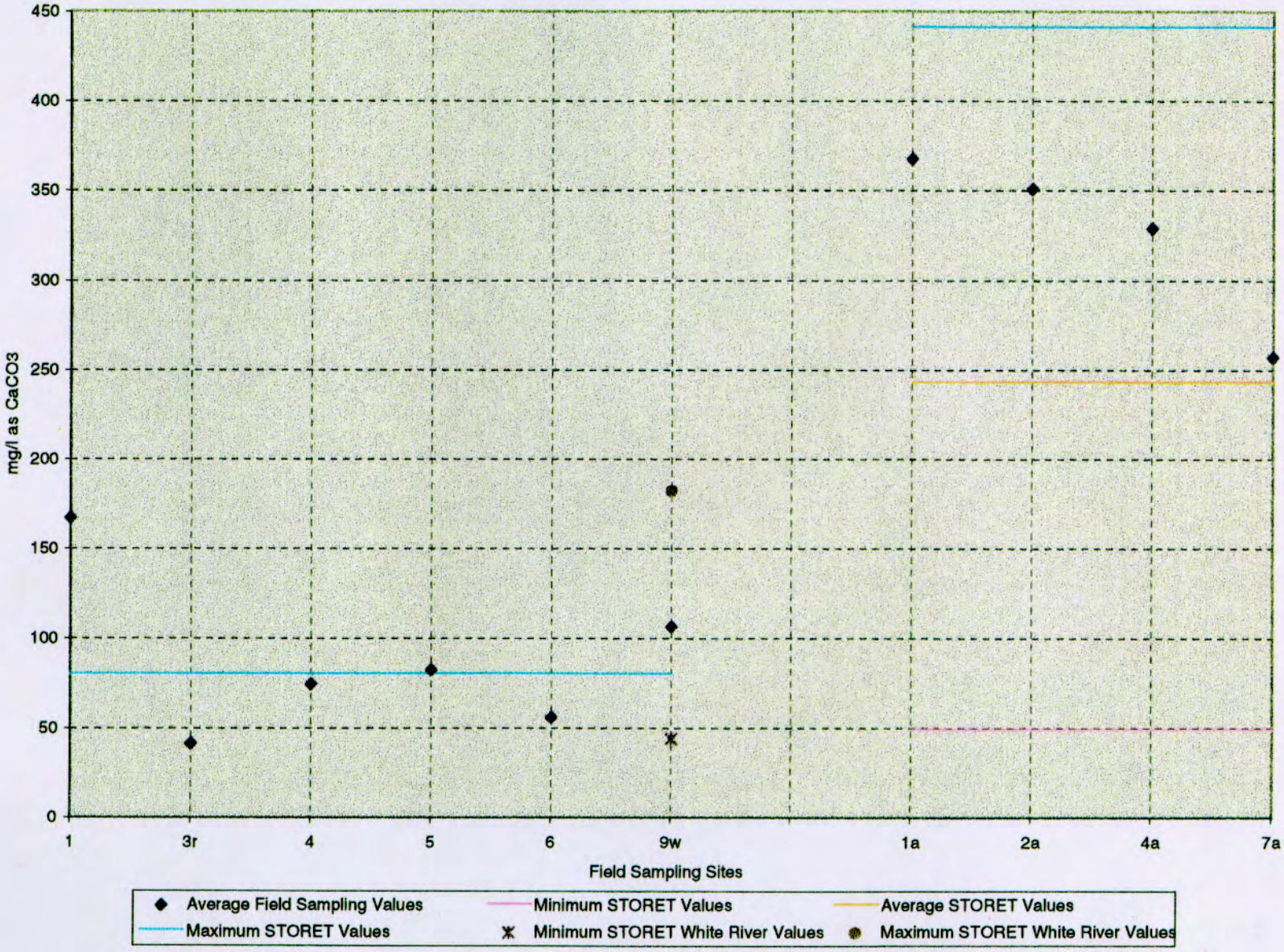


Figure 21 - Conductivity

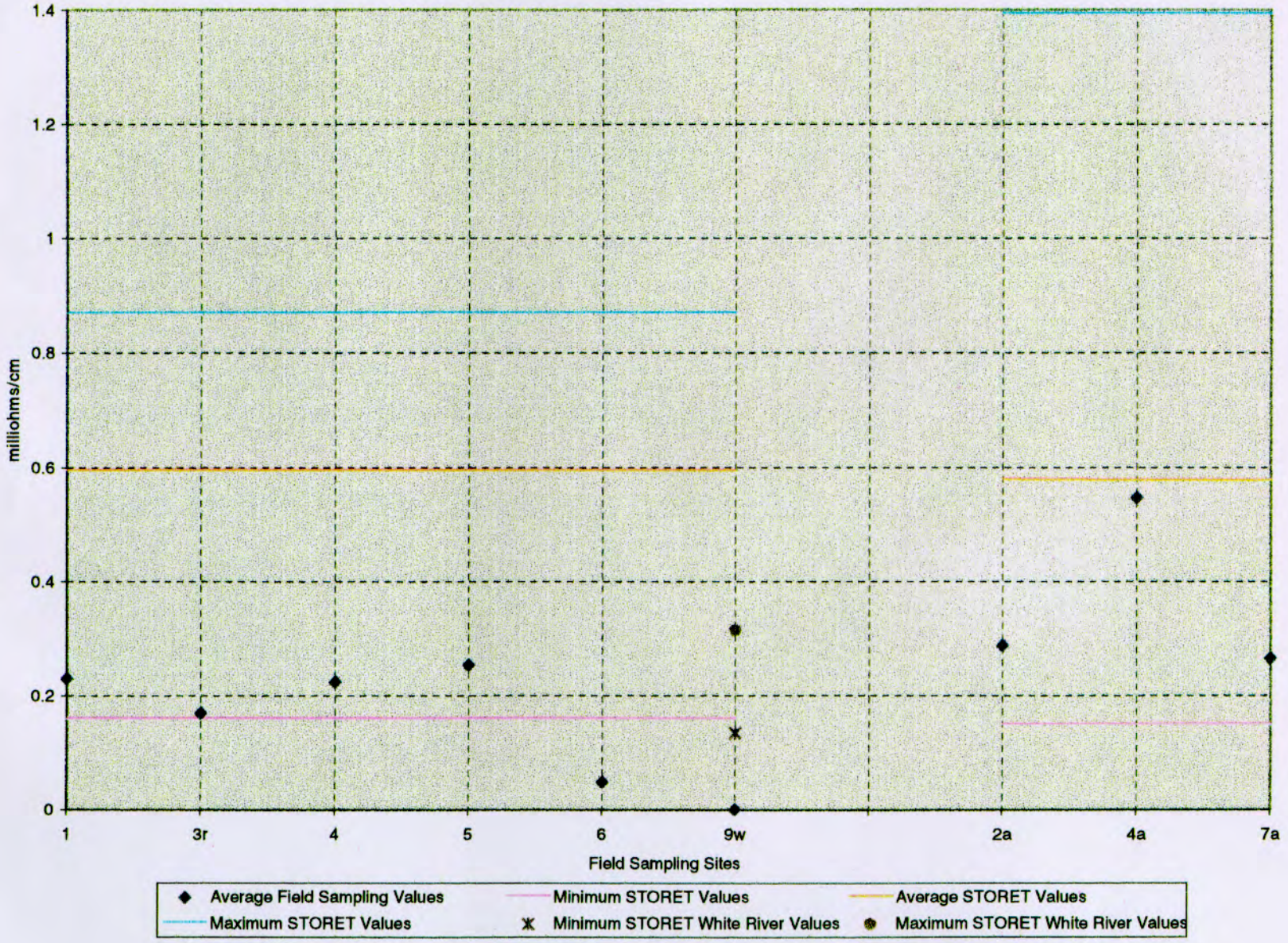


Figure 22 - Copper

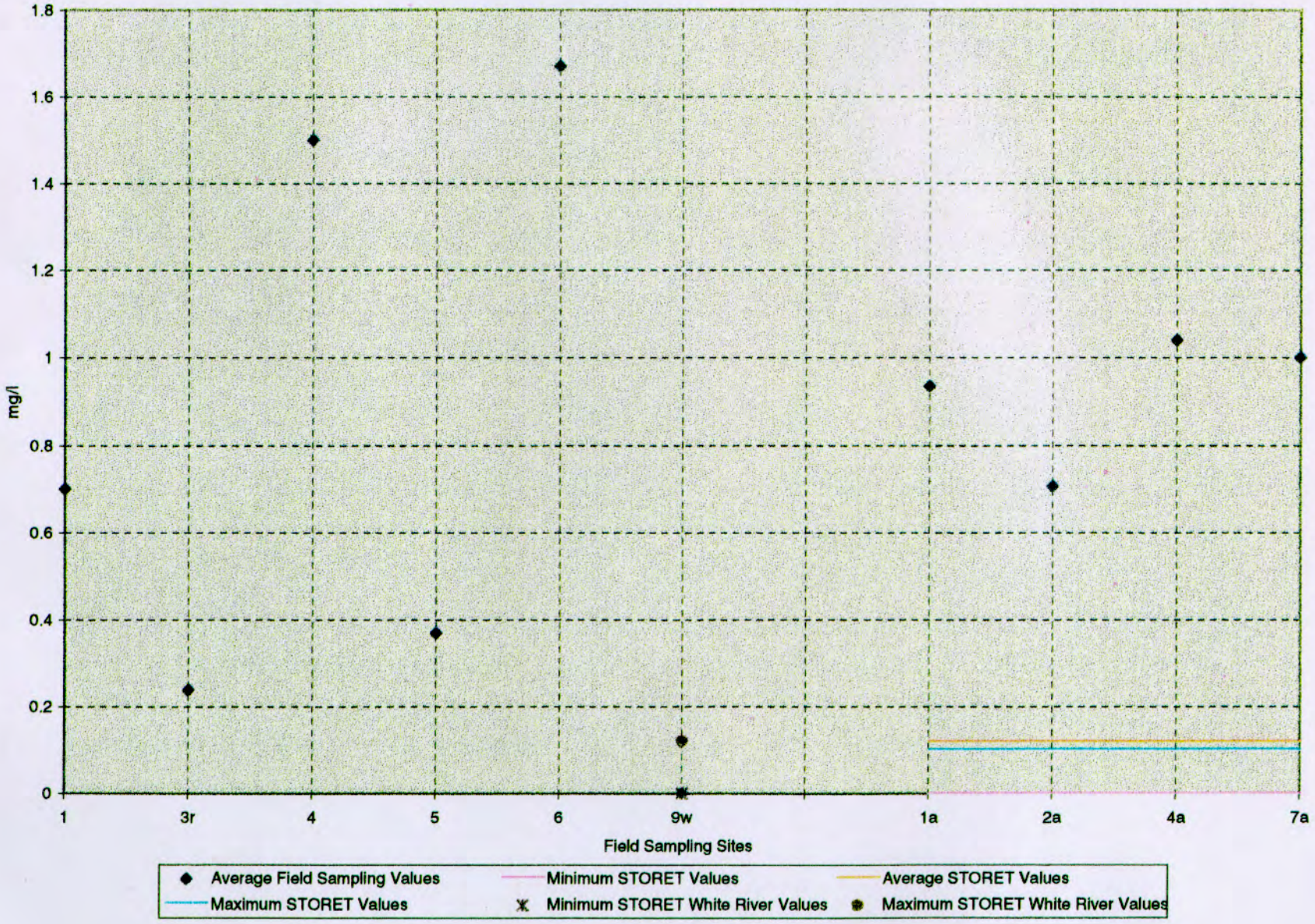


Figure 23 - Iron

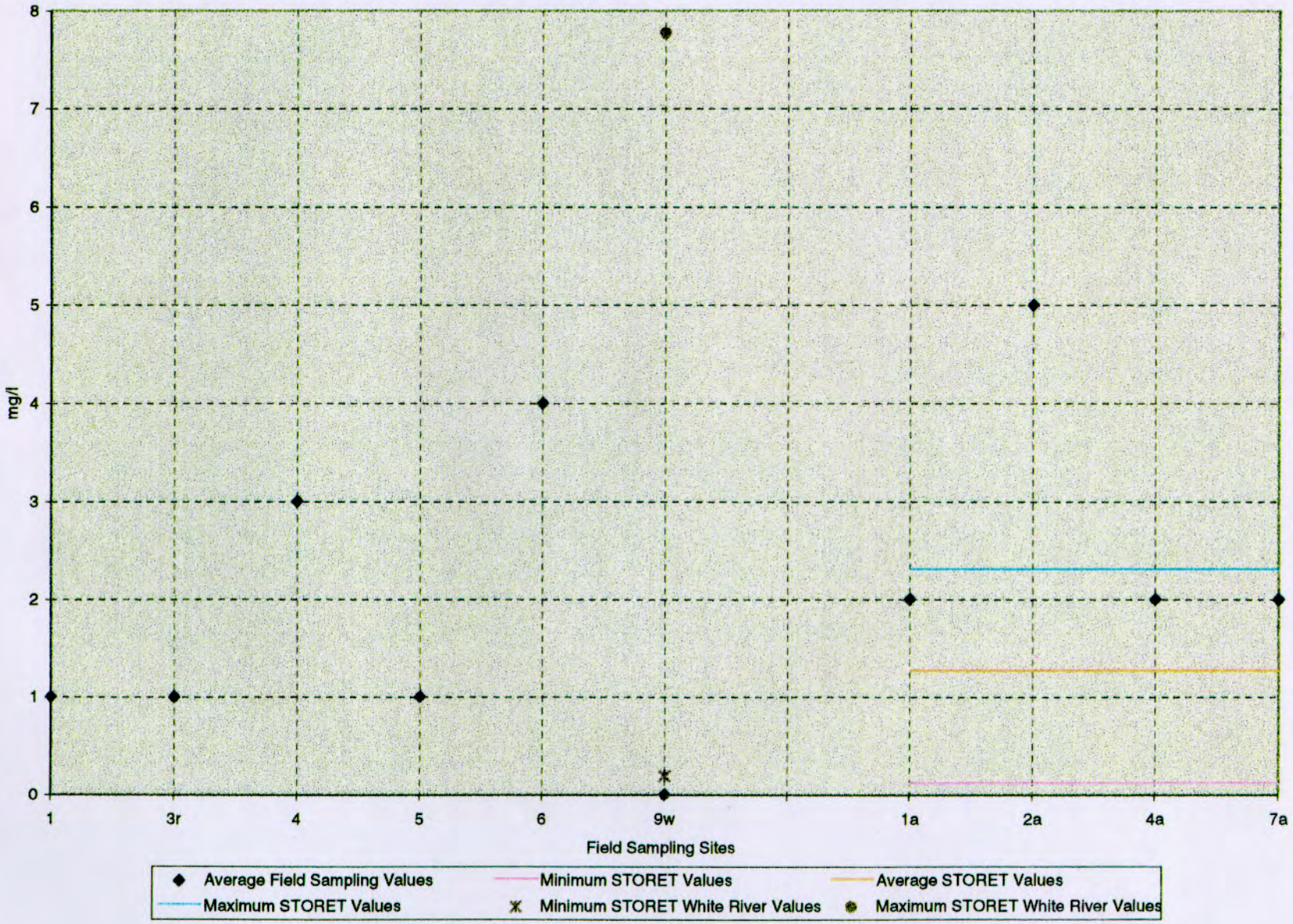


Figure 24 - Nitrate

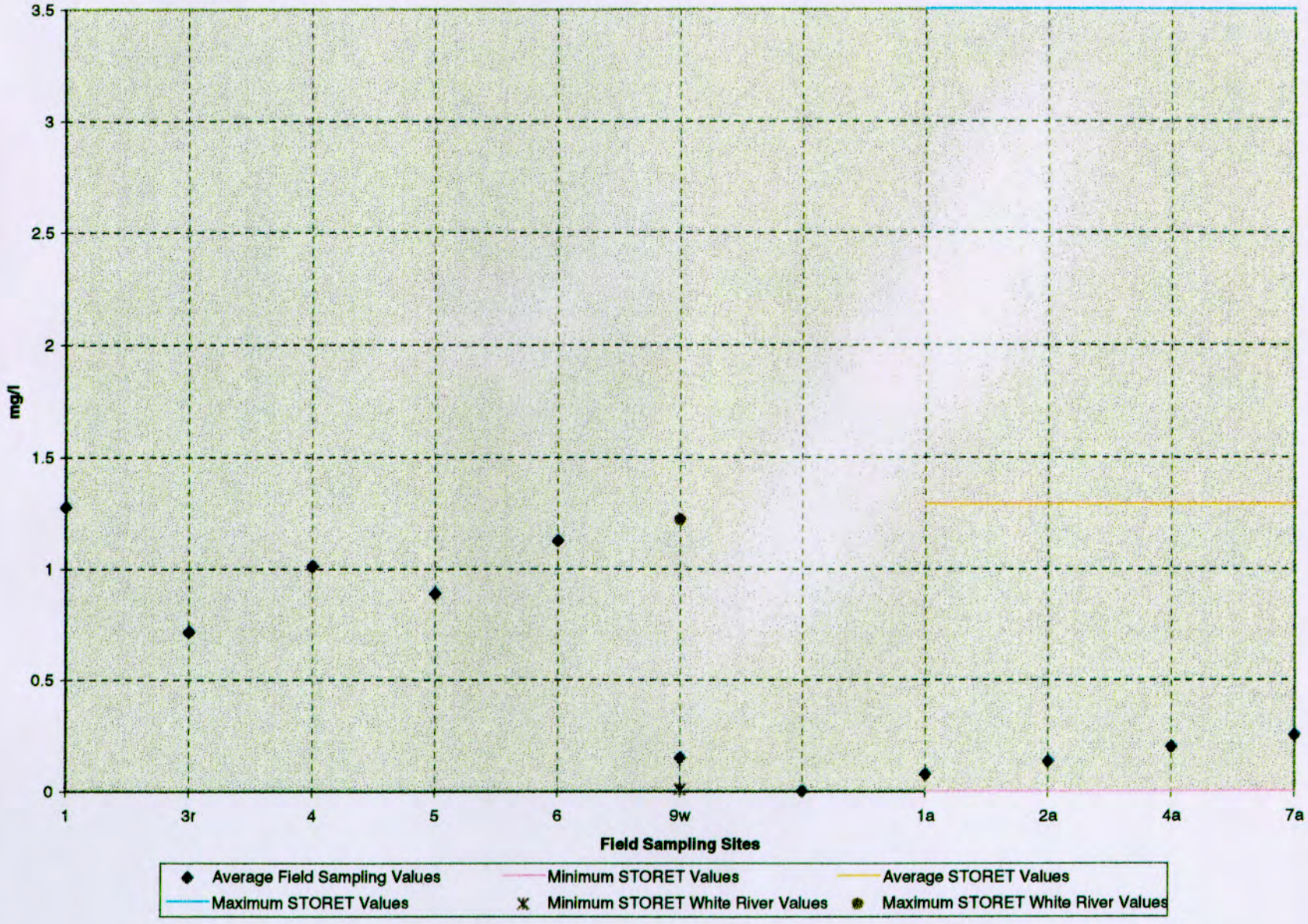


Figure 25 - pH

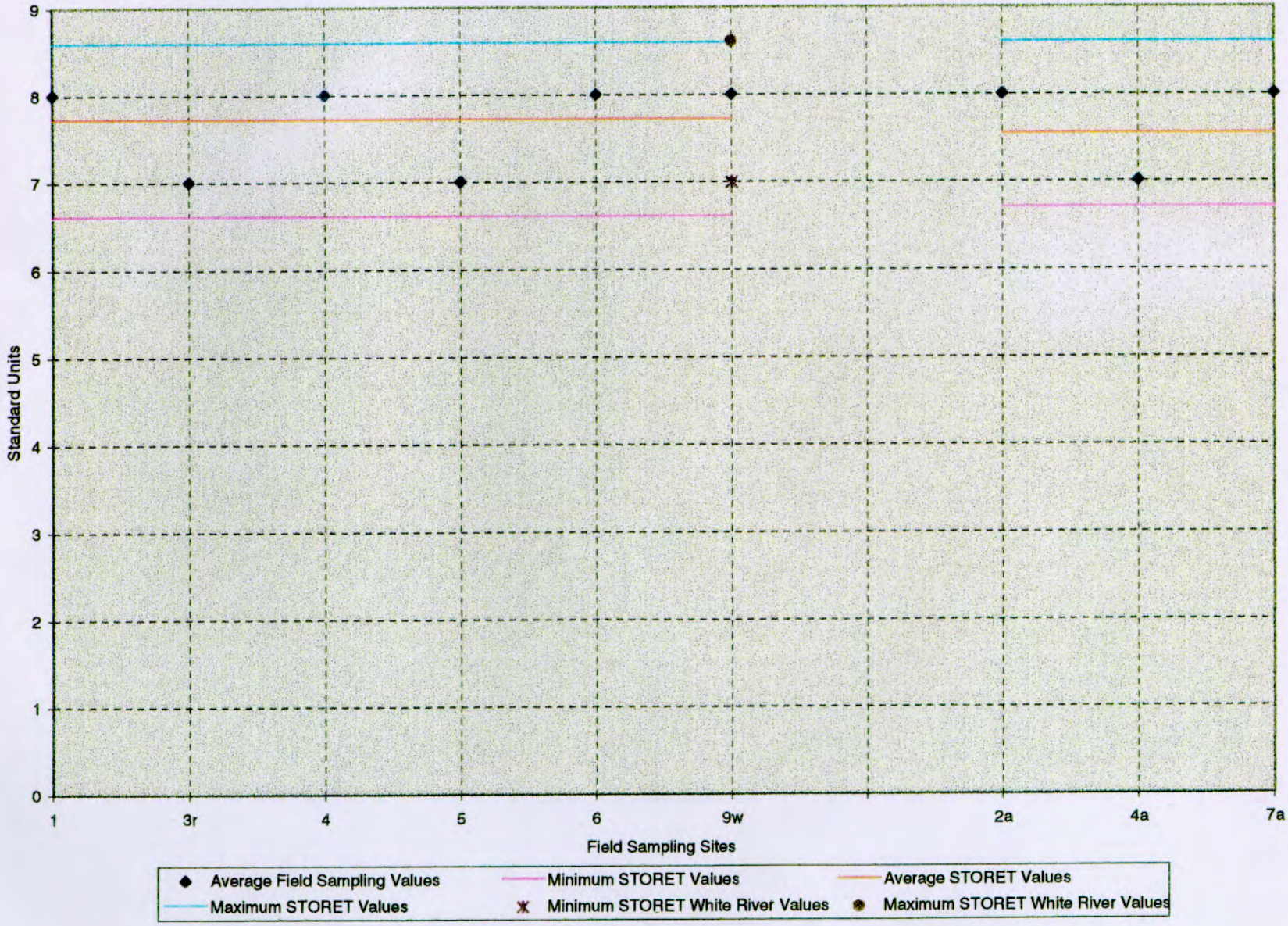

9
8
7
6
5
4
3
2
1
0
Standard Units
1
3r
4
5
6
9w
2a
4a
7a
Field Sampling Sites
Average Field Sampling Values
Minimum STORET Values
Average STORET Values
Maximum STORET Values
Minimum STORET White River Values
Maximum STORET White River Values

Figure 26 - Dissolved Solids

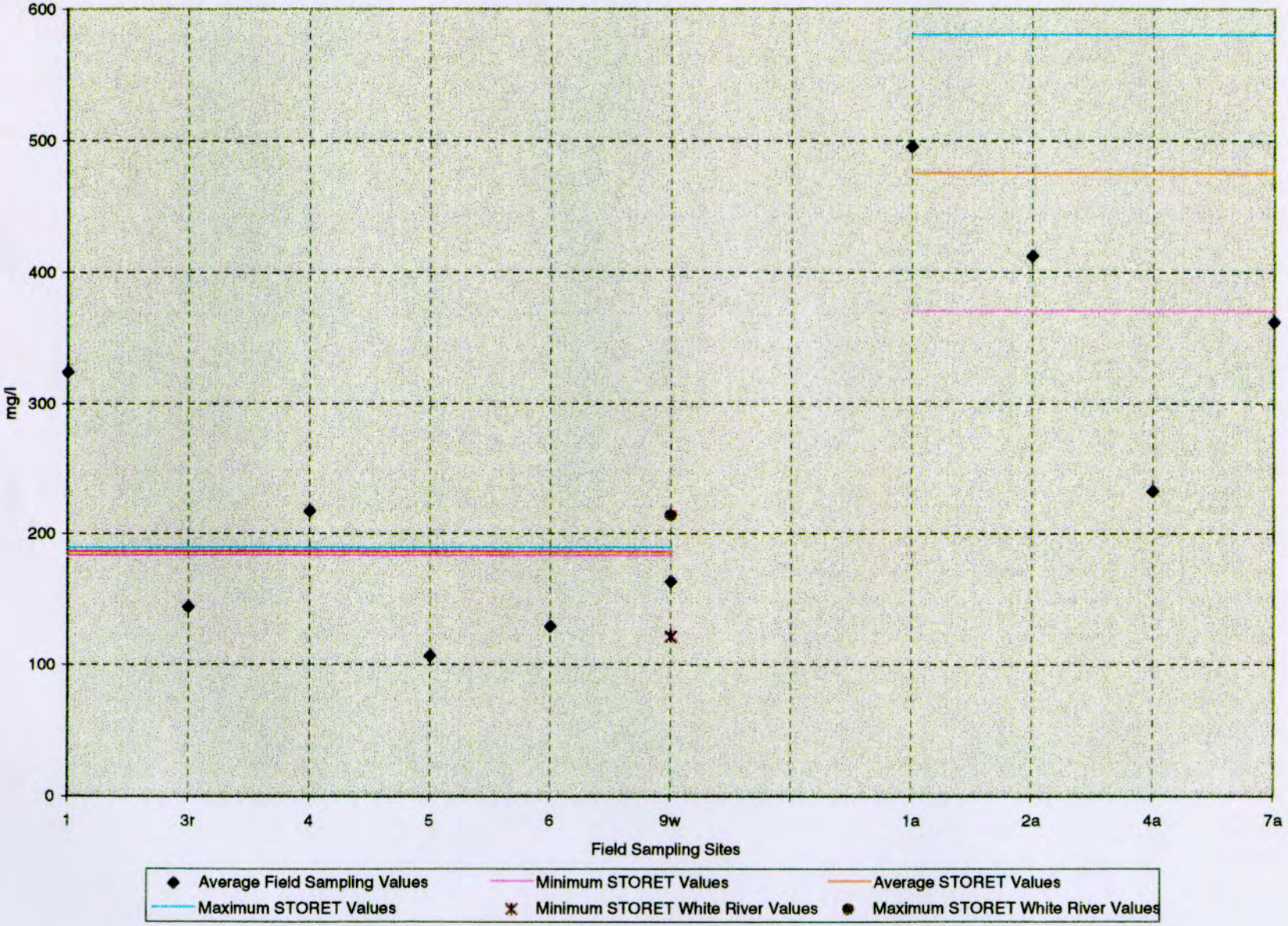


Figure 27 - Suspended Solids

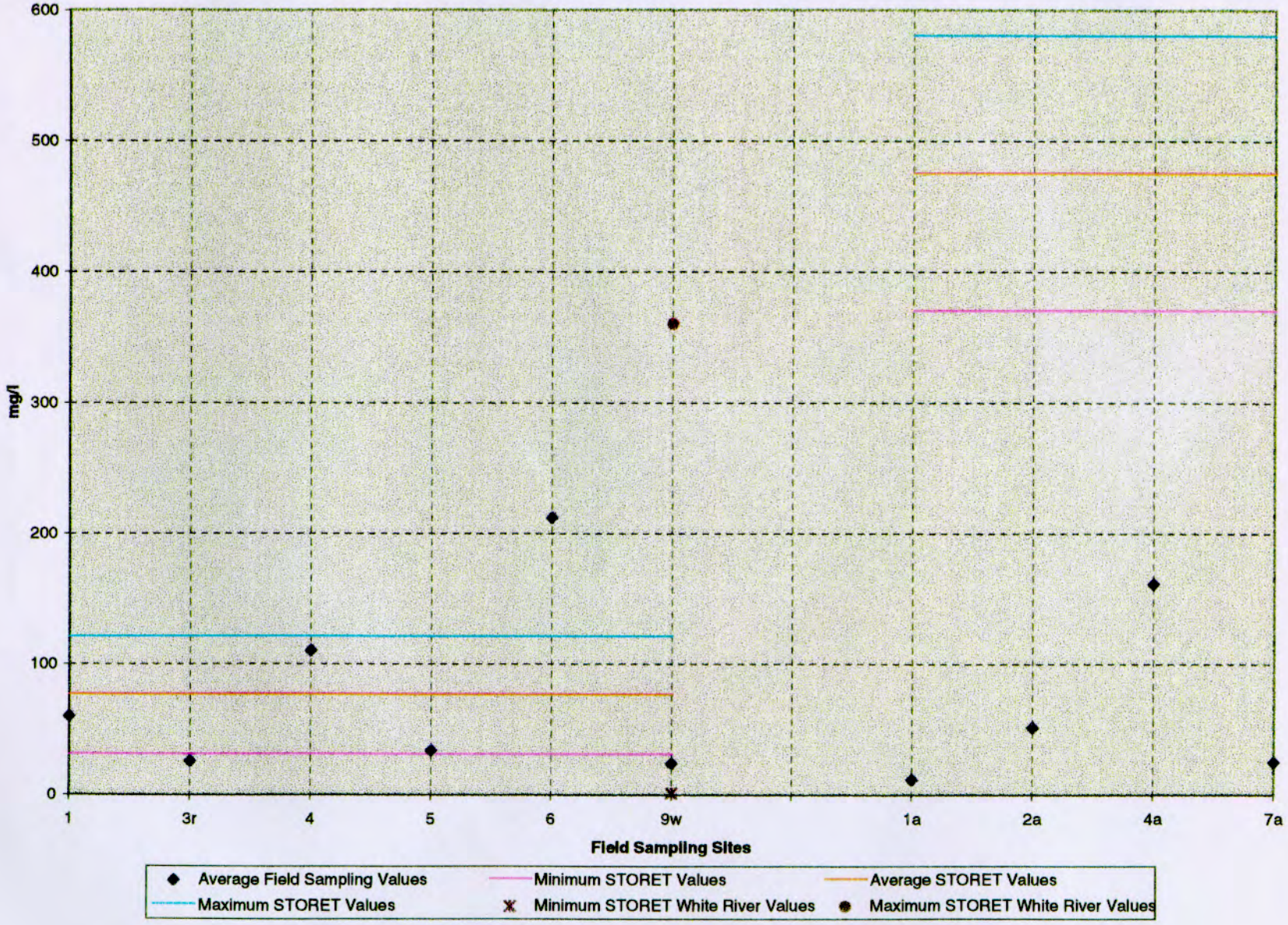


Figure 28 - Temperature

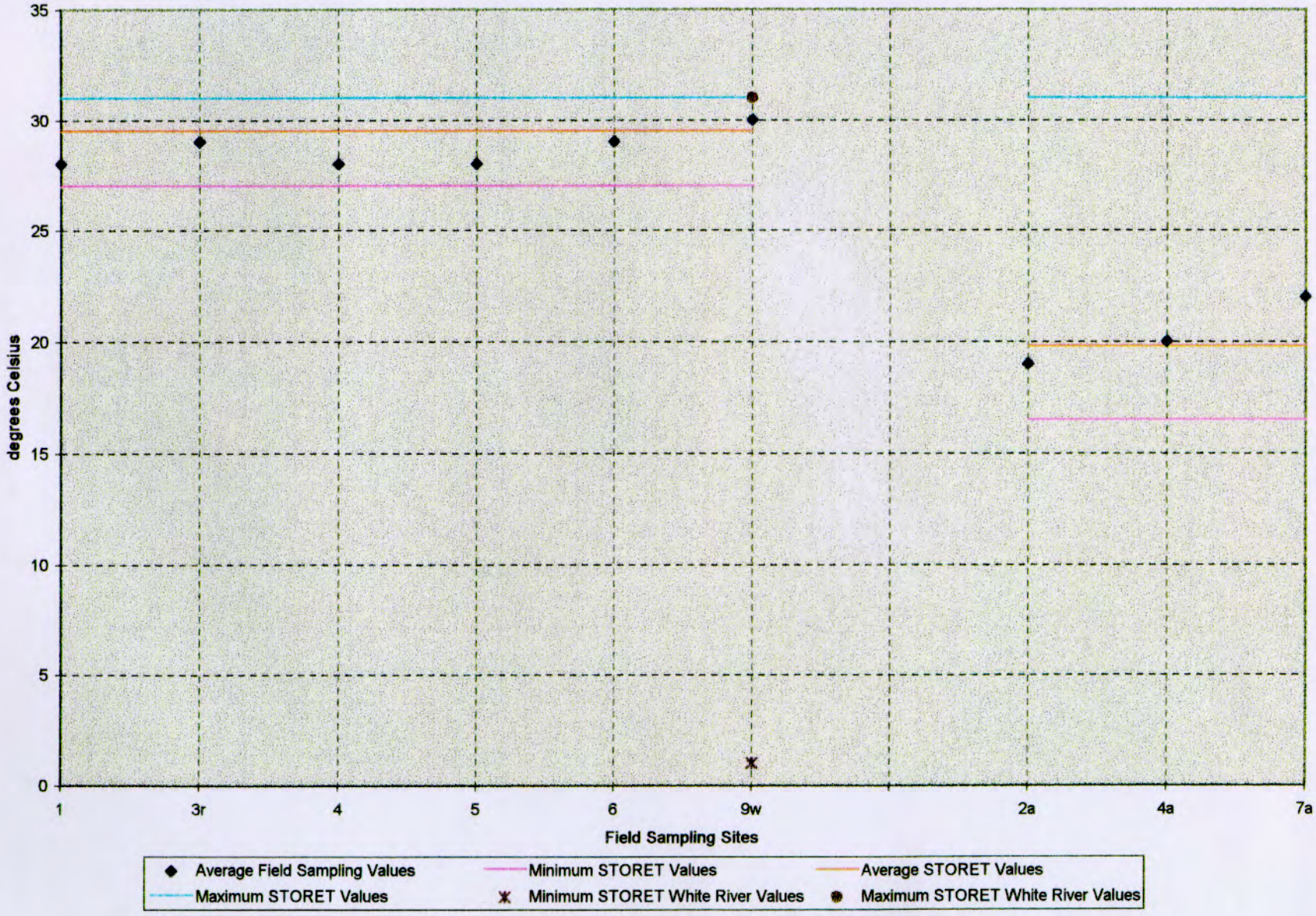


Figure 29 - True Color

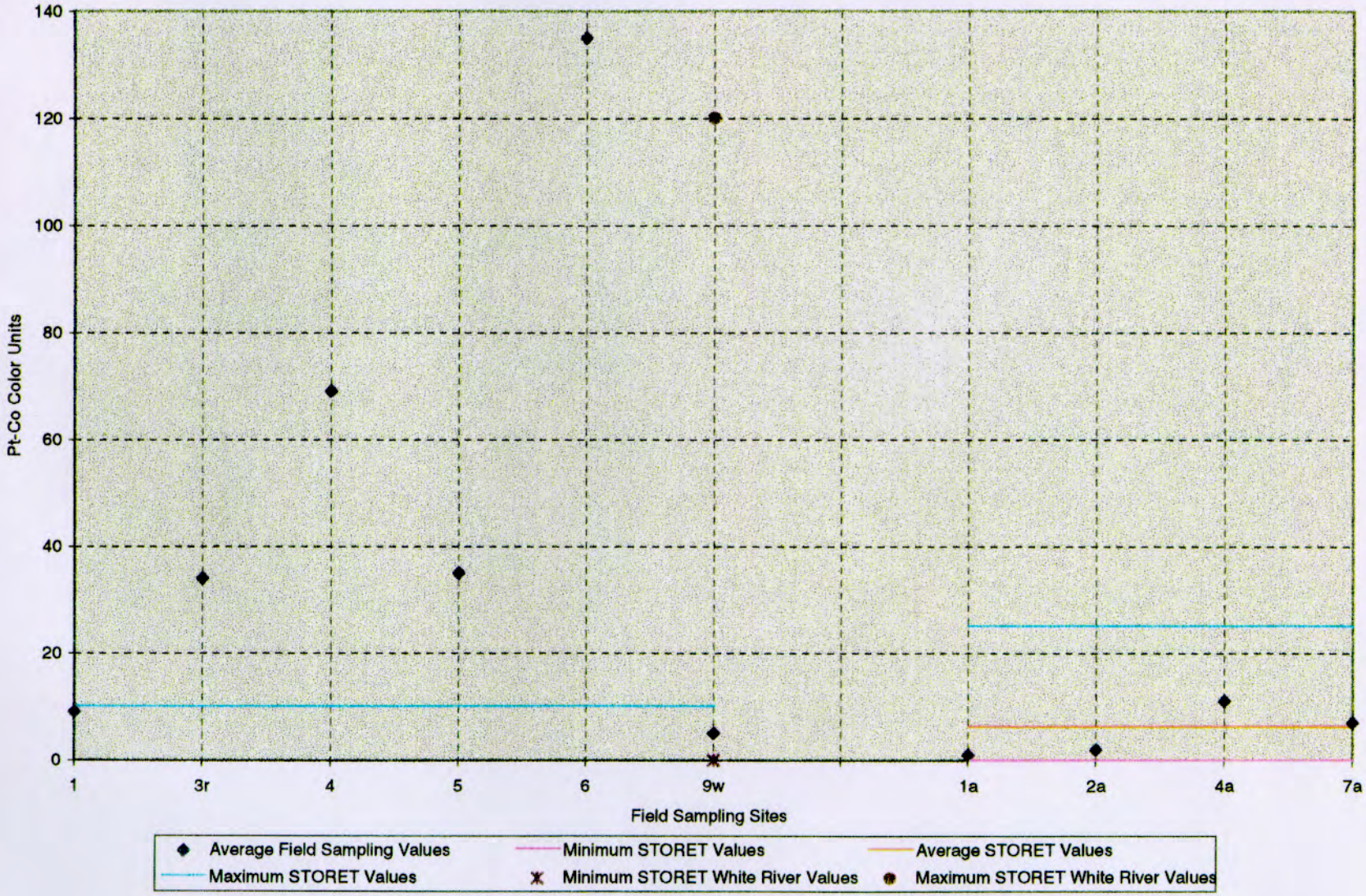
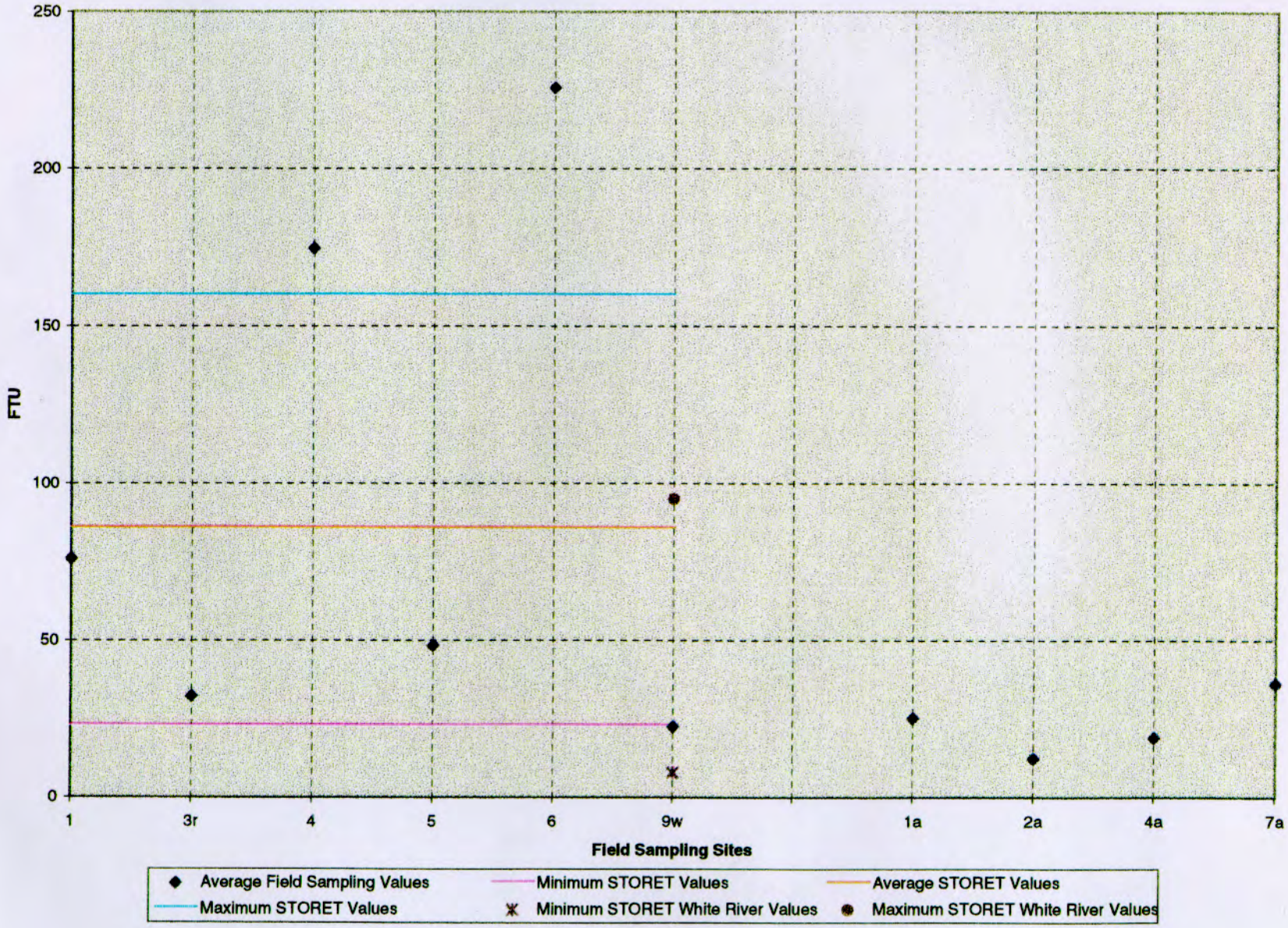


Figure 30 - Turbidity



values of all three water sources indicate a buffered, slightly basic water. Based on an analysis of the field data and the data in the STORET data base, the pH of the irrigation water should not change when surface water is used to replace the majority of the ground water.

Temperature: The temperature values for the surface water (see Figure 28) were somewhat higher on the average than the alluvial water as would be anticipated. The field data for the White River was within the historical data. Although the White River temperature can be significantly lower than the alluvial well water, these extreme values occur in the winter periods when neither irrigation nor crop production would be taking place. In addition, the White River water will be diverted to surface storage reservoirs or be held in the canals where the water should equilibrate with the atmospheric conditions and be very similar to the surface water presently being used for irrigation. The field data generally was closer to the historical minimum values for both water sources but also confirmed the validity of the historical data base. The White River water temperature exhibited a wider range than either the alluvial water or the presently used surface water. The temperature of the surface water diverted into the project area should not exceed the recommended values in the EPA document.

Dissolved Solids: Dissolved solids values (Figure 26) determined in the Summer did not fit the historical pattern. The alluvial water values and surface water values were generally lower than the historical data. Dissolved solids levels in the White River historically have fluctuated widely; however, the historical average value and the values observed in the field studies are significantly lower than the values for the alluvial water and very close to the presently used surface water. High values of dissolved solids could represent a potential for inorganics build-up in the soil or "salting" as has occurred in some of the Western states where irrigation is extensively practiced. All of the dissolved solids values are below the maximum value of 15,000 mg/L recommended by EPA for fish and aquatic life. Other inorganics which are generally of concern to agriculture, i.e., chlorides, were not part of the analytical program; however, because of the similarity of the dissolved solids values in the White River and the presently used surface/ground water, little impact is envisioned from inorganics in the surface water over what is presently being encountered.

Suspended Solids: Suspended solids represent materials which may settle out in the transfer structures or the fields and create a maintenance problem over a long time period. The alluvial water values represented iron oxide created when the water was oxygenated during discharge and were greater than the limited historical values. The values for the presently used surface water reflect the condition of the reservoirs and the wave action when the samples were obtained. The field data do not fit the historical maximum and minimum ranges. Not surprisingly, the White River historical values are significantly greater than the values for the presently used waters although the observed White River values were similar to the presently used irrigation water. The lack of validation of the historical data base by this limited field testing is not significant when the anticipated variability is considered as well as the sensitivity of the value on sampling location. The major concern is that the historical average value of the White River is approximately four times the value of the presently used water. Substantial amounts of suspended solids (primarily silt/clay particles) will be introduced into the study region when the diversion of surface water occurs. The fate of these solids over a long period of diversion is unknown. The EPA has not established quantitative limits for either suspended solids or turbidity as pertains to fish and aquatic life.

Hardness (Total): Hardness represents the presence of calcium and magnesium ions in the water and is an other indicator of the potential build-up of inorganics in the soil over a long period of time. The hardness levels in the field data for the alluvial wells were greater than the historical STORET data. Likewise, the values for the surface water were generally close to the maximum values of the limited historical data. The field data for the White River were only slightly above the historical average values and in the same range as the values for the surface water presently being used. The long-term concern of hardness in the irrigation water is the same as with dissolved solids, i.e., ultimate inorganic build-up in the soil. In this case, a comparison of the historical data for both the White River and the alluvial wells would indicate that use of larger amounts of surface water would reduce the long term problem of inorganic build-up in the soil. A comparison of the data presented in Figures 19 and 20 indicates that the calcium hardness in the White River is approximately twice the magnesium hardness. The calcium to magnesium ratio is slightly lower in the alluvial water. This

difference in relative proportions should not have a significant impact on agricultural activity in the region. In a similar fashion, fish and aquatic life should not be disrupted by the change in hardness due to a predominately surface water since the hardness in the White River water is very close to the presently used surface water and in general less than the alluvial water.

Alkalinity: Alkalinity is a quantitative measure of the ability of water to resist changes in pH or, stated an other way, the buffering capacity of a water. The ions which create the property of alkalinity are hydroxides, carbonates and bicarbonates which entered the water by the dissociation of calcium and magnesium salts. Hydroxides are probably not present because of the neutral to slightly basic pH of the water. The field data for the alluvial wells and the surface waters did not match the historical data. As shown in Figure 18, the ground water values were higher than the historical values while the surface water values were lower than the values found in the data base. In all cases, the alkThe non-carbonate hardness (difference between the total hardness and the alkalinity) of the White River water is approximately one-third of the alluvial water non-carbonate hardness. This fraction of the inorganics is typically populated by chlorides and sulfates. Thus, the substitution of substantial amounts of White River water for alluvial water will result in less inorganics accumulating in the soil over a prolonged irrigation.

Analysis of the data presented in Figures 18 through 30 indicates that the White River water is not appreciably different from the surface water presently being used for irrigation in the study area. The major difference is the historical dissolved solids maximum value for the White River water which approached 5,000 mg/L. Based on published data[6] for irrigation water, the total dissolved solids should be less than 500 mg/L with a limiting concentration of 1,500 mg/L. This same reference indicated that other parameters of interest were

	threshold	limiting
conductivity, microohms/cm	750	2,250
pH	7.0 -8.5	6.0 - 9.0
copper, mg/L	0.1	1.0

where the threshold concentration is the level where the irrigator may be come concerned and seek additional water and the limiting concentration is the level where the yield of high value crops may be drastically reduced. Recommended maximum concentrations of trace

[6] The Water Encyclopedia

metals in irrigation water[7] have been published as 0.2 mg/L copper and 5 mg/L iron for water used continuously on soil and as 5 mg/L copper, 20 mg/L iron for water used up to 20 years on fine textured soils.

Although the extreme value of the dissolved solids exceeds the limiting values recommended for irrigation water, the historical average value for the White River water is substantially below the recommended value of 500 mg/L. The recommended limited values for conductivity relate to the concern for dissolved solids which contribute to "salting" of agricultural soil and the use of the conductivity parameter as an indicator of dissolved solids. Analysis of conductivity data, both historical and field collected, for both the White River water and the surface water presently being used for irrigation indicates that water from both sources is well below the values of concern. Likewise, iron and copper values are in the micro-gram per liter range for both ground and surface waters.

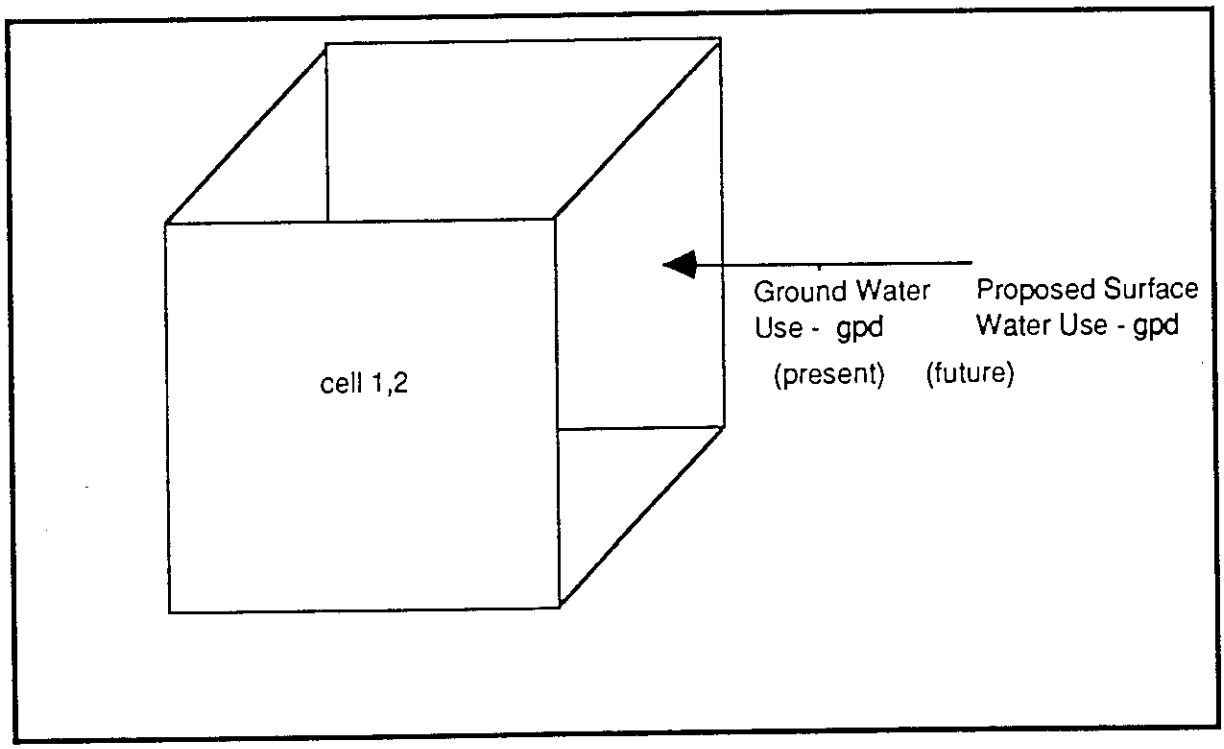
[7] Quality of Irrigation Water

VIII. MONITORING AND PREDICTION OF POTENTIAL WATER QUALITY CHANGES

An evaluation of the historical and field data for the selected parameters indicates that the surface water diversion project will have limited negative impact on the quality of the water used for irrigation in the Grand Prairie region. A possible fallacy to this analysis is the assumption that the quality of the water extracted from the White River will not change as it moves from the point of diversion to the lower reaches of the project nor will the surface water quality vary beyond the historical values. Because of the higher probability of water quality variations with the surface water, the surface water diversion project should include a substantial water quality monitoring component.

Using the average ground water quality estimated from the GIS coverages and the surface water quality for the White River from the STORET data base along with the water balance values from Waldron's work, a rough estimation of the potential change in the selected water quality parameters can be made for the study region. The MODFLOW model cells of Waldron's model would be used as the basic unit of study.

An estimation of the present water quality would be developed by assuming a one year water cycle, the 1994 water use values from Waldron's model, and the average ground water quality. A mass balance approach would be used assuming no uptake of the selected parameters by the crops and a worse case scenario where the water used would be equated to the water lost through evaporation and therefore the inorganics would remain in the soil. A typical calculation is shown diagrametrically as follows for one cell in the study region.



	Water Quality		Present Conditions		Future Conditions
Projected Change Parameter	conc., mg/L	residue, lb/day	conc., mg/L	residue, lb/day	lb/day
Dissolved solids					
Hardness (total)					
Alkalinity					
Suspended solids					

Using the year 2015 as the point of project implementation, the above procedure would be repeated for each MODFLOW cell using the proposed surface water augmentation level. The water quality after project augmentation may change as it is moved from the point of diversion to the point of use in the region. Using existing transport models, the change in selected parameters can be simulated when the water quality data base is combined with the data base containing the hydraulic characteristics of the project. The final product would be a GIS based model of water quality changes which could be used by the Corps to assist in the monitoring the environmental impact of the project.

IX. SUMMARY AND RECOMMENDATIONS

The existing water quality data base for the Grand Prairie study area was questionable to perform projections of changes due to the surface water diversion project. While the ground water data base was extensive, the period of record extends from 1929 to 1988 and is inconsistent in that few locations were sampled through out the entire period of record. Accordingly, limited field verification of the historical data was performed during the Summer of 1996.

Irrigation water presently being used in the study area is a mixture of ground water extracted from the alluvial and Sparta Sand aquifers and surface water captured in tail water recovery systems. Often the ground water is pumped into the man-made reservoirs used for tail water recovery creating a mixture of unknown proportions. Based on the historical as well as the field data collected as part of this investigation, continued use of the water of the present quality should have no long term effect on crop productivity in the study region. The key characteristic of importance to agricultural productivity is salinity or total dissolved solids. Salinity does not appear to be a problem in the study area. The waters presently being used have moderate levels of total dissolved solids, well below the suggested limits for long-term agricultural activity. Likewise, the diversion of surface water into the region for the purpose of irrigation should not negatively impact the fish and aquatic life in the natural conveyance structures which will be used as part of the project.

Present and future agricultural practices in the Grand Prairie region [rice, corn, soy beans, and wheat] rely heavily on irrigation. With one exception, the historical and field data describing the water quality of the White River indicates that the replacement of significant amounts of ground water with White River water will have a positive impact on the long term productivity of the soil. In general, the surface water is lower in hardness and alkalinity than the ground water which should directionally place less inorganics in the soil. The suspended material in the White River water is greater than the ground water and the local surface water presently being used; however, the suspended solids will probably settle in the transfer canals and storage basins prior to use. The remaining colloidal clay particles should not significantly impact the crops being irrigated. Monitoring of the water quality after the project is implemented as well as the development of a fate and transport model should be part of the environmental management portion of this project.

Appendix A

STORET Sampling Locations and Identification Numbers

Groundwater Locations

Statid	County
07078120	ARKANSAS
07078180	ARKANSAS
341850091320901	ARKANSAS
342057091280601	ARKANSAS
342307091195001	ARKANSAS
342321091295501	ARKANSAS
342416091243701	ARKANSAS
342459091245901	ARKANSAS
342645091270401	ARKANSAS
342658091260101	ARKANSAS
342711091270901	ARKANSAS
342715091281301	ARKANSAS
342733091214301	ARKANSAS
342736091240101	ARKANSAS
342738091245601	ARKANSAS
342738091254301	ARKANSAS
342750091252201	ARKANSAS
342752091250101	ARKANSAS
342757091253401	ARKANSAS
342820091245301	ARKANSAS
342831091245401	ARKANSAS
342839091303201	ARKANSAS
342840091323101	ARKANSAS
342843091291801	ARKANSAS
342847091345702	ARKANSAS
342922091315201	ARKANSAS
342925091314701	ARKANSAS
343018091325201	ARKANSAS
343110091252301	ARKANSAS
343534091384701	PRAIRIE
343638091230801	MONROE
343639091335201	PRAIRIE
343705091331702	PRAIRIE
343705091331801	PRAIRIE
343714091342801	PRAIRIE
343728091282101	PRAIRIE
343732091345701	PRAIRIE
343751091363501	PRAIRIE
343811091331401	PRAIRIE
343827091345401	PRAIRIE
344056091261301	PRAIRIE
344124091374001	PRAIRIE
344227091432401	LONOKE
344233091295701	PRAIRIE
344420091310001	PRAIRIE
344620091281301	PRAIRIE
344636091375201	PRAIRIE
344643091283701	PRAIRIE
344644091382801	PRAIRIE
344653091345001	PRAIRIE
344653091345002	PRAIRIE
344658091274701	PRAIRIE
344705091443701	LONOKE
344708091285001	PRAIRIE
344956091353801	PRAIRIE
344957091372501	PRAIRIE
344959091362601	PRAIRIE
345019091350001	PRAIRIE
345040091353301	PRAIRIE

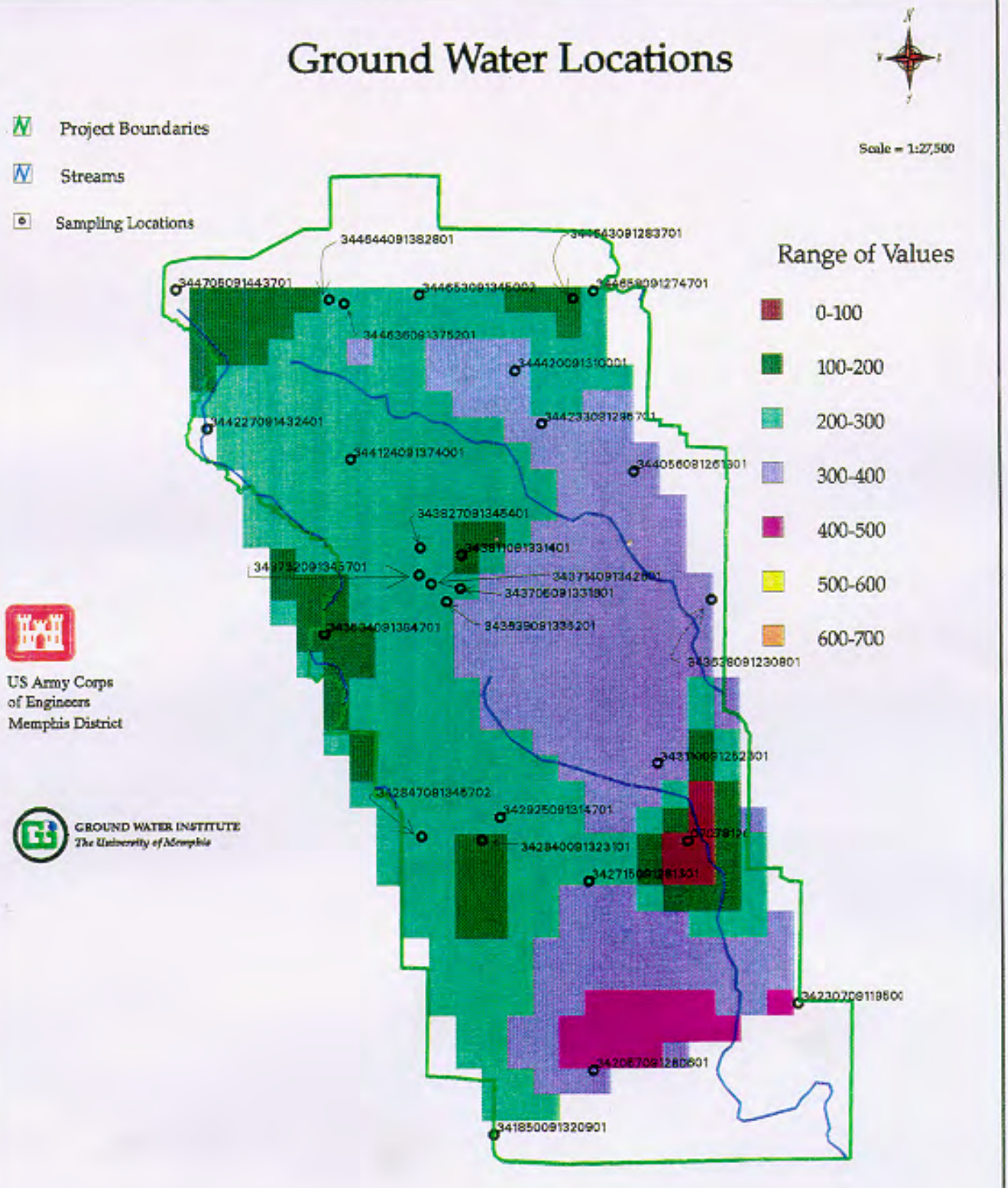
Surface Water Locations

Statid	County
030	MONROE
05UWS042	ARKANSAS
060190	PRAIRIE
060191	PRAIRIE
060192	PRAIRIE
060207	ARKANSAS
060208	ARKANSAS
060209	ARKANSAS
060210	ARKANSAS
060463	LONOKE
060464	ARKANSAS
060465	ARKANSAS
AR0000353	ARKANSAS
AR0022411	PRAIRIE
AR0033383	ARKANSAS
AR0034380	ARKANSAS
AR0035611	PRAIRIE
AR0035793	MONROE
AR0038008	PRAIRIE

Appendix B

STORET Information as a Geographic Information System (GIS) Coverage

Ground Water Locations

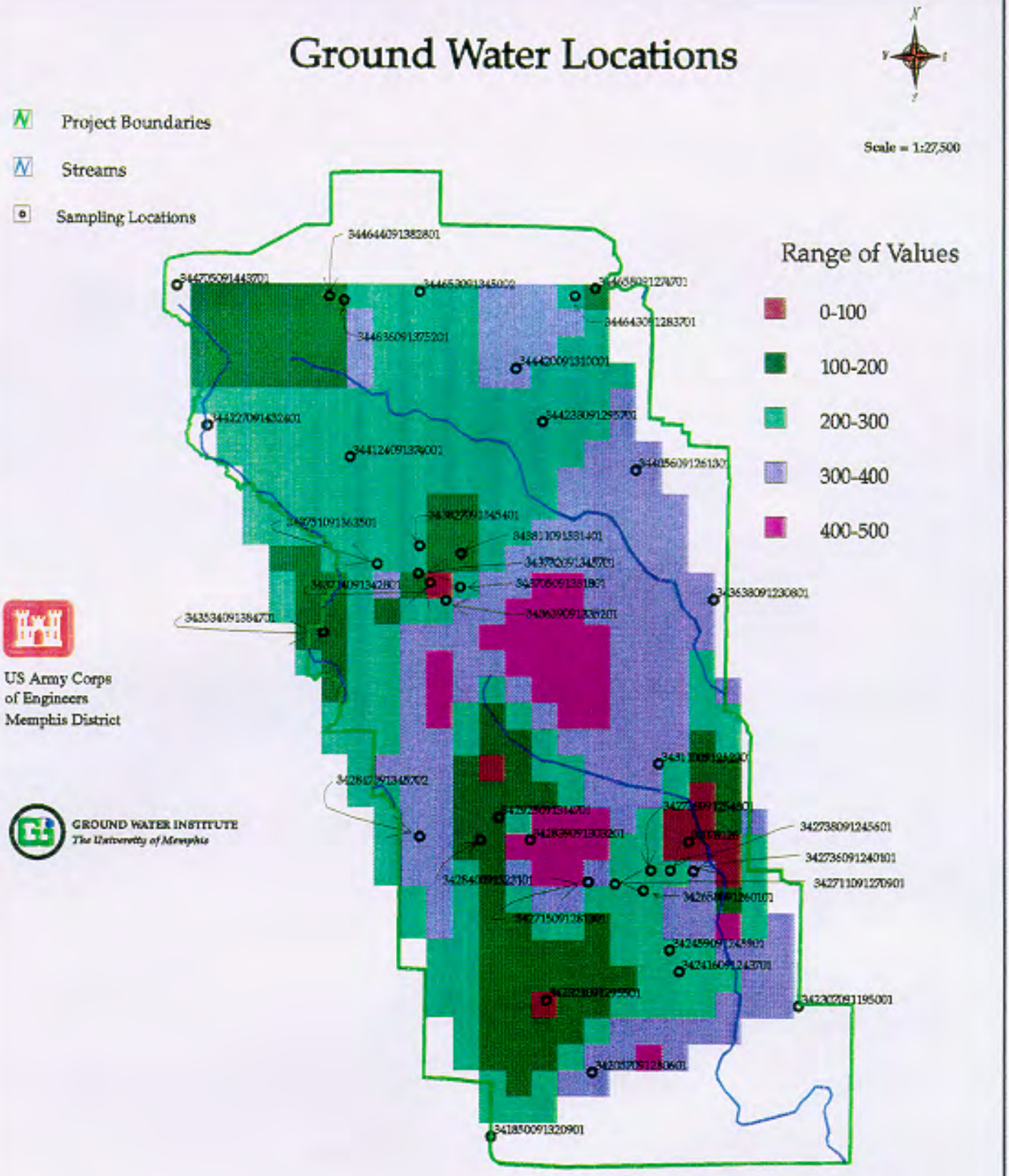


Alkalinity (mg/l as $CaCO_3$)

STORET Sampling Data

Figure B-1

Ground Water Locations



Calcium Hardness (mg/l as $CaCO_3$)

STORET Sampling Data

Figure B-2

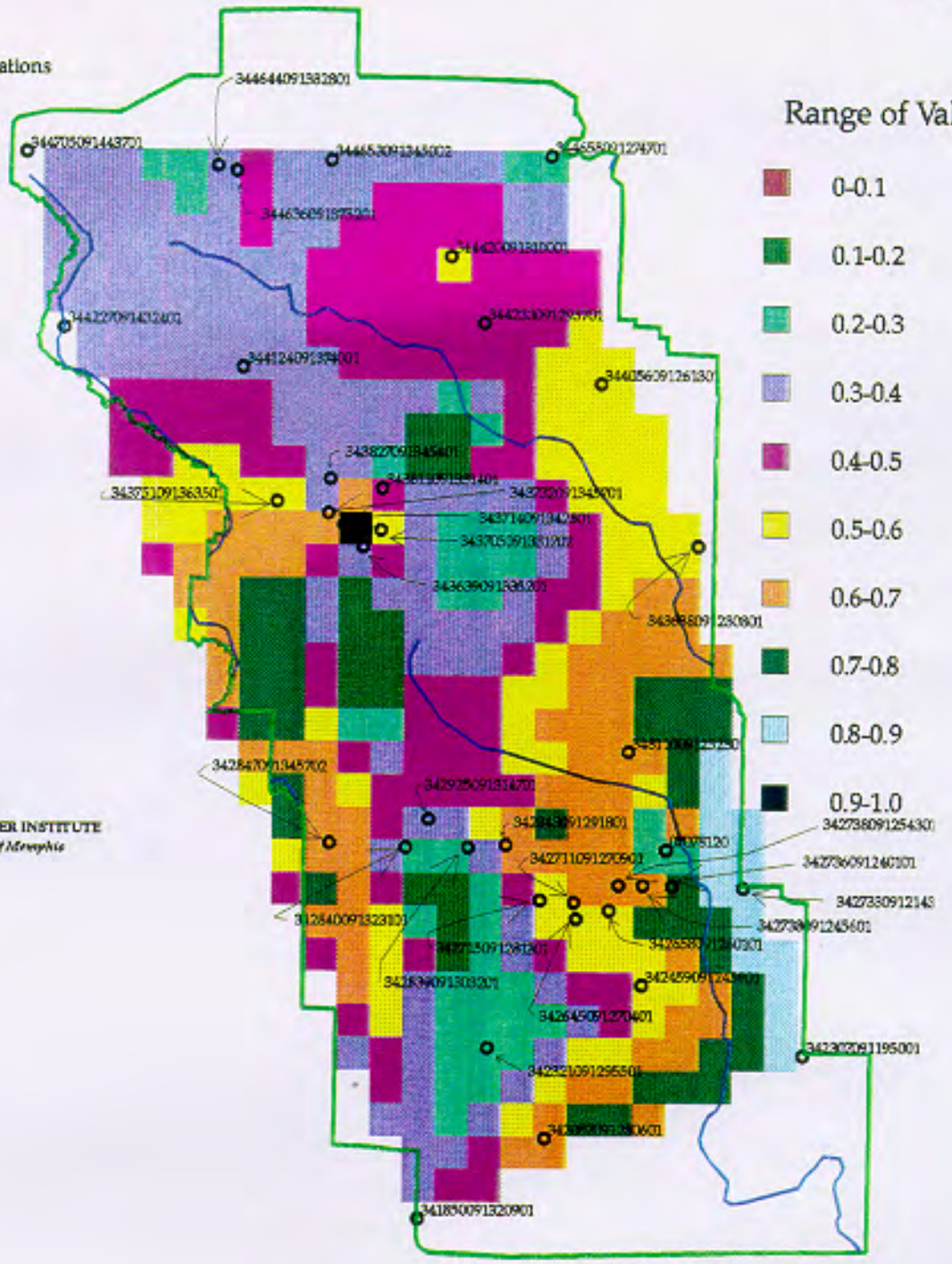
Ground Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

Conductivity (milliohms/cm)

STORET Sampling Data

Figure B-3

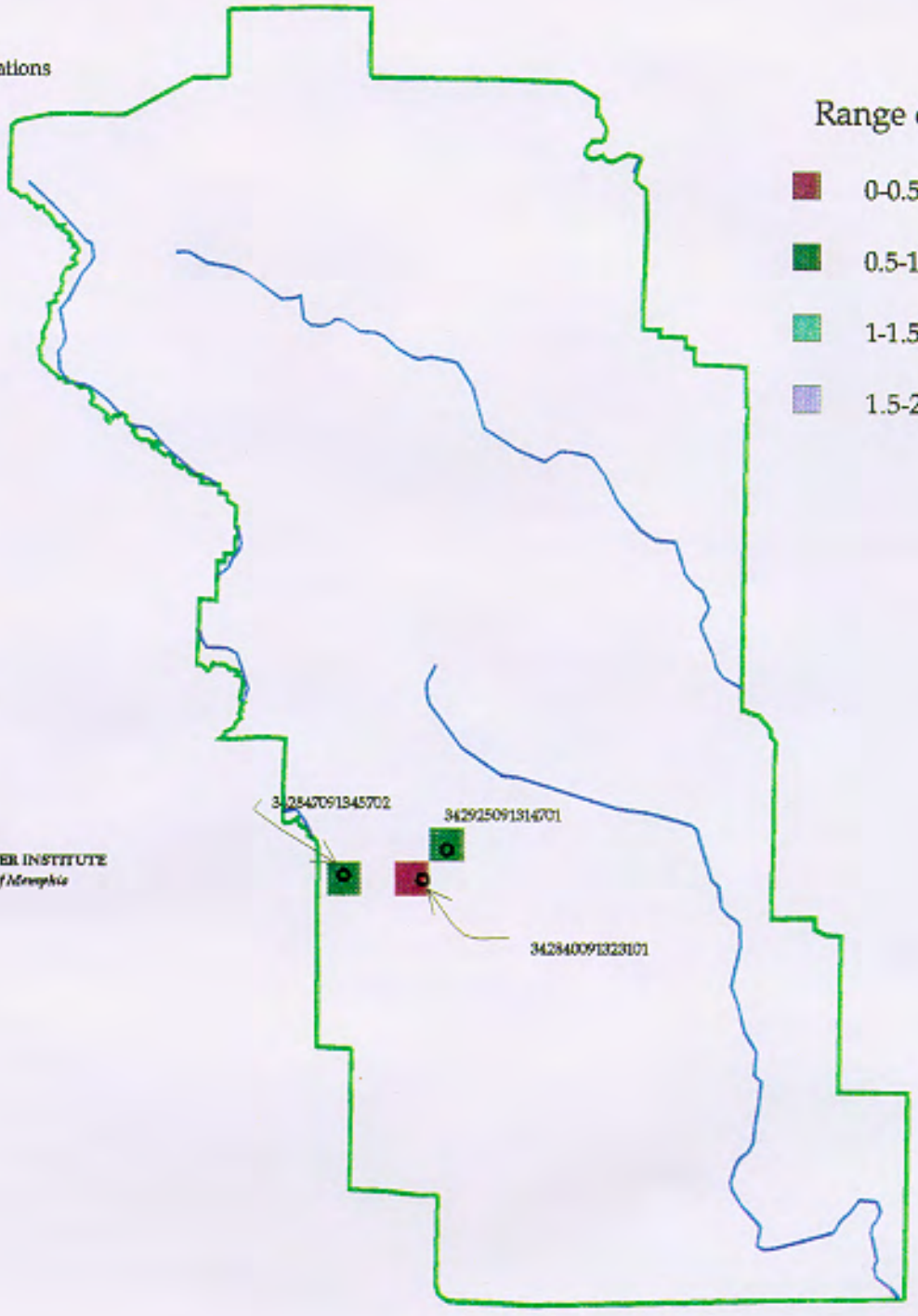
Ground Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



US Army Corps
of Engineers
Memphis District

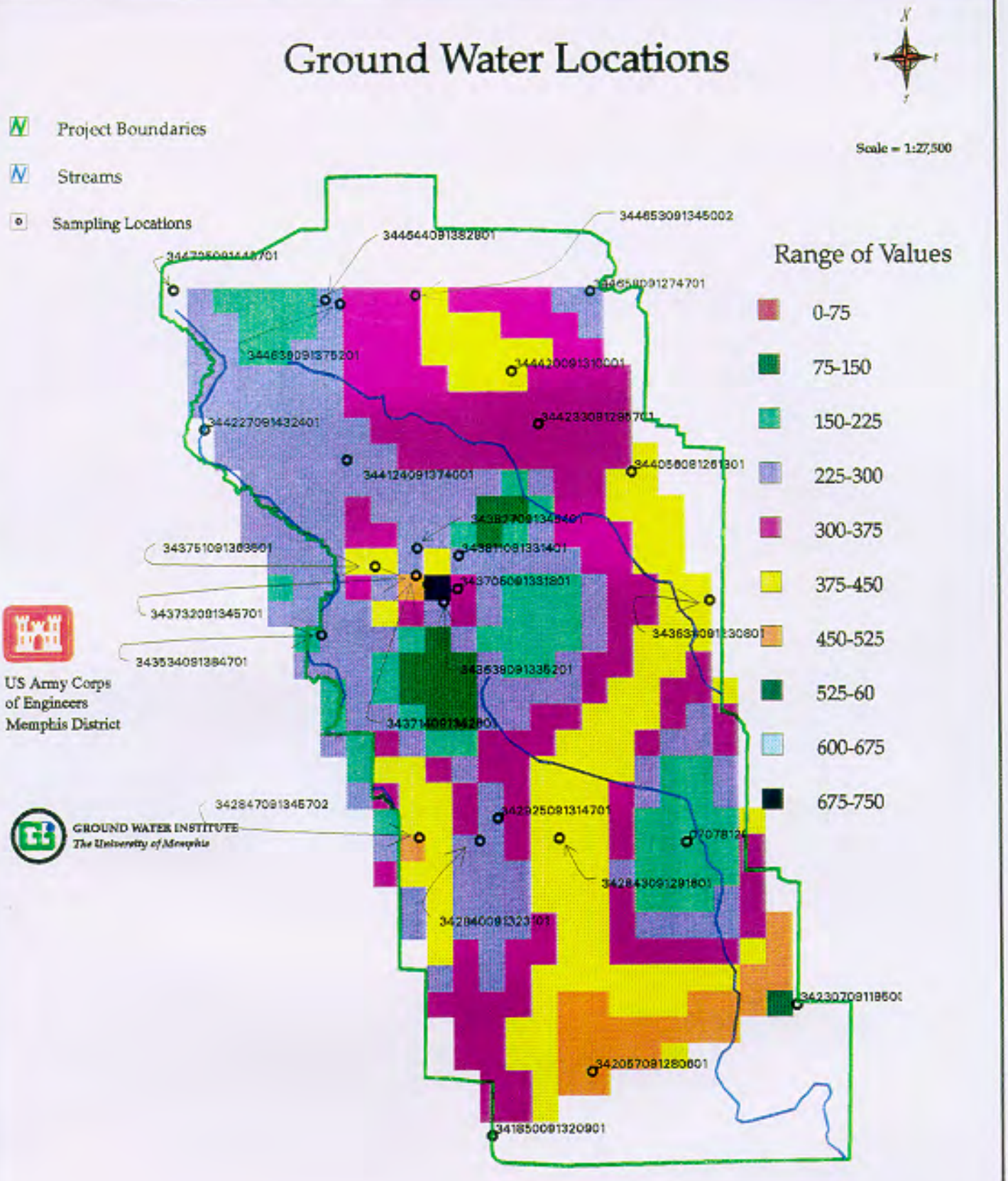
GROUND WATER INSTITUTE
The University of Memphis

Copper (mg/l)

STORET Sampling Data

Figure B-4

Ground Water Locations

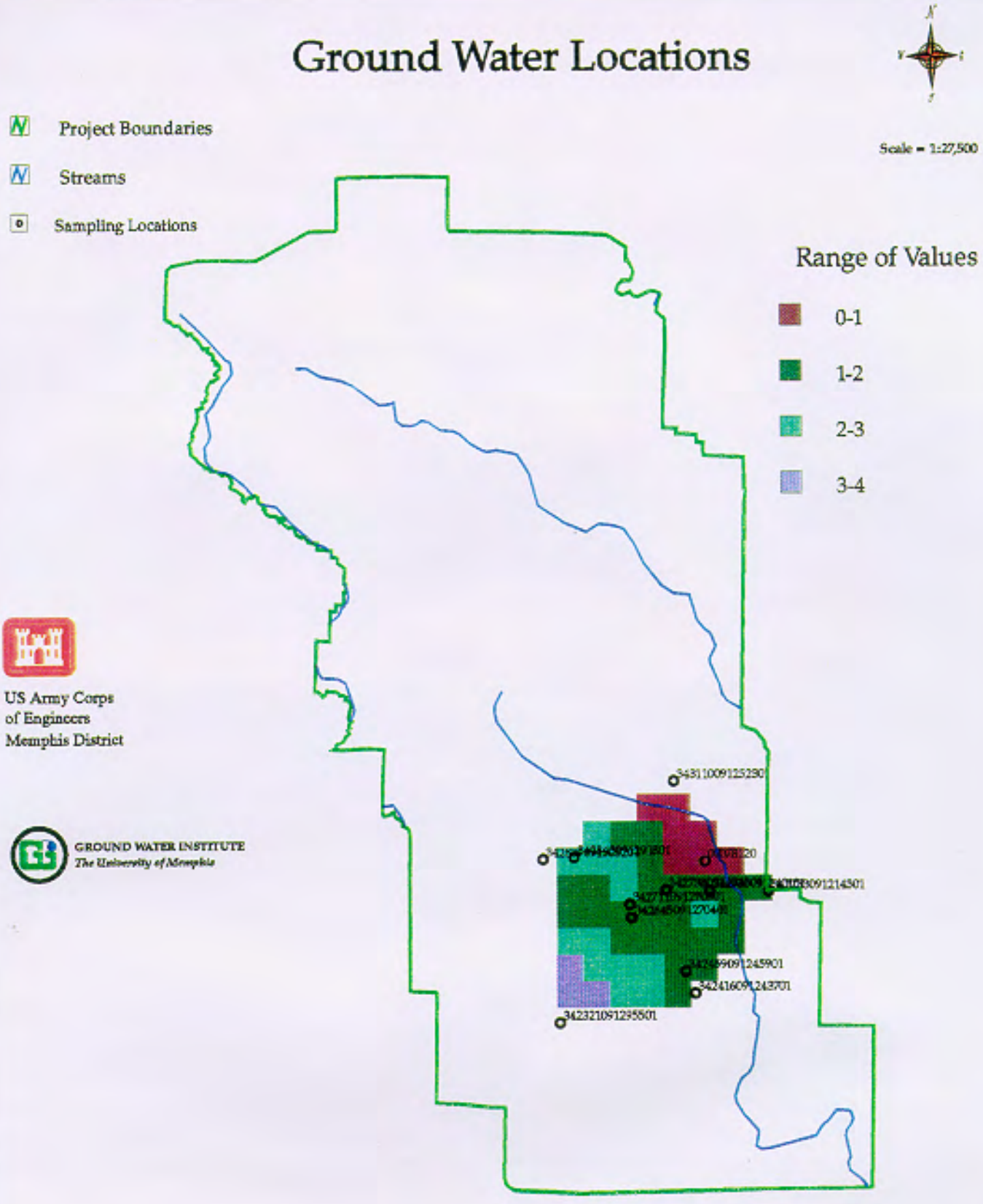


Dissolved Solids (mg/l)

STORET Sampling Data

Figure B-5

Ground Water Locations



Iron (mg/l)

STORET Sampling Data

Figure B-6

Ground Water Locations

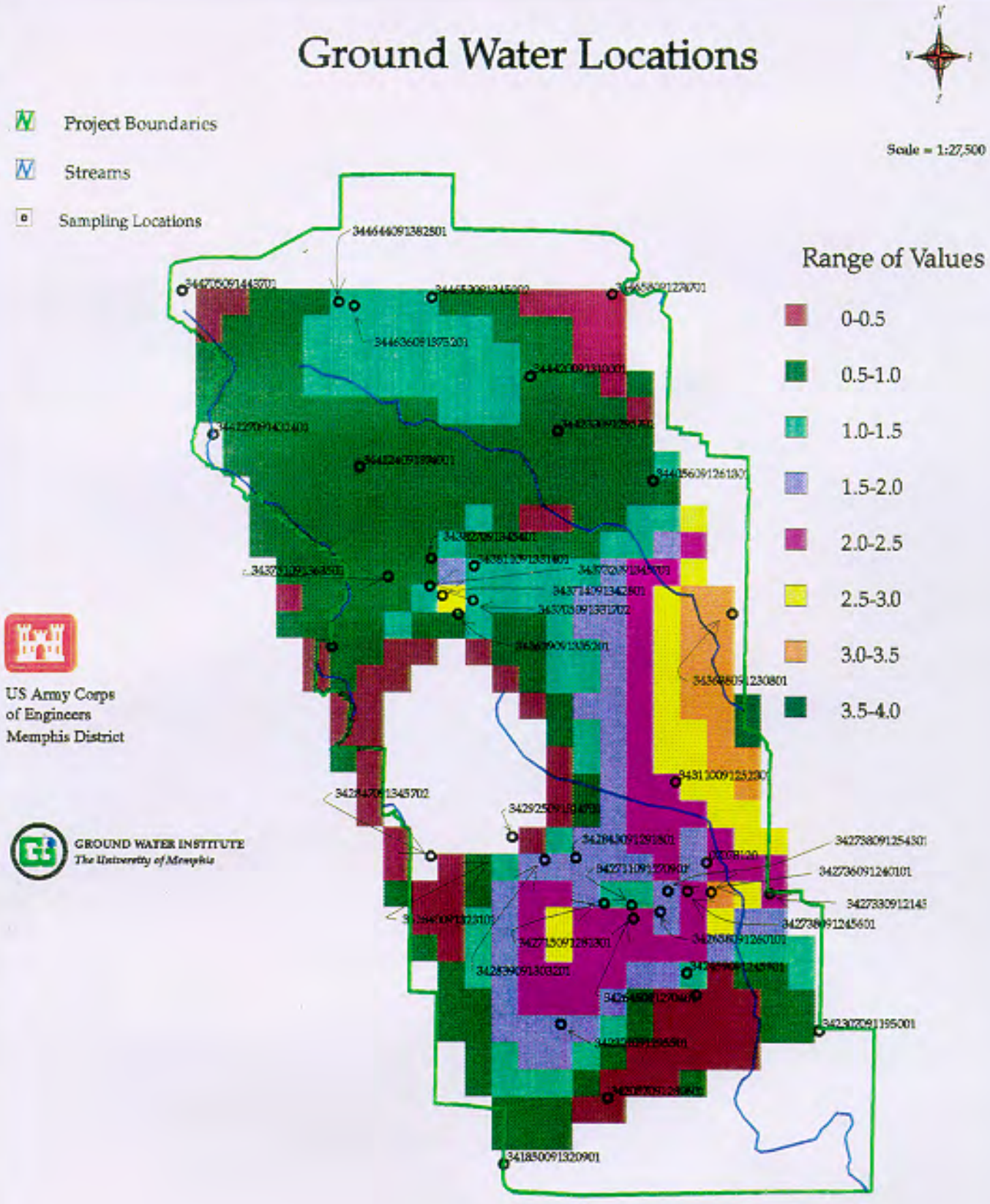


Figure B-7

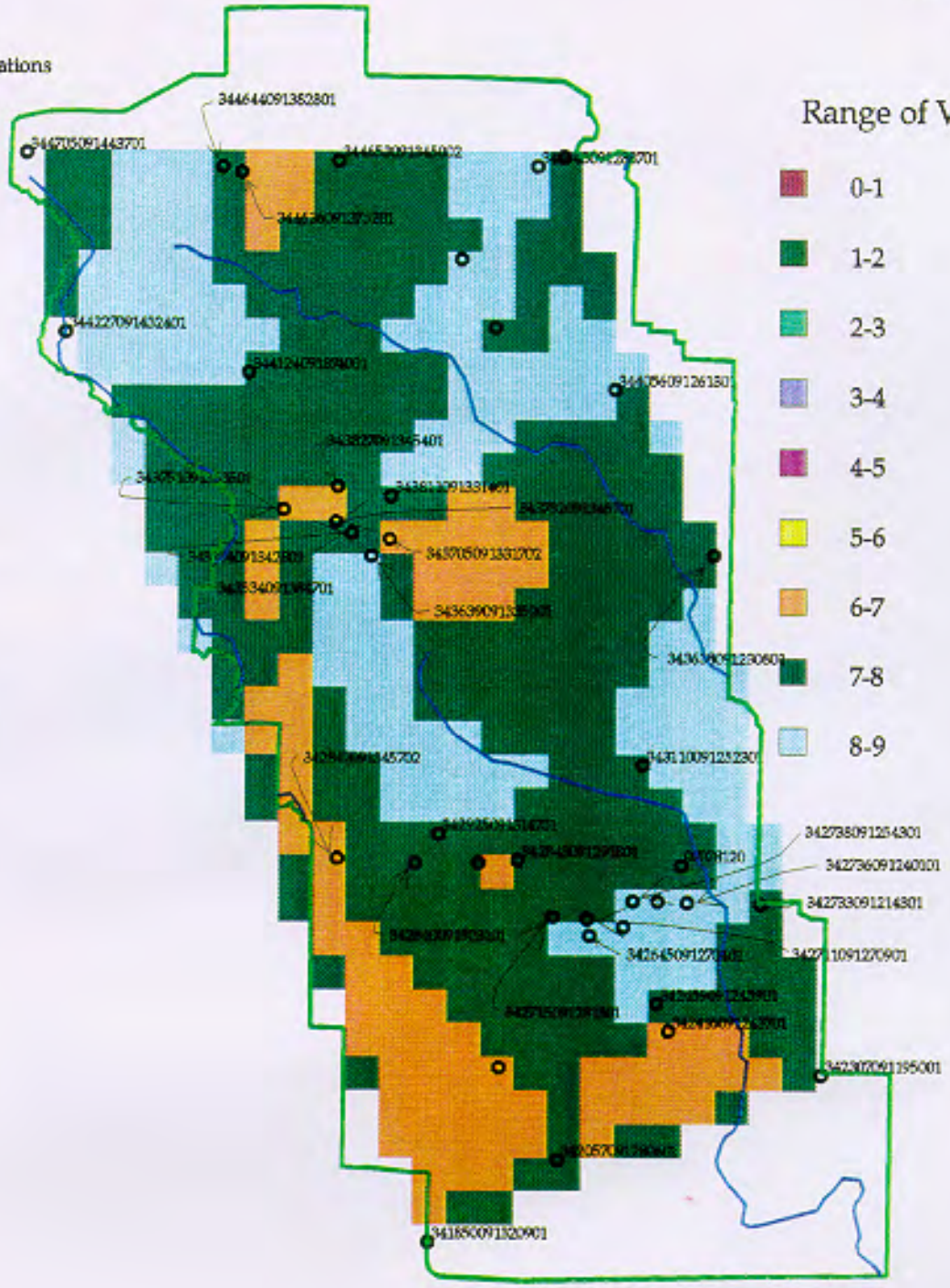
Ground Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



US Army Corps
of Engineers
Memphis District

pH (SU)

STORET Sampling Data

Figure B-8

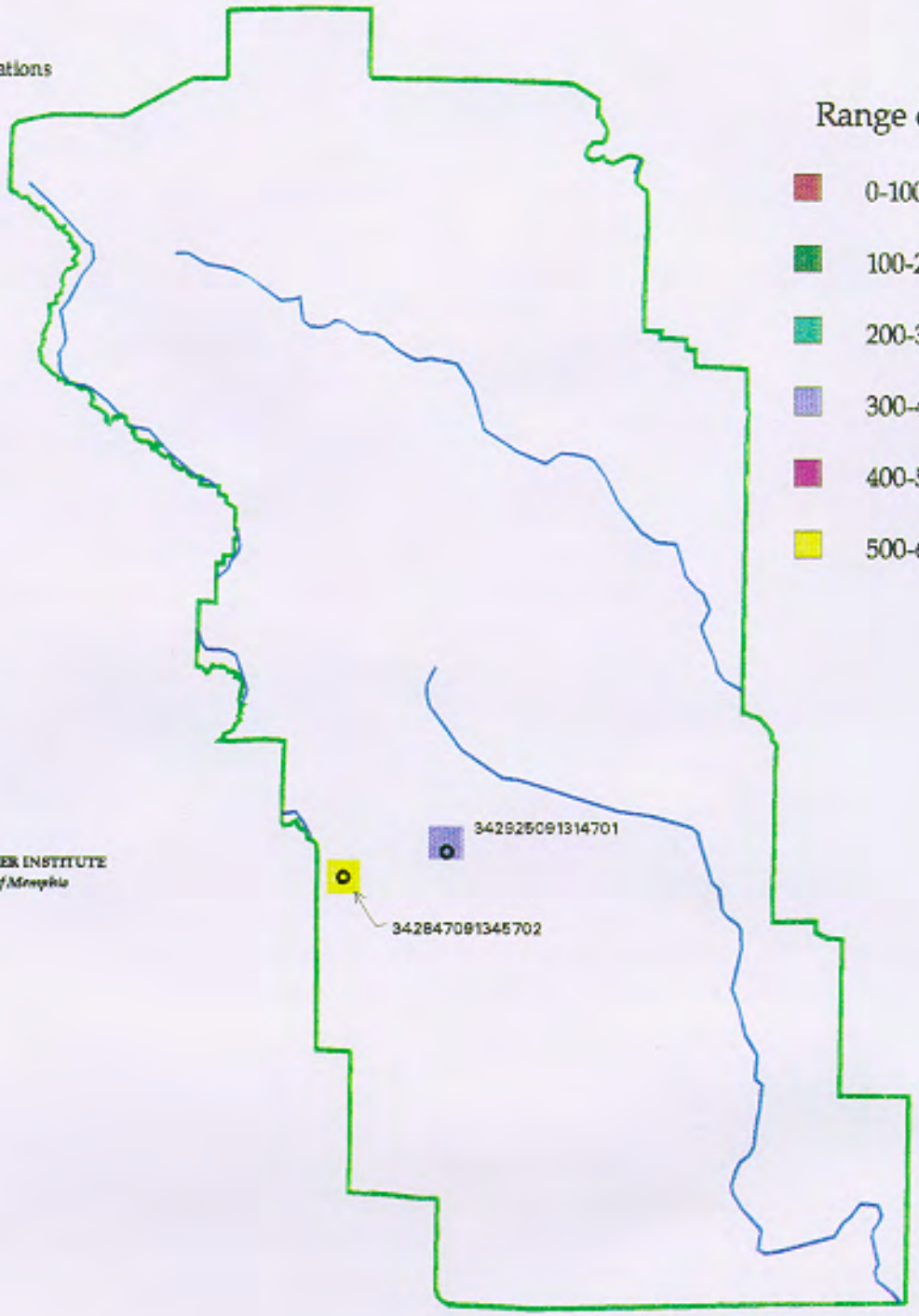
Ground Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

- 0-100
- 100-200
- 200-300
- 300-400
- 400-500
- 500-600

US Army Corps
of Engineers
Memphis District

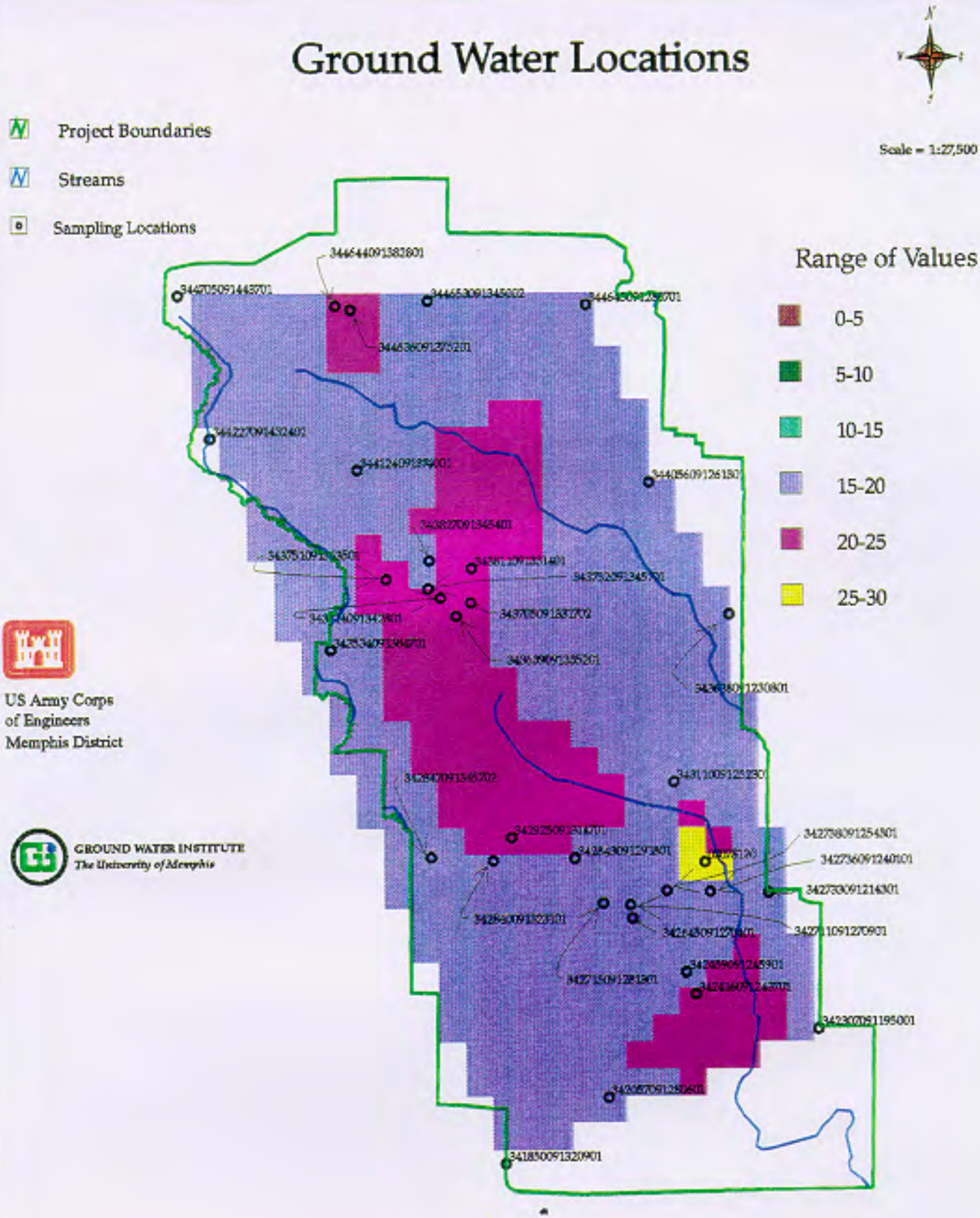
GROUND WATER INSTITUTE
The University of Memphis

Suspended Solids (mg/l)

STORET Sampling Data

Figure B-9

Ground Water Locations

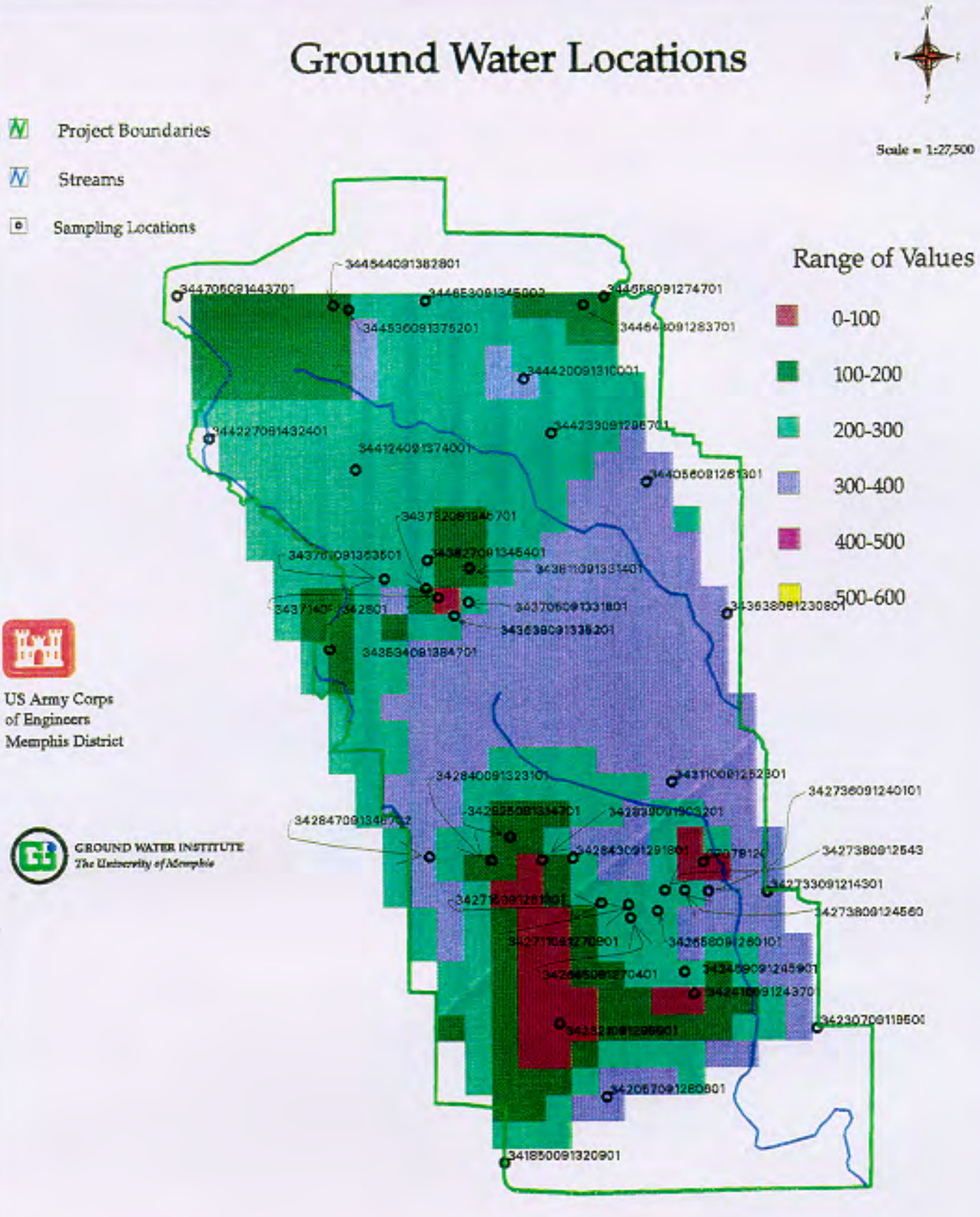


Temperature (Celsius)

STORET Sampling Data

Figure B-10

Ground Water Locations



Total Hardness (mg/l as $CaCO_3$)

STORET Sampling Data

Figure B-11

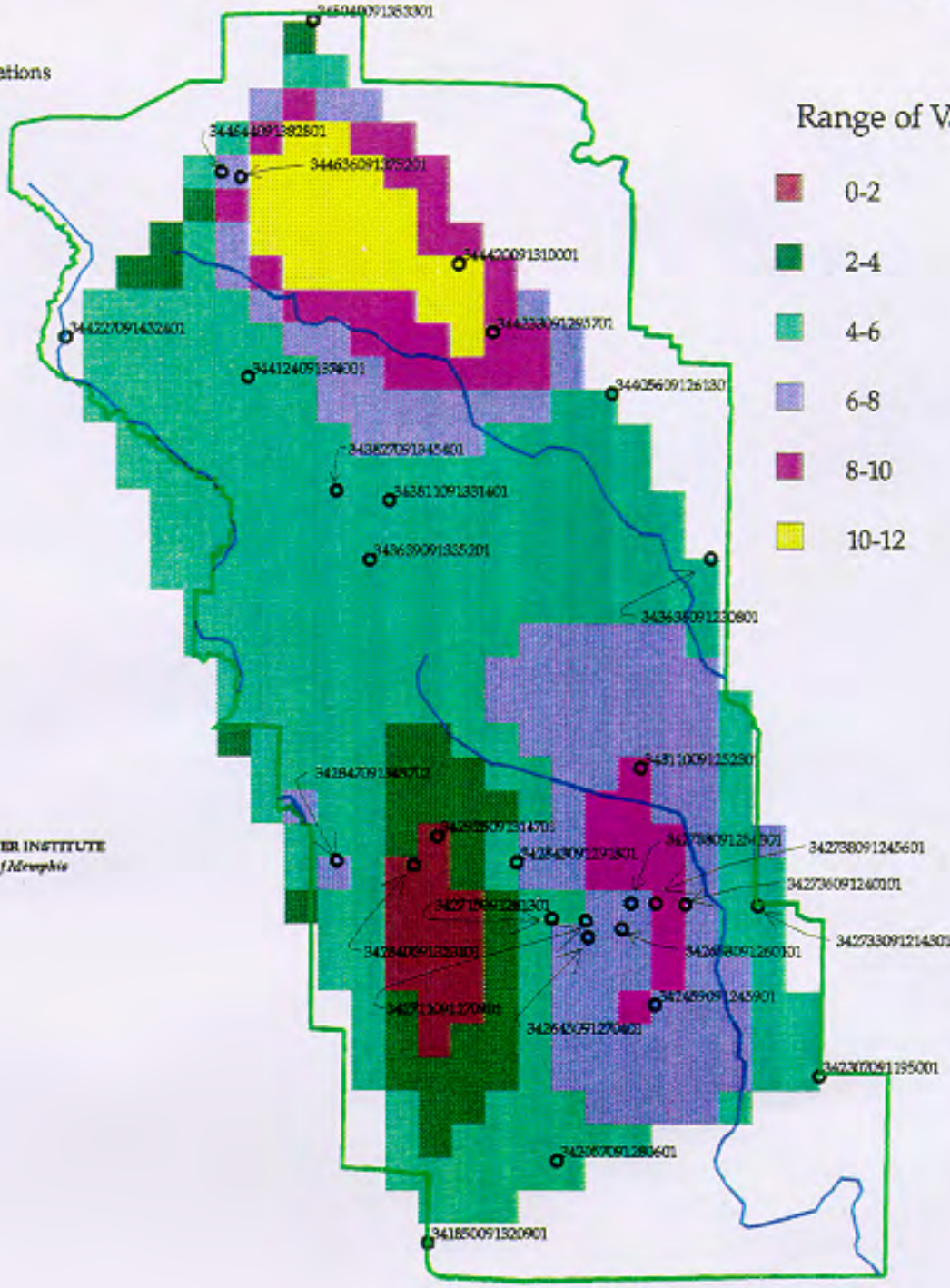
Ground Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

True Color (Pt-Co)

STORET Sampling Data

Figure B-12

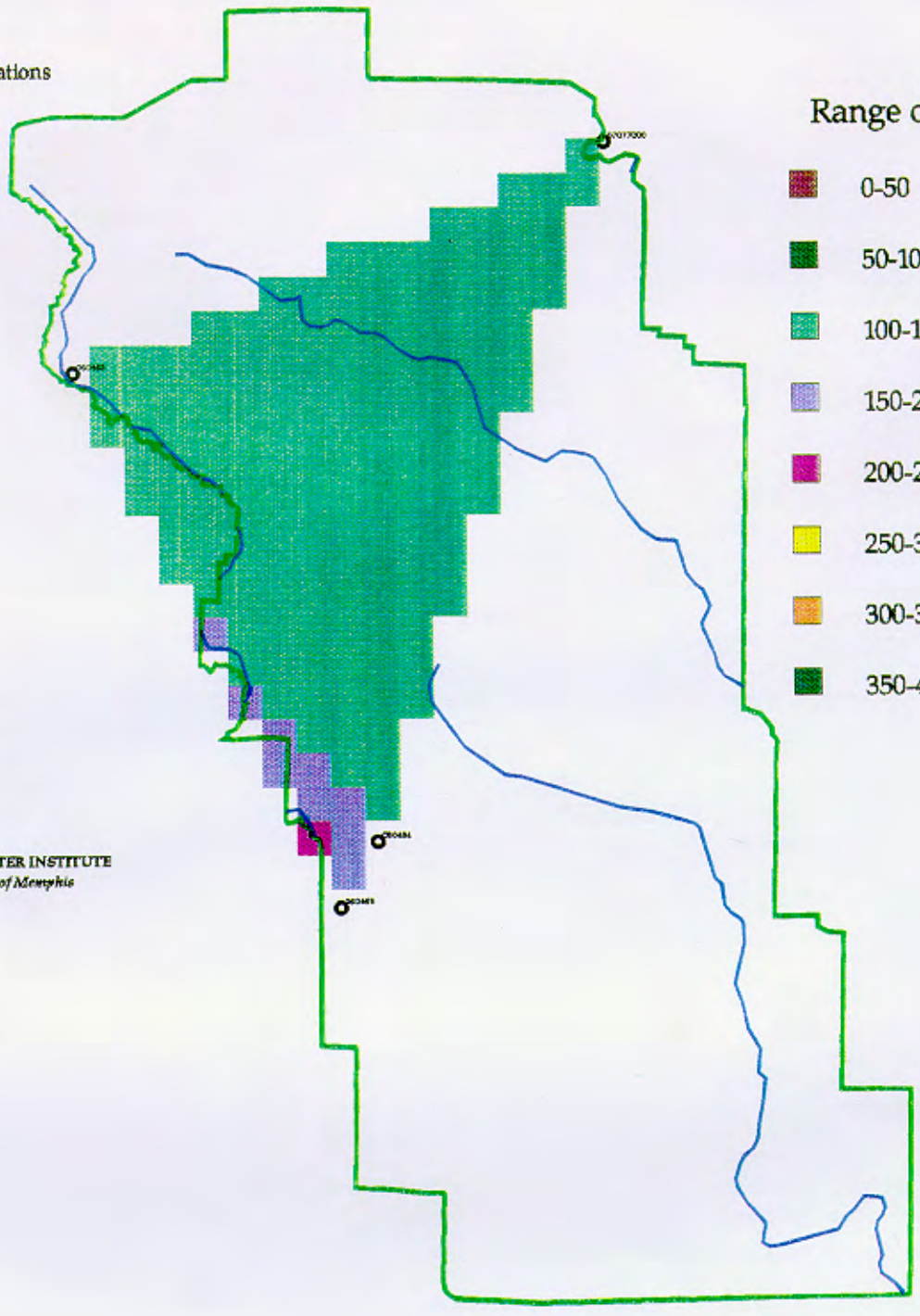
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

- 0-50
- 50-100
- 100-150
- 150-200
- 200-250
- 250-300
- 300-350
- 350-400

US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

Alkalinity (mg/l as $CaCO_3$)

STORET Sampling Data

Figure B-13

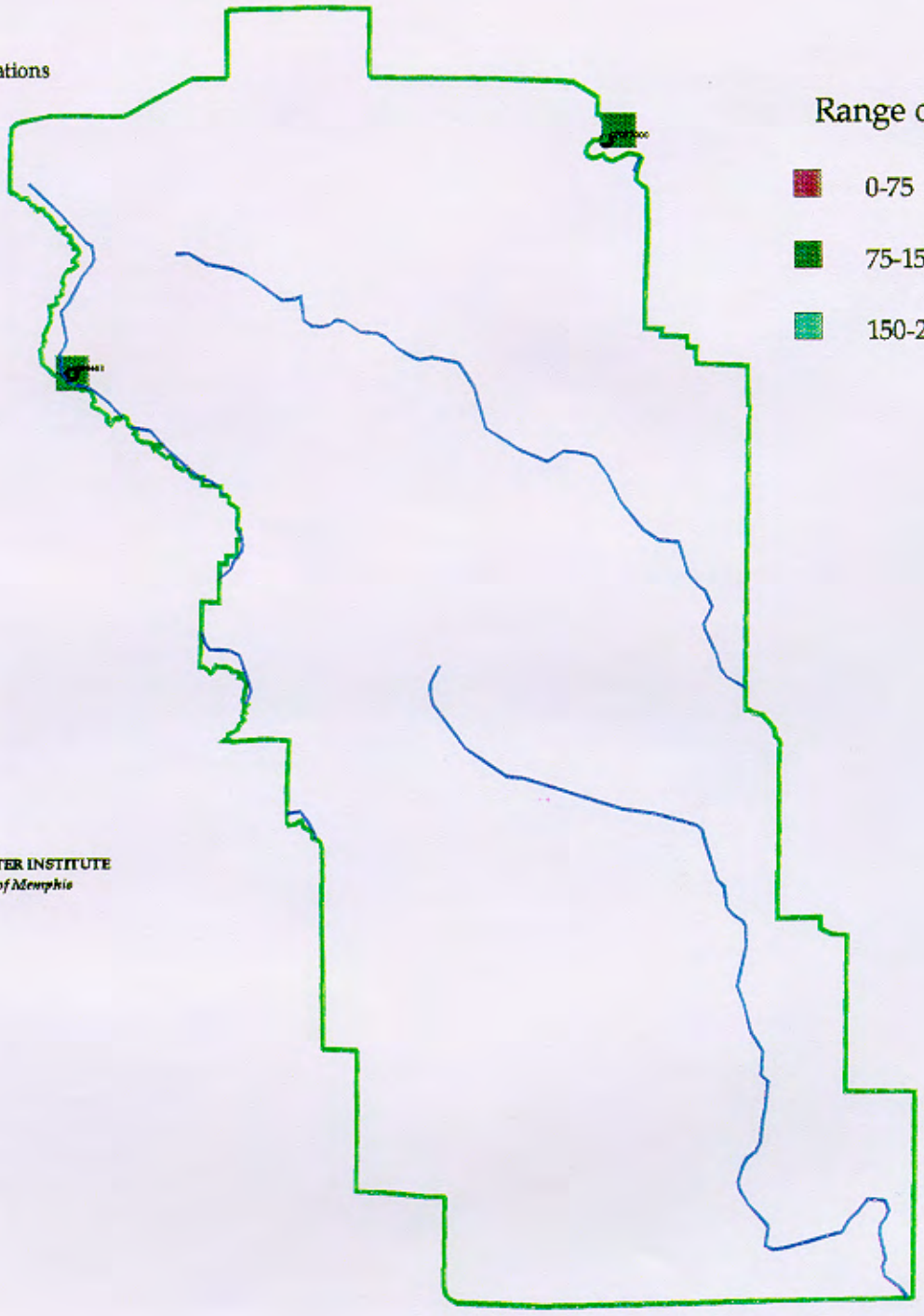
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

0-75

75-150

150-225

US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

Calcium Hardness (mg/l as $CaCO_3$)

STORET Sampling Data

Figure B-14

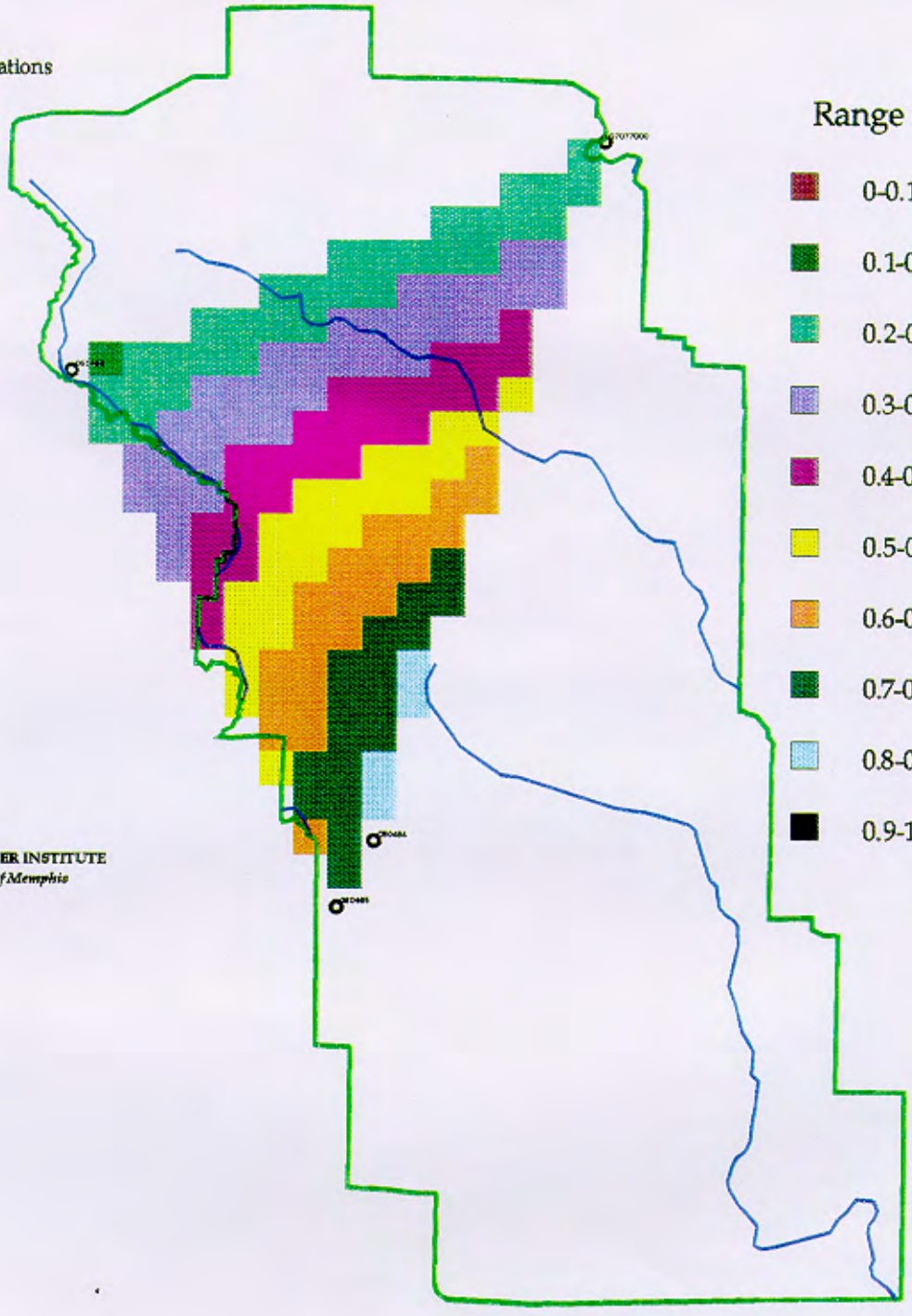
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

- 0-0.1
- 0.1-0.2
- 0.2-0.3
- 0.3-0.4
- 0.4-0.5
- 0.5-0.6
- 0.6-0.7
- 0.7-0.8
- 0.8-0.9
- 0.9-1.0

US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

Conductivity (milliohms/cm)

STORET Sampling Data

Figure B-15

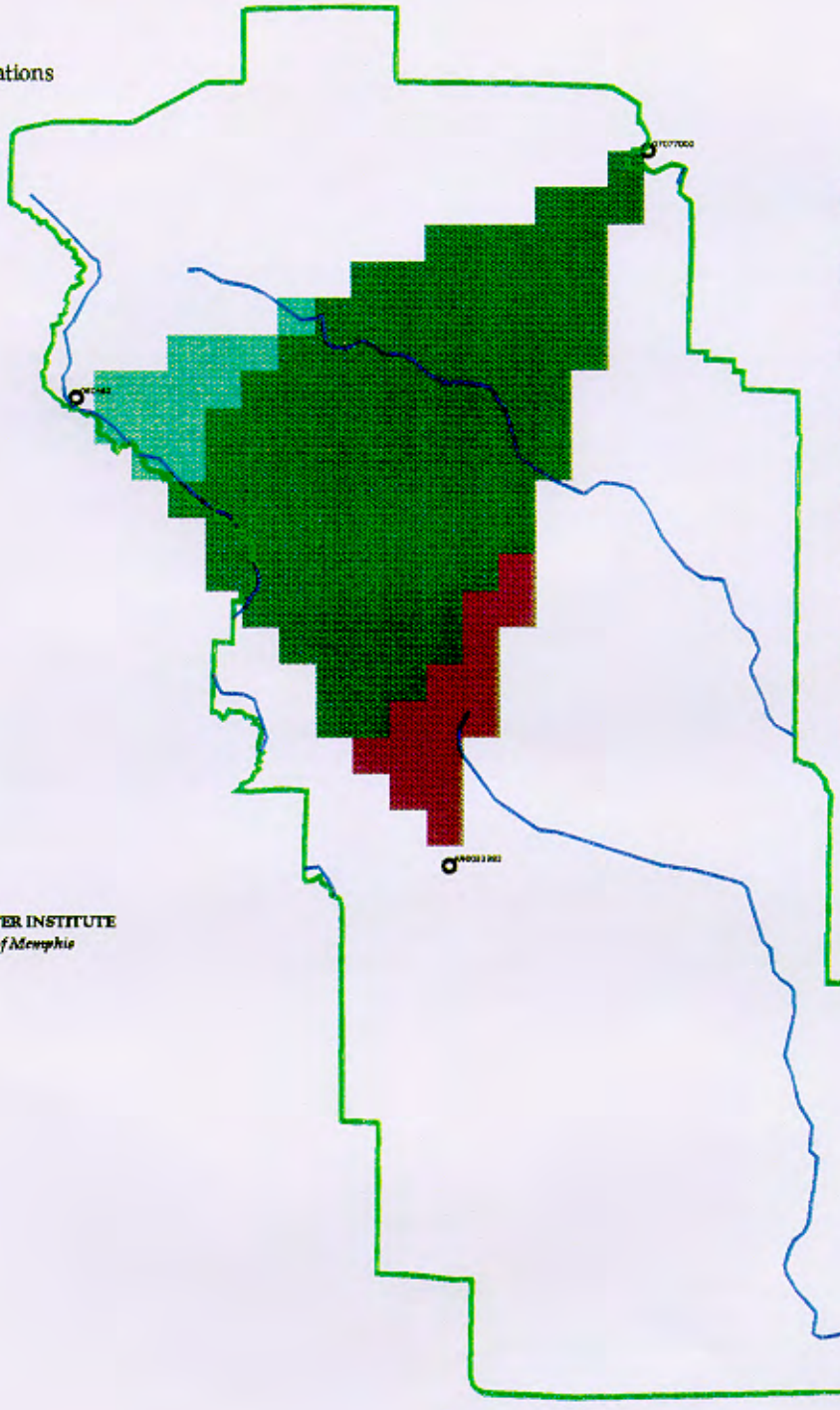
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

- 0-50
- 50-100
- 100-150
- 150-200
- 200-250
- 250-300
- 300-350
- 350-400
- 400-450

US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

Dissolved Solids (mg/l)

STORET Sampling Data

Figure B-16

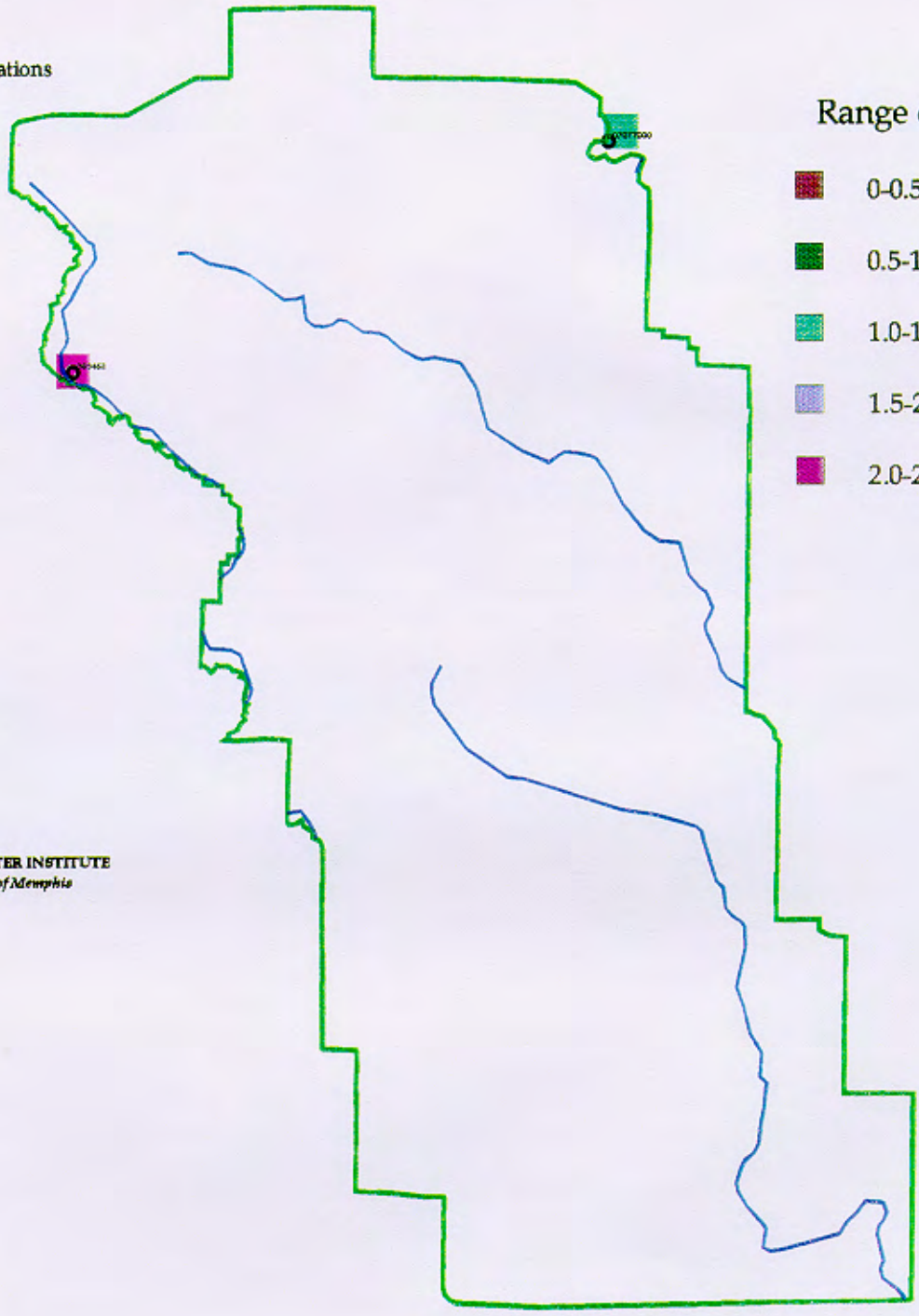
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

- 0-0.5
- 0.5-1.0
- 1.0-1.5
- 1.5-2.0
- 2.0-2.5

US Army Corps
of Engineers
Memphis District

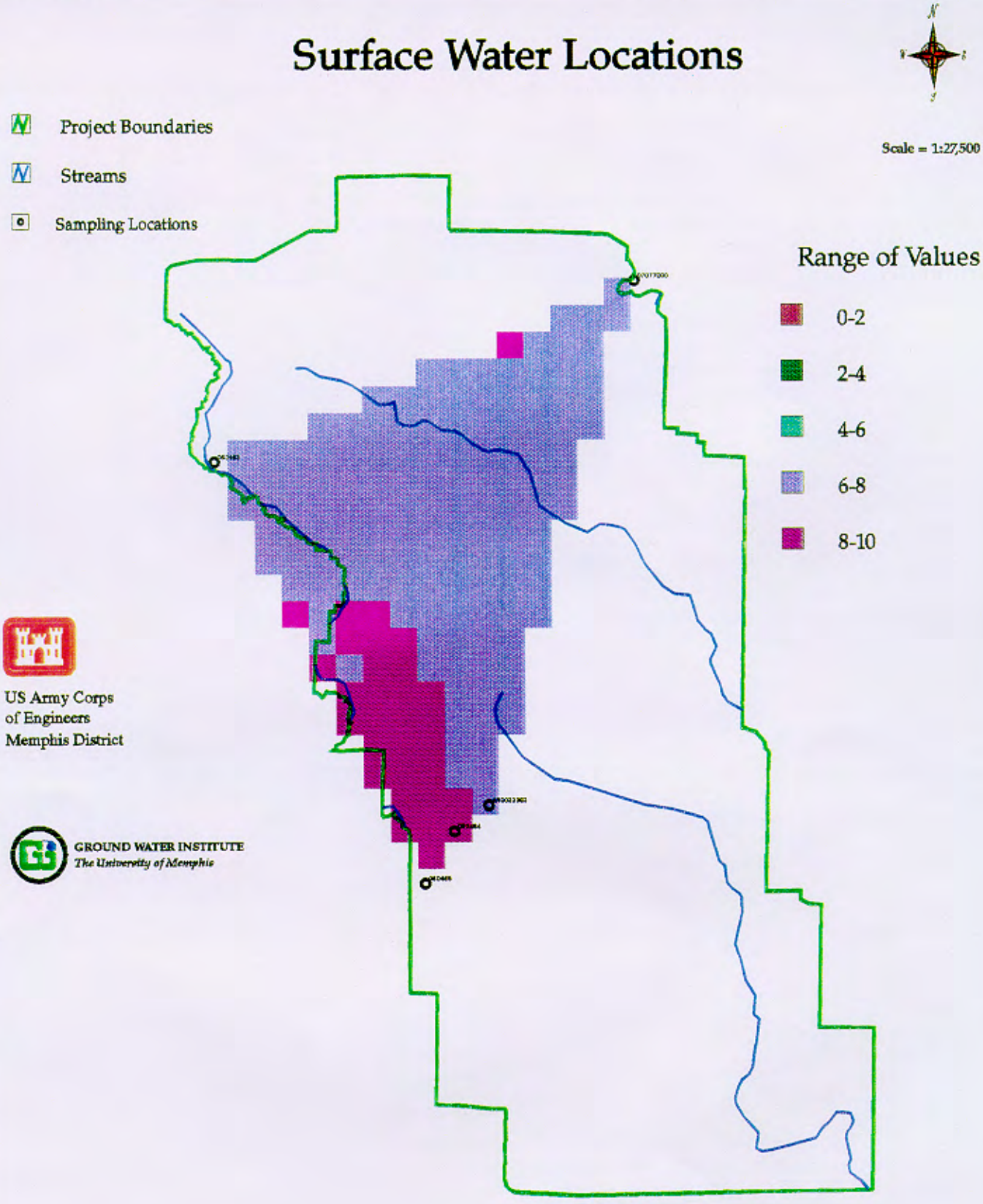
GROUND WATER INSTITUTE
The University of Memphis

Nitrate (mg/l)

STORET Sampling Data

Figure B-17

Surface Water Locations



pH (SU)

STORET Sampling Data

Figure B-18

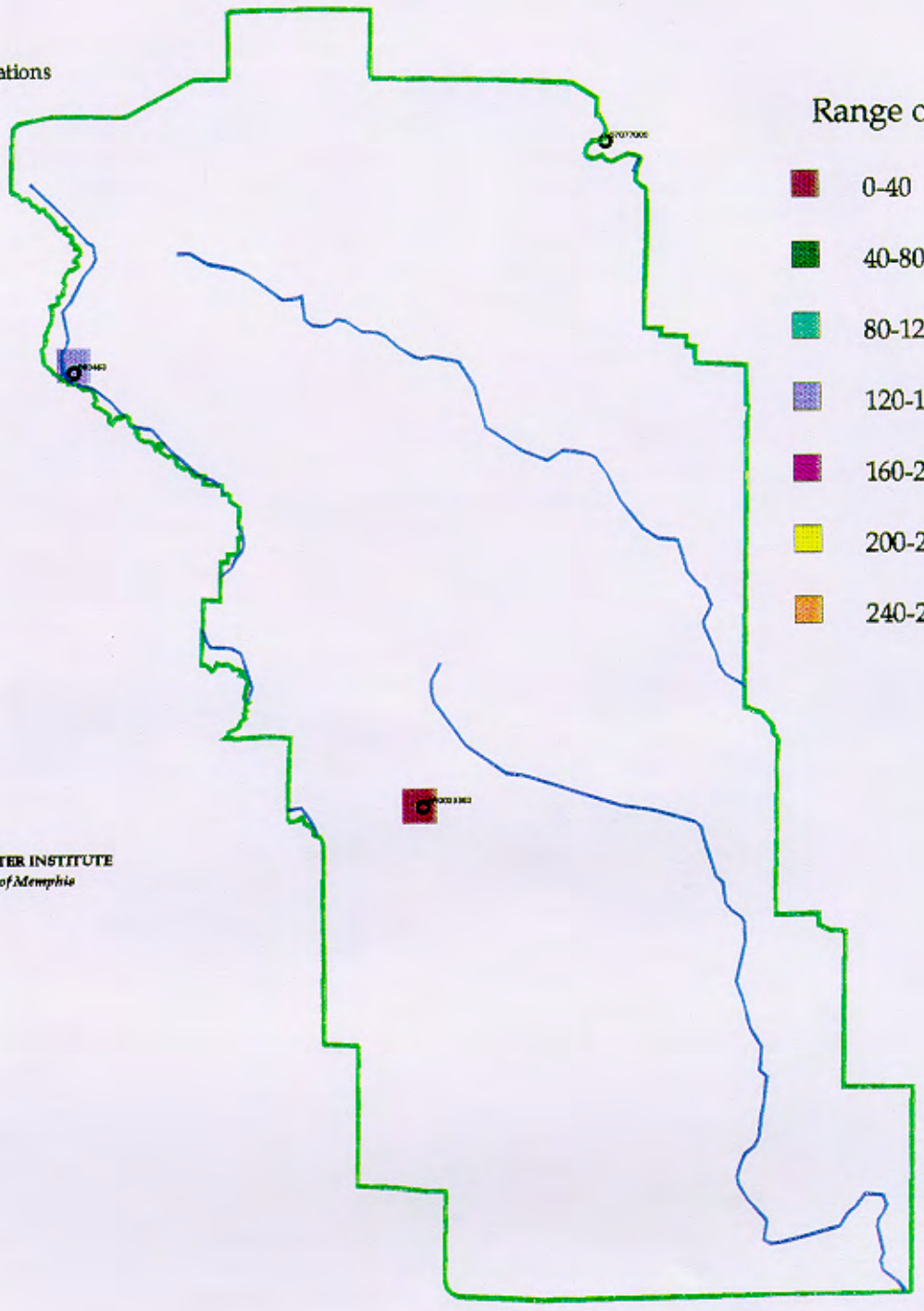
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

- 0-40
- 40-80
- 80-120
- 120-160
- 160-200
- 200-240
- 240-280

US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

Suspended Solids (mg/l)

STORET Sampling Data

Figure B-19

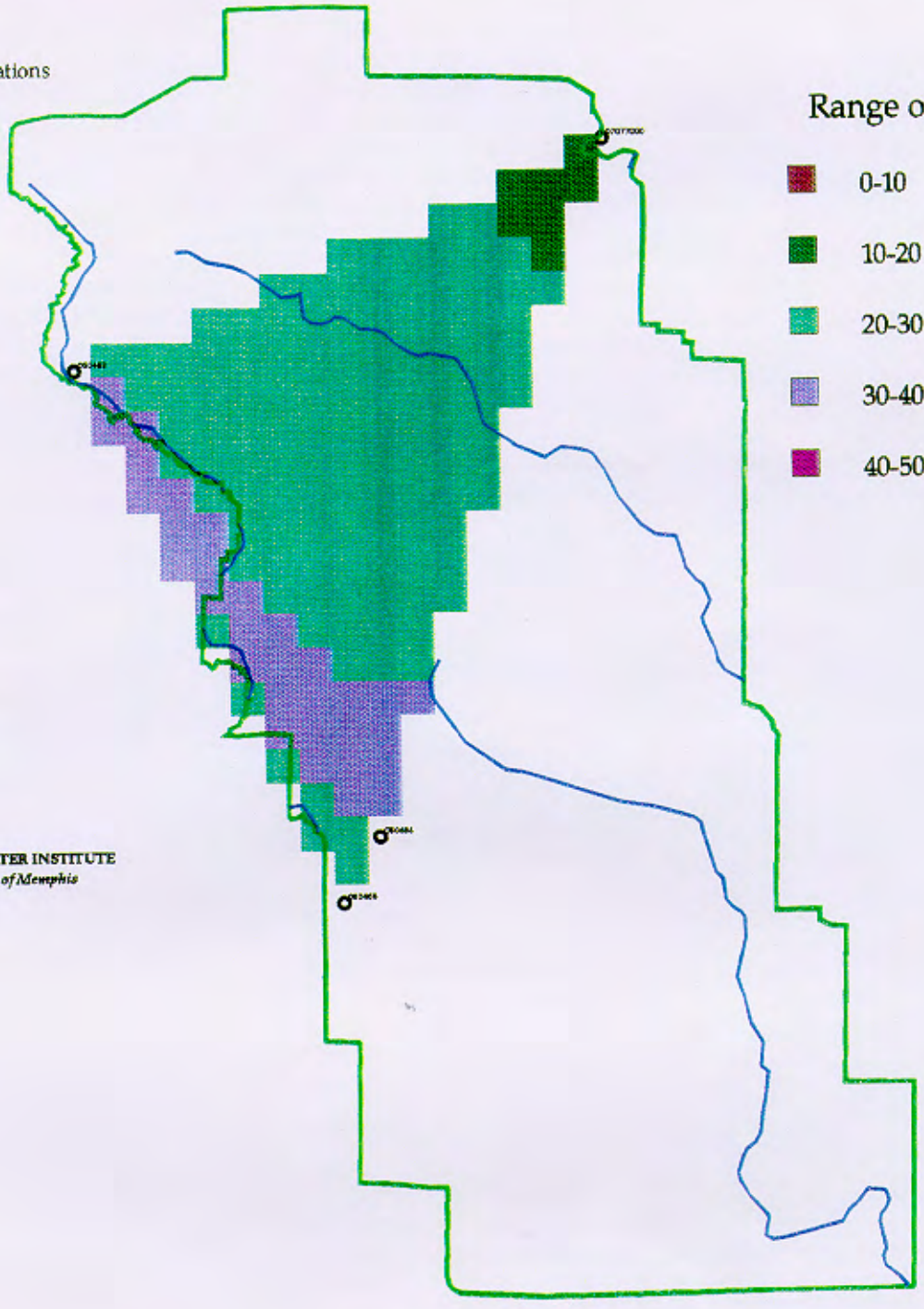
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

0-10

10-20

20-30

30-40

40-50

US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

Temperature (degrees Celsius)

STORET Sampling Data

Figure B-20

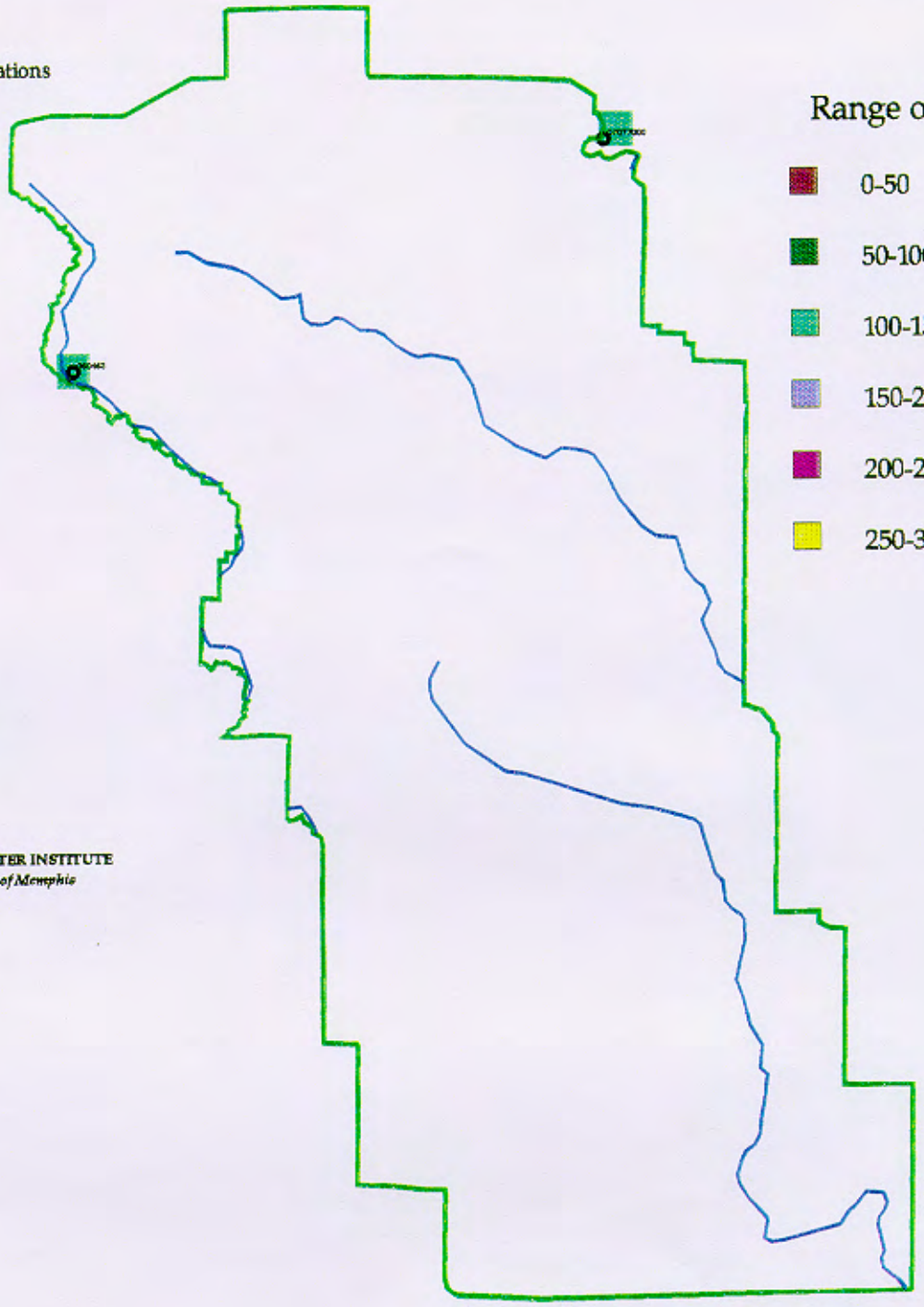
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

- 0-50
- 50-100
- 100-150
- 150-200
- 200-250
- 250-300

US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

Total Hardness (mg/l as $CaCO_3$)

STORET Sampling Data

Figure B-21

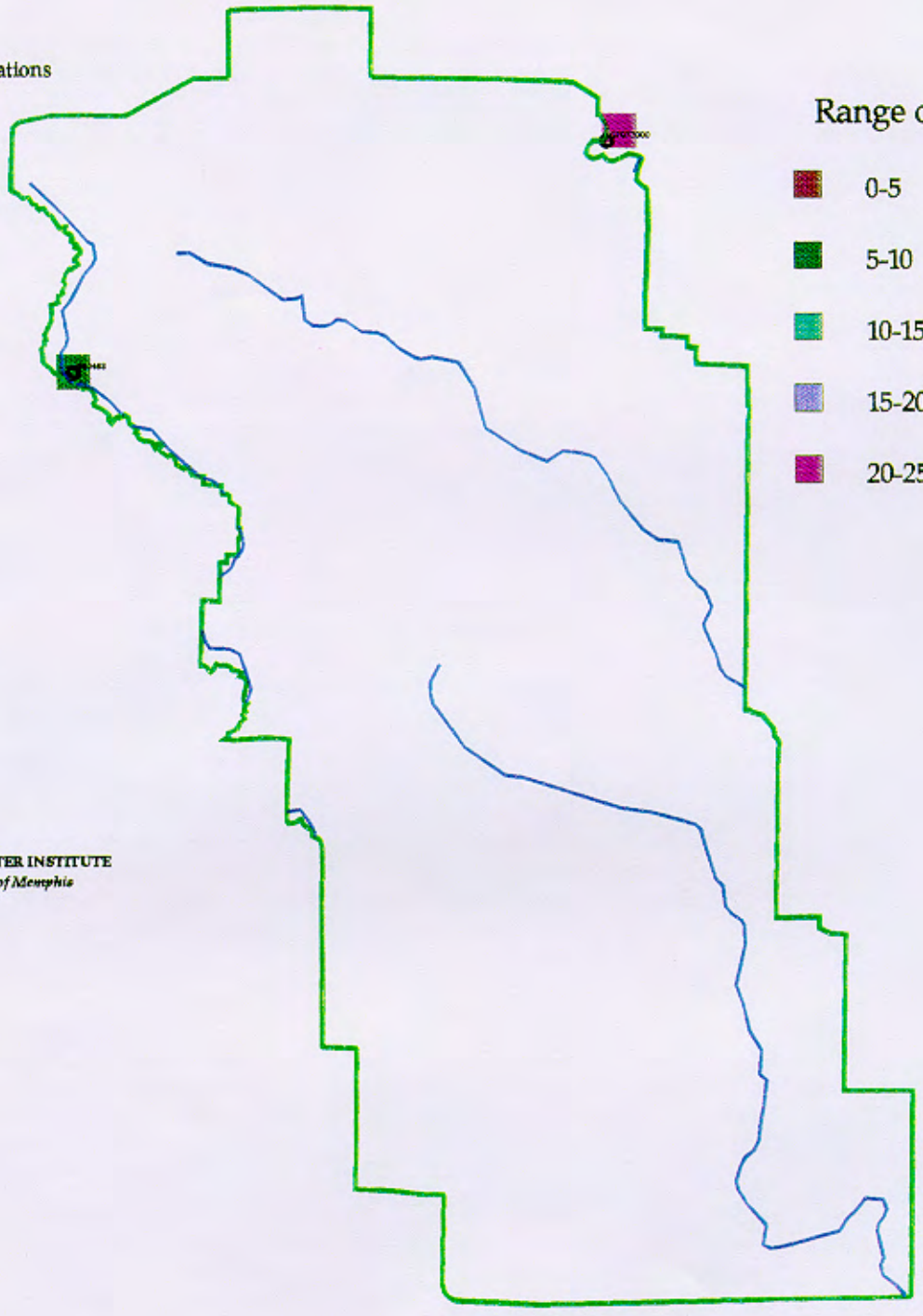
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

- 0-5
- 5-10
- 10-15
- 15-20
- 20-25

US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

True Color (Pt-Co)

STORET Sampling Data

Figure B-22

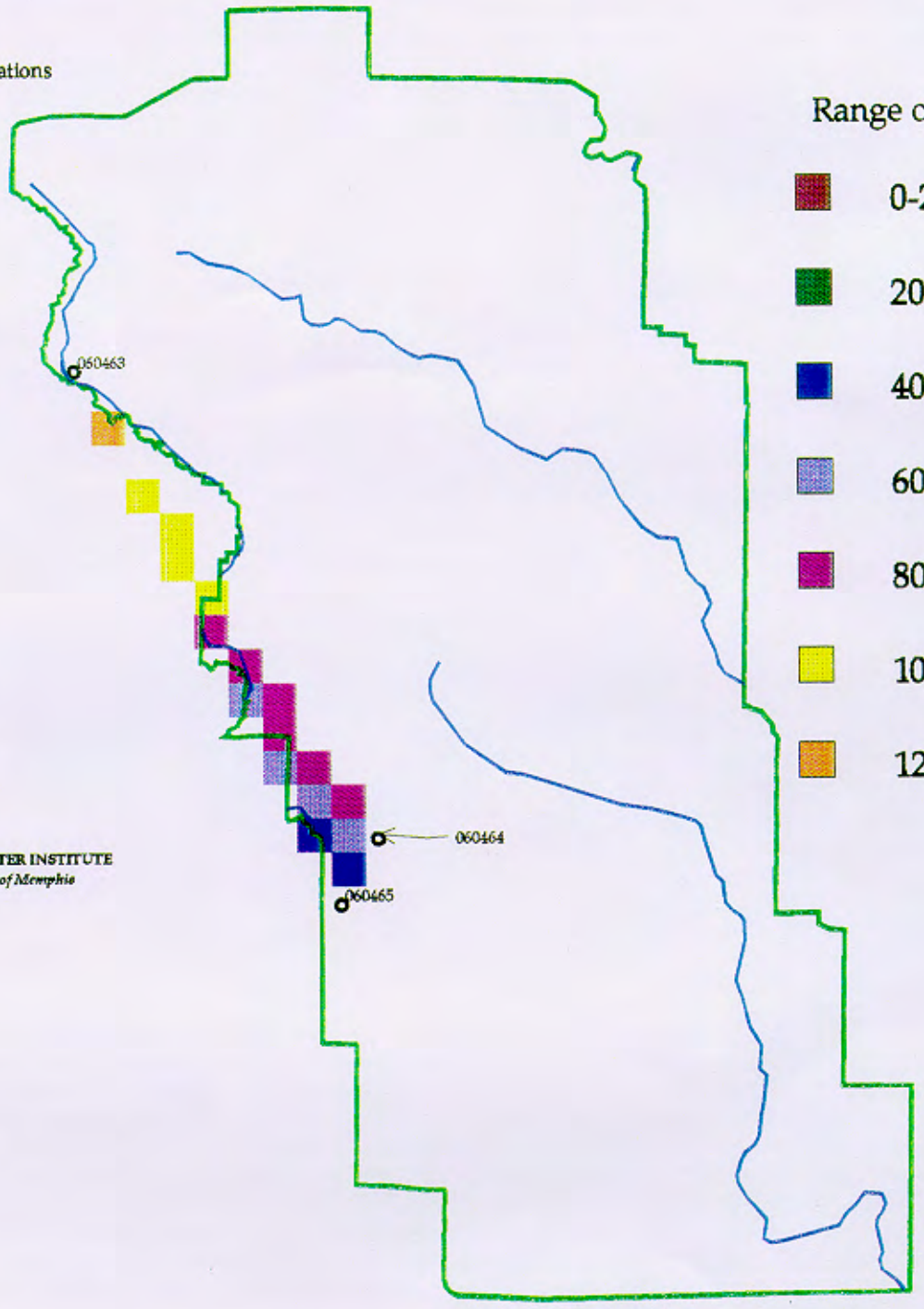
Surface Water Locations

Project Boundaries

Streams

Sampling Locations

Scale = 1:27,500



Range of Values

- 0-20
- 20-40
- 40-60
- 60-80
- 80-100
- 100-120
- 120-140

US Army Corps
of Engineers
Memphis District

GROUND WATER INSTITUTE
The University of Memphis

Turbidity (FTU)

STORET Sampling Data

Figure B-23

Appendix C

Water Quality Data (Field & STORTET)

White River STORET Sampling Data

For Sampling Times from May through August

Parm#	Value	Short Name	Station Number	Begin S
10	19	WATER TEMP CENT	050113	5/1/74
10	22	WATER TEMP CENT	050113	5/29/74
10	24	WATER TEMP CENT	050113	6/26/74
10	24	WATER TEMP CENT	050113	7/24/74
10	23	WATER TEMP CENT	050113	8/21/74
10	20	WATER TEMP CENT	050113	5/19/75
10	24	WATER TEMP CENT	050113	6/11/75
10	26	WATER TEMP CENT	050113	7/15/75
10	25	WATER TEMP CENT	050113	8/18/75
10	20	WATER TEMP CENT	050113	5/19/76
10	23	WATER TEMP CENT	050113	6/21/76
10	24	WATER TEMP CENT	050113	7/26/76
10	24	WATER TEMP CENT	050113	8/23/76
10	20	WATER TEMP CENT	050113	6/7/77
10	25	WATER TEMP CENT	050113	6/27/77
10	29	WATER TEMP CENT	050113	7/19/77
10	27	WATER TEMP CENT	050113	8/22/77
10	19	WATER TEMP CENT	050113	5/15/78
10	25	WATER TEMP CENT	050113	6/12/78
10	28	WATER TEMP CENT	050113	7/11/78
10	28	WATER TEMP CENT	050113	8/14/78
10	23	WATER TEMP CENT	050113	5/1/79
10	20	WATER TEMP CENT	050113	6/5/79
10	24	WATER TEMP CENT	050113	7/10/79
10	22	WATER TEMP CENT	050113	7/31/79
10	20	WATER TEMP CENT	050113	5/20/80
10	26	WATER TEMP CENT	050113	7/1/80
10	25	WATER TEMP CENT	050113	7/22/80
10	27	WATER TEMP CENT	050113	8/19/80
10	19	WATER TEMP CENT	050113	5/19/81
10	26	WATER TEMP CENT	050113	6/16/81
10	29	WATER TEMP CENT	050113	7/14/81
10	27	WATER TEMP CENT	050113	8/11/81
10	22	WATER TEMP CENT	050113	5/4/82
10	24	WATER TEMP CENT	050113	6/1/82
10	24	WATER TEMP CENT	050113	6/29/82
10	31	WATER TEMP CENT	050113	7/20/82
10	26	WATER TEMP CENT	050113	8/17/82

Parm#	Value	Short Name	Station Number	Begin S
400	8	PH SU	7077000	8/5/92
410	128	T ALK CACO3 MG/L	50113	7/19/77
410	145	T ALK CACO3 MG/L	50113	7/11/78
410	113	T ALK CACO3 MG/L	50113	7/10/79
410	145	T ALK CACO3 MG/L	50113	7/22/80
410	83	T ALK CACO3 MG/L	7077000	5/29/46
410	154	T ALK CACO3 MG/L	7077000	8/2/54
410	136	T ALK CACO3 MG/L	7077000	6/20/56
410	106	T ALK CACO3 MG/L	7077000	6/18/57
410	146	T ALK CACO3 MG/L	7077000	7/26/60
410	64	T ALK CACO3 MG/L	7077000	5/21/68
410	125	T ALK CACO3 MG/L	7077000	6/27/68
410	144	T ALK CACO3 MG/L	7077000	7/30/68
410	118	T ALK CACO3 MG/L	7077000	5/8/69
410	144	T ALK CACO3 MG/L	7077000	6/12/69
410	142	T ALK CACO3 MG/L	7077000	7/16/69
410	146	T ALK CACO3 MG/L	7077000	8/19/69
410	118	T ALK CACO3 MG/L	7077000	5/27/70
410	132	T ALK CACO3 MG/L	7077000	7/15/75
410	115	T ALK CACO3 MG/L	7077000	6/21/76
410	130	T ALK CACO3 MG/L	7077000	8/30/77
410	150	T ALK CACO3 MG/L	7077000	7/11/78
410	110	T ALK CACO3 MG/L	7077000	7/10/79
410	150	T ALK CACO3 MG/L	7077000	7/22/80
500	189	RESIDUE TOTAL MG/L	50113	5/1/74
500	195	RESIDUE TOTAL MG/L	50113	5/29/74
500	185	RESIDUE TOTAL MG/L	50113	6/26/74
500	210	RESIDUE TOTAL MG/L	50113	7/24/74
500	185	RESIDUE TOTAL MG/L	50113	8/21/74
500	156	RESIDUE TOTAL MG/L	50113	5/19/75
500	295	RESIDUE TOTAL MG/L	50113	6/11/75
500	197	RESIDUE TOTAL MG/L	50113	7/15/75
500	208	RESIDUE TOTAL MG/L	50113	8/18/75
500	231	RESIDUE TOTAL MG/L	50113	5/19/76
500	215	RESIDUE TOTAL MG/L	50113	6/21/76
500	194	RESIDUE TOTAL MG/L	50113	7/26/76
500	219	RESIDUE TOTAL MG/L	50113	8/23/76
500	189	RESIDUE TOTAL MG/L	7077000	5/1/74

10	19	WATER	TEMP	CENT	050113	5/3/83	500	185	RESIDUE	TOTAL	MG/L	7077000	8/21/74
10	21	WATER	TEMP	CENT	050113	5/31/83	500	156	RESIDUE	TOTAL	MG/L	7077000	5/19/75
10	26	WATER	TEMP	CENT	050113	7/5/83	500	295	RESIDUE	TOTAL	MG/L	7077000	6/11/75
10	27	WATER	TEMP	CENT	050113	8/9/83	500	197	RESIDUE	TOTAL	MG/L	7077000	7/15/75
10	18	WATER	TEMP	CENT	050113	5/8/84	500	208	RESIDUE	TOTAL	MG/L	7077000	8/18/75
10	26	WATER	TEMP	CENT	050113	6/19/84	500	231	RESIDUE	TOTAL	MG/L	7077000	5/19/76
10	25	WATER	TEMP	CENT	050113	7/31/84	500	215	RESIDUE	TOTAL	MG/L	7077000	6/21/76
10	26	WATER	TEMP	CENT	050113	8/28/84	500	194	RESIDUE	TOTAL	MG/L	7077000	7/26/76
10	22	WATER	TEMP	CENT	050113	5/21/85	500	219	RESIDUE	TOTAL	MG/L	7077000	8/23/76
10	23	WATER	TEMP	CENT	050113	6/18/85	515	141	RESIDUE	DISS-105C	MG/L	50113	5/1/74
10	23	WATER	TEMP	CENT	050113	7/23/85	515	136	RESIDUE	DISS-105C	MG/L	50113	5/29/74
10	23	WATER	TEMP	CENT	050113	8/20/85	515	135	RESIDUE	DISS-105C	MG/L	50113	6/26/74
10	21	WATER	TEMP	CENT	050113	5/27/86	515	159	RESIDUE	DISS-105C	MG/L	50113	7/24/74
10	27	WATER	TEMP	CENT	050113	6/17/86	515	153	RESIDUE	DISS-105C	MG/L	50113	8/21/74
10	22	WATER	TEMP	CENT	050113	7/8/86	515	129	RESIDUE	DISS-105C	MG/L	50113	5/19/75
10	27	WATER	TEMP	CENT	050113	8/26/86	515	167	RESIDUE	DISS-105C	MG/L	50113	6/11/75
10	24	WATER	TEMP	CENT	050113	5/26/87	515	156	RESIDUE	DISS-105C	MG/L	50113	7/15/75
10	20	WATER	TEMP	CENT	050113	6/23/87	515	165	RESIDUE	DISS-105C	MG/L	50113	8/18/75
10	27	WATER	TEMP	CENT	050113	7/21/87	515	161	RESIDUE	DISS-105C	MG/L	50113	5/19/76
10	21	WATER	TEMP	CENT	050113	7/27/88	515	214	RESIDUE	DISS-105C	MG/L	50113	6/21/76
10	22	WATER	TEMP	CENT	050113	8/7/88	515	152	RESIDUE	DISS-105C	MG/L	50113	7/26/76
10	27	WATER	TEMP	CENT	050113	8/23/88	515	154	RESIDUE	DISS-105C	MG/L	50113	8/23/76
10	23	WATER	TEMP	CENT	050113	5/23/89	515	141	RESIDUE	DISS-105C	MG/L	7077000	5/1/74
10	25	WATER	TEMP	CENT	050113	6/27/89	515	153	RESIDUE	DISS-105C	MG/L	7077000	8/21/74
10	27	WATER	TEMP	CENT	050113	7/25/89	515	129	RESIDUE	DISS-105C	MG/L	7077000	5/19/75
10	28	WATER	TEMP	CENT	050113	8/22/89	515	167	RESIDUE	DISS-105C	MG/L	7077000	6/11/75
10	20	WATER	TEMP	CENT	050113	5/22/90	515	156	RESIDUE	DISS-105C	MG/L	7077000	7/15/75
10	25	WATER	TEMP	CENT	050113	6/26/90	515	165	RESIDUE	DISS-105C	MG/L	7077000	8/18/75
10	28	WATER	TEMP	CENT	050113	7/31/90	515	161	RESIDUE	DISS-105C	MG/L	7077000	5/19/76
10	25	WATER	TEMP	CENT	050113	8/28/90	515	214	RESIDUE	DISS-105C	MG/L	7077000	6/21/76
10	20	WATER	TEMP	CENT	050113	5/1/91	515	152	RESIDUE	DISS-105C	MG/L	7077000	7/26/76
10	22	WATER	TEMP	CENT	050113	6/12/91	515	154	RESIDUE	DISS-105C	MG/L	7077000	8/23/76
10	23	WATER	TEMP	CENT	050113	7/10/91	515	158	RESIDUE	DISS-105C	MG/L	7077000	6/7/77
10	23	WATER	TEMP	CENT	050113	8/13/91	515	131	RESIDUE	DISS-105C	MG/L	7077000	6/27/77
10	21	WATER	TEMP	CENT	050113	5/13/92	515	151	RESIDUE	DISS-105C	MG/L	7077000	7/19/77
10	23	WATER	TEMP	CENT	050113	6/9/92	530	48	RESIDUE	TOT NFLT	MG/L	50113	5/1/74
10	23	WATER	TEMP	CENT	050113	7/7/92	530	59	RESIDUE	TOT NFLT	MG/L	50113	5/29/74
10	25	WATER	TEMP	CENT	050113	8/5/92	530	50	RESIDUE	TOT NFLT	MG/L	50113	6/26/74
10	19	WATER	TEMP	CENT	050113	5/12/93	530	51	RESIDUE	TOT NFLT	MG/L	50113	7/24/74

10	19	WATER	TEMP	CENT	050113	6/1/93	530	32	RESIDUE TOT NFLT	MG/L	50113	8/21/74
10	25	WATER	TEMP	CENT	050113	7/7/93	530	27	RESIDUE TOT NFLT	MG/L	50113	5/19/75
10	26	WATER	TEMP	CENT	050113	8/10/93	530	128	RESIDUE TOT NFLT	MG/L	50113	6/11/75
10	20	WATER	TEMP	CENT	07077000	5/21/68	530	41	RESIDUE TOT NFLT	MG/L	50113	7/15/75
10	21	WATER	TEMP	CENT	07077000	6/27/68	530	43	RESIDUE TOT NFLT	MG/L	50113	8/18/75
10	21	WATER	TEMP	CENT	07077000	5/1/70	530	70	RESIDUE TOT NFLT	MG/L	50113	5/19/76
10	22	WATER	TEMP	CENT	07077000	5/27/70	530	1	RESIDUE TOT NFLT	MG/L	50113	6/21/76
10	24.5	WATER	TEMP	CENT	07077000	8/5/70	530	42	RESIDUE TOT NFLT	MG/L	50113	7/26/76
10	19	WATER	TEMP	CENT	07077000	5/1/74	530	65	RESIDUE TOT NFLT	MG/L	50113	8/23/76
10	23	WATER	TEMP	CENT	07077000	8/21/74	530	63	RESIDUE TOT NFLT	MG/L	50113	6/7/77
10	20	WATER	TEMP	CENT	07077000	5/19/75	530	38	RESIDUE TOT NFLT	MG/L	50113	7/19/77
10	24	WATER	TEMP	CENT	07077000	6/11/75	530	36	RESIDUE TOT NFLT	MG/L	50113	8/22/77
10	26	WATER	TEMP	CENT	07077000	7/15/75	530	37	RESIDUE TOT NFLT	MG/L	50113	5/15/78
10	25	WATER	TEMP	CENT	07077000	8/18/75	530	43	RESIDUE TOT NFLT	MG/L	50113	6/12/78
10	20	WATER	TEMP	CENT	07077000	5/19/76	530	40	RESIDUE TOT NFLT	MG/L	50113	8/14/78
10	23	WATER	TEMP	CENT	07077000	6/21/76	530	33	RESIDUE TOT NFLT	MG/L	50113	5/1/79
10	24	WATER	TEMP	CENT	07077000	7/26/76	530	40	RESIDUE TOT NFLT	MG/L	50113	6/5/79
10	24	WATER	TEMP	CENT	07077000	8/23/76	530	100	RESIDUE TOT NFLT	MG/L	50113	7/10/79
10	20	WATER	TEMP	CENT	07077000	6/7/77	530	31	RESIDUE TOT NFLT	MG/L	50113	7/31/79
10	25	WATER	TEMP	CENT	07077000	6/27/77	530	24	RESIDUE TOT NFLT	MG/L	50113	5/20/80
10	29	WATER	TEMP	CENT	07077000	7/19/77	530	28	RESIDUE TOT NFLT	MG/L	50113	7/1/80
10	27	WATER	TEMP	CENT	07077000	8/22/77	530	26	RESIDUE TOT NFLT	MG/L	50113	8/19/80
10	28.5	WATER	TEMP	CENT	07077000	8/30/77	530	63	RESIDUE TOT NFLT	MG/L	50113	6/16/81
10	19	WATER	TEMP	CENT	07077000	5/15/78	530	42	RESIDUE TOT NFLT	MG/L	50113	7/14/81
10	25	WATER	TEMP	CENT	07077000	6/12/78	530	78	RESIDUE TOT NFLT	MG/L	50113	5/4/82
10	28	WATER	TEMP	CENT	07077000	7/11/78	530	52	RESIDUE TOT NFLT	MG/L	50113	6/1/82
10	28	WATER	TEMP	CENT	07077000	8/14/78	530	60	RESIDUE TOT NFLT	MG/L	50113	6/29/82
10	23	WATER	TEMP	CENT	07077000	5/1/79	530	28	RESIDUE TOT NFLT	MG/L	50113	7/20/82
10	20	WATER	TEMP	CENT	07077000	6/5/79	530	44	RESIDUE TOT NFLT	MG/L	50113	8/17/82
10	24	WATER	TEMP	CENT	07077000	7/10/79	530	21	RESIDUE TOT NFLT	MG/L	50113	5/3/83
10	22	WATER	TEMP	CENT	07077000	7/31/79	530	30	RESIDUE TOT NFLT	MG/L	50113	5/31/83
10	20	WATER	TEMP	CENT	07077000	5/20/80	530	48	RESIDUE TOT NFLT	MG/L	50113	7/5/83
10	26	WATER	TEMP	CENT	07077000	7/1/80	530	24	RESIDUE TOT NFLT	MG/L	50113	8/9/83
10	25	WATER	TEMP	CENT	07077000	7/22/80	530	33	RESIDUE TOT NFLT	MG/L	50113	5/8/84
10	27	WATER	TEMP	CENT	07077000	8/19/80	530	42	RESIDUE TOT NFLT	MG/L	50113	6/19/84
10	19	WATER	TEMP	CENT	07077000	5/19/81	530	10	RESIDUE TOT NFLT	MG/L	50113	7/31/84
10	26	WATER	TEMP	CENT	07077000	6/16/81	530	33	RESIDUE TOT NFLT	MG/L	50113	8/28/84
10	29	WATER	TEMP	CENT	07077000	7/14/81	530	38	RESIDUE TOT NFLT	MG/L	50113	5/21/85
10	27	WATER	TEMP	CENT	07077000	8/11/81	530	52	RESIDUE TOT NFLT	MG/L	50113	6/18/85

10	22	WATER	TEMP	CENT	07077000	5/4/82	530	44	RESIDUE TOT NFLT	MG/L	50113	7/23/85
10	24	WATER	TEMP	CENT	07077000	6/1/82	530	38	RESIDUE TOT NFLT	MG/L	50113	8/20/85
10	24	WATER	TEMP	CENT	07077000	6/29/82	530	52	RESIDUE TOT NFLT	MG/L	50113	5/27/86
10	31	WATER	TEMP	CENT	07077000	7/20/82	530	28	RESIDUE TOT NFLT	MG/L	50113	8/26/86
10	26	WATER	TEMP	CENT	07077000	8/17/82	530	47	RESIDUE TOT NFLT	MG/L	50113	5/26/87
10	19	WATER	TEMP	CENT	07077000	5/3/83	530	29	RESIDUE TOT NFLT	MG/L	50113	7/21/87
10	21	WATER	TEMP	CENT	07077000	5/31/83	530	30	RESIDUE TOT NFLT	MG/L	50113	8/23/88
10	26	WATER	TEMP	CENT	07077000	7/5/83	530	69	RESIDUE TOT NFLT	MG/L	50113	5/23/89
10	27	WATER	TEMP	CENT	07077000	8/9/83	530	30	RESIDUE TOT NFLT	MG/L	50113	6/27/89
10	18	WATER	TEMP	CENT	07077000	5/8/84	530	18	RESIDUE TOT NFLT	MG/L	50113	7/25/89
10	26	WATER	TEMP	CENT	07077000	6/19/84	530	45	RESIDUE TOT NFLT	MG/L	50113	6/26/90
10	25	WATER	TEMP	CENT	07077000	7/31/84	530	74	RESIDUE TOT NFLT	MG/L	50113	7/31/90
10	26	WATER	TEMP	CENT	07077000	8/28/84	530	62	RESIDUE TOT NFLT	MG/L	50113	6/12/91
10	22	WATER	TEMP	CENT	07077000	5/21/85	530	72	RESIDUE TOT NFLT	MG/L	50113	7/10/91
10	23	WATER	TEMP	CENT	07077000	6/18/85	530	37	RESIDUE TOT NFLT	MG/L	50113	8/13/91
10	23	WATER	TEMP	CENT	07077000	7/23/85	530	31	RESIDUE TOT NFLT	MG/L	50113	5/13/92
10	23	WATER	TEMP	CENT	07077000	8/20/85	530	46	RESIDUE TOT NFLT	MG/L	50113	6/9/92
10	21	WATER	TEMP	CENT	07077000	5/27/86	530	34	RESIDUE TOT NFLT	MG/L	50113	7/7/92
10	27	WATER	TEMP	CENT	07077000	6/17/86	530	28	RESIDUE TOT NFLT	MG/L	50113	8/5/92
10	22	WATER	TEMP	CENT	07077000	7/8/86	530	18	RESIDUE TOT NFLT	MG/L	50113	6/1/93
10	27	WATER	TEMP	CENT	07077000	8/26/86	530	78	RESIDUE TOT NFLT	MG/L	50113	7/7/93
10	24	WATER	TEMP	CENT	07077000	5/26/87	530	26	RESIDUE TOT NFLT	MG/L	50113	8/10/93
10	20	WATER	TEMP	CENT	07077000	6/23/87	530	48	RESIDUE TOT NFLT	MG/L	7077000	5/1/74
10	27	WATER	TEMP	CENT	07077000	7/21/87	530	32	RESIDUE TOT NFLT	MG/L	7077000	8/21/74
10	21	WATER	TEMP	CENT	07077000	7/27/88	530	27	RESIDUE TOT NFLT	MG/L	7077000	5/19/75
10	22	WATER	TEMP	CENT	07077000	8/7/88	530	128	RESIDUE TOT NFLT	MG/L	7077000	6/11/75
10	27	WATER	TEMP	CENT	07077000	8/23/88	530	41	RESIDUE TOT NFLT	MG/L	7077000	7/15/75
10	23	WATER	TEMP	CENT	07077000	5/23/89	530	43	RESIDUE TOT NFLT	MG/L	7077000	8/18/75
10	25	WATER	TEMP	CENT	07077000	6/27/89	530	70	RESIDUE TOT NFLT	MG/L	7077000	5/19/76
10	27	WATER	TEMP	CENT	07077000	7/25/89	530	1	RESIDUE TOT NFLT	MG/L	7077000	6/21/76
10	28	WATER	TEMP	CENT	07077000	8/22/89	530	42	RESIDUE TOT NFLT	MG/L	7077000	7/26/76
10	20	WATER	TEMP	CENT	07077000	5/22/90	530	65	RESIDUE TOT NFLT	MG/L	7077000	8/23/76
10	25	WATER	TEMP	CENT	07077000	6/26/90	530	63	RESIDUE TOT NFLT	MG/L	7077000	6/7/77
10	28	WATER	TEMP	CENT	07077000	7/31/90	530	38	RESIDUE TOT NFLT	MG/L	7077000	7/19/77
10	25	WATER	TEMP	CENT	07077000	8/28/90	530	36	RESIDUE TOT NFLT	MG/L	7077000	8/22/77
10	20	WATER	TEMP	CENT	07077000	5/1/91	530	360	RESIDUE TOT NFLT	MG/L	7077000	8/30/77
10	22	WATER	TEMP	CENT	07077000	6/12/91	530	37	RESIDUE TOT NFLT	MG/L	7077000	5/15/78
10	23	WATER	TEMP	CENT	07077000	7/10/91	530	43	RESIDUE TOT NFLT	MG/L	7077000	6/12/78
10	23	WATER	TEMP	CENT	07077000	8/13/91	530	40	RESIDUE TOT NFLT	MG/L	7077000	8/14/78

10	21	WATER TEMP CENT	07077000	5/13/92
10	23	WATER TEMP CENT	07077000	6/9/92
10	23	WATER TEMP CENT	07077000	7/7/92
10	25	WATER TEMP CENT	07077000	8/5/92
70	31	TURB JKSN JTU	050113	5/1/74
70	32	TURB JKSN JTU	050113	5/29/74
70	30	TURB JKSN JTU	050113	6/26/74
70	24	TURB JKSN JTU	050113	7/24/74
70	16	TURB JKSN JTU	050113	8/21/74
70	20	TURB JKSN JTU	050113	5/19/75
70	55	TURB JKSN JTU	050113	6/11/75
70	20	TURB JKSN JTU	050113	7/15/75
70	25	TURB JKSN JTU	050113	8/18/75
70	55	TURB JKSN JTU	050113	5/19/76
70	95	TURB JKSN JTU	050113	6/21/76
70	36	TURB JKSN JTU	050113	7/26/76
70	30	TURB JKSN JTU	050113	8/23/76
70	31	TURB JKSN JTU	07077000	5/1/74
70	16	TURB JKSN JTU	07077000	8/21/74
70	20	TURB JKSN JTU	07077000	5/19/75
70	55	TURB JKSN JTU	07077000	6/11/75
70	20	TURB JKSN JTU	07077000	7/15/75
70	25	TURB JKSN JTU	07077000	8/18/75
70	55	TURB JKSN JTU	07077000	5/19/76
70	95	TURB JKSN JTU	07077000	6/21/76
70	35	TURB JKSN JTU	07077000	7/26/76
70	30	TURB JKSN JTU	07077000	8/23/76
80	30	COLOR PT-CO UNITS	050113	5/1/74
80	20	COLOR PT-CO UNITS	050113	5/29/74
80	30	COLOR PT-CO UNITS	050113	6/26/74
80	5	COLOR PT-CO UNITS	050113	7/24/74
80	10	COLOR PT-CO UNITS	050113	8/21/74
80	25	COLOR PT-CO UNITS	050113	5/19/75
80	10	COLOR PT-CO UNITS	050113	6/11/75
80	15	COLOR PT-CO UNITS	050113	7/15/75
80	15	COLOR PT-CO UNITS	050113	8/18/75
80	10	COLOR PT-CO UNITS	050113	5/19/76
80	60	COLOR PT-CO UNITS	050113	6/21/76
80	20	COLOR PT-CO UNITS	050113	7/26/76

530	33	RESIDUE TOT NFLT MG/L	7077000	5/1/79
530	40	RESIDUE TOT NFLT MG/L	7077000	6/5/79
530	100	RESIDUE TOT NFLT MG/L	7077000	7/10/79
530	31	RESIDUE TOT NFLT MG/L	7077000	7/31/79
530	24	RESIDUE TOT NFLT MG/L	7077000	5/20/80
530	28	RESIDUE TOT NFLT MG/L	7077000	7/1/80
530	26	RESIDUE TOT NFLT MG/L	7077000	8/19/80
530	63	RESIDUE TOT NFLT MG/L	7077000	6/16/81
530	42	RESIDUE TOT NFLT MG/L	7077000	7/14/81
530	78	RESIDUE TOT NFLT MG/L	7077000	5/4/82
530	52	RESIDUE TOT NFLT MG/L	7077000	6/1/82
530	60	RESIDUE TOT NFLT MG/L	7077000	6/29/82
530	28	RESIDUE TOT NFLT MG/L	7077000	7/20/82
530	44	RESIDUE TOT NFLT MG/L	7077000	8/17/82
530	21	RESIDUE TOT NFLT MG/L	7077000	5/3/83
530	30	RESIDUE TOT NFLT MG/L	7077000	5/31/83
530	48	RESIDUE TOT NFLT MG/L	7077000	7/5/83
530	24	RESIDUE TOT NFLT MG/L	7077000	8/9/83
530	33	RESIDUE TOT NFLT MG/L	7077000	5/8/84
530	42	RESIDUE TOT NFLT MG/L	7077000	6/19/84
530	10	RESIDUE TOT NFLT MG/L	7077000	7/31/84
530	33	RESIDUE TOT NFLT MG/L	7077000	8/28/84
530	38	RESIDUE TOT NFLT MG/L	7077000	5/21/85
530	52	RESIDUE TOT NFLT MG/L	7077000	6/18/85
530	44	RESIDUE TOT NFLT MG/L	7077000	7/23/85
530	38	RESIDUE TOT NFLT MG/L	7077000	8/20/85
530	52	RESIDUE TOT NFLT MG/L	7077000	5/27/86
530	28	RESIDUE TOT NFLT MG/L	7077000	8/26/86
530	47	RESIDUE TOT NFLT MG/L	7077000	5/26/87
530	29	RESIDUE TOT NFLT MG/L	7077000	7/21/87
530	30	RESIDUE TOT NFLT MG/L	7077000	8/23/88
530	69	RESIDUE TOT NFLT MG/L	7077000	5/23/89
530	30	RESIDUE TOT NFLT MG/L	7077000	6/27/89
530	18	RESIDUE TOT NFLT MG/L	7077000	7/25/89
530	45	RESIDUE TOT NFLT MG/L	7077000	6/26/90
530	74	RESIDUE TOT NFLT MG/L	7077000	7/31/90
530	62	RESIDUE TOT NFLT MG/L	7077000	6/12/91
530	72	RESIDUE TOT NFLT MG/L	7077000	7/10/91
530	37	RESIDUE TOT NFLT MG/L	7077000	8/13/91

80	5	COLOR	PT-CO	UNITS	050113	8/23/76	530	31	RESIDUE TOT NFLT	MG/L	7077000	5/13/92
80	15	COLOR	PT-CO	UNITS	050113	6/7/77	530	46	RESIDUE TOT NFLT	MG/L	7077000	6/9/92
80	60	COLOR	PT-CO	UNITS	050113	6/27/77	530	34	RESIDUE TOT NFLT	MG/L	7077000	7/7/92
80	40	COLOR	PT-CO	UNITS	050113	5/15/78	530	28	RESIDUE TOT NFLT	MG/L	7077000	8/5/92
80	50	COLOR	PT-CO	UNITS	050113	6/12/78	615	0.01	NO2-N	TOTAL MG/L	50113	6/7/77
80	15	COLOR	PT-CO	UNITS	050113	7/11/78	615	0.01	NO2-N	TOTAL MG/L	50113	6/27/77
80	5	COLOR	PT-CO	UNITS	050113	8/14/78	615	0	NO2-N	TOTAL MG/L	50113	7/19/77
80	30	COLOR	PT-CO	UNITS	050113	5/1/79	615	0.05	NO2-N	TOTAL MG/L	50113	8/22/77
80	50	COLOR	PT-CO	UNITS	050113	6/5/79	615	0.04	NO2-N	TOTAL MG/L	50113	5/15/78
80	10	COLOR	PT-CO	UNITS	050113	7/10/79	615	0.02	NO2-N	TOTAL MG/L	50113	6/12/78
80	5	COLOR	PT-CO	UNITS	050113	7/31/79	615	0.01	NO2-N	TOTAL MG/L	50113	7/11/78
80	25	COLOR	PT-CO	UNITS	050113	5/20/80	615	0.01	NO2-N	TOTAL MG/L	50113	8/14/78
80	40	COLOR	PT-CO	UNITS	050113	7/1/80	615	0.01	NO2-N	TOTAL MG/L	50113	5/1/79
80	15	COLOR	PT-CO	UNITS	050113	7/22/80	615	0.01	NO2-N	TOTAL MG/L	50113	6/5/79
80	10	COLOR	PT-CO	UNITS	050113	8/19/80	615	0.02	NO2-N	TOTAL MG/L	50113	7/10/79
80	3	COLOR	PT-CO	UNITS	07077000	7/26/60	615	0.01	NO2-N	TOTAL MG/L	50113	7/31/79
80	36	COLOR	PT-CO	UNITS	07077000	5/21/68	615	0.01	NO2-N	TOTAL MG/L	50113	5/20/80
80	10	COLOR	PT-CO	UNITS	07077000	6/27/68	615	0.01	NO2-N	TOTAL MG/L	50113	7/1/80
80	4	COLOR	PT-CO	UNITS	07077000	7/30/68	615	0.01	NO2-N	TOTAL MG/L	50113	7/22/80
80	3	COLOR	PT-CO	UNITS	07077000	5/8/69	615	0.01	NO2-N	TOTAL MG/L	50113	8/19/80
80	10	COLOR	PT-CO	UNITS	07077000	6/12/69	615	0.01	NO2-N	TOTAL MG/L	7077000	6/7/77
80	5	COLOR	PT-CO	UNITS	07077000	7/16/69	615	0.01	NO2-N	TOTAL MG/L	7077000	6/27/77
80	7	COLOR	PT-CO	UNITS	07077000	8/19/69	615	0.01	NO2-N	TOTAL MG/L	7077000	7/19/77
80	2	COLOR	PT-CO	UNITS	07077000	6/29/70	615	0.05	NO2-N	TOTAL MG/L	7077000	8/22/77
80	30	COLOR	PT-CO	UNITS	07077000	5/1/74	615	0.04	NO2-N	TOTAL MG/L	7077000	5/15/78
80	10	COLOR	PT-CO	UNITS	07077000	8/21/74	615	0.02	NO2-N	TOTAL MG/L	7077000	6/12/78
80	25	COLOR	PT-CO	UNITS	07077000	5/19/75	615	0.01	NO2-N	TOTAL MG/L	7077000	7/11/78
80	10	COLOR	PT-CO	UNITS	07077000	6/11/75	615	0.01	NO2-N	TOTAL MG/L	7077000	8/14/78
80	15	COLOR	PT-CO	UNITS	07077000	7/15/75	615	0.01	NO2-N	TOTAL MG/L	7077000	5/1/79
80	15	COLOR	PT-CO	UNITS	07077000	8/18/75	615	0.01	NO2-N	TOTAL MG/L	7077000	6/5/79
80	10	COLOR	PT-CO	UNITS	07077000	5/19/76	615	0.02	NO2-N	TOTAL MG/L	7077000	7/10/79
80	60	COLOR	PT-CO	UNITS	07077000	6/21/76	615	0.01	NO2-N	TOTAL MG/L	7077000	7/31/79
80	20	COLOR	PT-CO	UNITS	07077000	7/26/76	615	0.01	NO2-N	TOTAL MG/L	7077000	5/20/80
80	5	COLOR	PT-CO	UNITS	07077000	8/23/76	615	0.01	NO2-N	TOTAL MG/L	7077000	7/1/80
80	15	COLOR	PT-CO	UNITS	07077000	6/7/77	615	0.01	NO2-N	TOTAL MG/L	7077000	7/22/80
80	60	COLOR	PT-CO	UNITS	07077000	6/27/77	615	0.01	NO2-N	TOTAL MG/L	7077000	8/19/80
80	40	COLOR	PT-CO	UNITS	07077000	5/15/78	620	0.43	NO3-N	TOTAL MG/L	50113	5/1/74
80	50	COLOR	PT-CO	UNITS	07077000	6/12/78	620	0.59	NO3-N	TOTAL MG/L	50113	5/29/74
80	15	COLOR	PT-CO	UNITS	07077000	7/11/78	620	0.57	NO3-N	TOTAL MG/L	50113	6/26/74

80	5	COLOR PT-CO UNITS	07077000	8/14/78
80	30	COLOR PT-CO UNITS	07077000	5/1/79
80	50	COLOR PT-CO UNITS	07077000	6/5/79
80	10	COLOR PT-CO UNITS	07077000	7/10/79
80	5	COLOR PT-CO UNITS	07077000	7/31/79
80	25	COLOR PT-CO UNITS	07077000	5/20/80
80	40	COLOR PT-CO UNITS	07077000	7/1/80
80	15	COLOR PT-CO UNITS	07077000	7/22/80
80	10	COLOR PT-CO UNITS	07077000	8/19/80
95	188	CNDUCTVY AT 25C MICROMHO	050113	5/1/74
95	217	CNDUCTVY AT 25C MICROMHO	050113	5/29/74
95	195	CNDUCTVY AT 25C MICROMHO	050113	6/26/74
95	232	CNDUCTVY AT 25C MICROMHO	050113	7/24/74
95	244	CNDUCTVY AT 25C MICROMHO	050113	8/21/74
95	207	CNDUCTVY AT 25C MICROMHO	050113	5/19/75
95	266	CNDUCTVY AT 25C MICROMHO	050113	6/11/75
95	268	CNDUCTVY AT 25C MICROMHO	050113	7/15/75
95	266	CNDUCTVY AT 25C MICROMHO	050113	8/18/75
95	271	CNDUCTVY AT 25C MICROMHO	050113	5/19/76
95	246	CNDUCTVY AT 25C MICROMHO	050113	6/21/76
95	280	CNDUCTVY AT 25C MICROMHO	050113	7/26/76
95	273	CNDUCTVY AT 25C MICROMHO	050113	8/23/76
95	277	CNDUCTVY AT 25C MICROMHO	050113	6/7/77
95	176	CNDUCTVY AT 25C MICROMHO	050113	6/27/77
95	248	CNDUCTVY AT 25C MICROMHO	050113	7/19/77
95	202	CNDUCTVY AT 25C MICROMHO	050113	5/15/78
95	241	CNDUCTVY AT 25C MICROMHO	050113	6/12/78
95	281	CNDUCTVY AT 25C MICROMHO	050113	7/11/78
95	314	CNDUCTVY AT 25C MICROMHO	050113	8/14/78
95	184	CNDUCTVY AT 25C MICROMHO	050113	5/1/79
95	180	CNDUCTVY AT 25C MICROMHO	050113	6/5/79
95	244	CNDUCTVY AT 25C MICROMHO	050113	7/10/79
95	248	CNDUCTVY AT 25C MICROMHO	050113	7/31/79
95	242	CNDUCTVY AT 25C MICROMHO	050113	5/20/80
95	168	CNDUCTVY AT 25C MICROMHO	07077000	5/29/46
95	315	CNDUCTVY AT 25C MICROMHO	07077000	8/2/54
95	267	CNDUCTVY AT 25C MICROMHO	07077000	6/20/56
95	203	CNDUCTVY AT 25C MICROMHO	07077000	6/18/57
95	276	CNDUCTVY AT 25C MICROMHO	07077000	7/26/60

620	0.31	NO3-N TOTAL MG/L	50113	7/24/74
620	0.8	NO3-N TOTAL MG/L	50113	8/21/74
620	0.32	NO3-N TOTAL MG/L	50113	5/19/75
620	0.39	NO3-N TOTAL MG/L	50113	6/11/75
620	0.11	NO3-N TOTAL MG/L	50113	7/15/75
620	0.44	NO3-N TOTAL MG/L	50113	8/18/75
620	0.18	NO3-N TOTAL MG/L	50113	5/19/76
620	0.23	NO3-N TOTAL MG/L	50113	6/21/76
620	0.28	NO3-N TOTAL MG/L	50113	7/26/76
620	0.22	NO3-N TOTAL MG/L	50113	8/23/76
620	0.19	NO3-N TOTAL MG/L	50113	6/7/77
620	0.12	NO3-N TOTAL MG/L	50113	6/27/77
620	0.17	NO3-N TOTAL MG/L	50113	8/22/77
620	0.12	NO3-N TOTAL MG/L	50113	5/1/79
620	0.19	NO3-N TOTAL MG/L	50113	6/5/79
620	0.28	NO3-N TOTAL MG/L	50113	7/10/79
620	0.32	NO3-N TOTAL MG/L	50113	7/31/79
620	0.22	NO3-N TOTAL MG/L	50113	5/20/80
620	0.24	NO3-N TOTAL MG/L	50113	7/1/80
620	0.11	NO3-N TOTAL MG/L	50113	7/22/80
620	0.01	NO3-N TOTAL MG/L	50113	8/19/80
620	0.43	NO3-N TOTAL MG/L	7077000	5/1/74
620	0.8	NO3-N TOTAL MG/L	7077000	8/21/74
620	0.32	NO3-N TOTAL MG/L	7077000	5/19/75
620	0.39	NO3-N TOTAL MG/L	7077000	6/11/75
620	0.11	NO3-N TOTAL MG/L	7077000	7/15/75
620	0.44	NO3-N TOTAL MG/L	7077000	8/18/75
620	0.18	NO3-N TOTAL MG/L	7077000	5/19/76
620	0.23	NO3-N TOTAL MG/L	7077000	6/21/76
620	0.28	NO3-N TOTAL MG/L	7077000	7/26/76
620	0.22	NO3-N TOTAL MG/L	7077000	8/23/76
620	0.19	NO3-N TOTAL MG/L	7077000	6/7/77
620	0.12	NO3-N TOTAL MG/L	7077000	6/27/77
620	0.17	NO3-N TOTAL MG/L	7077000	8/22/77
620	0.26	NO3-N TOTAL MG/L	7077000	5/15/78
620	0.27	NO3-N TOTAL MG/L	7077000	6/12/78
620	0.03	NO3-N TOTAL MG/L	7077000	7/11/78
620	0	NO3-N TOTAL MG/L	7077000	8/14/78
620	0.12	NO3-N TOTAL MG/L	7077000	5/1/79

95	136	CNDUCTVY AT 25C MICROMHO	07077000	5/21/68
95	255	CNDUCTVY AT 25C MICROMHO	07077000	6/27/68
95	292	CNDUCTVY AT 25C MICROMHO	07077000	7/30/68
95	231	CNDUCTVY AT 25C MICROMHO	07077000	5/8/69
95	281	CNDUCTVY AT 25C MICROMHO	07077000	6/12/69
95	278	CNDUCTVY AT 25C MICROMHO	07077000	7/16/69
95	285	CNDUCTVY AT 25C MICROMHO	07077000	8/19/69
95	150	CNDUCTVY AT 25C MICROMHO	07077000	5/1/70
95	242	CNDUCTVY AT 25C MICROMHO	07077000	5/27/70
95	188	CNDUCTVY AT 25C MICROMHO	07077000	5/1/74
95	244	CNDUCTVY AT 25C MICROMHO	07077000	8/21/74
95	207	CNDUCTVY AT 25C MICROMHO	07077000	5/19/75
95	266	CNDUCTVY AT 25C MICROMHO	07077000	6/11/75
95	268	CNDUCTVY AT 25C MICROMHO	07077000	7/15/75
95	266	CNDUCTVY AT 25C MICROMHO	07077000	8/18/75
95	271	CNDUCTVY AT 25C MICROMHO	07077000	5/19/76
95	246	CNDUCTVY AT 25C MICROMHO	07077000	6/21/76
95	280	CNDUCTVY AT 25C MICROMHO	07077000	7/26/76
95	273	CNDUCTVY AT 25C MICROMHO	07077000	8/23/76
95	277	CNDUCTVY AT 25C MICROMHO	07077000	6/7/77
95	176	CNDUCTVY AT 25C MICROMHO	07077000	6/27/77
95	248	CNDUCTVY AT 25C MICROMHO	07077000	7/19/77
95	263	CNDUCTVY AT 25C MICROMHO	07077000	8/30/77
95	202	CNDUCTVY AT 25C MICROMHO	07077000	5/15/78
95	241	CNDUCTVY AT 25C MICROMHO	07077000	6/12/78
95	281	CNDUCTVY AT 25C MICROMHO	07077000	7/11/78
95	314	CNDUCTVY AT 25C MICROMHO	07077000	8/14/78
95	184	CNDUCTVY AT 25C MICROMHO	07077000	5/1/79
95	180	CNDUCTVY AT 25C MICROMHO	07077000	6/5/79
95	244	CNDUCTVY AT 25C MICROMHO	07077000	7/10/79
95	248	CNDUCTVY AT 25C MICROMHO	07077000	7/31/79
300	8.3	DO MG/L	050113	5/1/74
300	6.9	DO MG/L	050113	5/29/74
300	7.5	DO MG/L	050113	6/26/74
300	9.4	DO MG/L	050113	7/24/74
300	8.4	DO MG/L	050113	8/21/74
300	7.7	DO MG/L	050113	5/19/75
300	8	DO MG/L	050113	6/11/75
300	7.9	DO MG/L	050113	7/15/75

620	0.19	NO3-N TOTAL MG/L	7077000	6/5/79
620	0.28	NO3-N TOTAL MG/L	7077000	7/10/79
620	0.32	NO3-N TOTAL MG/L	7077000	7/31/79
620	0.22	NO3-N TOTAL MG/L	7077000	5/20/80
620	0.24	NO3-N TOTAL MG/L	7077000	7/1/80
620	0.11	NO3-N TOTAL MG/L	7077000	7/22/80
620	0.01	NO3-N TOTAL MG/L	7077000	8/19/80
900	106	TOT HARD CACO3 MG/L	50113	6/26/74
900	126	TOT HARD CACO3 MG/L	50113	7/15/75
900	134	TOT HARD CACO3 MG/L	50113	6/21/76
900	138	TOT HARD CACO3 MG/L	50113	7/11/78
900	328	TOT HARD CACO3 MG/L	50113	7/10/79
900	134	TOT HARD CACO3 MG/L	50113	7/14/81
900	150	TOT HARD CACO3 MG/L	50113	8/11/81
900	11	TOT HARD CACO3 MG/L	50113	5/4/82
900	126	TOT HARD CACO3 MG/L	50113	6/1/82
900	156	TOT HARD CACO3 MG/L	50113	7/20/82
900	148	TOT HARD CACO3 MG/L	50113	8/17/82
900	106	TOT HARD CACO3 MG/L	50113	5/3/83
900	110	TOT HARD CACO3 MG/L	50113	5/31/83
900	124	TOT HARD CACO3 MG/L	50113	7/5/83
900	132	TOT HARD CACO3 MG/L	50113	8/9/83
900	94	TOT HARD CACO3 MG/L	50113	5/8/84
900	142	TOT HARD CACO3 MG/L	50113	6/19/84
900	164	TOT HARD CACO3 MG/L	50113	7/31/84
900	126	TOT HARD CACO3 MG/L	50113	8/28/84
900	118	TOT HARD CACO3 MG/L	50113	5/21/85
900	126	TOT HARD CACO3 MG/L	50113	7/23/85
900	122	TOT HARD CACO3 MG/L	50113	8/20/85
900	108	TOT HARD CACO3 MG/L	50113	5/27/86
900	106	TOT HARD CACO3 MG/L	50113	6/17/86
900	166	TOT HARD CACO3 MG/L	50113	7/8/86
900	138	TOT HARD CACO3 MG/L	50113	8/26/86
900	140	TOT HARD CACO3 MG/L	50113	6/23/87
900	160	TOT HARD CACO3 MG/L	50113	7/21/87
900	144	TOT HARD CACO3 MG/L	50113	5/24/88
900	104	TOT HARD CACO3 MG/L	50113	7/27/88
900	150	TOT HARD CACO3 MG/L	50113	8/7/88
900	142	TOT HARD CACO3 MG/L	50113	8/23/88

300	7.4	DO	MG/L	050113	8/18/75
300	9.4	DO	MG/L	050113	5/19/76
300	7.3	DO	MG/L	050113	6/21/76
300	8	DO	MG/L	050113	7/26/76
300	9.2	DO	MG/L	050113	8/23/76
300	7.9	DO	MG/L	050113	6/7/77
300	5.9	DO	MG/L	050113	6/27/77
300	8.3	DO	MG/L	050113	7/19/77
300	7.9	DO	MG/L	050113	8/22/77
300	7.7	DO	MG/L	050113	5/15/78
300	8.2	DO	MG/L	050113	6/12/78
300	8.8	DO	MG/L	050113	7/11/78
300	9.5	DO	MG/L	050113	8/14/78
300	8.6	DO	MG/L	050113	5/1/79
300	7.7	DO	MG/L	050113	6/5/79
300	8.5	DO	MG/L	050113	7/10/79
300	8.6	DO	MG/L	050113	7/31/79
300	9	DO	MG/L	050113	5/20/80
300	8.9	DO	MG/L	050113	7/1/80
300	8.9	DO	MG/L	050113	7/22/80
300	8.9	DO	MG/L	050113	8/19/80
300	8.1	DO	MG/L	050113	5/19/81
300	7.1	DO	MG/L	050113	6/16/81
300	8.3	DO	MG/L	050113	7/14/81
300	8.4	DO	MG/L	050113	8/11/81
300	8.8	DO	MG/L	050113	5/4/82
300	7.8	DO	MG/L	050113	6/29/82
300	8	DO	MG/L	050113	8/17/82
300	8.4	DO	MG/L	050113	5/3/83
300	7.7	DO	MG/L	050113	5/31/83
300	8.2	DO	MG/L	050113	7/5/83
300	8.4	DO	MG/L	050113	8/9/83
300	9.6	DO	MG/L	050113	6/19/84
300	10	DO	MG/L	050113	7/31/84
300	10	DO	MG/L	050113	8/28/84
300	7.4	DO	MG/L	050113	5/21/85
300	8.5	DO	MG/L	050113	6/18/85
300	9	DO	MG/L	050113	7/23/85
300	8.9	DO	MG/L	050113	8/20/85

900	124	TOT HARD CACO3	MG/L	50113	5/23/89
900	128	TOT HARD CACO3	MG/L	50113	6/27/89
900	140	TOT HARD CACO3	MG/L	50113	7/25/89
900	158	TOT HARD CACO3	MG/L	50113	8/22/89
900	100	TOT HARD CACO3	MG/L	50113	5/22/90
900	110	TOT HARD CACO3	MG/L	50113	6/26/90
900	124	TOT HARD CACO3	MG/L	50113	7/31/90
900	124	TOT HARD CACO3	MG/L	50113	8/28/90
900	74	TOT HARD CACO3	MG/L	50113	5/1/91
900	130	TOT HARD CACO3	MG/L	50113	6/12/91
900	136	TOT HARD CACO3	MG/L	50113	7/10/91
900	164	TOT HARD CACO3	MG/L	50113	8/13/91
900	134	TOT HARD CACO3	MG/L	50113	5/13/92
900	120	TOT HARD CACO3	MG/L	50113	6/9/92
900	142	TOT HARD CACO3	MG/L	50113	7/7/92
900	128	TOT HARD CACO3	MG/L	50113	8/5/92
900	111	TOT HARD CACO3	MG/L	50113	5/12/93
900	125	TOT HARD CACO3	MG/L	50113	6/1/93
900	149	TOT HARD CACO3	MG/L	50113	7/7/93
900	170	TOT HARD CACO3	MG/L	50113	8/10/93
900	170	TOT HARD CACO3	MG/L	7077000	8/2/54
900	144	TOT HARD CACO3	MG/L	7077000	6/20/56
900	108	TOT HARD CACO3	MG/L	7077000	6/18/57
900	149	TOT HARD CACO3	MG/L	7077000	7/26/60
900	69	TOT HARD CACO3	MG/L	7077000	5/21/68
900	127	TOT HARD CACO3	MG/L	7077000	6/27/68
900	147	TOT HARD CACO3	MG/L	7077000	7/30/68
900	125	TOT HARD CACO3	MG/L	7077000	5/8/69
900	0	TOT HARD CACO3	MG/L	7077000	6/12/69
900	148	TOT HARD CACO3	MG/L	7077000	7/16/69
900	147	TOT HARD CACO3	MG/L	7077000	8/19/69
900	134	TOT HARD CACO3	MG/L	7077000	6/29/70
900	126	TOT HARD CACO3	MG/L	7077000	7/15/75
900	130	TOT HARD CACO3	MG/L	7077000	6/21/76
900	140	TOT HARD CACO3	MG/L	7077000	8/30/77
900	140	TOT HARD CACO3	MG/L	7077000	7/11/78
900	330	TOT HARD CACO3	MG/L	7077000	7/10/79
900	134	TOT HARD CACO3	MG/L	7077000	7/14/81
900	150	TOT HARD CACO3	MG/L	7077000	8/11/81

300	8.5	DO	MG/L	050113	5/27/86	900	11	TOT HARD CACO3	MG/L	7077000	5/4/82
300	7.2	DO	MG/L	050113	6/17/86	900	126	TOT HARD CACO3	MG/L	7077000	6/1/82
300	9.4	DO	MG/L	050113	7/8/86	900	156	TOT HARD CACO3	MG/L	7077000	7/20/82
300	10	DO	MG/L	050113	8/26/86	900	148	TOT HARD CACO3	MG/L	7077000	8/17/82
300	10.9	DO	MG/L	050113	5/26/87	900	120	TOT HARD CACO3	MG/L	7077000	5/21/85
300	8.7	DO	MG/L	050113	6/23/87	900	130	TOT HARD CACO3	MG/L	7077000	7/23/85
300	10	DO	MG/L	050113	5/24/88	900	120	TOT HARD CACO3	MG/L	7077000	8/20/85
300	11.4	DO	MG/L	050113	8/7/88	900	110	TOT HARD CACO3	MG/L	7077000	5/27/86
300	8.8	DO	MG/L	050113	8/23/88	900	110	TOT HARD CACO3	MG/L	7077000	6/17/86
300	7.9	DO	MG/L	050113	5/23/89	900	170	TOT HARD CACO3	MG/L	7077000	7/8/86
300	7.5	DO	MG/L	050113	6/27/89	900	140	TOT HARD CACO3	MG/L	7077000	8/26/86
300	8.4	DO	MG/L	050113	7/25/89	900	140	TOT HARD CACO3	MG/L	7077000	6/23/87
300	7.6	DO	MG/L	050113	8/22/89	900	160	TOT HARD CACO3	MG/L	7077000	7/21/87
300	7.4	DO	MG/L	050113	5/22/90	900	140	TOT HARD CACO3	MG/L	7077000	5/24/88
300	8.1	DO	MG/L	050113	6/26/90	900	100	TOT HARD CACO3	MG/L	7077000	7/27/88
300	9.9	DO	MG/L	050113	7/31/90	900	150	TOT HARD CACO3	MG/L	7077000	8/7/88
300	8.9	DO	MG/L	050113	8/28/90	900	140	TOT HARD CACO3	MG/L	7077000	8/23/88
300	6.8	DO	MG/L	050113	5/1/91	1042	14	COPPER CU,TOT	UG/L	50113	5/1/74
300	8.7	DO	MG/L	050113	6/12/91	1042	0	COPPER CU,TOT	UG/L	50113	5/29/74
300	8.6	DO	MG/L	050113	7/10/91	1042	0	COPPER CU,TOT	UG/L	50113	6/26/74
300	7.6	DO	MG/L	050113	8/13/91	1042	0	COPPER CU,TOT	UG/L	50113	7/24/74
300	8.4	DO	MG/L	050113	5/13/92	1042	5	COPPER CU,TOT	UG/L	50113	8/21/74
300	8.3	DO	MG/L	050113	6/9/92	1042	0	COPPER CU,TOT	UG/L	50113	5/19/75
300	6.9	DO	MG/L	050113	7/7/92	1042	4	COPPER CU,TOT	UG/L	50113	6/11/75
300	6.8	DO	MG/L	050113	8/5/92	1042	1	COPPER CU,TOT	UG/L	50113	7/15/75
300	5.5	DO	MG/L	050113	5/12/93	1042	3	COPPER CU,TOT	UG/L	50113	6/21/76
300	6.8	DO	MG/L	050113	6/1/93	1042	5	COPPER CU,TOT	UG/L	50113	7/19/77
300	7.2	DO	MG/L	050113	7/7/93	1042	16	COPPER CU,TOT	UG/L	50113	7/11/78
300	5.7	DO	MG/L	050113	8/10/93	1042	27	COPPER CU,TOT	UG/L	50113	7/10/79
300	6.1	DO	MG/L	07077000	5/21/68	1042	15	COPPER CU,TOT	UG/L	50113	7/31/79
300	7.6	DO	MG/L	07077000	6/27/68	1042	15	COPPER CU,TOT	UG/L	50113	5/20/80
300	7.3	DO	MG/L	07077000	7/30/68	1042	15	COPPER CU,TOT	UG/L	50113	7/1/80
300	6.1	DO	MG/L	07077000	5/1/70	1042	15	COPPER CU,TOT	UG/L	50113	7/22/80
300	7.3	DO	MG/L	07077000	5/27/70	1042	15	COPPER CU,TOT	UG/L	50113	8/19/80
300	8.2	DO	MG/L	07077000	5/1/74	1042	14	COPPER CU,TOT	UG/L	50113	6/16/81
300	8.4	DO	MG/L	07077000	8/21/74	1042	10	COPPER CU,TOT	UG/L	50113	8/11/81
300	7.6	DO	MG/L	07077000	5/19/75	1042	10	COPPER CU,TOT	UG/L	50113	5/4/82
300	8	DO	MG/L	07077000	6/11/75	1042	10	COPPER CU,TOT	UG/L	50113	6/1/82
300	7.9	DO	MG/L	07077000	7/15/75	1042	8	COPPER CU,TOT	UG/L	50113	6/29/82

300	7.4	DO	MG/L	07077000	8/18/75	1042	10	COPPER	CU,TOT	UG/L	50113	7/20/82
300	9.4	DO	MG/L	07077000	5/19/76	1042	10	COPPER	CU,TOT	UG/L	50113	8/17/82
300	7.3	DO	MG/L	07077000	6/21/76	1042	10	COPPER	CU,TOT	UG/L	50113	5/3/83
300	8	DO	MG/L	07077000	7/26/76	1042	10	COPPER	CU,TOT	UG/L	50113	5/31/83
300	9.2	DO	MG/L	07077000	8/23/76	1042	10	COPPER	CU,TOT	UG/L	50113	7/5/83
300	7.9	DO	MG/L	07077000	6/7/77	1042	10	COPPER	CU,TOT	UG/L	50113	8/9/83
300	5.9	DO	MG/L	07077000	6/27/77	1042	10	COPPER	CU,TOT	UG/L	50113	5/8/84
300	8.3	DO	MG/L	07077000	7/19/77	1042	10	COPPER	CU,TOT	UG/L	50113	6/19/84
300	7.9	DO	MG/L	07077000	8/22/77	1042	10	COPPER	CU,TOT	UG/L	50113	7/31/84
300	8.5	DO	MG/L	07077000	8/30/77	1042	10	COPPER	CU,TOT	UG/L	50113	8/28/84
300	7.7	DO	MG/L	07077000	5/15/78	1042	15	COPPER	CU,TOT	UG/L	50113	5/21/85
300	8.2	DO	MG/L	07077000	6/12/78	1042	15	COPPER	CU,TOT	UG/L	50113	6/18/85
300	8.8	DO	MG/L	07077000	7/11/78	1042	15	COPPER	CU,TOT	UG/L	50113	7/23/85
300	9.5	DO	MG/L	07077000	8/14/78	1042	15	COPPER	CU,TOT	UG/L	50113	8/20/85
300	8.6	DO	MG/L	07077000	5/1/79	1042	15	COPPER	CU,TOT	UG/L	50113	5/27/86
300	7.7	DO	MG/L	07077000	6/5/79	1042	15	COPPER	CU,TOT	UG/L	50113	6/17/86
300	8.5	DO	MG/L	07077000	7/10/79	1042	15	COPPER	CU,TOT	UG/L	50113	7/8/86
300	8.6	DO	MG/L	07077000	7/31/79	1042	15	COPPER	CU,TOT	UG/L	50113	8/26/86
300	9	DO	MG/L	07077000	5/20/80	1042	16	COPPER	CU,TOT	UG/L	50113	5/26/87
300	8.9	DO	MG/L	07077000	7/1/80	1042	15	COPPER	CU,TOT	UG/L	50113	7/21/87
300	8.9	DO	MG/L	07077000	7/22/80	1042	15	COPPER	CU,TOT	UG/L	50113	5/24/88
300	8.9	DO	MG/L	07077000	8/19/80	1042	16	COPPER	CU,TOT	UG/L	50113	7/27/88
300	8.1	DO	MG/L	07077000	5/19/81	1042	15	COPPER	CU,TOT	UG/L	50113	8/7/88
300	7.1	DO	MG/L	07077000	6/16/81	1042	15	COPPER	CU,TOT	UG/L	50113	8/23/88
300	8.3	DO	MG/L	07077000	7/14/81	1042	15	COPPER	CU,TOT	UG/L	50113	5/23/89
300	8.4	DO	MG/L	07077000	8/11/81	1042	22	COPPER	CU,TOT	UG/L	50113	6/27/89
300	8.8	DO	MG/L	07077000	5/4/82	1042	21	COPPER	CU,TOT	UG/L	50113	7/25/89
300	7.8	DO	MG/L	07077000	6/29/82	1042	64	COPPER	CU,TOT	UG/L	50113	8/22/89
300	8	DO	MG/L	07077000	8/17/82	1042	14	COPPER	CU,TOT	UG/L	7077000	5/1/74
300	8.4	DO	MG/L	07077000	5/3/83	1042	5	COPPER	CU,TOT	UG/L	7077000	8/21/74
300	7.7	DO	MG/L	07077000	5/31/83	1042	0	COPPER	CU,TOT	UG/L	7077000	5/19/75
300	8.2	DO	MG/L	07077000	7/5/83	1042	4	COPPER	CU,TOT	UG/L	7077000	6/11/75
300	8.4	DO	MG/L	07077000	8/9/83	1042	2	COPPER	CU,TOT	UG/L	7077000	7/15/75
300	9.6	DO	MG/L	07077000	6/19/84	1042	20	COPPER	CU,TOT	UG/L	7077000	6/21/76
300	10	DO	MG/L	07077000	7/31/84	1042	20	COPPER	CU,TOT	UG/L	7077000	8/30/77
300	10	DO	MG/L	07077000	8/28/84	1042	20	COPPER	CU,TOT	UG/L	7077000	7/11/78
300	7.4	DO	MG/L	07077000	5/21/85	1042	30	COPPER	CU,TOT	UG/L	7077000	7/10/79
300	8.5	DO	MG/L	07077000	6/18/85	1042	20	COPPER	CU,TOT	UG/L	7077000	7/31/79
300	9	DO	MG/L	07077000	7/23/85	1042	20	COPPER	CU,TOT	UG/L	7077000	5/20/80

300	8.9	DO	MG/L	07077000	8/20/85
300	8.5	DO	MG/L	07077000	5/27/86
300	7.2	DO	MG/L	07077000	6/17/86
300	9.4	DO	MG/L	07077000	7/8/86
300	10	DO	MG/L	07077000	8/26/86
300	10.9	DO	MG/L	07077000	5/26/87
300	8.7	DO	MG/L	07077000	6/23/87
300	10	DO	MG/L	07077000	5/24/88
300	11.4	DO	MG/L	07077000	8/7/88
300	8.8	DO	MG/L	07077000	8/23/88
300	7.9	DO	MG/L	07077000	5/23/89
300	7.5	DO	MG/L	07077000	6/27/89
300	8.4	DO	MG/L	07077000	7/25/89
300	7.6	DO	MG/L	07077000	8/22/89
300	7.4	DO	MG/L	07077000	5/22/90
300	8.1	DO	MG/L	07077000	6/26/90
300	9.9	DO	MG/L	07077000	7/31/90
300	8.9	DO	MG/L	07077000	8/28/90
300	6.8	DO	MG/L	07077000	5/1/91
300	8.7	DO	MG/L	07077000	6/12/91
300	8.6	DO	MG/L	07077000	7/10/91
300	7.6	DO	MG/L	07077000	8/13/91
300	8.4	DO	MG/L	07077000	5/13/92
300	8.3	DO	MG/L	07077000	6/9/92
300	6.9	DO	MG/L	07077000	7/7/92
300	6.8	DO	MG/L	07077000	8/5/92
400	7.81	PH	SU	050113	5/1/74
400	7.79	PH	SU	050113	5/29/74
400	7.09	PH	SU	050113	6/26/74
400	8.15	PH	SU	050113	7/24/74
400	8	PH	SU	050113	8/21/74
400	7.69	PH	SU	050113	5/19/75
400	7.9	PH	SU	050113	6/11/75
400	8.16	PH	SU	050113	7/15/75
400	8.02	PH	SU	050113	8/18/75
400	8.29	PH	SU	050113	5/19/76
400	7.91	PH	SU	050113	6/21/76
400	8	PH	SU	050113	7/26/76
400	8.22	PH	SU	050113	8/23/76

1042	20	COPPER	CU,TOT UG/L	7077000	7/1/80
1042	20	COPPER	CU,TOT UG/L	7077000	7/22/80
1042	20	COPPER	CU,TOT UG/L	7077000	8/19/80
1042	14	COPPER	CU,TOT UG/L	7077000	6/16/81
1042	10	COPPER	CU,TOT UG/L	7077000	8/11/81
1042	10	COPPER	CU,TOT UG/L	7077000	5/4/82
1042	10	COPPER	CU,TOT UG/L	7077000	6/1/82
1042	8	COPPER	CU,TOT UG/L	7077000	6/29/82
1042	10	COPPER	CU,TOT UG/L	7077000	7/20/82
1042	10	COPPER	CU,TOT UG/L	7077000	8/17/82
1042	10	COPPER	CU,TOT UG/L	7077000	5/3/83
1042	10	COPPER	CU,TOT UG/L	7077000	5/31/83
1042	10	COPPER	CU,TOT UG/L	7077000	7/5/83
1042	10	COPPER	CU,TOT UG/L	7077000	8/9/83
1042	10	COPPER	CU,TOT UG/L	7077000	5/8/84
1042	10	COPPER	CU,TOT UG/L	7077000	6/19/84
1042	10	COPPER	CU,TOT UG/L	7077000	7/31/84
1042	10	COPPER	CU,TOT UG/L	7077000	8/28/84
1042	15	COPPER	CU,TOT UG/L	7077000	5/21/85
1042	15	COPPER	CU,TOT UG/L	7077000	6/18/85
1042	15	COPPER	CU,TOT UG/L	7077000	7/23/85
1042	15	COPPER	CU,TOT UG/L	7077000	8/20/85
1042	15	COPPER	CU,TOT UG/L	7077000	5/27/86
1042	15	COPPER	CU,TOT UG/L	7077000	6/17/86
1042	15	COPPER	CU,TOT UG/L	7077000	7/8/86
1042	15	COPPER	CU,TOT UG/L	7077000	8/26/86
1042	16	COPPER	CU,TOT UG/L	7077000	5/26/87
1042	15	COPPER	CU,TOT UG/L	7077000	7/21/87
1042	15	COPPER	CU,TOT UG/L	7077000	5/24/88
1042	16	COPPER	CU,TOT UG/L	7077000	7/27/88
1042	15	COPPER	CU,TOT UG/L	7077000	8/7/88
1042	15	COPPER	CU,TOT UG/L	7077000	8/23/88
1042	15	COPPER	CU,TOT UG/L	7077000	5/23/89
1042	22	COPPER	CU,TOT UG/L	7077000	6/27/89
1042	21	COPPER	CU,TOT UG/L	7077000	7/25/89
1042	64	COPPER	CU,TOT UG/L	7077000	8/22/89
1045	726	IRON	FE,TOT UG/L	50113	5/1/74
1045	820	IRON	FE,TOT UG/L	50113	5/29/74
1045	1652	IRON	FE,TOT UG/L	50113	6/26/74

400	8.09	PH	SU	050113	6/7/77	1045	508	IRON FE,TOT	UG/L	50113	7/24/74
400	7.2	PH	SU	050113	6/27/77	1045	964	IRON FE,TOT	UG/L	50113	8/21/74
400	8.2	PH	SU	050113	7/19/77	1045	1047	IRON FE,TOT	UG/L	50113	5/19/75
400	8.25	PH	SU	050113	8/22/77	1045	7768	IRON FE,TOT	UG/L	50113	6/11/75
400	7.49	PH	SU	050113	5/15/78	1045	866	IRON FE,TOT	UG/L	50113	7/15/75
400	7.75	PH	SU	050113	6/12/78	1045	1221	IRON FE,TOT	UG/L	50113	6/21/76
400	8.12	PH	SU	050113	7/11/78	1045	2183	IRON FE,TOT	UG/L	50113	7/11/78
400	8.43	PH	SU	050113	8/14/78	1045	478	IRON FE,TOT	UG/L	50113	7/10/79
400	7.8	PH	SU	050113	5/1/79	1045	534	IRON FE,TOT	UG/L	50113	7/31/79
400	7.64	PH	SU	050113	6/5/79	1045	1367	IRON FE,TOT	UG/L	50113	5/20/80
400	7.76	PH	SU	050113	7/10/79	1045	375	IRON FE,TOT	UG/L	50113	7/1/80
400	7.77	PH	SU	050113	7/31/79	1045	355	IRON FE,TOT	UG/L	50113	8/19/80
400	7.93	PH	SU	050113	5/20/80	1045	726	IRON FE,TOT	UG/L	7077000	5/1/74
400	8.16	PH	SU	050113	7/1/80	1045	964	IRON FE,TOT	UG/L	7077000	8/21/74
400	8.24	PH	SU	050113	7/22/80	1045	1047	IRON FE,TOT	UG/L	7077000	5/19/75
400	8.33	PH	SU	050113	8/19/80	1045	7768	IRON FE,TOT	UG/L	7077000	6/11/75
400	7.77	PH	SU	050113	5/19/81	1045	866	IRON FE,TOT	UG/L	7077000	7/15/75
400	7.85	PH	SU	050113	6/16/81	1045	1200	IRON FE,TOT	UG/L	7077000	6/21/76
400	8.11	PH	SU	050113	7/14/81	1045	9000	IRON FE,TOT	UG/L	7077000	8/30/77
400	8.35	PH	SU	050113	8/11/81	1045	2200	IRON FE,TOT	UG/L	7077000	7/11/78
400	7.82	PH	SU	050113	5/4/82	1045	480	IRON FE,TOT	UG/L	7077000	7/10/79
400	7.99	PH	SU	050113	6/1/82	1045	530	IRON FE,TOT	UG/L	7077000	7/31/79
400	7.89	PH	SU	050113	6/29/82	1045	1400	IRON FE,TOT	UG/L	7077000	5/20/80
400	7.85	PH	SU	050113	7/20/82	1045	380	IRON FE,TOT	UG/L	7077000	7/1/80
400	7.99	PH	SU	050113	8/17/82	1045	360	IRON FE,TOT	UG/L	7077000	8/19/80
400	7.8	PH	SU	050113	5/3/83	31616	140	FEC COLIMFM-FCBR	/100ML	50113	5/1/74
400	7.66	PH	SU	050113	5/31/83	31616	460	FEC COLIMFM-FCBR	/100ML	50113	6/26/74
400	7.9	PH	SU	050113	7/5/83	31616	87	FEC COLIMFM-FCBR	/100ML	50113	7/24/74
400	8.02	PH	SU	050113	8/9/83	31616	94	FEC COLIMFM-FCBR	/100ML	50113	8/21/74
400	7.45	PH	SU	050113	5/8/84	31616	55	FEC COLIMFM-FCBR	/100ML	50113	5/19/75
400	8.03	PH	SU	050113	6/19/84	31616	87	FEC COLIMFM-FCBR	/100ML	50113	6/11/75
400	8.27	PH	SU	050113	7/31/84	31616	80	FEC COLIMFM-FCBR	/100ML	50113	7/15/75
400	8.21	PH	SU	050113	8/28/84	31616	140	FEC COLIMFM-FCBR	/100ML	50113	8/18/75
400	7.88	PH	SU	050113	5/21/85	31616	13	FEC COLIMFM-FCBR	/100ML	50113	5/19/76
400	7.99	PH	SU	050113	6/18/85	31616	5	FEC COLIMFM-FCBR	/100ML	50113	7/26/76
400	8.19	PH	SU	050113	7/23/85	31616	5	FEC COLIMFM-FCBR	/100ML	50113	8/23/76
400	8.11	PH	SU	050113	8/20/85	31616	13	FEC COLIMFM-FCBR	/100ML	50113	6/7/77
400	7.92	PH	SU	050113	5/27/86	31616	10	FEC COLIMFM-FCBR	/100ML	50113	7/19/77
400	7.66	PH	SU	050113	6/17/86	31616	64	FEC COLIMFM-FCBR	/100ML	50113	8/22/77

400	8.15	PH	SU	050113	7/8/86	31616	40	FEC COLIMFM-FCBR /100ML	50113	5/15/78
400	8.48	PH	SU	050113	8/26/86	31616	162	FEC COLIMFM-FCBR /100ML	50113	6/12/78
400	8.27	PH	SU	050113	5/26/87	31616	210	FEC COLIMFM-FCBR /100ML	50113	7/11/78
400	8.33	PH	SU	050113	6/23/87	31616	147	FEC COLIMFM-FCBR /100ML	50113	8/14/78
400	8.54	PH	SU	050113	7/21/87	31616	80	FEC COLIMFM-FCBR /100ML	50113	5/1/79
400	7.86	PH	SU	050113	7/27/88	31616	155	FEC COLIMFM-FCBR /100ML	50113	6/5/79
400	8.55	PH	SU	050113	8/7/88	31616	1190	FEC COLIMFM-FCBR /100ML	50113	7/10/79
400	8.29	PH	SU	050113	8/23/88	31616	370	FEC COLIMFM-FCBR /100ML	50113	7/31/79
400	7.9	PH	SU	050113	5/23/89	31616	100	FEC COLIMFM-FCBR /100ML	50113	5/20/80
400	8.02	PH	SU	050113	6/27/89	31616	8	FEC COLIMFM-FCBR /100ML	50113	7/1/80
400	8.06	PH	SU	050113	7/25/89	31616	44	FEC COLIMFM-FCBR /100ML	50113	7/22/80
400	8.37	PH	SU	050113	8/22/89	31616	4	FEC COLIMFM-FCBR /100ML	50113	8/19/80
400	7.75	PH	SU	050113	5/22/90	31616	140	FEC COLIMFM-FCBR /100ML	50113	6/16/81
400	7.94	PH	SU	050113	6/26/90	31616	279	FEC COLIMFM-FCBR /100ML	50113	7/14/81
400	8.18	PH	SU	050113	7/31/90	31616	8	FEC COLIMFM-FCBR /100ML	50113	8/11/81
400	8.31	PH	SU	050113	8/28/90	31616	20	FEC COLIMFM-FCBR /100ML	50113	5/4/82
400	7.64	PH	SU	050113	5/1/91	31616	4	FEC COLIMFM-FCBR /100ML	50113	6/1/82
400	8.08	PH	SU	050113	6/12/91	31616	40	FEC COLIMFM-FCBR /100ML	50113	6/29/82
400	8.25	PH	SU	050113	7/10/91	31616	12	FEC COLIMFM-FCBR /100ML	50113	7/20/82
400	8.52	PH	SU	050113	8/13/91	31616	64	FEC COLIMFM-FCBR /100ML	50113	8/17/82
400	8.15	PH	SU	050113	5/13/92	31616	90	FEC COLIMFM-FCBR /100ML	50113	5/3/83
400	7.23	PH	SU	050113	6/9/92	31616	20	FEC COLIMFM-FCBR /100ML	50113	5/31/83
400	7.51	PH	SU	050113	7/7/92	31616	76	FEC COLIMFM-FCBR /100ML	50113	7/5/83
400	8.04	PH	SU	050113	8/5/92	31616	8	FEC COLIMFM-FCBR /100ML	50113	8/9/83
400	7.77	PH	SU	050113	5/12/93	31616	260	FEC COLIMFM-FCBR /100ML	50113	5/8/84
400	7.97	PH	SU	050113	6/1/93	31616	450	FEC COLIMFM-FCBR /100ML	50113	6/19/84
400	8.28	PH	SU	050113	7/7/93	31616	10	FEC COLIMFM-FCBR /100ML	50113	7/31/84
400	8.24	PH	SU	050113	8/10/93	31616	15	FEC COLIMFM-FCBR /100ML	50113	8/28/84
400	8.5	PH	SU	07077000	8/2/54	31616	10	FEC COLIMFM-FCBR /100ML	50113	5/21/85
400	8.7	PH	SU	07077000	6/20/56	31616	130	FEC COLIMFM-FCBR /100ML	50113	6/18/85
400	7.9	PH	SU	07077000	6/18/57	31616	220	FEC COLIMFM-FCBR /100ML	50113	7/23/85
400	7.8	PH	SU	07077000	7/26/60	31616	50	FEC COLIMFM-FCBR /100ML	50113	8/20/85
400	7.4	PH	SU	07077000	5/21/68	31616	900	FEC COLIMFM-FCBR /100ML	50113	5/27/86
400	8	PH	SU	07077000	6/27/68	31616	60	FEC COLIMFM-FCBR /100ML	50113	6/17/86
400	8	PH	SU	07077000	7/30/68	31616	600	FEC COLIMFM-FCBR /100ML	50113	7/8/86
400	8.2	PH	SU	07077000	5/8/69	31616	4	FEC COLIMFM-FCBR /100ML	50113	8/26/86
400	8	PH	SU	07077000	6/12/69	31616	10	FEC COLIMFM-FCBR /100ML	50113	5/26/87
400	8.4	PH	SU	07077000	7/16/69	31616	10	FEC COLIMFM-FCBR /100ML	50113	6/23/87
400	8.1	PH	SU	07077000	8/19/69	31616	4	FEC COLIMFM-FCBR /100ML	50113	7/21/87

White River STORET Sampling Data

For Sampling Times from May through August

400	7.5	PH	SU	07077000	5/1/70	31616	18	FEC COLIMFM-FCBR /100ML	50113	5/21/91
400	7.6	PH	SU	07077000	5/27/70	31616	210	FEC COLIMFM-FCBR /100ML	50113	6/18/91
400	7.81	PH	SU	07077000	5/1/74	31616	20	FEC COLIMFM-FCBR /100ML	50113	5/13/93
400	8	PH	SU	07077000	8/21/74	31616	10	FEC COLIMFM-FCBR /100ML	50113	8/5/93
400	7.69	PH	SU	07077000	5/19/75	31616	230	FEC COLIMFM-FCBR /100ML	7077000	8/19/69
400	7.9	PH	SU	07077000	6/11/75	31616	40	FEC COLIMFM-FCBR /100ML	7077000	6/29/70
400	8.16	PH	SU	07077000	7/15/75	31616	94	FEC COLIMFM-FCBR /100ML	7077000	8/21/74
400	8.02	PH	SU	07077000	8/18/75	31616	55	FEC COLIMFM-FCBR /100ML	7077000	5/19/75
400	8.3	PH	SU	07077000	5/19/76	31616	87	FEC COLIMFM-FCBR /100ML	7077000	6/11/75
400	7.9	PH	SU	07077000	6/21/76	31616	140	FEC COLIMFM-FCBR /100ML	7077000	8/18/75
400	8	PH	SU	07077000	7/26/76	31616	13	FEC COLIMFM-FCBR /100ML	7077000	5/19/76
400	8.2	PH	SU	07077000	8/23/76	31616	5	FEC COLIMFM-FCBR /100ML	7077000	7/26/76
400	8.1	PH	SU	07077000	6/7/77	31616	5	FEC COLIMFM-FCBR /100ML	7077000	8/23/76
400	7.2	PH	SU	07077000	6/27/77	31616	13	FEC COLIMFM-FCBR /100ML	7077000	6/7/77
400	8.2	PH	SU	07077000	7/19/77	31616	10	FEC COLIMFM-FCBR /100ML	7077000	7/19/77
400	8.3	PH	SU	07077000	8/22/77	31616	64	FEC COLIMFM-FCBR /100ML	7077000	8/22/77
400	8.3	PH	SU	07077000	8/30/77	31616	40	FEC COLIMFM-FCBR /100ML	7077000	5/15/78
400	7.5	PH	SU	07077000	5/15/78	31616	160	FEC COLIMFM-FCBR /100ML	7077000	6/12/78
400	7.8	PH	SU	07077000	6/12/78	31616	210	FEC COLIMFM-FCBR /100ML	7077000	7/11/78
400	8.1	PH	SU	07077000	7/11/78	31616	150	FEC COLIMFM-FCBR /100ML	7077000	8/14/78
400	8.4	PH	SU	07077000	8/14/78	31616	80	FEC COLIMFM-FCBR /100ML	7077000	5/1/79
400	7.8	PH	SU	07077000	5/1/79	31616	160	FEC COLIMFM-FCBR /100ML	7077000	6/5/79
400	7.6	PH	SU	07077000	6/5/79	31616	1200	FEC COLIMFM-FCBR /100ML	7077000	7/10/79
400	7.8	PH	SU	07077000	7/10/79	31616	370	FEC COLIMFM-FCBR /100ML	7077000	7/31/79
400	7.8	PH	SU	07077000	7/31/79	31616	100	FEC COLIMFM-FCBR /100ML	7077000	5/20/80
400	7.9	PH	SU	07077000	5/20/80	31616	8	FEC COLIMFM-FCBR /100ML	7077000	7/1/80
400	8.2	PH	SU	07077000	7/1/80	31616	44	FEC COLIMFM-FCBR /100ML	7077000	7/22/80
400	8.2	PH	SU	07077000	7/22/80	31616	4	FEC COLIMFM-FCBR /100ML	7077000	8/19/80
400	8.3	PH	SU	07077000	8/19/80	31616	140	FEC COLIMFM-FCBR /100ML	7077000	6/16/81
400	7.8	PH	SU	07077000	5/19/81	31616	280	FEC COLIMFM-FCBR /100ML	7077000	7/14/81
400	7.9	PH	SU	07077000	6/16/81	31616	8	FEC COLIMFM-FCBR /100ML	7077000	8/11/81
400	8.1	PH	SU	07077000	7/14/81	31616	20	FEC COLIMFM-FCBR /100ML	7077000	5/4/82
400	8.4	PH	SU	07077000	8/11/81	31616	4	FEC COLIMFM-FCBR /100ML	7077000	6/1/82
400	7.8	PH	SU	07077000	5/4/82	31616	40	FEC COLIMFM-FCBR /100ML	7077000	6/29/82
400	8	PH	SU	07077000	6/1/82	31616	12	FEC COLIMFM-FCBR /100ML	7077000	7/20/82
400	7.9	PH	SU	07077000	6/29/82	31616	64	FEC COLIMFM-FCBR /100ML	7077000	8/17/82
400	7.9	PH	SU	07077000	7/20/82	31616	90	FEC COLIMFM-FCBR /100ML	7077000	5/3/83
400	8	PH	SU	07077000	8/17/82	31616	20	FEC COLIMFM-FCBR /100ML	7077000	5/31/83
400	7.8	PH	SU	07077000	5/3/83	31616	76	FEC COLIMFM-FCBR /100ML	7077000	7/5/83

400	7.7	PH	SU	07077000	5/31/83	31616	8	FEC COLIMFM-FCBR /100ML		7077000	8/9/83
400	7.9	PH	SU	07077000	7/5/83	31616	260	FEC COLIMFM-FCBR /100ML		7077000	5/8/84
400	8	PH	SU	07077000	8/9/83	31616	450	FEC COLIMFM-FCBR /100ML		7077000	6/19/84
400	7.5	PH	SU	07077000	5/8/84	31616	10	FEC COLIMFM-FCBR /100ML		7077000	7/31/84
400	8	PH	SU	07077000	6/19/84	31616	15	FEC COLIMFM-FCBR /100ML		7077000	8/28/84
400	8.3	PH	SU	07077000	7/31/84	31616	10	FEC COLIMFM-FCBR /100ML		7077000	5/21/85
400	8.2	PH	SU	07077000	8/28/84	31616	130	FEC COLIMFM-FCBR /100ML		7077000	6/18/85
400	7.9	PH	SU	07077000	5/21/85	31616	220	FEC COLIMFM-FCBR /100ML		7077000	7/23/85
400	8	PH	SU	07077000	6/18/85	31616	50	FEC COLIMFM-FCBR /100ML		7077000	8/20/85
400	8.2	PH	SU	07077000	7/23/85	31616	900	FEC COLIMFM-FCBR /100ML		7077000	5/27/86
400	8.1	PH	SU	07077000	8/20/85	31616	60	FEC COLIMFM-FCBR /100ML		7077000	6/17/86
400	7.92	PH	SU	07077000	5/27/86	31616	600	FEC COLIMFM-FCBR /100ML		7077000	7/8/86
400	7.66	PH	SU	07077000	6/17/86	31616	4	FEC COLIMFM-FCBR /100ML		7077000	8/26/86
400	8.15	PH	SU	07077000	7/8/86	31616	10	FEC COLIMFM-FCBR /100ML		7077000	5/26/87
400	8.48	PH	SU	07077000	8/26/86	31616	10	FEC COLIMFM-FCBR /100ML		7077000	6/23/87
400	8.27	PH	SU	07077000	5/26/87	31616	4	FEC COLIMFM-FCBR /100ML		7077000	7/21/87
400	8.33	PH	SU	07077000	6/23/87	46570	106	CAL HARD CA MG	MG/L	50113	6/26/74
400	8.54	PH	SU	07077000	7/21/87	46570	128	CAL HARD CA MG	MG/L	50113	7/15/75
400	7.86	PH	SU	07077000	7/27/88	46570	134	CAL HARD CA MG	MG/L	50113	6/21/76
400	8.55	PH	SU	07077000	8/7/88	46570	133	CAL HARD CA MG	MG/L	50113	7/11/78
400	8.29	PH	SU	07077000	8/23/88	46570	52	CAL HARD CA MG	MG/L	50113	7/10/79
400	7.9	PH	SU	07077000	5/23/89	46570	141	CAL HARD CA MG	MG/L	50113	7/22/80
400	8.02	PH	SU	07077000	6/27/89	46570	149	CAL HARD CA MG	MG/L	7077000	7/26/60
400	8.06	PH	SU	07077000	7/25/89	46570	69	CAL HARD CA MG	MG/L	7077000	5/21/68
400	8.37	PH	SU	07077000	8/22/89	46570	127	CAL HARD CA MG	MG/L	7077000	6/27/68
400	7.75	PH	SU	07077000	5/22/90	46570	148	CAL HARD CA MG	MG/L	7077000	7/30/68
400	7.94	PH	SU	07077000	6/26/90	46570	125	CAL HARD CA MG	MG/L	7077000	5/8/69
400	8.18	PH	SU	07077000	7/31/90	46570	143	CAL HARD CA MG	MG/L	7077000	6/12/69
400	8.31	PH	SU	07077000	8/28/90	46570	148	CAL HARD CA MG	MG/L	7077000	7/16/69
400	7.6	PH	SU	07077000	5/1/91	46570	147	CAL HARD CA MG	MG/L	7077000	8/19/69
400	8.1	PH	SU	07077000	6/12/91	46570	133	CAL HARD CA MG	MG/L	7077000	6/29/70
400	8.3	PH	SU	07077000	7/10/91	46570	128	CAL HARD CA MG	MG/L	7077000	7/15/75
400	8.5	PH	SU	07077000	8/13/91	46570	134	CAL HARD CA MG	MG/L	7077000	6/21/76
400	8.2	PH	SU	07077000	5/13/92	46570	136	CAL HARD CA MG	MG/L	7077000	8/30/77
400	7.2	PH	SU	07077000	6/9/92	46570	133	CAL HARD CA MG	MG/L	7077000	7/11/78
400	7.5	PH	SU	07077000	7/7/92	46570	52	CAL HARD CA MG	MG/L	7077000	7/10/79
						46570	143	CAL HARD CA MG	MG/L	7077000	7/22/80

GWI San[illegible]g Data

For Sampling Times from May thr August

Temperature (degrees Celsius)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	26.5	28	25.9	29	29
2	28.8	27.9	n/a	n/a'	
2a	19.7	20.4	19	n/a'	18
3d	29.1	n/a	n/a	n/a'	25
3r	29.5	29.7	28.3	30	
4	26	29.7	26.6	32	28
4a	19.3	20.1	19.4	n/a'	23
4c					19
4d					22
5	27.7	31.4	27	27	26
6	28.4	30.6	29.1	30	29
7a	n/a	20.2	18.8	20	
7r					30
8a	n/a	n/a	19.1	27	
9w	n/a	n/a	n/a	30	

pH (SU)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	8.48	7.7	6.9	8.3	8.24
2	7.27	7.2	n/a	n/a	
2a	8.36	7	6.6	n/a	8.22
3d	7.17	n/a	n/a	n/a	7.18
3r	7.37	7	6	7.8	
4	7.58	7.7	7.5	8	8.71
4a	7.57	7	6.6	n/a	7.79
4c					7.97
4d					7.51
5	7.41	6.8	6.3	7.9	7.55
6	7.82	7.6	7.7	7.7	8.07
7a	n/a	6.9	7	7.9	
7r					8.74
8a	n/a	n/a	6.7	7.6	
9w	n/a	n/a	n/a	8.3	

Conductivity (milliohms/cm)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	0.09	0.11	0.49	n/a	n/a
1a	n/a	n/a	n/a	n/a	n/a
2	0.54	0.1	n/a	n/a	n/a
2a	0.2	0.16	0.5	n/a	n/a
3d	0.043	n/a	n/a	n/a	n/a
3r	0.4	0.037	0.07	n/a	n/a
4	0.28	0.041	0.35	n/a	n/a
4a	0.63	0.39	0.62	n/a	n/a
4c	n/a	n/a	n/a	n/a	n/a
4d	n/a	n/a	n/a	n/a	n/a
5	0.08	0.31	0.37	n/a	n/a
6	0.08	0.033	0.033	n/a	n/a
7a	n/a	0.27	0.26	n/a	n/a
7r					n/a
8a	n/a	n/a	0.23	n/a	n/a
9w	n/a	n/a	n/a	n/a	n/a

Alkalinity (mg/l)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	265	308	247	177	164
1a	n/a	n/a	417	n/a	367
2	74	201	n/a	n/a	
2a	619	639	387	n/a	304
3d	30	n/a	n/a	n/a	46
3r	77	90	55	49	
4	151	97	69	71	69
4a	522	491	289	n/a	
4c					296
4d					71
5	78	64	50	99	68
6	65	63	43	53	58
7a	n/a	499	298	323	
7r					82
8a	n/a	n/a	266	89	
9w	n/a	n/a	127	130	

Apparent Color (Pt-Co)					
Site Location	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**
1	610	289	378	407.5	316.5
1a	n/a	n/a	226	n/a	61
2	3625	847	n/a	n/a	
2a	78	36	8135	n/a	66
3d	1020	n/a	n/a	n/a	71
3r	177	104.5	n/a	185	
4	1050	64.35	1115	830	409
4a	112	1310	138.5	n/a	
4c					
4d					81
5	212	154.5	197.5	99	297
6	1450	1292.5	992.5	53	1177.5
7a	n/a	125	149.5	323	
7r					330
8a	n/a	n/a	153	89	
9w	n/a	n/a	179.5	130	

True Color (Pt-Co)					
Site Location	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**
1	3	8	9	20.5	6.5
1a	n/a	n/a	2	n/a	0
2	5	49	n/a	n/a	
2a	3	0	3.5	n/a	2.5
3d	2	n/a	n/a	n/a	16.5
3r	3	62	35	37	
4	2	36	225	45	35.5
4a	3	6	25	n/a	
4c					0
4d					28
5	45	72	4.5	31.5	21
6	2	289	142.5	126	116.5
7a	n/a	4	0	0	
7r					22.5
8a	n/a	n/a	0	29.5	
9w	n/a	n/a	4	5.5	

Turbidity (FTU)					
Site Location	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**
1	123	57	66	78	56
1a	n/a	n/a	38.5	n/a	12
2	555	154	n/a	n/a	
2a	15	6.5	14.5	n/a	13
3d	185	n/a	n/a	n/a	11
3r	33	21.5	34.5	40	
4	206	229	225	135	77.5
4a	19	13	25	n/a	
4c					
4d					13.5
5	38	29	44.5	75	55
6	261	224	242.5	220	181.5
7a	n/a	4	41.5	35	
7r					63.5
8a	n/a	n/a	33.5	27	
9w	n/a	n/a	28	17	

Iron (mg/l)					
Site Location	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**
1	1.27	0.675	1.21	0.985	0.75
1a	n/a	n/a	2.88	n/a	1.785
2	3.3	1.805	n/a	n/a	
2a	15	0.905	1.28	n/a	1.055
3d	2.91	n/a	n/a	n/a	0.705
3r	0.83	0.525	1.14	0.64	
4	3.3	3.3	5.325	2.645	1.465
4a	2	1.245	1.36	n/a	
4c					
4d					0.585
5	0.91	1.3	1.75	1.31	1.27
6	3.3	3.3	4.875	3.3	3.065
7a	n/a	2.905	1.265	2.63	
7r					0.965
8a	n/a	n/a	2.29	0.45	
9w	n/a	n/a	0.325	0.15	

Total Solids (mg/l)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	500	446	409	302.66	257.34
1a	n/a	n/a	506	n/a	507.33
2	504	351	n/a	n/a	
2a	408	525	506	n/a	415.33
3d	223	n/a	n/a	n/a	96
3r	179	98	141	260.67	
4	381	405	425	253.99	170
4a	409	389	383	n/a	
4c					428.67
4d					117.34
5	114	82	119	246	141.34
6	368	250	372	400.67	312.67
7a	n/a	428	497	472.67	
7r					149.33
8a	n/a	n/a	448	162.67	
9w	n/a	n/a	200	174.68	

Suspended Solids (mg/l)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	113	19	75	50	41
1a	n/a	n/a	14	n/a	8.67
2	347	138	n/a	n/a	
2a	0	179	17	n/a	9.33
3d	91	n/a	n/a	n/a	10.67
3r	14	22	25	42	
4	183	3	175	121.33	68
4a	12	455	17	n/a	
4c					8
4d					14
5	24	19	19	84.67	22.29
6	271	226	198	208.67	155.33
7a	n/a	23	18	16.67	
7r					40.67
8a	n/a	n/a	12	18.67	
9w	n/a	n/a	29	18.67	

Dissolved Solids (mg/l)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	387	427	334	252.66	216.34
1a	na/	n/a	492	n/a	498.66
2	157	213	n/a	n/a	
2a	408	346	489	n/a	406
3d	132	n/a	n/a	n/a	85.33
3r	165	76	116	218.67	
4	198	402	250	132.66	102
4a	397	-66	366	n/a	
4c					420.67
4d					103.34
5	90	63	100	161.33	119.05
6	97	24	174	192	157.34
7a	n/a	405	479	456	
7r					108.66
8a	n/a	n/a	436	144	
9w	n/a	n/a	171	156.01	

Total Hardness (mg/l)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	198	172.5	272.5	287.5	172.5
1a	n/a	n/a	462.5	n/a	407.5
2	207	127.5	n/a	n/a	
2a	470	427.5	365	n/a	382.5
3d	78	n/a	n/a	n/a	97.5
3r	220	122.5	82.5	77.5	
4	120	102.5	137.5	102.5	137.5
4a	n/a	407.5	377.5	n/a	
4c					450
4d					122.5
5	n/a	40	117.5	205	167.5
6	n/a	57.5	87.5	152.5	77.5
7a	n/a	372.5	475	397.5	
7r					105
8a	n/a	n/a	327.5	172.5	
9w	n/a	n/a	160	172.5	

Calcium Hardness (mg/l)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	183	127.5	180	197.5	147.5
1a	n/a	n/a	412.5	n/a	322.5
2	162	77.5	n/a	n/a	
2a	375	372.5	317.5	n/a	337.5
3d	60	n/a	n/a	n/a	47.5
3r	30	37.5	42.5	55	
4	73	62.5	62.5	72.5	100
4a	n/a	367.5	290	n/a	
4c					305
4d					77.5
5	n/a	20	45	140	122.5
6	n/a	32.5	30	97.5	62.5
7a	n/a	277.5	375	297.7	
7r					77.5
8a	n/a	n/a	302.5	87.5	
9w	n/a	n/a	105	107.5	

Magnesium Hardness (mg/l)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	15	45	92.5	90	25
1a	n/a	n/a	50	n/a	85
2	45	50	n/a	n/a	
2a	95	55	47.5	n/a	45
3d	18	n/a	n/a	n/a	50
3r	190	85	40	22.5	
4	47	40	75	30	37.5
4a	n/a	40	87.5	n/a	
4c					145
4d					45
5	n/a	20	72.5	65	45
6	n/a	25	57.5	55	15
7a	n/a	95	100	99.8	
7r					27.5
8a	n/a	n/a	25	85	
9w	n/a	n/a	55	65	

Nitrate (mg/l)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	n/a	0.8	1.7	1.45	1.15
1a	n/a	n/a	0	n/a	0.15
2	n/a	1.4	n/a	n/a	
2a	n/a	0.2	0.1	n/a	0.1
3d	n/a	n/a	n/a	n/a	0.35
3r	n/a	1	0.7	0.45	
4	n/a	1.8	0.7	0.4	1.15
4a	n/a	0.2	0.2	n/a	
4c					305
4d					0.5
5	n/a	1	1.15	0.6	0.8
6	n/a	1.6	1.55	0.8	0.55
7a	n/a	0.3	0.45	0	
7r					0.7
8a	n/a	n/a	0.55	0.2	
9w	n/a	n/a	0.15	0.15	

Copper (mg/l)

Site Location	Week 1	Week 2	Week 3	Week 4	Week 5
1	n/a	0.76	0.815	0.675	0.55
1a	n/a	n/a	1.22	n/a	0.65
2	n/a	2.105	n/a	n/a	
2a	n/a	1.245	0.515	n/a	0.355
3d	n/a	n/a	n/a	n/a	0.065
3r	n/a	0.2	0.2	0.315	
4	n/a	2.76	1.505	1.02	0.715
4a	n/a	0.57	1.51	n/a	
4c					145
4d					0.095
5	n/a	0.18	0.28	0.675	0.34
6	n/a	2.05	1.74	1.605	1.275
7a	n/a	1.03	1.67	0.65	
7r					0.56
8a	n/a	n/a	1.14	0.18	
9w	n/a	n/a	0.37	0.215	

COD (mg/l)					
Site Location	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**
1	n/a	0	26	22	21.5
1a	n/a	n/a	13	n/a	0.5
2	n/a	0	n/a	n/a	
2a	n/a	0	4	n/a	0
3d	n/a	n/a	n/a	n/a	13
3r	n/a	2.5	49.5	31.5	
4	n/a	n/a	35.5	32	24.5
4a	n/a	1	2.5	n/a	
4c					305
4d					3.5
5	n/a	0	26	30	21.5
6	n/a	0	31	24	18.5
7a	n/a	0	12.5	6.5	
7r					21.5
8a	n/a	n/a	0	13.5	
9w	n/a	n/a	13	4.5	

SECTION IV

SECTION 404(b)(1)

SECTION IV

GRAND PRAIRIE AREA DEMONSTRATION PROJECT ARKANSAS

SECTION 404 (b) 1 EVALUATION REPORT

I. PROJECT DESCRIPTION

a. Location. The Grand Prairie project area is located in southeast Arkansas and includes significant portions of Prairie and Arkansas counties and small portions of Monroe and Lonoke counties. The project area is adjacent to the White River, extending generally southward from the vicinity of Interstate Highway 40 to DeWitt, Arkansas, at the southeast corner of the study area. Stuttgart, Arkansas, is the major community within the project area. The project area is shown in Plates 1 and 2 of the General Reevaluation Report. The area is comprised of various wetland types, unique upland hardwood bluffs at the north, traditional delta farmland, and historic prairie sites.

b. General Description. The primary purpose of the project is to provide supplemental agricultural water (irrigation), agricultural water conservation, and groundwater preservation. The project includes construction of a major pump station on the west bank of the White River at DeValls Bluff, Arkansas, and an elaborate water distribution system which utilizes existing channels, new canals, and pipelines to provide inter-basin transfer of surface water from the White River to the water-depleted project area. One hundred twenty weirs would be built in existing streams, and numerous other hydraulic structures (e.g., gated check structures, wasteways, culverts, siphons, turnouts) would be constructed in association with the water delivery system. Descriptions and plate drawings of the various hydraulic structures are contained in Volume 3, Appendix B, Section I - Hydraulics & Hydrology. Water conservation measures, groundwater management strategies, retrofit of existing farm irrigation systems, and new on-farm storage reservoirs are also integral parts of this project. It is important to note that this Section 404 evaluation applies only to the major import system. In order for a farmer to construct an on-farm project feature in a wetland, the farmer would have to apply for and obtain an individual Section 404(b)(1) permit.

c. Authority and Purpose. Depletion of the alluvial aquifer in eastern Arkansas, due to extensive agricultural water use, prompted the U. S. House of Representatives, Committee on Public Works and Transportation, to adopt a resolution in September 1982 authorizing the Memphis District, U. S. Army Corps of Engineers, to examine the feasibility of agricultural water supply and conservation improvements in the region. The Water Resources Development Act (WRDA) of 1996 reauthorized the Grand Prairie - Bayou Meto Project. The Grand Prairie - Bayou Meto Project was previously authorized by the Flood Control Act of 1950 and deauthorized in 1989 pursuant to Section 1001(b) of WRDA 1986.

d. General Description of Dredged and Fill Material. Earthen material would be excavated during canal, pipeline, weir, inlet channel, and pump station construction. Excavated material from canal construction would be deposited along both sides of many canal sections to form levees.

Material excavated in preparation for pump station construction and from inlet channel construction would be placed adjacent to and surrounding the pump station. Material excavated from pipeline construction would be spread back over the pipelines. Minimal excavation would be performed at each weir site in order to smooth out humps and depressions in the channel; this excavation is necessary to provide a uniform thickness of riprap. Fill for the weirs, turnouts, wasteways, siphons, check structures, and transition would consist of limestone riprap and filter gravel brought in from quarries. In addition, semi-compacted earth fill and gravel would be deposited in order to construct an access road to the pump station; and limestone riprap would be placed at the mouth of the pump station inlet channel for scour protection.

(1) Texture of Material. The excavated material would be comprised mainly of loam, silt and clay with clay being dominate in some areas. Most all of the soils of the uplands, delta, prairie, and wetland sites would be comprised of clays. Throughout the entire Grand Prairie terrace, a layer of loess covers thick deposits of clays and silty clays. About 57 percent of the area consists of level to moderately sloping, loamy soils that formed in thick beds of loess. About 43 percent consists of level, nearly level, or gently undulating, loamy and clayey soils that formed in alluvium. The soils of the area are moderate to high in nutrients. Canals and pipelines excavated through the Crowley soils at the northern portion of the project area would encounter a mixture of silt loam, silty clay, and clay. Limestone riprap and filter gravel would comprise the construction material for wasteways, weirs, turnouts, siphons, check structures, a transition, and inlet channel protection. Semi-compacted earth fill and gravel would constitute the materials deposited to construct the pump station access road.

(2) Quantity of Material. It is estimated that 314,410 tons of filter gravel and limestone riprap, 1,066 cubic yards of gabions, and 42,400 cubic yards of earth fill and gravel would be deposited in wetlands and waters of the U.S. A breakdown of the fill quantities for various project items is presented in Table 1.

Table 1

WASTEWAYS, gabions	1,066 cu yd
PUMP STATION ACCESS ROAD, earth fill & gravel	42,400 cu yd
PUMP STATION INLET CHANNEL, riprap	11,800 tons
WEIRS, riprap & filter gravel	291,730 tons
INVERTED SIPHONS, riprap & filter gravel	5,735 tons
TURNOUTS, riprap & filter gravel	4,461 tons
CHECK STRUCTURES, riprap & filter gravel	579 tons
TRANSITIONS, riprap & filter gravel	105 tons

It is estimated that approximately 15,549,880 cubic yards of earthen material would be excavated for the pumping station, the pumping station inlet channel, pipelines and canals. However, only 705,786 cubic yards of this excavated material would be placed in wetlands. A breakdown of excavation quantities is shown in Table 2.

Table 2

PUMPING STATION	105,000 cu yd
INLET CHANNEL	501,880 cu yd
CANALS and PIPELINES	14,943,000 cu yd
Total:	15,549,880 cu yd

(3) Source of Material. Earthen material would be excavated during canal, inlet channel, pump station, and pipeline construction. Riprap, gravel, and earth fill would be hauled in from nearby quarries and borrow pits. Gabions would be fabricated from wire and crushed limestone.

e. Description of Proposed Discharge Sites.

(1) Location. Excavated material would be deposited along both sides of the newly

constructed canals and graded and shaped into levees wherever topography and channel depth dictate a need for levees. Material excavated for pump station and inlet channel construction would be deposited in an area adjacent to and surrounding the pump station. Excess material from pipeline construction would be placed as cover material then spread or landscaped. Riprap and filter gravel would be placed in the bottom of channels and along banks at wasteways, weirs, inverted siphons, turnouts, check structures, a transition, and at the mouth of the pump station inlet channel. In addition, rock gabions would be used to fortify wasteways at six different sites. Earth fill and gravel would be placed in a farmed wetland in order to build an access road to the pump station.

(2) Size. The smallest areas practical would be utilized for deposition sites. Construction of the project would result in the loss of approximately 128 acres of wetlands. In addition, it is estimated that 57 acres of wetlands would be temporarily impacted by vegetative clearing; these wetlands would be allowed to regenerate following project construction. Of the 128 acres permanently lost, approximately 50 acres would be lost as a result of fill material deposition.

(3) Type of Site. Riprap and filter gravel would be placed in channel bottoms and along the banks at inverted siphons, turnouts, weirs, check structures, one transition site, and the mouth of the pumping station inlet channel. In addition, gabions would be installed for scour protection at six wasteways. Earthen material would be deposited on agricultural lands and naturally vegetated areas (e.g., bottomland hardwoods, marsh).

(4) Type of Habitat. Approximately 24 acres of bottomland hardwoods, 7 acres of forested swamp, 30 acres of scrub/shrub swamp, and 3 acres of marsh would be lost to project construction; 50% (32 acres) of these losses would be directly attributable to fill deposition. In addition, approximately 64 acres of farmed wetland would be lost as a result of the project; 18 acres of farmed wetland would be lost due to the placement of fill and excavated material.

(5) Timing and Duration of Discharge. Project construction is assumed to begin in 1999 and take about six years to complete. The canal and pipeline construction is assumed to take place from 1999 to 2005. The pumping plant would be built from 1999 to 2003.

f. Description of Disposal Method. Excavated material would be handled by dragline or excavator and augmented by conventional road construction equipment and deposited to form levees along the canals. Riprap would be deposited by dragline or excavator and dozer. Construction in "wet" areas, such as weir construction sites, may require the use of specialized equipment such as an amphibious excavator.

II. FACTUAL DETERMINATIONS.

a. Physical Substrate Determinations.

(1) Substrate Elevation and Slope. The study area lies in the alluvial plain of the Mississippi River Embayment with elevations of all the wetland sites designated for use as

disposal sites for excavated material being below elevation 200 feet NGVD which is also below the ordinary high water level of each site.

The discharge areas in the wetlands along the constructed canals would be altered with deposition. Canal levees would range in height from 2 feet to 18 feet above the existing ground surface. Once pipelines are placed, they would be covered with the excavated material; any excess material would be spread over the immediate area in order to minimize impacts to existing topography. There should not be any changes in depth, current pattern, water fluctuations, or bottom contours and substrate elevations on any wetlands outside the disposal areas.

Material excavated during pump station and inlet channel construction would be used to raise the area adjacent to and surrounding the pump station to a general elevation of 190 feet NGVD.

The placement of riprap at the inlet channel mouth, wasteways, inverted siphons, turnouts, check structures, and the transition site would not change the elevation or slope of any existing streams. Wetlands outside the deposition areas would not be altered by riprap in the channels and along the banks. Riprap weirs of varying heights would be constructed in existing streams.

(2) Sediment Type. Sediment is comprised primarily of sand, silt, loess, and various clays.

(3) Dredged and Fill Material Movement. There would be no foreseeable movement of fill or excavated material. The embankments would be seeded; and riprap would be placed in order to protect the banks and channel bottoms at wasteways, inverted siphons, turnouts, check structures, the transition site, and the inlet channel mouth. Also, nine "check structures" that would be placed in the new canals would help to prevent bottom and bank scour.

(4) Physical effects on Benthos. Where deposition of riprap takes place in existing streams, the physical destruction of the benthic community is expected. However, recolonization is expected to take place within one year. Although riprap would cover some of the existing benthic communities, it would provide future attachment and shelter sites for existing organisms and new species which would invade this new habitat.

(5) Other Effects. Slight increases in water table elevations could indirectly affect the substrate in the vicinity of new canals and receiving streams.

(6) Actions Taken to Minimize Impacts. No excavated material would be placed where it would disrupt the normal hydrologic regime. The first layers of excavated material would be covered with "cleaner" material from the deeper layers of excavation and would be planted with a grass cover to reduce erosion and possible leaching of contaminants from the

excavated material.

b. Water Circulation, Fluctuation, and Salinity Determination.

(1) Water Quality. Since water quality in the Grand Prairie is currently only fair to poor, it is not expected that project deposition would alter the existing levels. There would be increased silt loads and turbidity, and a resuspension of pesticides with excavation and deposition activities. However, these levels should decrease markedly upon completion of work. Also, there should be an overall significant improvement in water quality in the channels and receiving streams because of the periodic introduction of "fresh", relatively clear water from the White River. In addition, the newly constructed canals would not be subjected to the typical rates of sediment inflows that result from tillage up to top bank because of the levees and the vegetative barrier provided by the prairie restoration project. Further information is provided in Volume 9 Appendix C, Section III, Water Quality. Section III contains a water quality report, *EASTERN ARKANSAS GROUND WATER QUALITY ASSESSMENT,* prepared in 1997 by the Ground Water Institute of the University of Memphis. The following water quality data, assumptions, and conclusions are taken from the above report.

(a) Salinity. Not applicable.

(b) Water Chemistry. The pH ranged from 7.0 to 8.0; therefore, pH falls within the 6.5 to 9.0 range for freshwater life as stated in the EPA publication *Quality Criteria for Water* and in the Arkansas Water Quality Standards. The pH of these streams would not significantly change when surface water from the White River is introduced into the system. The deposition of excavated and riprap materials would not have any effect on pH levels wherever deposition occurs.

(c) Clarity. Initial deposition of fill material would produce a relatively short term increase in turbidity which should return to pre-construction levels of between 10 and 440 JTU. The suspended material in the White River water is greater than the local surface water of the study area; however, the suspended solids would probably settle in the initial transfer canals and storage basins.

(d) Color. No expected change.

(e) Odor. No expected change.

(f) Taste. No expected change. The ditches and bayous are not currently used as a municipal water supply, nor are they expected to be used as such.

(g) Dissolved Gas Levels. Dissolved oxygen (DO) levels were generally acceptable with a range of 5.5 to 11.0 mg/l, above the minimum acceptable level of 5.0 mg/l established by the EPA. Biochemical oxygen demand (BOD) ranged from less than 5.0 mg/l to

30 mg/l. BOD and DO levels of the system are expected to improve with the introduction of White River water. Furthermore, the presence of weirs and check dams and the pumping agitation provided would tend to oxygenate the water. Volume 9, Appendix C, Section III, provides additional information. The deposition of excavated material and riprap into wetlands would not change DO or BOD levels in the streams.

(h) Nutrients. Nitrate concentrations for the study area averaged 0.8 mg/l. No concentration limits have been specified for surface waters by either EPA or state authorities. Currently high levels of stream nutrients would not be exceeded with project deposition of riprap and excavated material at the embankments or the areas where construction would occur.

(I) Eutrophication. No expected change.

(j) Others as appropriate. Although the water temperature of the White River varies more than that of the receiving streams, temperatures would quickly equilibrate during passage through the upper distribution canals. The temperature of the diverted surface water should not exceed recommended EPA values. Water temperatures of the streams would not be affected by any type of discharge material. Moreover, water temperatures for the entire area are primarily affected by air temperature, solar radiation, and the degree of vegetative shading along the watercourses.

(2) Current Patterns and Circulation.

(a) Current Patterns and Flow. Deposition of excavated material in embankments along the new canals would not disrupt any water currents or flow in the area during normal or flood stage conditions. Operation of the pump station would have minimal effects on current patterns and stream flows at low and normal stages. Material deposited in the vicinity of the pump station would be contained within a specific area in order to prevent significant impacts to overbank flows and current patterns of the White River. Riprap would not alter flows or current patterns where it is deposited for erosion. There may be a localized reduction in flow and development of eddy currents along the riprap-water interface as the water flows over the riprap. These reductions would not have a noticeable effect on the main stream flow characteristics. Weirs would have a pooling effect on the receiving streams.

(b) Velocity. Operation of the pumping station would obviously create velocities within the new canals and receiving streams. However, overall velocities would be dissipated by the weirs and check dams. Velocity changes within the receiving streams would be within acceptable limits. Deposition of riprap and excavated material at other locations would not affect velocities of the associated streams and ditches.

(c) Stratification. No stratification would occur in the receiving streams beyond that which may normally takes place under existing conditions.

(d) Hydrologic Regime. No change in overall hydrologic structure or disruption of flow patterns is anticipated beyond those previously discussed.

(3) Normal Water Level Fluctuations. The receiving streams have been channelized and, generally, flows are extremely low during the summer months. Additional water from the White River and the pooling effect of the weirs would provide minimum summer water levels that are substantially higher that existing summer levels. Rainfall would also affect water level fluctuations. Since the pump station would operate on an "as needed" basis for irrigation; the project would generally provide water level fluctuations between minimum pools and bank full.

(4) Salinity Gradients. Not applicable.

(5) Actions Taken to Minimize Impacts. The placement of excavated material and riprap at all locations would be done during low water periods to avoid disruption of periodic water inundation patterns and reduce the amounts of erosion back into the watercourse.

c. Suspended Particulate/Turbidity Determinations.

(1) Expected changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Sites. No significant increase in suspended particulate levels or extended periods of turbidity are expected with deposition of fill material. Discharge activities would increase turbidity at those sites but return to preconstruction levels of 10 to 440 JTUs. Suspended and dissolved solid levels are typical of streams in agricultural areas, ranging from 4.0 to 420.0 mg/l for suspended solids and from 35.0 to 332.0 mg/l for dissolved solids. These levels are not hazardous to aquatic organisms. Excavated material which is placed in embankments would be deposited during drier months to reduce suspended solids and turbidity levels in the streams and wetlands. Seeding of the embankments would significantly reduce particulate runoff once the grasses become established.

(2) Effects on Chemical and Physical Properties of the Water Column.

(a) Light Penetration. Deposition of excavated material and riprap would produce a relatively ephemeral increase in turbidity during construction. This should return to near existing levels after construction.

(b) Dissolved Oxygen. Deposition of fill and excavated material into the wetlands or the waterways would not adversely impact DO levels of streams. In fact, the accumulated effects of pumping activities and turbulence at the weir and check dam sites would tend to oxygenate the water.

(c) Toxic Metals and Organics. When sediment is disturbed during project construction, the possibility exists that some of the pesticide materials may be transferred

to the water column (mobilization) either through resuspension of the sediment solids, disposal of the interstitial water, or desorption from the resuspended solids. Further information is presented in Appendix C, Section III, Water Quality.

(d) Pathogens. No increase in pathogenic levels is foreseen with project implementation.

(e) Aesthetics. Increase turbidity during deposition would have minor, short-term impacts on the aesthetic value of existing channels. Overall, the project would increase the aesthetic value of most receiving streams by maintaining minimum pools year-round.

(3) Effects on Biota.

(a) Primary Production. Submerged vegetation is mainly confined to the shoreline. A minor setback in production would take place until revegetation transpires. In places where riprap is deposited, different species would invade the new niche but at a slower rate. Deposition of earthen material would bury plant communities in 50 acres of wetlands; primary production would be transformed to drier associations of plants at these deposition sites.

(b) Suspension/Filter Feeders. Mussel populations are extremely limited in the receiving streams. However, any mussels present would be eliminated at the deposition sites; these sites should slowly recolonize after construction. Prior to construction of the pump station inlet channel, mussels would be removed from the portion of the White River within the construction impact zone and released in other areas of the river with suitable habit. Riprap deposited at the mouth of the inlet channel would provide future attachment sites for mussels.

(c) Sight Feeders. Fish would be temporarily displaced during construction of hydraulic structures within existing channels. However, fish would become reestablished in these areas following construction. Riprap would provide new habitat and slightly increase the fishery resource at those specific sites.

(4) Actions Taken to Minimize Impacts. Water current or circulation patterns would be slightly altered. Deposition of fill and excavated material would take place during periods of low flow. All pumping would be in accordance with the 1986 State Water Allocation Plan. All construction activities would comply with the *Best Management Practices for Construction Activities* (BMPs).

d. Contaminant Determinations. It is not expected that any significant amounts of contaminants would be introduced, translocated or increased by pumping activities or the discharge of gravel, riprap, and earthen material.

e. Aquatic Ecosystem and Organism Determination.

(1) Plankton Effects. Effects, if any, on plankton communities are expected to be insignificant and of short duration.

(2) Benthos Effects. The benthic community would be physically removed where deposition takes place in water and excluded from the 50 acres of wetlands used for disposal. The arthropod community should reestablish itself in the streams to near existing numbers after a year. The deposition of riprap would physically cover the existing benthos in the existing streams and ditches; but, over the life of the project, riprap would provide attachments and sheltered sites for new species. This should lead to a slight increase in diversity and numbers within the immediate riprap areas. Shellfish populations would take a good while to repopulate the deposition sites. However, no significant adverse effects should occur on adjacent shellfish populations.

(3) Nekton Effects. Deposition activities in the watercourses would disrupt feeding and spawning habits of free-swimming organisms, but recolonization of the disrupted areas would take place in a short time. Riprapped sections of stream bank should attract a slightly greater number of organisms due to the additional structure.

(4) Aquatic Food Web Effects. Destruction of the primary plant and animal producers would occur at deposition sites in the stream channels. Thus, construction would initially affect the flow of energy from primary producers to the higher aquatic trophic levels. Disposal in the 50 acres of wetlands would also destroy aquatic wildlife edge habitat, food chains, and communities there. Temporary losses would be somewhat offset in the streams with the riprap areas providing new niches for different species. Finally, vegetative cover on the embankments and prairie establishment on canal levees would provide beneficial habitat and increase food chains and community structures for associated upland species.

(5) Special Aquatic Sites Effects.

(a) Sanctuaries and Refuges. Deposition should not have significant effects on aquatic resources within Wattensaw Wildlife Management Area, White River National Wildlife Refuge, or Cache River National Wildlife Refuge.

(b) Wetlands. Approximately 32 acres of bottomland hardwoods, forested swamp, shrub/scrub swamp, and marsh would be lost within the project area as a direct result of earthen material deposition. This represents 0.1% of the naturally vegetated wetlands (28,387 acres) within the project area. Also, approximately 18 acres of farmed wetland would be lost to the deposition of fill and excavated material. Earthen material deposition would raise the substrate elevation, resulting in the establishment of plant species adapted to dryer site conditions. The loss of these wetlands would be offset by land acquisition and subsequent wetlands restoration.

(c) Mud Flats. Not applicable.

(d) Vegetated shallows. Not applicable.

(e) Riffle Pool Complexes. The flatness and the alluvial composition of the land precludes the formation of riffle-pool areas. Hence, there would not be any adverse change in hydrologic movement with project implementation and deposition. No permanent adverse change in hydrologic movement would be expected with riprap deposition and pumping activities. The current would create a small riffling effect at the rock-water interface which would be conducive for new benthic invertebrate species.

(6) Threatened and Endangered Species. One endangered mussel species, pink mucket pearly mussel (*Lampsilis abrupta*), is known to inhabit the study area reach of the White River; and one endangered fish species, pallid sturgeon (*Scaphirhynchus albus*), could potentially occur within the White River. The bald eagle (*Haliaeetus leucocephalus*) is a threatened species that utilizes the study area. The project should have no adverse impacts on these species.

(7) Other Wildlife. Weir construction would affect small areas that are used for foraging, breeding, and spawning. Discharge activities would temporarily inhibit movement of animals in the affected channels and in the wetland areas adjacent to them. These areas would be reinvaded and return to near existing population levels. The 50 wetland disposal acres would be altered for use by wetland and aquatic species, but much of this acreage would provide habitat for upland fauna. It is not expected that there would be any long-term adverse impacts on either resident or transient mammals, birds, fish, reptiles, or amphibians.

(8) Actions Taken to Minimize Impacts. Project construction would coincide with low water flows. Riprap and other fill material would be selectively placed so as to minimize aquatic community disruption. Clearing limits for pipeline construction would be limited in width to 25 feet.

f. Proposed Disposal Site Determinations.

(1) Mixing Zone Determination. The smallest practical dispersal zone would be used for deposition in the streams as well as the smallest practicable tonnage of riprap. Actual calculations of the mixing zones in the receiving streams could not be made for several reasons. First, there are no gage records for normal low flows during the construction season. Second, no data are available for initial suspended sediment concentrations. Third, the specific gravity of the soil particles is not known.

(2) Determination of Compliance with Applicable Water Quality Standards. Water quality standards are discussed in further detail in Volume 9, Appendix C, Section III. The pesticides and heavy metals in introduced surface waters of the White River would not degrade the water quality of the receiving streams. Strict adherence and compliance with State of

Arkansas water quality criteria would be maintained.

(3) Potential Effects on Human Use Characteristics.

(a) Municipal and Private Water Supply. Not applicable.

(b) Recreational and Commercial Fisheries. No commercial fishing takes place in the tributary streams. Recreational fishing is minimal due to intermittent and sporadic flow in most area streams. While fish would leave the immediate vicinity during project construction, no significant impacts would be expected to occur to fisheries as a result of deposition of riprap and excavated material. Fishery habitat would actually improve in the receiving streams because of weirs and introduced flows.

(c) Water Related Recreation. Fill and excavated material would not be placed in or near recreational areas; therefore, deposition would not hinder any recreational activities. Small game and big game hunting would eventually increase due to the acquisition and reforestation of mitigation lands.

(d) Aesthetics. The deposition on 50 acres of wetlands would temporarily reduce the natural aesthetic values of the project area until the levees are revegetated with prairie grasses and vegetation regenerates on pipeline construction sites. Also, increased turbidity would decrease the aesthetic value of the water during construction and maintenance activities.

(e) Parks, National Historic Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves. The deposition of fill and excavated material would not have significant impacts on Wattensaw State Wildlife Management Area, White River National Wildlife Refuge, or Cache River National Wildlife Refuge.

g. Determination of Cumulative Effects on the Aquatic Ecosystem. The disposal of fill material into waters of the United States should have no adverse cumulative impacts on the aquatic ecosystem.

h. Determination of Secondary Effects on the Aquatic Ecosystem. No adverse secondary impacts to the aquatic ecosystem should occur as a result of depositing fill material into waters of the United States.

FINDING OF COMPLIANCE
FOR
GRAND PRAIRIE AREA DEMONSTRATION PROJECT
ARKANSAS

1. No significant adaptations of the guidelines were made relative to this evaluation.

2. Alternative disposal sites for excavated material were not evaluated because most excavated material must be used for levee construction immediately adjacent to the new canals. However, excess dredged material not needed for levee construction would be hauled to alternative sites. Riprap fill material would be needed for weirs, inverted siphons, turnouts, check structures, a transition, and scour protection at the mouth of the pump station inlet channel; no alternative sites are practicable.

3. The planned disposal of gravel, riprap, and earthen material would not violate any applicable state water quality standards with the possible exception of turbidity. All other standards would be maintained during and following the placement of fill and riprap material. Water quality analyses in 1996 for project canals revealed that construction and operation of the import system would be in full compliance of Section 307 of the Clean Water Act.

4. The use of the selected disposal sites would not harm any threatened or endangered species or their critical habitats.

5. The proposed disposal of fill and excavated material would not result in significant adverse effects on human health and welfare.

a. No disposal sites, fill sites or embankments would be located near municipal water supply intakes. None of the existing streams are used for municipal or private water supply.

b. Commercial fishing is non-existent in the receiving streams. Sportfishing in most of these streams is very limited and should improve with project construction and operation.

c. No significant impact is foreseen on plankton communities.

d. Spawning and nursery areas for fish would be increased due to the new canals, check dams, and weirs.

e. Shellfish are scarce in the receiving streams, and no significant impacts are anticipated.

f. Aquatic wildlife edge habitat, food chains, and community structure would be altered in wetland disposal sites. The drier land that would become available following deposition would provide beneficial habitat and increase food chains and community structure for those associated upland species. Riprap areas would create additional habitat for various benthic

macroinvertebrates.

g. There are no special aquatic sites within the project area that may be adversely impacted.

6. The life stages of aquatic life and other wildlife dependent on the aquatic ecosystem would be affected. Discharge activities would eliminate movement in relation to feeding, spawning, breeding, and nursery areas of animals that utilize the existing channel embankment edge habitats. Discharge activities would temporarily inhibit movements of animals in the affected channels and in the wetland areas adjacent to the channels. However, many species of wildlife would be able to use newly created upland sites. Fishery habitat would improve as a result of introduced flows, new aquatic acreage, check dams, and weirs. Riprapped areas would also provide new niches for aquatic invertebrates.

7. There would be no adverse impacts on recreational and economic values with deposition of fill and excavated material into wetlands. The establishment of grasses on embankments and revegetation of pipeline rights-of-way would offset degradation of aesthetic values.

8. Appropriate steps to minimize potential impacts of the discharge on aquatic ecosystems include the placement of fill and excavated material during periods of low flow and low rainfall, and the seeding of the embankments to retard erosion.

9. The proposed deposition of fill and excavated material complies with the Section 404(b)(1) guidelines.

SECTION V

FISHERIES

EFFECTS OF GRAND PRAIRIE IRRIGATION PROJECT ON FISHES OF THE WHITE RIVER AND TRIBUTARIES

K. Jack Killgore, Jan Jeffrey Hoover, James P. Kirk, and Larry G. Sanders

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
Vicksburg, Mississippi 39180-6199

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PREFACE

Gains and losses in fish habitat resulting from the East Arkansas Region Comprehensive Study, Grand Prairie Demonstration Project are described. This project proposes to pump water from the White River at DeValls Bluff, Arkansas to a series of canals and streams in the Grand Prairie terrace of the Mississippi Alluvial Plain for crop irrigation and waterfowl management. It will be the largest irrigation project in the state of Arkansas. This report is an appendix to an Environmental Impact Statement for the Grand Prairie Project being prepared by the US Army Engineer District, Memphis (CEMVM).

The following individuals at the U.S. Army Engineer Waterways Experiment Station (CEWES) assisted with field work: Steven Reid Adams, Eric David Dibble, Steven Gordon George, Sherry Lynn Harrel, James Morrow, Catherine Murphy, and Tracy Robinson. Field assistance and identification of juvenile and adult fishes were provided by Dr. Neil Harrison Douglas, Northeast Louisiana University; Mr. Bob Wallus identified larval fishes. Voucher specimens of fish were deposited at the Northeast Louisiana University Museum of Zoology. Mr. Andy Gaines, CELMM, furnished project specifications and hydraulic data for baseline and alternative conditions. Mr. Edward Lambert was project biologist for CEMVM. Mr. Steve Filipek, Arkansas Game and Fish Commission, and Mr. Curtis Nelms, United States Fish and Wildlife Service, provided technical comments on study design. Ms. Lori Walton, White River Irrigation District, assisted in site selection and access to Delta streams.

During the conduct of this study Dr. John Harrison, was Director, Environmental Laboratory, Dr. Conrad J. Kirby was Chief, Ecological Research Division, and Dr. Edwin A. Theriot were Chief, Aquatic Ecology Branch at CEWES.

Commander and Director of CEWES during publication of this report was COL Bruce K. Howard, CE, and the Technical Director was Dr. Robert W. Whalin.

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ABSTRACT

We evaluated fishery-related effects of a proposed pumping station that will divert water from the White River at DeValls Bluff, Arkansas to a series of streams and canals in the Grand Prairie terrace. Potential entrainment of ichthyoplankton (eggs and larvae) at pump intake was determined from larval fish samples collected spring, summer, and early fall. A total of 6,179 individuals representing at least 30 species of larval fish were collected; dominant families were minnows (Cyprinidae), suckers (Catostomidae), and shad (Clupeidae). Total number of larvae (all taxa) potentially entrained ranged from 1.1 to 14.1 percent depending on pumping alternative and month. Entrainment potential was greatest in summer due to high densities of native cyprinids and low flows in the channel. Sucker larvae were most vulnerable to entrainment in April and May; and for shad May through June.

Effects of pump-induced stage reductions on connectivity of 16 oxbow lakes located between RM 123 near De Valls Bluff to RM 59 were evaluated during August 1996. Controlling elevation, which is the elevation that the lake inlet is connected to the White River relative to the stage at Clarendon gaging station, indicated none of the lakes will be effected from pump-induced stage reductions based on median monthly stage.

Juvenile and adult fishes were collected from the White River (channel) and receiving streams/canals (tributaries) to determine representative fish species sensitive to changes in physical habitat, identify physical parameters that best explain variation in fishes, and quantify potential impacts using multivariate regression models as specified in the Habitat Evaluation Procedure. Sixty-three species of fish collected were dominated taxonomically by minnows (16 species), sunfishes (15 species), and darters (8 species). Forty-seven species were observed in the channel, 34 in the tributaries. Qualitative similarity between channel and tributary fish communities was low; only 19 species were observed in both communities. Fish community indices and abundance of 5 numerically dominant species suggested that discharge structured channel fish assemblages, and geomorphology structured tributary fish assemblages.

In the White River, pump-induced reductions in HU's ranged from 0-2500 HU's /month but were consistently less than 3% for any alternative. There were no effects in January, February, November, and December. The greatest reduction occurred in April and May for all alternatives (1.9-2.4%). These results indicate that even with a maximum stage reduction of 1-ft during peak pumping, impacts on littoral fishes in the White River will be minimal. Gain in HU's for the receiving streams and existing canals totaled 4,328/month. The project will also create approximately 184 miles of new canals resulting in 8,560 additional HU's per month.

INTRODUCTION

The alluvial aquifer in Eastern Arkansas is being depleted by agricultural irrigation and commercial withdrawal. Alternative sources of water are being evaluated by the U.S. Army Engineer District, Memphis (CELMM). CELMM proposes a pumping station that will deliver water from the White River at DeValls Bluff, AR, to a system of canals, streams, and pipelines in the surrounding farmland that lies within the Grand Prairie terrace. Four pumping capacities (alternatives) are being considered: 1480, 1640, 1800, and 1960 cfs. Engineering requirements include a canal (2000 ft in length, 104 ft bottom width, 28 ft maximum depth) constructed on the west bank of the White River. The canal will divert water from the river to a pumping station where water will be pumped from the bottom of the canal to the outlet channel of the receiving streams.

Effects of water withdrawal from the White River and replenishment of streams in the delta on fish and riverine habitat were evaluated from field studies conducted during 1996. A primary concern was larval fish entrainment at pump intake. Water velocities in the diversion canal will range from 0 ft/sec during floods to approximately 1 ft/sec during lower river stages. Thus, ichthyoplankton drifting along the west bank of the White River could be diverted to the canal and towards the pump intake. Stage reductions in the White River during pumping was also a concern. A maximum 1-ft stage reduction in the White River will also occur periodically during peak pumping; this may reduce littoral habitat quality and prevent fish access to contiguous oxbow lakes.

Objectives were to evaluate: (1) potential entrainment of ichthyoplankton (eggs and larvae) at pump intake, (2) isolation of oxbow lakes contiguous with the White River due to reduced stage elevations during pumping, (3) reduction in littoral fish habitat in the White River at reduced discharge, and (4) changes in fish habitat of receiving streams and canals in the Grand Prairie.

DESCRIPTION OF STUDY AREA

The White River has the largest drainage area (17,143 square miles) of any river basin in Arkansas, arising in Northwestern Arkansas and flowing into the Mississippi River (Robison and Buchannan 1986). Our study area included the lower White River from Interstate 40 Bridge (RM 126.5) to St. Charles, Arkansas (RM 57), and Grand Prairie region in southeast Arkansas. The I-40 bridge corresponded to the upstream boundary of pump-induced stage reductions. White River stages below St. Charles are controlled primarily from Mississippi River backwater and would not be affected by pumping.

Under the authority of the Rivers and Harbor Act of 1960, a 125-ft wide channel is maintained in the lower White River to provide commercial barge navigation. Minimum channel depth is 8-ft when stages at the Clarendon gage is 12-ft or higher; 5-ft depth at stages less than 12-ft. Dominant substrate is sand or clay and most instream structure consists of fallen trees along the shoreline. Channel morphology is a characteristic bendway-run (straight stretch) sequence; point sandbars form at each bendway. Water velocities can exceed 4 ft/sec. Flooding typically occurs from late February through May and connects numerous oxbow lakes to the river. Average annual discharge at Clarendon, AR for the period 1940-1986 is 30,389 cfs but ranged from 2,827 to 275,366 cfs..

The tributary study area includes the Grand Prairie region, bordered on the east by the White River Delta, and lies within four counties in southeast Arkansas: Prairie, Arkansas, Monroe, and Lonoke. Cultivation of the prairie began around 1900 (Irving et al. 1980) and currently consists of approximately 238,000 acres of croplands. Crops include rice, soybeans, and to a lesser extent, corn and milo. Numerous streams, canals, and pipelines form an integrated irrigation system. There are approximately 1000 acres of riverine (streams, canals, ditches) habitat, 17,000 acres of impoundments, and 30,000 acres of wetlands that are primarily bottomland hardwoods and swamps. LaGrue Bayou, a tributary of the White River, is the largest stream; smaller streams are tributaries to LaGrue Bayou, White River, or Red River (Mill and

Stuggart King Bayou). All streams have been channelized to increase discharge capacity and numerous fixed-crest weirs are located throughout the delta; weirs provide low-water pools and prevent establishment of trees in the channel. Two large weirs occur in the lower reach of LaGrue Bayou; stop logs are used to manage water levels. These weirs prevent upstream movement of fish. Peckerwood Lake, constructed as a water supply reservoir, occurs in the northern section of the Grand Prairie and is the largest waterbody in the tributary study area.

METHODS

Larval fish

Larval fish entrainment was evaluated from diel samples collected semi-monthly or monthly from Mar-Oct 96 in the White River near DeValls Bluff. Two sites were sampled (Figure 1):

a. River channel immediately upstream of the RR bridge and adjacent to the proposed entrance canal where water will be diverted to the pump. These data were used to estimate entrainable fish
b. Inlet to Horseshoe Lake. This site represents a typical inlet permanently connected to the White River. However, there are no natural inlets that represent the relatively deep (28 feet maximum depth), flowing (1 ft/sec maximum velocity) channel of the proposed entrance canal; Horseshoe Inlet is shallower (<15ft) and often non-flowing. These data were used to describe ichthyofauna of natural inlets but were not used to estimate entrainable fishes.

Paired "bongo" nets (0.75-m diameter, 4.5-m long, 505-μm mesh) were used to actively sample the White River channel. Net samples were of 5-min duration fished from a stationary boat. Collections were stratified vertically (surface, mid-column, and bottom) and horizontally (both shores and mid-channel) to assess different densities of larvae relative to the entire cross-sectional assemblage; a total of 18 net-samples were collected each sampling period. A General Oceanics Model 2035-B flow meter was mounted in the mouth of each net to measure velocity of water passing through the net. Meter readings and duration of sampling were converted to an estimate of water volume filtered for each sample. Samples were fixed and preserved in 5% buffered formalin. In the laboratory, fishes were identified to the lowest practical taxon and enumerated. Catch was expressed as density (e.g., number of larval fishes/100 m^3 of water filtered) and used to describe temporal patterns in occurrence and relative abundance.

Plexiglas light traps (Killgore 1994) were fished along the western shoreline of the White River to determine fish taxa occurring at the entrance of the proposed diversion canal that were not collected with bongo nets. A 12-hour Cyalume yellow chemical light stick was used as a light source for attracting fishes. Five floating traps were set 1-2 hours before dark and retrieved the following morning; sampling duration was approximately 14 hours per set.

Horseshoe Inlet was usually too shallow to sample with bongo nets, so fishes were collected with a standard 0.5-m diameter, 505-μm mesh ichthyoplankton net and with light traps. A single ichthyoplankton net attached to a 2.5-m-long steel handle was mounted to the side of a 18-ft boat approximately 1 m behind the bow. The net was submersed immediately below the water surface and pushed slowly upstream in mid-channel; duration of a net sample was 5.0 minutes. A General Oceanics Model 2035-B flow meter was mounted in the mouth of the ichthyoplankton net to monitor flow/volume. Light traps were set along the western shore of the inlet and fished the same as described for the White River channel. Six net and five light trap samples were collected each sampling period.

Spatial and temporal patterns of net and light trap catches were analyzed using a Model I (fixed effects) two-way analysis of variance (ANOVA). Prior to ANOVA, net and light trap data were transformed to $\log_{10} + 1$ values because means were not normally distributed (Shapiro-Wilk statistic, $P<0.01$). Main effects were sampling period (day versus night) and habitat (river versus inlet). Catches for nets and light traps were number of larvae per m^3 and number of larvae per night, respectively. Following significant ANOVA results, the Student-Newman-Keuls multiple range test was used to compare means among individual sampling periods and habitats. All data summaries and analyses were performed using Statistical Analysis System (SAS, Inc. 1989).

Contiguous Oxbow Lakes

Potential effects of pump-induced stage reductions on connectivity of oxbow lakes were evaluated during August 1996. Based on topographic maps, onsite inspection, and

recommendations from the Arkansas Game and Fish Commission, controlling elevation of 16 lakes were measured (Figure 2). Controlling elevation is the elevation that the lake inlet is connected to the White River relative to the stage at Clarendon gaging station. Access by fish was assumed to occur when river stage exceeds the controlling elevation of the inlet. Fourteen lakes were adjacent to the White River, from RM 123 near De Vall's Bluff to RM 59 just north of St. Charles, and 2 lakes were adjacent to the mouth of the Cache River.

A Topcon® ATF-C level was used to survey the bottom elevation of the shallowest portion of the inlet and the water surface elevation of the White River near each inlet. A stadia rod or boat mounted depth finder was used to locate the shallowest portion of inundated inlets. In addition, the water surface elevation of the White River was measured at the Clarendon gage and related to a benchmark located on the railroad bridge. This provided an exact relationship between field-measured elevations and stage height at the gage.

Discharge at Clarendon for baseline and post-project (pumping alternatives) conditions were obtained for the period 1940-1986. Baseline discharge was the range of measured values; post-project discharge incorporated pump-induced stage reductions according to projected water demand requirements, and maintenance of minimum flows identified in the Arkansas State Water Plan (Arkansas Soil and Water Conservation Commission 1988; Douglas et al. 1990). Median and 75% exceedance values (low water) were compared to controlling elevations of each lake by month. Months that lakes were connected were compared for baseline and each pumping alternative.

Fishes of the White River and Tributaries

Juvenile and adult fishes were collected from the White River (channel) and receiving streams/canals in the Grand Prairie region and used to: 1) determine representative fish species sensitive to changes in physical habitat, 2) identify physical parameters that best explain variation in fish diversity and abundance, and 3) quantify potential impacts using multivariate regression

models as specified in the Habitat Evaluation Procedure (USFWS 1980). Seventeen collections were made bi-monthly from March-October 1996 at five stations in the White River representing river bendways and straight stretches (Figure 1); 6 collections were also made in Horseshoe Inlet but these data were not used in HEP. Tributary stations were located in 22 streams and were sampled during late August to early October 1996 when effects of water diversion will be most pronounced (Figure 3). A total of 26 samples (most streams represented by a single station) were made. In addition, samples were collected immediately upstream and downstream of three weirs; these samples were analyzed separately from non-weir stations and not used in HEP.

Field Techniques

Physical habitat was described at each station using water quality, geomorphic, and hydraulic parameters. Temperature, conductivity, dissolved oxygen and pH were measured approximately 0.5 feet below water surface with a Hydrolab Model H20 multi-parameter water quality probe. Turbidity was recorded with a Hach 2100P turbidimeter. A cross-sectional transect was established at each station. Channel width was measured using a Lietz rangefinder. Depth and velocity were measured at 10 approximately equi-distant points along the transect. Depths greater than 20 ft were measured to the nearest 1 ft using a boat-mounted Hummingbird depth finder; depths 6-20 feet were measured to the nearest 0.1 ft using a surveyor's stadia rod; depths < 6 ft were measured to the nearest 0.1 ft using a Marsh-McBirney wading rod. Water velocity was measured with a Marsh-McBirney Flo-Mate Model 2000 velocity meter. For water depths < 3 ft, velocity was recorded at 60% of the depth from water surface; for water depth > 3 ft, velocity was averaged between two points 20% and 80% of the depth from water surface.

Fishes were collected using a 3.0 X 2.4 m seine of 5 mm mesh. Ten seine hauls were stratified among all apparent macrohabitats. Most large fishes were released. Voucher specimens and all small fishes were preserved in 10% formalin. In the laboratory, fishes were washed, sorted, counted, and identified. Taxonomy was consistent with that of Douglas (1974) and Robison and Buchanan (1988); nomenclature was consistent with Robins et al. (1991). Fishes

were deposited in collections of the Museum of Zoology, Northeast Louisiana University and the Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station.

Analytical techniques

Fishes were quantified as catch-per-unit-effort: i.e., number collected in 10 seine hauls at a single station. Some analyses (e.g., community similarity, distribution of species abundance) were performed on combined data for main channel assemblages and combined data for tributary assemblages; other analyses (diversity measures, multiple regression) were performed with data obtained for individual collections.

Similarity of channel and tributary communities was expressed using a qualitative and a quantitative coefficient. Jaccard's index, provides numerical expression of taxonomic similarity based on presence-absence of species (Jaccard 1908). It is calculated as

$$J = \frac{C}{A + B - C}$$

in which

C = number of taxa co-occurring in two species lists, a and b
(e.g., channel and tributaries)

A = total number of taxa occurring in species list a (e.g., channel)

B = total number of taxa occurring in species list b (e.g., tributaries)

J ranges from 0.00 (no taxa in common) to 1.00 (all taxa shared) and directly expresses the percentage of taxa shared between two collections. This index satisfies all logical conditions required of a binary (presence-absence) index of association (or similarity), although it exhibits slight curvilinear response to changes in species number (Hubalek 1982). It is sensitive, however, unbiased at small sample sizes, and interpreted unambiguously (Ludwig and Reynolds 1988).

Percent Similarity index provides numerical expression of compositional similarity based

on relative abundance of species (Linton et al., 1981). It is calculated as

$$PS = \sum_{i=1}^{S} \min(p_i a, p_i b)$$

in which

S = total number of taxa occurring in two lists
(e.g., channel and tributaries)

$p_i a$ = proportion of species i occurring in one list (e.g., channel)

$p_i b$ = proportion of species i occurring in another list (e.g., tributaries)

PS ranges from 0.00 (< 1% of individuals belong to species co-occurring in same relative abundance in both lists) to 1.00 (> 99% of individuals belong to species co-occurring in same relative abundance in both lists). It provides accurate representation of "real" similarity over a range 7-90% (Linton et al. 1981). Variants of this formula (e.g., Sorenson's Quantitative Index, Bray-Curtis Percent Similarity Index) are commonly used (Magurran 1988, Ludwig and Reynolds 1988); values, however, are influenced by disparities in total (absolute) abundances between the two sets of species abundance data (pers. obs.). Since catch rates are influenced by physical habitats, we used the formula that does not directly incorporate total numbers of individuals caught. Both the Jaccard Index and Percent Similarity are frequently used in community ecology studies.

Fish community structure for channel and tributaries was graphically represented as "dominance-diversity" curves: percentage comprised by each species (log scale) plotted against rank of that species based on its abundance (e.g., Sheldon 1987). Most ecological communities, especially those consisting of moderate to large numbers of species, approximate a log-normal distribution, presumably a reflection of the Central Limit Theorem of statistics (Magurran 1988). Thus, our curve was tested for departure from log-normal distribution of species-abundance by comparing number of species observed for series of progressively doubling ranges (octaves) of fish abundance (0-1, 1-2, 2-4, 4-8, 8-16, 16-32, 32-64 individuals, etc.) with that predicted by a

empirically-based log-normal model using chi-square (x^2) analysis (Ludwig and Reynolds 1988). In a series of iterations, two variables, S_o (modal number of species) and a (inverse measure of dispersion around that mode), were independently adjusted, so that model may better fit data, indicated by lower values for chi-square statistic. When chi-square is minimized or when model is judged to adequately fit data, a and S_o, may be used to estimate theoretical (total) number of species (S*) in that system, including those too rare to be observed, with this equation:

$$S^* = 1.77(S_o/a).$$

Collective diversity of channel and tributary fish communities was quantified as "species richness" using rarefaction (Hurlbert 1971; Ludwig and Reynolds 1988). Technique compensates for different fish abundances among communities and, for any sample of specified size, quantifies total number of species expected. This allows species richness for an equally-sized subsample to be compared between communities.

We chose to model fish-habitat relationships by using measures of fish diversity as dependent (response) variables. This offers several advantages over traditional approaches to impact/benefit assessment: i) obviates the necessity of selecting evaluation species; ii) represents habitat for majority of species in community; iii) provides dependent variable associated with community functions (e.g., stability, food web complexity, etc.). Diversity measures are frequently sensitive to environmental disturbances (Magurran 1988) and are positively correlated with habitat quality (Gorman and Karr 1978; Foltz 1982) and water quality (Barbour and Brown 1974; Jackson and Harvey 1989; Keller and Crisman 1990).

Multiple measures of diversity were calculated for individual fish collections to determine which measure provided best description of diversity-habitat relationships: species richness, heterogeneity, or evenness. Because numerous indices exist for each of these measures, we chose formulae that were discriminant, relatively unbiased, and satisfied logical and mathematical criteria specified in comparative studies of related indices (Ludwig and Reynolds 1988; Magurran 1988; and citations therein).

Species richness, S, is number of species obtained from a uniform sampling effort (10 seine hauls). Shannon's heterogeneity function incorporates two functions of diversity: species richness and evenness (equitability of relative abundance among species). Several variants of this index exist, based on choice of log-functions. We used a common variant based on natural log:

$$H' = -\sum_{i=1}^{S} (p_i \ln p_i)$$

Values of H' can range from near-zero (domination by a single species) to lnS (all species equally abundant). In most natural communities, H' ranges from 1.50 - 4.50 (citations in Magurran 1988); values for stream fish collections made using our field methodology typically range from 0.50-3.00 (pers.obs.).

Equitability of relative abundance, or evenness, was calculated separately as:

$$E = \frac{H'}{\ln S}$$

or the ratio of observed Shannon functions to maximum possible value given that number of species; E ranges from near-zero (domination by a single species) to 1.00 (when all species are equally abundant).

Relationships between fish diversity and physical habitat were determined by correlating site-specific measures of fish diversity with habitat measurements. Those factors exhibiting high or significant correlations are presumed to influence the occurrence (richness) and/or abundance (evenness) of the greatest number of fish species, while those with low or nonsignificant correlations are presumed to influence fewer kinds or less abundant fish.

We used a stepwise linear regression procedure, MAXR (SAS 1989), to identify groups of habitat variables significantly correlated with fish diversity and with abundance of individual species. Independent variables used in analysis were temperature, conductivity, pH, turbidity, stream width, mean depth, mean velocity, and discharge. Discharge for main channel was

determined from stage-discharge relationships at the Clarendon gage; discharge for tributaries was calculated by multiplying cross-sectional stream area times mean channel velocity. Dissolved oxygen was not used as a variable because of extreme diel variation and because values exceeded 100% saturation at some stations where dense growths of blue-green algae occurred. Dependent variables were diversity measures (richness, heterogeneity, evenness) so three models were generated for each community.

Hydraulic, geomorphic, and fish abundance data were $\log_{10}$ transformed because: i) physical characteristics of stream channels are interrelated as power functions (Meffe and Sheldon 1988); ii) numbers of fishes varied by 2-3 orders of magnitude. Diversity measures were not transformed because they are logarithmic functions. Transformed data provided homogeneity of variance and normal distributions of individual variables and improved linear relationships among variables. Such transformations also legitimize statistical tests of significance and reduce bias generated by outliers (Meffe and Sheldon 1988). Models were considered statistically significant if $p < 0.05$. During iterations, variables that increased $r^2 > 5\%$ and for which individual probability values were < 0.05 were retained in the model. A maximum of three independent variables was included in each model. Final model for each community was that with highest r^2 and lowest p values.

Habitat Evaluation Procedure

Effects of pumping water from the White River to the Grand Prairie were quantified using the Habitat Evaluation Procedure. Habitat Suitability Index values were determined from previously described multiple regression models (USFWS 1980) and used to calculate Habitat Units for pre- and post-project conditions. Generic form of this equation is:

$$\text{Community Index} = b + m_1(\text{Habitat parameter 1}) + m_2(\text{Habitat parameter 2})...$$

in which b (y-intercept) and m (slope) are constants calculated from linear relationships between

dependent and independent variables. Model output is standardized to a 0-1 scale using the following relationship:

$$HSI = \frac{\text{Predicted Value of Community Index}}{\text{Maximum Value of Community Index}}$$

in which 0 indicates no habitat value, and 1.0 indicates optimal habitat. This index was used as a Habitat Suitability Index (HSI) to rate habitat quality for pre- and post-project conditions. Maximum value for the community index was estimated from field collections and zoogeographic patterns of species abundance. HSI values were multiplied by area (i.e., acre-feet) to obtain Habitat Units (HU) according to the following equation:

$$HU = \text{Habitat Suitability Index} \times \text{Area}$$

RESULTS AND DISCUSSION

Temporal and Spatial Abundance of Larval Fish

We collected a total of 6,179 larval fish: 2,521 fish in 522 net samples, 3,658 fish in 107 light traps (Table 1). Nets collected more larval fish than light traps in the White river channel, but light traps collected a greater number of fish in Horseshoe Inlet. Nets were more effective in collecting individuals in the families Clupeidae (shad), Catostomidae (suckers), and Sciaenidae (freshwater drum), indicating that species in these families occurred in the pelagic drift rather than along the shoreline where light traps were set. Except for silvery minnow, light traps were more effective in collecting individuals in the family Cyprinidae (minnows/shiners), suggesting that these species were shoreline inhabitants rather than pelagic forms, especially in the main channel.

The dominant families in both river and inlet were Cyprinidae and Catostomidae, comprising at least 7 and 5 species, respectively, and accounting for approximately 90% of the total number of fish collected. The families Clupeidae and Sciaenidae were common in the river, but not the inlet. The family Centrarchidae was comprised of at least 5 species, but abundance was low. Other families were uncommon, with any given family comprising less than 1% of the total individuals in either river or inlet.

Total number of confirmed species collected between the two gears was 30: 28 in the river, 22 in the inlet. However, nets collected more taxa than light traps. Taxa collected only by nets were paddlefish (river only), gar, mooneye, common carp, silvery minnow, white sucker (river only), catfish, white bass (river only), flier (river only), black crappie, sauger (river only), and freshwater drum. Taxa collected only by light traps and only in the inlet were stoneroller and brook silverside; harlequin darter was collected only in the river.

Specimens in the family Cyprinidae that could not be identified to species made up nearly 50% of the total catch. Approximately 20% of the total catch was comprised of carpsuckers and

buffalo. Blacktail shiner was the next most abundant species, with 13% of the total catch consisting of this fish. Other common species included bullhead minnow, gizzard shad, silvery minnow, and emerald shiner, each comprising 1-5% of the total catch. Species composition of larval fishes in the White River is typical of the lower (Gallagher and Conner 1980; Finger and Stewart 1987, Baker et al. 1991) and upper (Holland and Sylvester 1983) Mississippi River systems. Unusual was the low numbers of sunfishes, particularly in Horseshoe inlet which is a backwater habitat often predominated by larval sunfishes (Dewey and Jennings 1992; Turner et al. 1994).

There were significant differences in mean bongo net catch of all individuals in the White River among the eleven sampling dates ($F=34.1$; $df=10$; $p<0.0001$), but not for diel samples ($p=0.21$) or for the interaction of sampling date and time of day ($p=0.67$). No larval fish were collected in the channel during March or October. There were no significant ($P<0.05$) differences in vertical catch (i.e., surface, mid-depth, bottom) during any sampling date. However, catch was significantly higher along the right bank (looking upstream) or mid-channel on May 22. Deeper water in mid-channel ($\bar{x}$ = 21.0 ft.) and right bank ($\bar{x}$ = 23.3 ft.), compared to the left bank ($\bar{x}$ = 17.5), may have partly contributed to higher catches. Mean water velocities, however, were similar across the channel (2.3 - 2.7 ft/sec).

Suckers were the most abundant group collected in the channel (Table 2). Larval suckers were present in the collections from early May through mid-July, but catch was highest ($p<0.05$) in May. Prolonged spawning period was probably due to cyclic appearance of different species. Light traps indicated that suckers were also relatively abundant along the shoreline in late May, but minnows predominated during summer (Table 2). Shad larvae, and to a lesser extent drum larvae, were present in relatively low numbers from late spring through mid-summer. Drum were also collected in low numbers from May-July. Other taxa were absent or rare during the study.

Temporal trends in appearance and peak abundance of larval fish in Horseshoe Inlet was similar to that of the channel for net and light trap catches (Table 2). However, densities were 2-3

times higher in the Inlet. The highest mean net catch measured during the study (76.6 larvae/100 m^3) was in the inlet during late May; suckers, shad, and minnows predominated. The highest light trap catch (382 fish/night) occurred mid-September and was comprised totally of larval minnows; only juveniles and adults were collected in October. The only group of larval fishes collected with light traps in March were darters. Drum larvae comprised most of the light trap catches on June 26, albeit at comparably low numbers.

Collectively, fishes spawn throughout most of the year, principally during spring and summer when water temperatures range from 15-25°C. Spawning among co-occurring species is staggered so that reproduction by different species is temporally or spatially segregated. Early spawners include darters, suckers, and black basses (Micropterus spp.); late spawners include catfishes, sunfishes and minnows. Early spawners generally have a punctuated spawning strategy with larvae appearing for only short time, whereas larvae of late spawners often occur for prolonged periods. This type of spawning chronology was observed in the White River. Darter and sucker larvae were collected in spring for short periods, while minnows were collected spring and summer, reaching their peak abundance late summer. Overall, the spawning period of fishes in the White River during 1996 began late March and ended in October.

Adult spawning and subsequent appearance of larval fish are associated with flooding (Finger and Stewart 1987; Copp and Cellot 1988; Killgore and Baker 1996; Hoover et al. 1995), water temperature (Hontela and Stacy 1990; Wallus et al. 1990), and photoperiod (Sumpter 1990). Rising waters need to coincide with rising temperatures and lengthening daylight to be of maximum benefit to fishes, as this is the period of gonadal maturation. In the White River, the appearance of early spawners corresponded to spring floods and rising water temperature (Figure 4). Abundance decreased in June as water temperature rose above 25 °C and channel discharge declined. Low flows reduce habitat volume, may be associated with high temperatures and low dissolved oxygen, concentrates prey species that leads to higher predation (Kushlan 1974, Carlson and Duever 1977), and eventually cause shifts in habitat use and relative abundance within the channel (Schlosser 1991) including downstream movements of fish (Harvey 1987; Ross

et al. 1985). In the White River, fish abundance declined substantially on July 18 when water temperature was highest and discharge was lowest. However, fish abundance subsequently increased as discharge increased and temperature decreased until the spawning season had ended.

Potential Entrainment of Larval Fish

The Grand Prairie Project will divert water from the river into an entrance canal, approximately 2000-ft long and 104-ft wide, located off the left (west) bank of the river at DeValls Bluff. Velocities in the canal will range from approximately 0.2 ft/sec when river stage is near top bank, to 1 ft/sec at lower stages (pers. com., Andy Gaines, LMM). Therefore, larval fish drifting in the water column along the left bank of the White River can potentially be drawn towards the pump intake. Sustained swimming speed of larvae is three to seven body lengths per second (Webb 1975). In our study, the median length of larvae was approximately 10 mm which converts to a maximum sustained swimming speed of 0.23 ft/sec. This suggests that areas with water velocities greater than 0.2 ft/sec will have fish larvae being passively transported by ambient currents (*sensu* Scheidegger and Bain 1995), which will include the entrance canal during most months.

Entrainment is the number of larval fish drawn through the meshes of the debris screens and into the intake of the pumps. Mesh size of the debris screens will be 3-4 inches and water velocities at pump intakes located near the bottom of the canal will range from 5-6 ft/sec (pers. Com., Andy Gaines, LMM). Thus, demersal larvae in the entrance canal have the potential of passing through the debris screens and will not have sufficient swimming capability to avoid entrainment. Entrained larvae will be subjected to physical forces, including mechanical abrasion in the pump and piping, abrupt pressure changes, and turbulence (Schubel and Marcy 1978), and those larvae that survive will be displaced from a large river system to a series of small canals and channelized streams in the Grand Prairie. Consequently, we assume that any larvae entrained will suffer immediate mortality or eventually die in the receiving canals and streams.

Bongo net samples collected in the White River at DeValls Bluff were used to quantify numbers of larval fish potentially entrained. Since the entrance canal will be located on the left (west) bank and water will be pumped from the bottom, we assumed that demersal larvae collected along the west bank were most susceptible to entrainment. Percent number of larvae potentially entrained was determined by comparing total number of larvae in a river cross-section with total number of larvae in pumped water by month and pumping alternative. Total number of larvae in a river cross-section was calculated by multiplying mean number of larvae in eight of the nine bongo net samples (number/cfs) taken each sampling period times mean base discharge. Mean base discharge was calculated from gage readings at Clarendon taken from 1940-1986. Total number of larvae in pumped water was calculated by multiplying mean number of larvae in bongo net samples taken on the bottom of the river along the west bank times the amount of water pumped.

Total number of larvae (all taxa) potentially entrained ranged from 1.1 to 14.1 percent depending on pumping alternative and month (Table 3). Entrainment potential increased at higher pumping capacities, but only by 1- 3 percent. Entrainment potential was greatest in summer due to high densities of native cyprinids (Figure 5). Sucker larvae were most vulnerable to entrainment in April and May; May through June for shad. Values were relatively low for these taxa, however, because of disproportionally high numbers in the river cross-section.

Larval fish density (number/100 m^3) in the White River was considerably less than in Horseshoe Inlet (see below). Statistical comparisons of mean density between the two stations were significantly different ($p<0.05$, SNK comparison of means) for all taxa and individual families.

	White River (N=396)		Horseshoe Inlet (N=126)	
TAXA	Mean	SE	Mean	SE
All Taxa	3.4	0.4	18.5	3.2
Catostomidae	2.4	0.3	7.0	1.7
Clupeidae	0.5	0.1	3.9	1.0
Cyprinidae	0.2	0.1	7.1	1.8

These results have two implications. First, loss of larvae from the river, particularly cyprinids, is minor compared to total numbers that exist cumulatively in inlets and other backwaters of the White River. If densities measured in Horseshoe Inlet were used in impact assessment, percent entrainment would be virtually undetectable. Conversely, the entrance canal will be a sluggish, contiguous backwater as natural inlets so larval fish densities in the canal may be considerably higher than currently estimated. However, there are also several morphometric differences between the proposed canal and natural inlets that create uncertainty in predicted larval fish abundance. Steep banks and deep water (28-ft maximum) in the canal will be unlike any natural inlet in the White River, particularly during summer when water demand is high and channel flows are low. Horseshoe Lake was the deepest inlet surveyed during the study, but maximum depth was only 14 feet measured on June 5. Surface and bottom (14 ft) net samples were collected in the Inlet on this date; no fish were collected on the bottom. Ichthyoplankton monitoring of the canal may be necessary to resolve uncertainties of impact prediction.

Contiguous Oxbow Lakes

Oxbow lakes are former river channels. They can be permanently connected, seasonally contiguous, or permanently isolated from the main river, but retain water year-round. The shoreline is typically wooded and brush is abundant in the water near shore and ends of the lake. Oxbow lakes comprise nearly 10% of the non-channel aquatic habitat (during low water) of the lower Mississippi River Drainage (Baker et al. 1991). In many respects (e.g., stratification, large surface area, permanence), these lakes are more typical of deep isolated lakes than floodplain habitats. Nevertheless, those connected to main river channels either continuously or during floods could function as important fish nursery areas (Beecher et al. 1977) and feeding areas for riverine fishes such as paddlefish (Stockard 1907). Consequently, connectivity of backwater habitats to rivers is an important aspect in river management (Amoros 1991).

Connectivity of oxbow lakes to the White River was based on the controlling elevation in the inlet. All of the 16 lakes surveyed are connected to the White River either seasonally or

permanently (Table 4). Other lakes may be periodically connected to the White River, but they did not have obvious inlets. Many of the these had a maze of small (<2 ft wide) intermittent channels that could potentially run for miles. We assumed that fish moving between the White River and lake require relatively short, deep inlets, particularly large river fishes that use permanent, floodplain waterbodies as feeding and nursery areas (e.g., paddlefish, buffalo).

Eight of the 16 lakes are permanently connected at median monthly discharge with or without pumping; results were the same for all pumping alternatives. Big Weidmann Lake is connected to the White River approximately 9% of the year based on median monthly discharge. Cooks Lake, Round Lake, First Old River, Round Pond, Simpson Lake, Old River Lake and Little Weidmann are connected with the White River seasonally. The Arkansas State Water Plan (ASWP) will prohibit pumping at low flows (75% exceedance value) so connectivity of lakes will not be effected during summer and fall months (Figure 6).

A possible exception is a group of four lakes above RM 95 that have controlling discharges between 10,000 and 11,000 cfs (Table 4). During summer low flows, pumping may isolate these lakes before minimum flows in the river are reached. However, isolation will be temporary because controlling elevation of these lakes are extremely close to the minimum flows established by the Arkansas State Water Plan (10,670 and 9,650 cfs for July and August, respectively). These predictions were based on 1960 cfs pump alternative, but results were similar for other pumping capacities. Natural variability in the hydrograph will also confound predictions of connectivity and minimum depth suitable for fish passage (e.g., 1-2 feet). For example, the mean and standard deviation of discharges during July and August using the 1960 pumping alternative were 20,059 ± 12,187 and 17,043 ± 9,249, respectively. These variances are considerably higher than 1,000 cfs, which during time of low flows, is the amount of water that determines connectivity and prohibition on pumping in the four lakes. Consequently, once discharge approaches the 75% exceedance value, differences between the Arkansas State Water Plan minimums and post project flows should be monitored to insure that state minimums are maintained and suitable depths exist for fish passage.

Fishes of the White River and Tributaries

Species Composition

Fifty-seven species of fish were collected (Table 5). Fishes were dominated taxonomically by minnows (16 species), sunfishes (15 species), and darters (8 species). Forty-three species were observed in the channel, 33 in the tributaries. Qualitative similarity between channel and tributary fish communities was low; only 19 species were observed in both communities (J = 0.32). These were dominated by sunfishes (9 species). Likewise, quantitative similarity was low. Fewer than 15% of fishes co-occurred in the same relative abundance in channel and tributaries (PS=0.13). Quantitative similarity resulted primarily from abundances of gizzard shad > 9% in both communities, and from 5 relatively rare sunfishes (< 2% in either community).

Six species collected in the White River as larvae were not obtained as juveniles or adults: paddlefish, common carp, white sucker, spotted sucker, harlequin darter, and sauger (Table 1). None were collected in large numbers (< 1% of total individuals) and only the common carp is likely to occur in tributaries. Subsequent analysis are based on species counts from seining only but we note here that total number of fish species collected during this study was 63, 47 of which occurred in the channel, 34 in the tributaries.

Dominance-diversity curves for both communities approximate log-normal distributions, but species were more equitable in abundance in the channel than in the tributaries (Figure 7). In the channel, 6 species comprised 71% of all individuals, but the most abundant species, Mississippi silvery minnow (17%) was not disparately greater in abundance than emerald shiner, river carpsucker, gizzard shad, bullhead minnow, or blacktail shiner (16-9%) (Table 5). Progressively lower ranked species showed a gradual decline in relative abundance and a large number of species were rare (represented by 1-2 individuals). A log-normal model (a=0.100, S_o=5.1, X^2 = 3.87, 9 d.f.) represented the high dispersion across ranges of abundance and approximated observed number of species in the modal range of abundance (Figure 8). In the

tributaries, however, 4 species comprised 84% of individuals, and western mosquitofish (46%) was disparately more abundant than green sunfish, bluegill, and gizzard shad (19-9%). Progressively lower ranked species exhibited steep declines in relative abundance and fewer rare species were observed. A log-normal model (a=0.132, S_o=3.8, x^2=7.28, 12 d.f.) represented the lower degree of dispersion across ranges of abundance, but underestimated number of species in the modal range of abundance (Figure 8). Estimates of total number of species in each community, based on area under the log-normal curve and extrapolation beyond rarest range of abundance is 90 species in the channel, 51 species in the tributaries.

Rarefaction curves indicated that differences in species richness between channel and tributary fish communities was maximized (9 species) at sample sizes greater than 350 (Figure 9). Higher species richness of the channel, however, was apparent at much smaller sample sizes and was consistent over all sample sizes (n_{min} = 10, n_{max} = 3100).

Measures of diversity for individual collections were also higher for channel community than for tributaries. Means (s.d.) were:

Measure	Channel	Tributary
Species richness, S	11.18 (4.96)	8.54 (3.25)
Heterogeneity, H'	1.54 (0.52)	1.19 (0.46)
Evenness, E	0.65 (0.12)	0.57 (0.18)

Fish-Habitat Relationships

In the channel, species richness and heterogeneity were both positively correlated with water temperature and discharge (Table 6). Water temperature and discharge, however, were not significantly correlated with each other (r = 0.28, p = 0.27), so that as temperature or discharge increased, species richness and heterogeneity of the fish community increased. Evenness, however, was correlated with a separate water quality variable, conductivity. Therefore, correlation of heterogeneity with temperature and discharge was determined primarily by the

species richness component of that measure. Consequently, correlation between H' and temperature and discharge was lower. Model for species richness, then, was the selected as the best representation of diversity-habitat relationships in the channel.

In the tributaries, all measures of diversity were positively correlated with stream width (Table 6). Species richness was significantly correlated with width. Evenness, however, was more strongly correlated with pH than with width. As a result, heterogeneity was positively correlated with width and pH, and provided the best model.

Abundance of 5 numerically dominant species reflected patterns suggested by the fish diversity models, i.e., that discharge structured channel fish assemblages, and geomorphology structured tributary fish assemblages (Table 6). In the channel, only abundance of bullhead minnow (9 % of fishes) was positively correlated with discharge; abundance of emerald shiner, gizzard shad, and blacktail shiner (collectively 35% of fishes) decreased at higher discharges. In the tributaries, abundance of western mosquitofish (47% of fishes) was positively correlated with pH, negatively correlated with stream width. Green sunfish abundance (19%) was not significantly correlated with any habitat parameter, but a negative (albeit nonsignificant) relationship between fish abundance and stream width was suggested. Bluegill, golden shiner, and gizzard shad (collectively 22% of fishes) were significantly more abundant in deeper or wider streams.

Influence of weirs in Tributaries

Six tributary stations were at impoundments (3 weirs and a berm). Inclusion with other tributary stations had negligible influence on species-abundance relationships (Table 5, Figure 8) and diversity-habitat trends (Table 6). Bivariate plots of fish diversity and physical parameters, however, indicated that they were outliers, and removal improved diversity-habitat models (i.e., increase in r^2 from 0.34 to 0.57). This suggested that reaches influenced by impoundments function differently from other reaches. Physical and faunal data from four stations downstream

from weirs and berms illustrate this (Table 7).

Diversity of tributary fishes was positively correlated with stream width (Table 6) except near impoundments (Table 7). Lack of such a trend at impoundments suggests that those fishes may be responding differently to physical habitat and that other habitat variables may influence fish communities. Western mosquitofish and green sunfish were more abundant in narrow tributary reaches, gizzard shad in wide reaches (Table 6), and these patterns were evident at weirs (Table 7). Golden shiner and bluegill, however, were more abundant in deeper water of tributaries (Table 6), but around weirs were abundant only in very shallow water (Table 7). Weirs also provided habitat for fishes that were rare or sporadic in occurrence. White bass and spotted sunfish were found only around weirs, and golden topminnow and bantam sunfish were substantially more abundant at weirs than in other reaches. It is not possible to develop a statistically valid model for weirs without additional sampling, but we believe that water quality may be important determinants of fish diversity. Diversity (i.e., heterogeneity) at the six impounded stations sampled was positively correlated with turbidity ($r = 0.87$, $p = 0.023$), and a regression model for fish diversity based on all tributary stations (including weirs) indicated that diversity was positively correlated with conductivity ($r = 0.35$, $p = 0.046$).

Weirs and small dams are usually made of concrete and placed in a river or tributary to raise upstream water levels or maintain minimum pool elevations. These structures can prevent upstream and downstream movement of fishes. The ability to make migratory spawning runs is crucial to the maintenance of some fish populations (Schnick et al. 1981). However, dominant taxa of fishes in the tributaries (see Table 5) are not large, migratory species, but rather small habitat generalists that exhibit only localized movement. Absence of migratory species in tributaries is likely due to small steam size and presence of two dams in lower LaGrue Bayou that prevent upstream movement. Localized movement of fishes inhabiting the tributaries may not be totally prevented, however; predicted maximum water depths are 1-4 feet over the crest elevation of proposed weirs.

Management Implications

The White River drainage is the most distinctive of any drainage in the Western Mississippi Basin (Cross et al., 1988). Ichthyofauna consists of 150 native species, and 11 endemic forms (undescribed species, subspecies, or populations). Faunal diversity is attributable to geographic position of the drainage. It transverses highland and coastal plains, deriving a mixture of prairie and Ozarkian fishes, and it is proximate to speciose southeastern drainages. Many of the fishes in the White River have restricted or disjunct geographic distributions, occur in small upland creeks, or are large, rare, infrequently collected riverine fishes. Based on our species-abundance distributions, the sporadic occurrence of some species (e.g., river carpsucker), and the restricted range of habitats sampled for each community, estimates of 51 species in the tributaries and 90 species in the main channel are credible.

In the White River, temperature and discharge structure channel fish diversity and abundance of several numerically dominant species, geomorphology and pH structure tributary fish diversity and the abundance of a single numerically dominant fish. These observations are compatible with those of zoogeographers and macro-ecologists working in the Western Mississippi Basin. Low qualitative similarity (< 0.50) in faunal composition is frequently observed for proximate or adjacent systems, and is attributed to differences in variability in flow, temperature extremes, turbidity, and habitat diversity (Cross et al., 1988). Distribution of individual fish species in the state of Arkansas are correlated with temperature, turbidity, substrate, and local geology (Matthews et al., 1988).

Distribution of species guilds in Arkansas is also correlated with water quality gradients (Matthews et al., 1992). Big river species, such as emerald shiner and gizzard shad, occur in waters of high conductivity, low pH; delta and coastal plain species occur at intermediate conductivities and pH, and include tributary species such as mosquitofish and green sunfish, and channel species such as silvery and bullhead minnows. Coastal plain and upland border fishes, such as blacktail shiner and western sand darter, occur in waters of low conductivity, high pH.

Diversity, then, of regional faunas (as well as communities within a drainage) results from a complex of climate (i.e., temperature), drainage constraints (i.e., discharge), geomorphology (i.e., width) and water quality (i.e., pH).

Anthropogenic disturbance may also influence differences in species composition and diversity between channel and tributary communities primarily by reducing relative abundance of "intolerant" species, and enhancing relative abundance of "tolerant" species (Fausch et al. 1990; Jester et al. 1992). Habitat alterations threatening fishes in this region include impoundment and excessive consumption of water from irrigation (Cross et al. 1986). Channel and tributary communities respectively include 7 and 9 species considered intolerant of degraded water quality or habitat (Table 8). These species however comprise 18% of all fishes collected in the channel, but only 2% of tributary fishes. Conversely, channel and tributary communities respectively include 10 and 7 species considered tolerant of degraded water quality or habitat. They comprise 32% of channel fishes and 83% of tributary fishes. Tolerance classifications are not assigned based on preferences for specific habitats (Jester et al. 1992). Low ratio of intolerant to tolerant fishes, and possibly lower diversity, of tributary streams of the White River probably reflect some effect of environmental degradation due to intensive agriculture.

Effects of Pumping on Fishes of the White River and Delta Streams

White River

Regression analysis resulted in a significant model with the dependent variable, species richness (i.e., number of species), positively correlated to discharge and water temperature:

$$\text{Species Richness} = 0.542(\text{Temperature}) + 0.00039\ (\text{Mean Discharge}) - 7.431$$

$$r^2 = 0.85,\ p=0.0001,\ n=17.$$

Predicted species richness was divided by maximum observed species richness (i.e., 20 species) to obtain a HSI value. Water temperatures used in the model were values measured in the field during 1996; no change in water temperature was anticipated so these values were the same for baseline and post project. Baseline mean monthly discharge was calculated from daily measurements recorded at the Clarendon gage from 1940-1996. Post-project discharge incorporated pump-induced stage reductions according to projected water demand requirements, and maintenance of minimum flows identified in the Arkansas State Water Plan. Although discharge was used as the independent variable in the model, it was significantly correlated with surface area (Pearson correlation coefficient=0.74, p=0.0008) and wetted perimeter (Pearson correlation coefficient=0.73, p=0.0009). Wetted perimeter is the cross-sectional length of the stream bed in contact with the water. Thus, discharge regulates other morphometric variables sensitive to stage reductions.

HSI was calculated by month for baseline and post-project and multiplied by area to obtain Habitat Units (HU). Area was expressed as mean monthly acre-feet of water using baseline and post-project discharge based on measurements recorded at the Clarendon gage from 1940-1996. Pump-induced reductions in HU's were less than 3% for any alternative (Table 9). There were no effects in January, February, November, and December. The greatest reduction occurred in April and May for all alternatives (1.9-2.4%). These results indicate that even with a maximum stage reduction of 1-ft during peak pumping, impacts on littoral fishes in the White River will be minimal.

Tributaries

Regression analysis of data collected in the tributaries resulted in a significant model with the dependent variable, heterogeneity (species diversity), positively correlated with width:

$$\text{Species Diversity} = 1.20(\text{width}) - 0.26$$

$$r^2 = 0.42,\ p=0.0003,\ n=26.$$

Discharge-related variables, including width, were all log-transformed. HSI was the ratio between predicted and maximum observed (2.0) species diversity. Pre-project widths were determined from our field data; post-project widths, including proposed new canals, were provided by LMM. Post-project conditions, however, were assumed to remain the same for each pumping alternative and for each month. Gain in HU's for the receiving streams and existing canals totaled 4,328/month (Table 10). Individual streams having the greatest gain included Little LaGrue Bayou, LaGrue Bayou, Mill Bayou, Honey Creek, Clearpoint Creek, and Elm Prong Mill. The project will also create approximately 184 miles of new canals resulting in 8560 additional HU's per month (Table 11). At least eight of the 33 proposed canals will exceed 100 ft in top width, conditions that should be suitable for rapid colonization and dispersal of resident fishes.

All tributary streams have been channelized, and during the summer, usually encounter extreme low flows. Consequently, additional water will increase wetted area and should improve habitat quality for fishes as indicated by gains in HU's. However, fauna of the tributaries are dominated by tolerant species and similarity to the parent fauna of the White River is low. Thus, mitigating loss in HU's in the White River using gains in HU's of the Grand Prairie should not be viewed as in-kind mitigation.

Threatened or Endangered Species

Arkansas does not list any fish species as endangered or threatened, but 48 species are listed as "inventory elements" which are equivalent to species of special concern (Schmidt, 1996). We collected three of these species: paddlefish, taillight shiner, and western sand darter. There are 13 other species known to occur in the White River drainage (exclusive of subterranean forms) that are also listed (Cross et al., 1988; Schmidt, 1996).

Paddlefish have been identified as a species of concern, particularly related to effects of peak discharge on spawning. Paddlefish are sensitive to changes in water levels, spawning when water levels are rapidly rising (Russell 1986). At DeValls Bluff, we collected one larval

paddlefish (total length=15mm) in a surface-towed bongo net at night on April 8; discharge was 34,200 cfs and water temperature was 19.8°C. Early growth of paddlefish is rapid, averaging 0.7 mm TL/day (Wallus et al. 1990). This suggests that the larvae was spawned around mid-March. Therefore, effects of pumping on either entrainment of larvae (due to low densities) or reduction of peak discharge that may delay spawning are not anticipated since pump-induced water level changes are minimal during early spring (see Figure 6).

The pallid sturgeon, *Scaphirhynchus albus*, is listed as endangered under the Endangered Species Act of 1973, and since it's distribution overlaps that of shovelnose sturgeon, pallid sturgeon may occur in the White River (see Robison and Buchanan 1986). However, pallid sturgeon rarely occur anywhere but main channels of highly turbid rivers so it is not anticipated that slight reductions in water surface elevations will affect main channel inhabitants such as pallid sturgeon.

Conclusions

1. Entrainment potential of larval fish occurs April -August. However, percent number entrained is relatively low compared to the total number in the river cross-section. Species in the Family Cyprinidae (minnows/shiners) will experience the highest loss, but this taxa is considerably more abundant in backwaters. Uncertainty in larval fish distribution in the proposed entrance canal results in speculation on actual numbers entrained.

2. Oxbow lakes that are presently connected to the White River will not be effected by pump-induced stage reductions during median discharges. There may be short-term effects on four lakes when discharge in the White River is at or above the 75% exceedance flow during July and August, but natural variability in the hydrograph confounds prediction of impacts at low flows.

3. Stage reductions in the White River will have minimal effect on littoral fishes; reductions in HU's were less than 3% for any alternative. HU's increased in the Grand Prairie region because of additional water in tributaries and canals.

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Table 1. Comparison of taxa and total numbers of larval fishes collected by ichthyoplankton net and light traps in the White River at DeValls Bluff and Horseshoe Lake Inlet from March-October, 1996. An asterisk indicates probable species.

Scientific Name	Common Name	Net		Light Traps		Total
		River	Inlet	River	Inlet	
Polyodontidae						
Polyodon spathula	Paddlefish	1	0	0	0	1
Lepisosteidae						
Lepisosteus oculatus	Spotted gar	1	0	0	0	1
L.osseus	Longnose gar	1	0	0	0	1
Clupeidae						
Dorosoma cepedianum	Gizzard shad	105	272	1	0	378
Dorosoma petenense	Threadfin shad	4	6	0	1	11
Unidentified Clupeidae	-	25	45	0	0	70
Hiodontidae						
Hiodon tergisus	Mooneye	4	1	0	0	5
Cyprinidae						
*Campostoma anomalum**	Stoneroller	0	0	0	1	1
Cyprinella venusta	Blacktail shiner	0	3	104	677	784
Cyprinus carpio	Common carp	6	3	0	0	9
*Hybognathus nuchalis**	MS Silvery minnow	1	64	0	0	65
Macrhybopsis aestevalis	Speckled chub	6	0	0	1	7
Macrhybopsis sp.	Chubs	5	1	0	4	10
Notropis atherinoides	Emerald shiner	1	25	8	30	64
Notropis sp.	Minnows/shiners	1	15	330	1385	1731
*Pimephales vigilax**	Bullhead minnow	0	126	3	210	339
Unidentified Cyprinidae	-	31	353	351	420	1155
Catostomidae						
Carpiodes carpio	River carpsucker	128	138	17	0	283
Carpiodes sp.	Carpsuckers	157	92	0	0	249
Catostomus commersoni	White sucker	4	0	0	0	4
Catostomus/Moxostoma	Sucker/Redhorse	26	1	0	0	27
Ictiobus sp.	Buffalo	132	159	7	4	302
Ictiobus/Carpiodes	Buffalo/Carpsuckers	229	127	0	0	356
Minytrema melanops	Spotted sucker	2	5	0	3	10
Moxostoma sp.	Redhorse	4	1	8	44	57
Unidentified Catostomidae	-	72	1	0	0	73
Ictaluridae						
Ictalurus sp.	Catfish	3	0	0	0	3
Atherinidae						
Labidesthes sicculus	Brook silverside	0	0	0	1	1
Unidentified Atherinidae	Silverside	0	0	1	2	3
Percichthyidae						
Morone chrysops	White bass	1	0	0	0	1
Morone sp.	Temperate bass	0	2	0	0	2
Centrarchidae						
Centrarchus macropterus	Flier	1	0	0	0	1
Lepomis sp.	Sunfish	0	16	1	19	36
Micropterus sp.	Black bass	0	0	0	3	3
Pomoxis annularis	White crappie	1	0	0	1	2
P. nigromaculatus	Black crappie	1	0	0	0	1
Pomoxis sp.	Crappie	8	1	0	0	9
Percidae						
Etheostoma histrio	Harlequin darter	4	0	1	0	5
Percina sp.	Darter	1	5	0	18	24
Stizostedion canadense	Sauger	2	0	0	0	2
Sciaenidae						
Aplodinotus grunniens	Freshwater drum	37	14	0	0	51
Unidentified Larvae	-	43	1	0	2	46
Sample Size		396	126	53	54	-
Total Number of Individuals		1043	1478	832	2826	6179
Number of Confirmed Species		24	18	10	14	30

Table 2. Mean ± SE net (number/100 m³) and light trap (number/night) catches of larval fish from the White River at DeValls Bluff and Horseshoe Inlet, 1996. No larval fish were collected on March 6 and October 30; these dates were not included in the table. Means identified with an asterisk along a row are significantly different ($P < 0.05$) using the Student-Neuman-Keuls (SNK) multiple comparison test.

Location/Taxa	Mar 27	Apr 17	May 8	May 22	Jun 5	Jun 26	Jul 18	Aug 5	Sep 12
White River-Net (n=36/Date)									
All Species	0.0	0.5 ± 0.1	14.3 ± 2.7*	16.4 ± 1.8*	2.6 ± 0.7	2.2 ± 0.7	1.1 ± 0.3	0.3 ± 0.2	0.1 ± 0.1
Clupeidae	0.0	0.0	0.7 ± 0.3	2.1 ± 0.4*	2.3 ± 0.7*	0.1 ± 0.1	0.0	0.0	0.0
Cyprinidae	0.0	0.0	0.3 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	0.7 ± 0.5	0.5 ± 0.2	0.3 ± 0.1	0.1 ± 0.1
Catostomidae	0.0	0.4 ± 0.1	12.7 ± 2.4*	12.3 ± 1.5*	0.1 ± 0.1	0.7 ± 0.2	0.2 ± 0.1	0.0	0.0
White River-LT (n=5/Date[1])									
All Species	0.0	0.0	0.0	9.2 ± 6.1	5.2 ± 1.9	22.6 ± 11.8	0.0	5.2 ± 5.2	124.2 ± 66.9*
Clupeidae	0.0	0.0	0.0	0.2 ± 0.2	0.0	0.0	0.0	0.0	0.0
Cyprinidae	0.0	0.0	0.0	2.4 ± 1.5	5.2 ± 1.9	22.2 ± 11.6	0.0	5.2 ± 5.2	124.2 ± 66.9*
Catostomidae	0.0	0.0	0.0	6.4 ± 4.2	0.0	0.0	0.0	0.0	0.0
Horseshoe Inlet-Net (n=12/Date[2])									
All Species[3]	0.0	0.0	49.4 ± 6.8*	76.6 ± 15.6*	8.7 ± 2.9	56.8 ± 14.1*	0.2 ± 0.2	0.6 ± 0.5	2.5 ± 1.9
Clupeidae	0.0	0.0	14.4 ± 4.9*	23.8 ± 5.6*	2.0 ± 0.6	0.6 ± 0.2	0.0	0.0	0.0
Cyprinidae	0.0	0.0	0.1 ± 0.1	16.1 ± 3.6	6.1 ± 2.8	49.3 ± 12.6*	0.2 ± 0.2	0.5 ± 0.3	2.3 ± 1.9
Catostomidae	0.0	0.0	34.5 ± 6.8*	35.1 ± 11.6*	0.0	3.9 ± 1.9	0.0	0.0	0.0
Horseshoe Inlet-LT (n=5/Date[2])									
All Species	3.4 ± 1.3	0.0	11.8 ± 9.4	2.4 ± 1.0	9.4 ± 5.8	3.6 ± 1.3	24.0 ± 7.9	130.4 ± 53.1	382.6 ±200.0*
Clupeidae	0.0	0.0	0.0	0.2 ± 0.2	0.0	0.0	0.0	0.0	0.0
Cyprinidae	0.0	0.0	0.2 ± 0.25	0.4 ± 0.2	8.2 ± 5.6	0.6 ± 0.6	24.0 ± 7.9	129.6 ± 52.5	382.6 ±200.0*
Catostomidae	0.0	0.0	11.5 ± 9.2*	1.0 ± 0.8	0.0	0.0	0.0	0.0	0.0

[1] Sample size was n=4 and n=3 in inlet and river, respectively on May 8.
[2] No net samples were collected at night on July 18 due to low water, n=6.
[3] Night catches were significantly higher than day catches on May 22 and June 26.

Table 3. Percent number of larval fish potentially entrained by month and pumping alternative in the White River at DeValls Bluff, Arkansas - Grand Prairie Demonstration Project.

Month	Mean No. in River (No/cfs)[1]	Mean Base Discharge (cfs)	Total No. in River X-section per second	Mean No. in Pumped Water[2] (No/cfs)	Amount of Water Pumped (cfs)	Total No. in Water Pumped per second	Percent No. of Larval Fish Entrained[3]
				1480 cfs			
JAN	0.00000	34060.53	0.00	0.00000	11.13	0.00	0
FEB	0.00000	37576.24	0.00	0.00000	11.48	0.00	0
MAR	0.00000	44478.40	0.00	0.00000	618.50	0.00	0
APR	0.15536	52379.98	8137.96	0.35663	956.09	340.97	4.0
MAY	5.67079	47838.00	271279.07	3.33326	915.19	3050.57	1.1
JUN	0.66383	31827.56	21128.03	2.38696	858.51	2049.24	8.8
JUL	0.33898	21629.68	7331.94	0.76976	1227.03	944.52	11.4
AUG	0.09887	18424.52	1821.60	0.15536	1188.43	184.64	9.2
SEP	0.04590	15392.80	706.58	0.00000	631.48	0.00	0
OCT	0.00000	13081.17	0.00	0.00000	126.34	0.00	0
NOV	0.00000	17604.57	0.00	0.00000	18.88	0.00	0
DEC	0.00000	30878.68	0.00	0.00000	0.97	0.00	0
				1640 cfs			
JAN	0.00000	34060.53	0.00	0.00000	11.13	0.00	0
FEB	0.00000	37576.24	0.00	0.00000	11.48	0.00	0
MAR	0.00000	44478.40	0.00	0.00000	684.85	0.00	0
APR	0.15536	52379.98	8137.96	0.35663	1058.30	377.42	4.4
MAY	5.67079	47838.00	271279.07	3.33326	993.24	3310.74	1.2
JUN	0.66383	31827.56	21128.03	2.38696	937.01	2236.60	9.6
JUL	0.33898	21629.68	7331.94	0.76976	1350.61	1039.64	12.4
AUG	0.09887	18424.52	1821.60	0.15536	1252.18	194.54	9.6
SEP	0.04590	15392.80	706.58	0.00000	609.33	0.00	0
OCT	0.00000	13081.17	0.00	0.00000	110.26	0.00	0
NOV	0.00000	17604.57	0.00	0.00000	18.87	0.00	0
DEC	0.00000	30878.68	0.00	0.00000	0.97	0.00	0
				1800 cfs			
JAN	0.00000	34060.53	0.00	0.00000	11.13	0.00	0
FEB	0.00000	37576.24	0.00	0.00000	11.48	0.00	0
MAR	0.00000	44478.40	0.00	0.00000	687.72	0.00	0
APR	0.15536	52379.98	8137.96	0.35663	1160.15	413.74	4.8
MAY	5.67079	47838.00	271279.07	3.33326	1066.12	3553.68	1.3
JUN	0.66383	31827.56	21128.03	2.38696	998.72	2383.90	10.1
JUL	0.33898	21629.68	7331.94	0.76976	1464.30	1127.16	13.3
AUG	0.09887	18424.52	1821.60	0.15536	1314.96	204.30	10.1
SEP	0.04590	15392.80	706.58	0.00000	588.36	0.00	0
OCT	0.00000	13081.17	0.00	0.00000	95.79	0.00	0
NOV	0.00000	17604.57	0.00	0.00000	18.86	0.00	0
DEC	0.00000	30878.68	0.00	0.00000	0.97	0.00	0
				1960 cfs			
JAN	0.00000	34060.53	0.00	0.00000	11.18	0.00	0
FEB	0.00000	37576.24	0.00	0.00000	11.52	0.00	0
MAR	0.00000	44478.40	0.00	0.00000	816.51	0.00	0
APR	0.15536	52379.98	8137.96	0.35663	1261.68	449.95	5.3
MAY	5.67079	47838.00	271279.07	3.33326	1087.06	3623.47	1.3
JUN	0.66383	31827.56	21128.03	2.38696	1034.34	2468.91	10.5
JUL	0.33898	21629.68	7331.94	0.76976	1570.42	1208.84	14.1
AUG	0.09887	18424.52	1821.60	0.15536	1381.60	214.65	10.5
SEP	0.04590	15392.80	706.58	0.00000	555.51	0.00	0
OCT	0.00000	13081.17	0.00	0.00000	92.00	0.00	0
NOV	0.00000	17604.57	0.00	0.00000	18.85	0.00	0
DEC	0.00000	30878.68	0.00	0.00000	0.97	0.00	0

[1] Mean number does not include bongo net samples collected on bottom along left bank
[2] Mean number represents bongo net samples collected on bottom along left bank
[3] Percent loss= [(Total in cross section + Total in Pumped Water)/Total in Pumped Water] * 100

Table 4. Controlling elevation (stage/discharge of connection with river) relative to the Clarendon gage of selected oxbow lakes on the floodplain of the White River, Arkansas. Different pumping alternatives (1480 - 1960 cfs pumps) had no effect on number of months that lakes were connected to river.

Name of Oxbow	River Mile	GPS Coordinates	Controlling Stage and Discharge		Months not Connected at Median Monthly Stage
			Feet	CFS	
HORSESHOE LAKE	123	34.48.3612 91.26.8562	12.9	12700	Always Connected
MILLER'S LAKE	114	34.45.5109 91.23.2350	12.8	12550	Always Connected
FIRST OLD RIVER	101	34.41.6490 91.19.7478	18.9	23090	Jul - Nov
LITTLE WEIDMANN	CACHE	34.42.2592 91.19.6600	15.0	15900	Sep - Oct
HOLE IN WALL	CACHE	34.44.2589 91.18.7966	11.7	10908	Always Connected
SLAUGHTER'S LAKE	108	32.42.1636 91.21.9458	11.4	10465	Always Connected
COOKS LAKE	78	34.30.2290 91.15.2270	23.4	33860	Jun - Dec
ROUND POND	75	34.33.6894 91.17.4343	17.9	21000	Aug - Nov
ROUND LAKE	85	34.29.2458 91.14.2743	21.9	29670	Jul - Nov
ROC ROE BAYOU	92	34.37.2183 91.20.5517	4.9	2635	Always Connected
EAST BAYOU	96	34.39.60 91.18.30	11.4	10465	Always Connected
MADDOX BAY	66	34.27.18 91.10.80	9.4	7659	Always Connected
SIMPSON LAKE	59	34.24.1407 91.08.3529	17.0	19200	Aug - Nov
MIDDLE OLD RIVER	107	34.43.0953 91.20.7234	11.1	10023	Always Connected
BIG WEIDMANN	THE HORN	34.43.30 91.20.46	27.7	66260	Jan - Dec
OLD RIVER LAKE	118	34.42.9598 91.22.0659	15.6	16860	Sep - Oct

Table 5. Relative abundance (percent of total number) of fishes in the littoral zone of the White River and in tributary (receiving) streams. Total number of individuals (N) is indicated.

Scientific Name	Common Name	White River N = 3,899	Tributaries N = 10,632
Family Lepisosteidae			
Lepisosteus oculatus	Spotted gar		0.1
L. osseus	Longnose gar		0.4
Family Clupeidae			
Dorosoma cepedianum	Gizzard shad	10.5	8.6
D. petenense	Threadfin shad	0.1	0.1
Family Hiodontidae			
Hiodon tergisus	Mooneye	< 0.1	
Family Cyprinidae			
Campostoma anomalum	Stoneroller	< 0.1	
Cyprinella venusta	Blacktail shiner	8.1	
Hybognathus nuchalis	MS Silvery minnow	16.7	
Macrhybopsis aestivalis	Speckled chub	0.2	
M. storeriana	Silver chub	3.7	
Notemigonus crysoleucas	Goldenshiner	< 0.1	3.8
Notropis amnis	Pallid shiner	0.2	
N. atherinoides	Emerald shiner	16.4	
N. buchanani	Ghost shiner	1.4	
N. maculatus	Taillight shiner		0.1
N. texanus	Weed shiner	1.4	
N. volucellus	Mimic shiner	5.1	
Opsopoeodus emiliae	Pugnose minnow	0.1	< 0.1
Pimephales notatus	Bluntnose minnow	< 0.1	
P. vigilax	Bullhead minnow	8.7	
Unidentified Cyprinidae	Young-of-Year minnows	0.6	
Family Catostomidae			
Carpiodes carpio	River carpsucker	10.6	< 0.1
Ictiobus bubalus	Smallmouth buffalo	< 0.1	
I. cyprinellus	Bigmouth buffalo		< 0.1
I. spp.	Young-of-year buffalo	4.8	
Moxostoma sp.	Young-of-year redhorse	1.3	
Unidentified Catostomidae	Young-of-year suckers	0.3	
Family Ictaluridae			
Ictalurus punctatus	Channel catfish		< 0.1
Family Aphredoderidae			
Aphredoderus sayanus	Pirate perch		< 0.1
Family Cyprinodontidae			
Fundulus chrysotus	Golden topminnow		0.5
F. dispar	Starhead topminnow		< 0.1
F. olivaceus	Blackspotted topminnow		0.3
Family Poeciliidae			
Gambusia affinis	Mosquitofish	0.6	46.4
Family Atherinidae			
Labidesthes sicculus	Brook silverside	0.8	0.7
Menidia beryllina	Inland silverside	0.2	
Family Percichthyidae			
Morone chrysops	White bass	0.6	< 0.1

Table 5. Concluded.

Scientific Name	Common Name	White River N = 3,899	Tributaries N = 10,632
Family Centrarchidae			
Centrarchus macropterus	Flier	0.1	
Elassoma zonatum	Banded pygmy sunfish		0.6
Lepomis cyanellus	Green sunfish	0.1	19.0
L. gulosus	Warmouth	< 0.1	1.7
L. humilis	Orangespotted sunfish	0.6	1.6
L. macrochirus	Bluegill	1.2	10.0
L. marginatus	Dollar sunfish		0.5
L. megalotis	Longear sunfish		0.5
L. microlophus	Redear sunfish	< 0.1	0.2
L. miniatus	Redspotted sunfish		0.3
L. symmetricus	Bantam sunfish		0.1
L. gulosus X macrochirus	Hybrid sunfish		< 0.1
L. spp.	Juvenile sunfishes		2.0
Micropterus punctulatus	Spotted bass	2.1	
M. salmoides	Largemouth bass	1.3	0.2
Pomoxis annularis	White crappie	0.2	2.2
P. nigromaculatus	Black crappie	< 0.1	0.7
Family Percidae			
Ammocrypta clara	Western sand darter	0.4	
E. chlorosomum	Bluntnose darter	0.1	< 0.1
E. gracile	Slough darter		0.1
E. proeliare	Cypress darter		0.1
Percina caprodes	Logperch	0.3	
P. maculata	Blackside darter	0.1	
P. sciera	Dusky darter	< 0.1	
P. shumardi	River darter	0.2	
Family Sciaenidae			
Aplodinotus grunniens	Freshwater drum	0.1	< 0.1
Total Number of species		41	34

Table 6. Fish diversity-habitat models developed using stepwise linear regression analyses for White River (Channel) and tributaries. Independent variables in each model are presented in their order of relative importance (i.e., percentage contribution to variance accounted for by the equation).

COMMUNITY INDICES	
Channel	
Species richness = -76.36 + 0.55(Temperature) + 17.89(Discharge)	$r^2 = 0.83$, $p < 0.0001$
Species Diversity (H') = -7.42 + 0.05(Temperature) + 1.84(Discharge)	$r^2 = 0.77$, $p < 0.0001$
Evenness = 1.32 - 0.002(Conductivity)	$r^2 = 0.29$, $p = 0.0248$
Tributaries	
Species richness = -0.87 + 7.73(Width)	$r^2 = 0.35$, $p < 0.0013$
Species Diversity (H') = 1.79 + 1.09(Width) - 0.26(pH)	$r^2 = 0.57$. $p < 0.0001$
E = 1.21 - 0.14(pH) + 0.29(Width)	$r^2 = 0.50$, $p < 0.0003$
INDIVIDUAL SPECIES	
Channel	
Silvery minnow = -0.47 + 0.11(Temperature) - 0.02(Turbidity)	$r^2 = 0.90$, $p < 0.0001$
Emerald shiner = 10.49 - 3.09(Discharge) + 1.45(Width)	$r^2 = 0.51$, $p < 0.006$
Gizzard shad = 23.56 + 0.05(Temperature) - 0.02(Conductivity) - 4.21(Discharge)	$r^2 = 0.66$, $p < 0.002$
Bullhead minnow = -6.03 - 1.04(pH) - 0.03(Turbidity) + 3.92(Discharge)	$r^2 = 0.45$, p 0.042
Blacktail shiner = 39.60 - 0.04(Conductivity) - 6.45(Discharge) - 0.03(Temperature)	$r^2 = 0.74$, $p < 0.0001$
Tributaries	
Mosquitofish = -1.52 + 0.58(pH) - 0.88(Width)	$r^2 = 0.50$, $p < 0.0001$
Green sunfish = 2.18 -0.95(Width) + 0.002(Conductivity)	$r^2 = 0.15$, $p < 0.1551$
Bluegill = 1.02 + 1.04(Depth)	$r^2 = 0.204$, $p < 0.020$
Gizzard shad = -1.36 + 0.01(Turbidity) + 0.63(Discharge) + 1.06(Width)	$r^2 = 0.61$, $p < 0.0001$
Golden shiner = 1.28 + 0.75(Depth) - 0.002(Conductivity) - 0.03(Temperature)	$r^2 = 0.39$, $p < 0.011$

Table 7. Fish diversity and abundance at 4 stations downstream from impounded (weir) tributaries in the Grand Prairie.

	Olena Creek	Little LaGrue Bayou	Hargrove Canal	Little LaGrue Bayou
Width (ft)	8.5	14.5	39.0	123.0
Depth (ft)	1.5	1.4	6.0	2.3
Richness (S)	11	9	5	17
Heterogeneity (H')	1.19	1.61	0.30	2.27
Evenness (E)	0.49	0.73	0.18	0.79
Mosquitofish	675	19	0	20
Green sunfish	278	52	0	1
Bluegill	15	40	21	17
Gizzard shad	0	0	464	4
Golden shiner	354	0	0	0

Table 8. Classification of White River fishes based on their tolerance of degraded water quality and habitat: I=intolerant, MI=moderately intolerant, MT=moderately tolerant, T=tolerant. Except where otherwise noted, classification is according to Jester et al., 1992.

Scientific Name	Common Name	Water Quality	Habitat
Family Lepisosteidae			
Lepisosteus oculatus	Spotted gar	T	MT
L. osseus	Longnose gar	T	T
Family Clupeidae			
Dorosoma cepedianum	Gizzard shad	MT	T
D. petenense	Threadfin shad	MI	MT
Family Hiodontidae			
Hiodon tergisus	Mooneye	MI	MI
Family Cyprinidae			
Campostoma anomalum	Stoneroller	MI	MI
Cyprinella venusta	Blacktail shiner	MT	MT
Hybognathus nuchalis	MS Silvery minnow	MT	I
Macrhybopsis aestivalis	Speckled chub	MI	I
M. storeriana	Silver chub	MT	M
Notemigonus crysoleucas	Goldenshiner	T	T
Notropis amnis	Pallid shiner	I	I
N. atherinoides	Emerald shiner	MT	MT
N. buchanani	Ghost shiner	MT	MT
N. maculatus	Taillight shiner	MI	I
N. texanus	Weed shiner[1]	MI	MI
N. volucellus	Mimic shiner	MI	MI
Opsopoeodus emiliae	Pugnose minnow	MI	MI
Pimephales notatus	Bluntnose minnow	MT	MT
P. vigilax	Bullhead minnow	T	T
Family Catostomidae			
Carpiodes carpio	River carpsucker	T	T
Ictiobus bubalus	Smallmouth buffalo	MT	MT
I. cyprinellus	Bigmouth buffalo	MT	MT
Moxostoma **sp.**	Young-of-Year redhorse[2]	MI	MI
Family Ictaluridae			
Ictalurus punctatus	Channel catfish	MT	MI
Family Aphredoderidae			
Aphredoderus sayanus	Pirate perch	MT	MI
Family Cyprinodontidae			
Fundulus chrysotus	Golden topminnow	MT	I
F. dispar	Starhead topminnow[3]	T	MI
F. olivaceus	Blackspotted topminnow	MT	MI
Family Poeciliidae			
Gambusia affinis	Mosquitofish	T	T
Family Atherinidae			
Labidesthes sicculus	Brook silverside	MT	MI
Menidia beryllina	Inland silverside	T	MT
Family Percichthyidae			
Morone chrysops	White bass	MT	MT

Table 8. Concluded.

Scientific Name	Common Name	Water Quality	Habitat
Family Centrarchidae			
Centrarchus macropterus	Flier	I	I
Elassoma zonatum	Banded pygmy sunfish	I	I
Lepomis cyanellus	Green sunfish	T	T
L. gulosus	Warmouth	MT	MT
L. humilis	Orangespotted sunfish	T	MT
L. macrochirus	Bluegill	MT	MT
L. marginatus	Dollar sunfish	MT	MI
L. megalotis	Longear sunfish	MT	MT
L. microlophus	Redear sunfish	MT	MT
L. miniatus	Redspotted sunfish	MT	MI
L. symmetricus	Bantam sunfish	I	I
Micropterus punctulatus	Spotted bass	MI	MI
M. salmoides	Largemouth bass	MT	MT
Pomoxis annularis	White crappie	T	MT
P. nigromaculatus	Black crappie	MT	MT
Family Percidae			
Ammocrypta clara	Western sand darter	I	I
E. chlorosomum	Bluntnose darter	MI	I
E. gracile	Slough darter	MT	I
E. proeliare	Cypress darter	MI	I
Percina caprodes	Logperch	MI	MI
P. maculata	Blackside darter	MI	I
P. sciera	Dusky darter	MI	MI
P. shumardi	River darter	MI	I
Family Sciaenidae			
Aplodinotus grunniens	Freshwater drum	MT	MT

[1] based on an apparent decline in range in Missouri (Pflieger, 1975)
[2] based on occurrence of *M. carinatum* in White River and its specialized feeding habits and sensitivity to pollution and turbidity (Robison and Buchanan 1988)
[3] based on moderate tolerances of degraded water quality by most *Fundulus* spp.(especially low dissolved oxygen), spawning requirements of dense vegetation, frequent association with habitat-intolerant *F. chrysotus* (Robison and Buchanan, 1988)

Table 9. Percent reduction in Habitat Units (HU) by month and pumping alternative in the lower White River, Arkansas - Grand Prairie Demonstration Project. Habitat Units for base (Pre-project) and Post-project (Pump) are the product of Habitat Suitability Index (HSI) and acre-feet per day (AFD). HSI is the ration between predicted and maximum observed (20) species richness. Predicted value is caclulated as: SPECIES RICHNESS = 0.542(TEMPERATURE) + 0.00039 (MEAN DISCHARGE) - 7.431, R^2 = 0.85, P=0.0001, N=17.

MONTH	HSI-Base	Acre-Feet Per Day (AFD)-Base	HU-BASE	HSI-Pump	Difference in HSI-Base And HSI-Pump	Difference in AFD-Base and AFD-Pump	Reducton in Habitat Units (HU)	Percent Loss in HU's
				1460 cfs				
JAN	0.43	67558.08	28923.67	0.43	0.00022	22.07	0.00	0.00
FEB	0.58	74531.38	43078.14	0.58	0.00022	22.77	0.01	0.00
MAR	0.79	88221.63	70037.28	0.78	0.01206	1226.77	14.80	0.02
APR	1.00	103894.18	103894.18	1.00	1.00000	1896.37	1896.37	1.82
MAY	1.00	94885.29	94885.29	1.00	1.00000	1815.25	1815.25	1.91
JUN	0.93	63129.05	58494.59	0.91	0.01674	1702.84	28.51	0.05
JUL	0.81	42901.84	34708.82	0.78	0.02393	2433.78	58.23	0.17
AUG	0.77	36544.51	28271.86	0.75	0.02317	2357.22	54.63	0.19
SEP	0.58	30531.17	17677.84	0.57	0.01231	1252.52	15.42	0.09
OCT	0.34	25946.13	8931.51	0.34	0.00246	250.60	0.62	0.01
NOV	0.30	34918.15	10368.57	0.30	0.00037	37.45	0.01	0.00
DEC	0.45	61246.96	27400.92	0.45	0.00002	1.92	0.00	0.00
				1640 cfs				
JAN	0.43	67558.08	28923.67	0.43	0.00022	22.08	0.00	0.00
FEB	0.58	74531.38	43078.14	0.58	0.00022	22.77	0.01	0.00
MAR	0.79	88221.63	70037.28	0.78	0.01335	1358.38	18.14	0.03
APR	1.00	103894.18	103894.18	1.00	1.00000	2099.11	2099.11	2.02
MAY	1.00	94885.29	94885.29	1.00	1.00000	1970.07	1970.07	2.08
JUN	0.93	63129.05	58494.59	0.91	0.01827	1858.53	33.96	0.06
JUL	0.81	42901.84	34708.82	0.78	0.02634	2678.89	70.55	0.20
AUG	0.77	36544.51	28271.86	0.75	0.02442	2483.66	60.64	0.21
SEP	0.58	30531.17	17677.84	0.57	0.01188	1208.59	14.36	0.08
OCT	0.34	25946.13	8931.51	0.34	0.00215	218.71	0.47	0.01
NOV	0.30	34918.15	10368.57	0.30	0.00037	37.42	0.01	0.00
DEC	0.45	61246.96	27400.92	0.45	0.00002	1.92	0.00	0.00
				1800 cfs				
JAN	0.43	67558.08	28923.67	0.43	0.00022	22.07	0.00	0.00
FEB	0.58	74531.38	43078.14	0.58	0.00022	22.77	0.01	0.00
MAR	0.79	88221.63	70037.28	0.78	0.01341	1364.08	18.29	0.03
APR	1.00	103894.18	103894.18	1.00	1.00000	2301.12	2301.12	2.21
MAY	1.00	94885.29	94885.29	1.00	1.00000	2114.63	2114.63	2.23
JUN	0.93	63129.05	58494.59	0.91	0.01948	1980.93	38.58	0.07
JUL	0.81	42901.84	34708.82	0.78	0.02855	2904.40	82.93	0.24
AUG	0.77	36544.51	28271.86	0.75	0.02564	2608.18	66.88	0.24
SEP	0.58	30531.17	17677.84	0.57	0.01147	1167.00	13.39	0.08
OCT	0.34	25946.13	8931.51	0.34	0.00187	189.99	0.35	0.00
NOV	0.30	34918.15	10368.57	0.30	0.00037	37.40	0.01	0.00
DEC	0.45	61246.96	27400.92	0.45	0.00002	1.92	0.00	0.00
				1960 cfs				
JAN	0.43	67558.08	28923.67	0.43	0.00022	22.17	0.00	0.00
FEB	0.58	74531.38	43078.14	0.58	0.00022	22.85	0.01	0.00
MAR	0.79	88221.63	70037.28	0.78	0.01592	1619.52	25.79	0.04
APR	1.00	103894.18	103894.18	1.00	1.00000	2502.50	2502.50	2.41
MAY	1.00	94885.29	94885.29	1.00	1.00000	2156.16	2156.16	2.27
JUN	0.93	63129.05	58494.59	0.91	0.02017	2051.58	41.38	0.07
JUL	0.81	42901.84	34708.82	0.78	0.03062	3114.88	95.39	0.27
AUG	0.77	36544.51	28271.86	0.75	0.02694	2740.36	73.83	0.26
SEP	0.58	30531.17	17677.84	0.57	0.01083	1101.84	11.94	0.07
OCT	0.34	25946.13	8931.51	0.34	0.00179	182.48	0.33	0.00
NOV	0.30	34918.15	10368.57	0.30	0.00037	37.39	0.01	0.00
DEC	0.45	61246.96	27400.92	0.45	0.00002	1.92	0.00	0.00

Table 10. Gain in Habitat Units (HU) (average by month) for tributary streams in the Grand Prairie region, Arkansas - Grand Prairie Demonstration Project. Habitat Units for base (pre-project) and post-project (with pumping) are the product of Habitat Suitability Index (HSI) and acre-feet (ACFT). HSI is the ratio between predicted and maximum observed (2.0) species diversity. Predicted value is calculated as: SPECIES DIVERSITY = $1.20(WIDTH_{Log10}) - 0.26$, $r^2 = 0.42$, P=0.0003, n=26.

STREAM	STREAM NUMBER	CHANNEL LENGTH (MILES)	BASE WIDTH (FT)	BASE HSI	BASE AREA (ACFT)	BASE HU	POST WIDTH (FT)	POST HSI	POST AREA (ACFT)	POST HU	GAIN IN HU
NO NAME	1300	1.5	6.0	0.33	0.7	0.22	39.0	0.82	22.55	18.52	18.30
NO NAME	1400	3.5	6.0	0.33	1.5	0.51	39.0	0.82	52.61	43.21	42.69
PATE BRANCH	1500	1.8	30.0	0.75	13.1	9.86	60.8	0.94	48.02	44.98	35.12
NO NAME	1510	0.5	8.0	0.41	0.1	0.12	16.8	0.60	2.14	1.29	1.17
NO NAME	1520	1.8	8.0	0.41	1.0	0.43	60.8	0.94	48.02	44.98	44.55
HONEY CREEK	2100	11.0	30.0	0.75	80.1	60.35	58.2	0.92	349.67	323.50	263.15
NO NAME	2200	0.5	8.0	0.41	0.3	0.12	60.8	0.94	13.34	12.50	12.38
LAGRUE BAYOU (LOWER)	2210	9.5	55.3	0.91	134.4	122.60	50.0	1.00	641.97	641.97	519.37
WASHINGTON CREEK	2220	2.0	30.0	0.75	14.5	10.95	60.8	0.94	53.35	49.97	39.02
NO NAME	2230	1.7	8.0	0.41	1.0	0.40	41.0	0.83	21.63	18.04	17.64
NO NAME	2240	3.0	8.0	0.41	1.7	0.71	60.8	0.94	80.03	74.96	74.25
NO NAME	2250	1.0	8.0	0.41	0.6	0.24	60.8	0.94	26.68	24.99	24.75
NO NAME	2260	0.5	8.0	0.41	0.3	0.12	60.8	0.94	13.34	12.50	12.38
S. FORK HURRICANE CRK	2300	1.8	18.2	0.62	6.3	3.96	35.0	0.79	18.98	15.05	11.09
OAK CREEK	2410	4.7	38.3	0.82	48.0	39.20	41.0	0.83	59.82	49.90	10.71
LITTLE HURRICANE	2500	2.6	19.0	0.63	6.0	3.80	37.0	0.81	33.09	26.72	22.92
LAGRUE BAYOU (UPPER)	3110	11.9	55.3	0.91	167.5	152.77	90.3	1.00	668.78	668.78	516.01
NO NAME	3110	0.5	8.0	0.41	0.3	0.12	41.0	0.83	6.36	5.31	5.19
NO NAME	3200	2.4	8.0	0.41	1.4	0.57	37.0	0.81	30.54	24.66	24.09
HURRICANE CREEK	3210	3.0	18.2	0.62	10.5	6.55	42.2	0.84	46.20	38.90	32.35
PAYNE CREEK	3221	2.4	6.0	0.33	1.1	0.35	37.0	0.81	30.54	24.66	24.31
BARNES CREEK	3230	4.9	8.0	0.41	2.8	1.17	54.9	0.91	84.18	76.62	75.45
JOHNSON BRANCH	3261	1.7	6.0	0.33	0.7	0.25	37.0	0.81	21.63	17.47	17.22
WOLF ISLAND SLASH	3510	4.5	21.2	0.66	28.9	19.14	46.5	0.87	103.33	89.58	70.45
LOST ISLAND BAYOU	5100	4.9	15.9	0.59	30.5	17.95	39.0	0.82	65.39	53.70	35.75
STUTTGART KING BAYOU	5300	3.6	41.0	0.83	43.4	36.22	72.0	0.98	137.25	134.59	98.37
NO NAME	5310	2.2	8.0	0.41	1.3	0.52	63.0	0.95	58.66	55.49	54.96
CLEARPOINT CREEK	5311	6.9	15.6	0.58	14.5	8.43	63.0	0.95	185.33	175.30	166.88
SHERRIL CREEK	5510	7.0	29.0	0.74	49.1	36.52	51.2	0.89	81.72	72.89	36.37
LITTLE LAGRUE LATERAL	5520	2.0	30.0	0.75	14.5	10.95	46.6	0.87	32.80	28.45	17.50
NO NAME	5530	0.5	8.0	0.41	0.3	0.12	41.0	0.83	6.36	5.31	5.19
LITTLE LAGRUE BAYOU	6100	40.9	55.3	0.91	573.9	523.40	85.8	1.00	1852.57	1852.57	1329.17
WILDCAT DITCH	6210	1.4	22.0	0.67	10.2	6.87	49.0	0.88	24.70	21.75	14.88
NO NAME	6220	1.9	8.0	0.41	1.1	0.45	46.0	0.86	27.63	23.88	23.42
HOLT BRANCH	6230	2.0	7.0	0.37	1.2	0.44	46.0	0.86	29.09	25.14	24.69
MILL BAYOU	6300	21.6	23.0	0.68	125.7	85.99	67.1	0.96	462.08	444.66	358.67
SOUTH MILL BAYOU	6310	4.6	23.0	0.68	26.1	17.86	52.5	0.90	85.70	77.00	59.14
E. STUTTGART KING BAYOU	6410	2.5	41.0	0.83	30.2	25.17	34.8	0.79	25.73	20.38	-4.80
ELM PRONG MILL	6500	7.5	23.0	0.68	43.1	29.52	59.0	0.93	182.78	169.78	140.26
HURRICANE BAYOU	6610	3.2	18.2	0.62	11.4	7.13	47.5	0.87	69.19	60.37	53.24
TOTAL	-	191.3	-	-	1499.8	1242.08	-	-	5803.78	5570.32	4328.24

Table 11. Gain in Habitat Units (HU) (average by month) for proposed canals in the Grand Prarie region, Arkansas - Grand Prairie Demonstration Project. Habitat Units are the product of Habitat Suitability Index (HSI) and acre-feet (ACFT). HSI is the ratio between predicted and maximum observed (2.0) species diversity. Predicted value is calculated as: SPECIES DIVERSITY = $1.20(WIDTH_{LOG10})$ - 0.26 , r^2 = 0.42, P=0.0003, n=26.

Canal Number	LENGTH (Miles)	WIDTH (ft)	HSI	Acre-Feet	Habitat Units
1000	4.0	140.8	1.00	671.5	671.50
1300	0.5	23.1	0.68	2.7	1.85
1400	0.8	22.6	0.68	3.9	2.65
1500	6.4	29.5	0.74	70.3	55.90
1510	0.3	24.0	0.70	1.6	1.11
1520	1.0	13.3	0.54	1.7	0.92
2000	8.4	131.6	1.00	1259.6	1259.60
2100	0.6	23.3	0.69	2.9	1.99
2200	13.0	47.2	0.87	273.2	238.74
2211	0.5	22.5	0.68	2.8	1.90
2230	0.3	27.4	0.73	2.4	1.75
2400	1.7	33.4	0.78	18.2	14.21
3000	12.0	126.8	1.00	1671.6	1671.60
3100	2.7	28.0	0.72	30.0	24.02
3200	7.1	49.8	0.83	98.7	85.10
3210	0.2	20.9	0.66	1.0	0.66
3220	3.7	16.3	0.59	11.6	7.41
3221	0.2	20.8	0.66	0.8	0.53
3240	0.7	10.1	0.47	0.7	0.33
3260	0.2	39.1	0.82	3.1	2.55
3300	2.3	25.3	0.71	13.8	9.78
3500A	7.4	35.2	0.79	85.0	67.52
4000	11.3	119.5	1.00	1418.7	1418.70
4100	1.0	25.3	0.71	6.3	4.47
4200	2.7	28.4	0.74	20.5	15.15
4400	1.3	25.4	0.71	8.4	6.01
4500	3.9	27.5	0.72	34.8	26.89
4520	1.4	19.2	0.64	5.1	3.25
5000	7.2	115.8	1.00	828.2	828.20
5200	5.4	34.4	0.77	44.6	34.31
5300	2.1	58.1	0.92	67.1	62.07
5310	0.4	33.7	0.78	4.4	3.45
5400	3.0	26.4	0.71	24.3	18.11
5500	14.2	36.4	0.80	183.6	149.53
5505	1.3	22.8	0.68	6.6	4.50
6000	17.9	75.3	0.96	813.0	783.64
6200	21.8	55.6	0.91	708.9	661.73
6215	1.2	99.2	1.00	117.5	117.50
6216	1.7	115.2	1.00	226.0	226.00
6230	1.2	12.0	0.51	1.7	0.88
6300	0.3	22.3	0.67	1.3	0.88
6310	0.4	22.5	0.68	2.1	1.43
6600	8.4	32.6	0.77	90.9	71.50
TOTAL	182.5	-	-	8841.1	8559.80

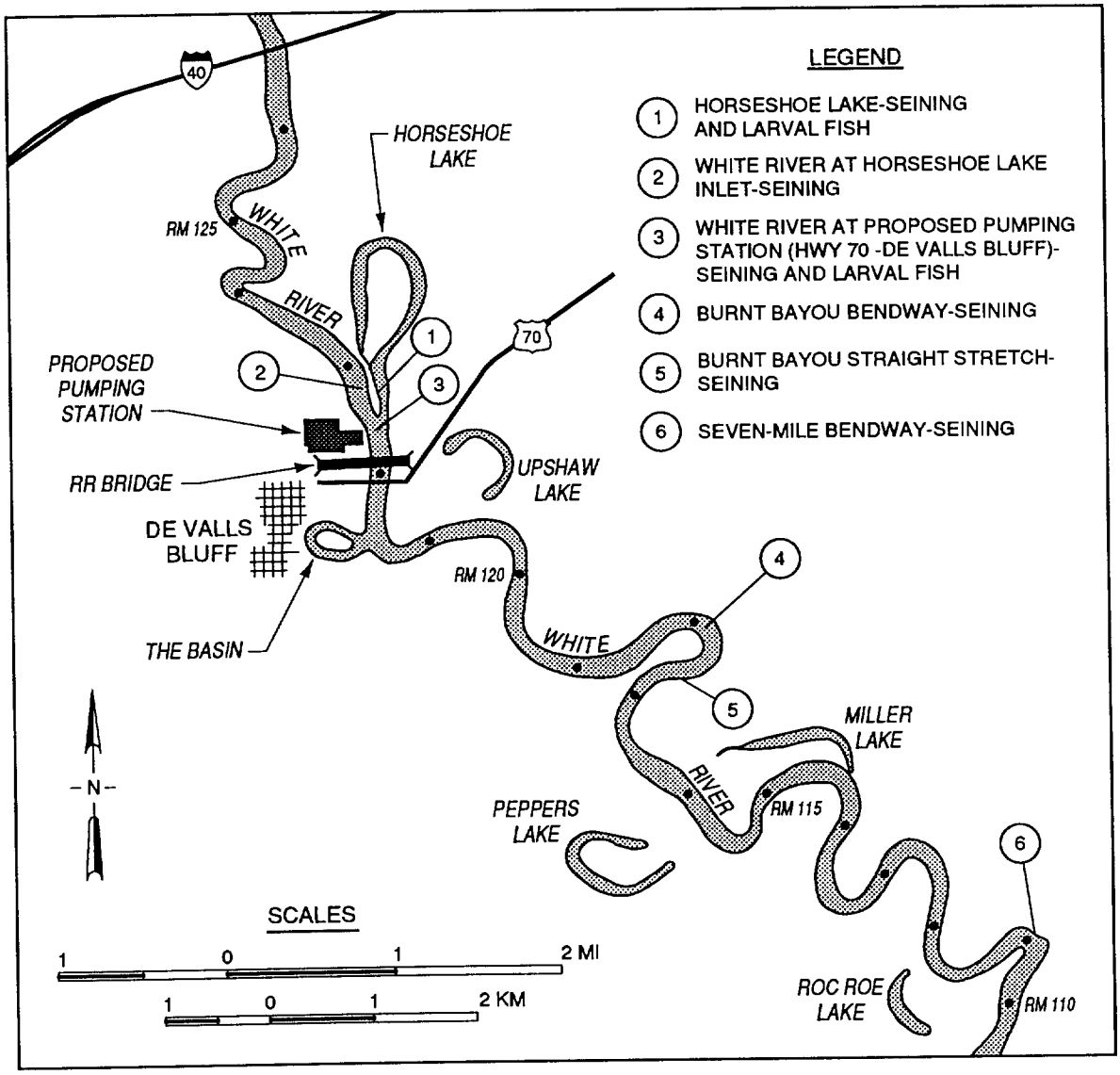

Figure 1. Location of seining and larval fish sampling stations on the White River, 1996.

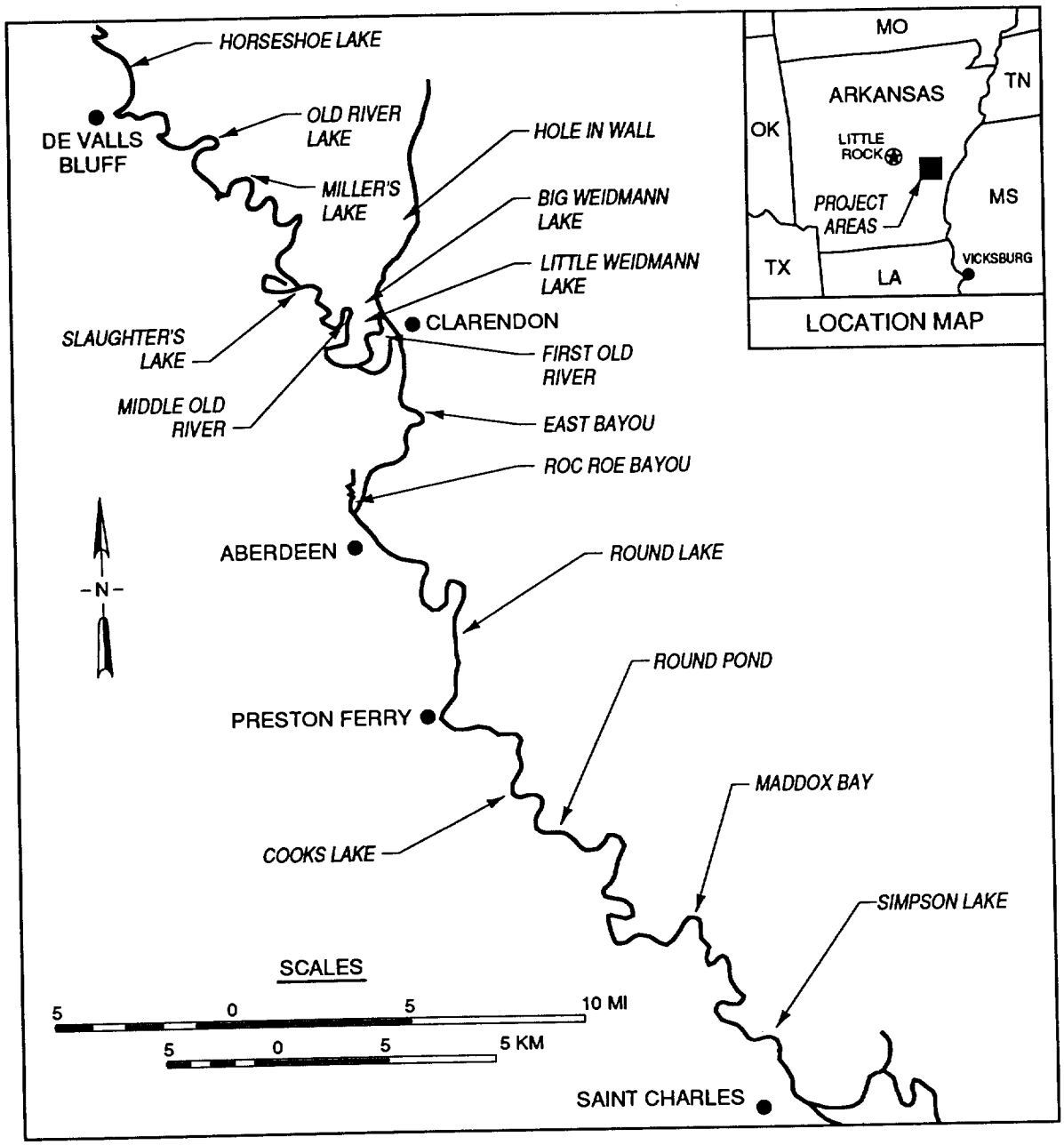

Figure 2. Location of oxbow lakes adjacent to the White River surveyed in 1996.

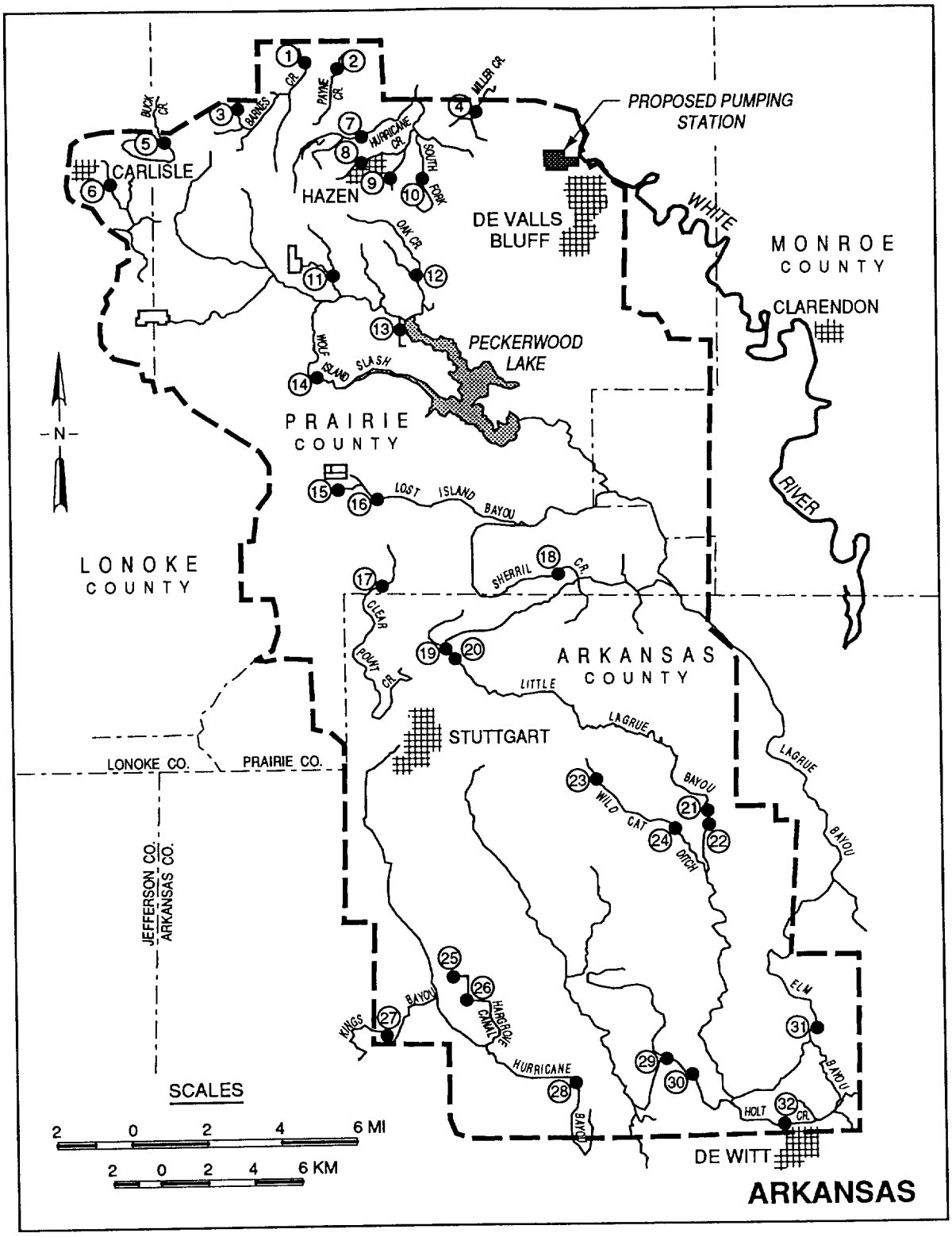

Figure 3. Location of sampling stations in the Grand Prairie Region, 1996

Location of Sampling Stations Corresponding to Numbers on Figure 3

01
AR Prairie Co. 10 October 1996
Barnes Creek at Center Point Ark.
SEC 35, T3N, R6W

02
AR Prairie Co. 10 October 1996
Payne Creek at Center Point, Ark.
SEC 1, T3N, R5W

03
AR Prairie Co. 10 October 1996
Barnes Creek 4.5 mi NE of Carlisle, Ark
SEC 8/9, T2N, R6W

04
AR Prairie Co. 10 October 1996
Miller Creek - Wattensas Area. 2 mi N of Hwy 70.
SEC 10/11, T2N, R5W

05
AR Prairie Co. 10 October 1996
Buck Creek near I-40 2.5 mi NNE of Carlisle, Ark
SEC 18, T2N, R6W

06
AR Arkansas Co. 10 October 1996
Trib to Bayou two Prairie-
Old Carlisle Cemetery, Carlisle, Ark.
SEC 23, T2N, R7W

07
AR Prairie Co. 10 October 1996
Hurricane Creek- 0.75 mi N of Hazen, Ark.
SEC 13, T2N, R5W

08
AR Prairie Co. 10 October 1996
Little (Hurricane) Creek- at Hazen, Ark.
SEC 19, T2N, R5W

09
AR Prairie Co. 10 October 1996
Hurricane Creek 1 mi E of Hazen, Ark- at Hwy 70.
SEC 20, T2N, R5W

10
AR Prairie Co. 10 October 1996
South Fork-1.5 mi E of Hazen, Ark- at Hwy 70.
SEC 21, T2N, R5W

11
AR Prairie Co 4 Sept 1996
Unnamed Creek 2.5 rd mi W of Siedenstricker, ARK,
SEC 1-2, T1N, R6W.

12
AR Prairie Co 4 Sept 1996
Oak Creek at Sieden stricker ARK. Approx. 13 mi N of Stuttgart
SEC 9 T2S, R5W.

13
AR Prairie Co 6 Sept 1996
Hooks Canal at Hwy 11; 3 mi NNE of Stovak Ark.
SEC.20.T1N,R5W Stuttgart Quad

14
AR Prairie Co 28 August 1996
Wolf Island Slash 2 rd mi NW of Slovak, Ark.

15
AR Prairie Co 6 Sept 1996
Unnamed canal 2 mi NW of Stuttgard Municipal Airport.
SEC13, T1S,R6W Stuttgart Quad.

16
AR Prairie co 28 August 1996
Lost Island Bayou (White River Drainage) 2 rd mi SE of Slovak Ark.
SEC 18, T1S, R5W.

17
AR Prairie co 28 August 1996
Clear point Creek (White River Drainage) 4 rd mi N of Stuttgart, ARK. SEC 31, T1S, R5W.

18
AR Prairie Co 4 Sept 1996
Sherril Creek 1 mi West of Ulm ARK, SEC 31 T1S, R4W.

19
AR Arkansas Co 29 Aug 1996K
Little LA Grue Bayou- **Below weir**, 2 mi N of Stuttgard, AR
SEC9, T2S,R5W

20
AR Arkansas Co 29 August 1996ttgard,
Little LaGrue Bayou (White River Drainage) 2 rd mi N of Stuggart
upstream of weir. SEC 9, T2S, R5W.

21
AR Arkansas Co 5 Sept 1996eir
Little LaGrue Bayou 4 rd mi NE of Almyra downstream of weir
SEC 12, T3S, R4W.

22
AR Arkansas Co 5 Sept 1996
Little LaGrue Bayou 4 mi NE of Almyra. upstream of Weir
SEC 12, T3S, R4W Dewitt Quad.

23
AR Arkansas Co 5 Sept 1996
Wildcat Ditch Upper at Hwy 130, 3 miles NE of Yoder Ark.
SEC 14, T3S, R4W. Dewitt Quad.

24
AR Arkansas Co 5 Sept 1996.
Wild Cat ditch 3 rd mi N of Almyra ARK, SEC 11, T3S, R4W

25
AR Arkansas Co 6 Sept 1996Hwy 165S
Hargrove canal upper out of reservoirs, 8 rd mi s of Stuttgart
SEC10, T4S,R4W Humphrey Quad.

26
AR Arkansas Co 6 Sept 1996C 10,
Hargrove Canal -Lower- 8 mi S of Stuttgart on Hwy 165.
SEC, T45, R4W Humphrey Quad.

27
AR Arkansas Co 6 Sept 1996
Kings Bayou Hwy 343 3 rd mi NW of Lodge Corner ARK,
SEC 17, T4S, R5W. Humphrey Quad.

28
AR Arkansas Co 6 Sept 1996
Hurracane Bayou 2 rd mi North of Eldridge Corner, ARK
SEC29, T4S,R4W

29
AR Arkansas Co. 9 October 1996
Unnamed Creek 2 mi N 165, 1 mi SE Olena
SEC 25/26, T4S, R3W

30
AR Arkansas Co. 9 October 1996
Unnamed Creek at Olena, Ark.
SEC 23, T4S, R4W

31
AR Arkansas Co. 9 October 1996
Elm Bayou- at Murphy RD- 3 mi N of Dewitt, Ark.
SEC 15, T4S,R3W

32
AR Arkansas Co. 9 October 1996
Holt Creek at Hwy 130- Dewitt, Ark. .
SEC 13,T4S,R3W

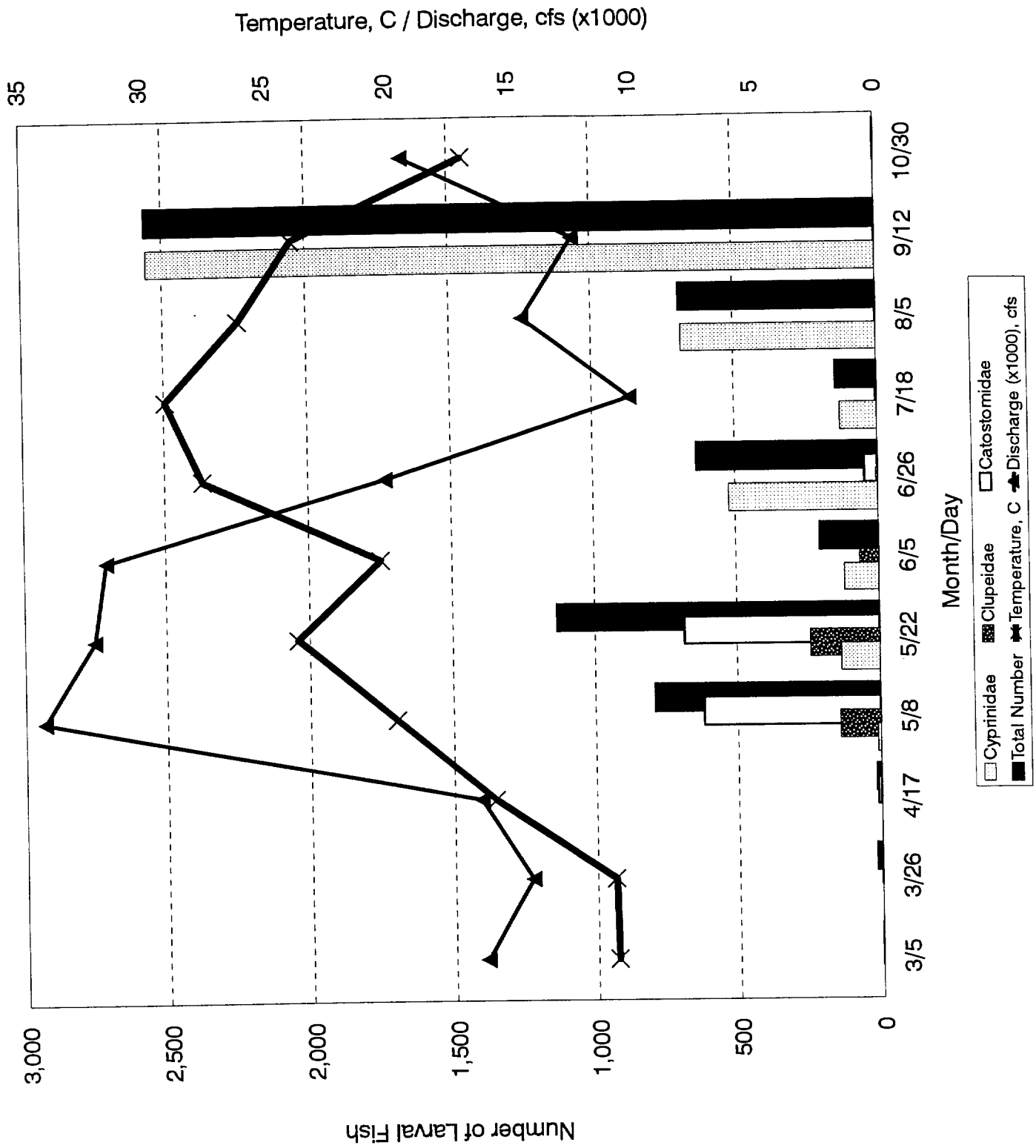

Figure 4. Total number of larval fish collected in the White River using ichthyoplankton nets and light traps related to water temperature and discharge.

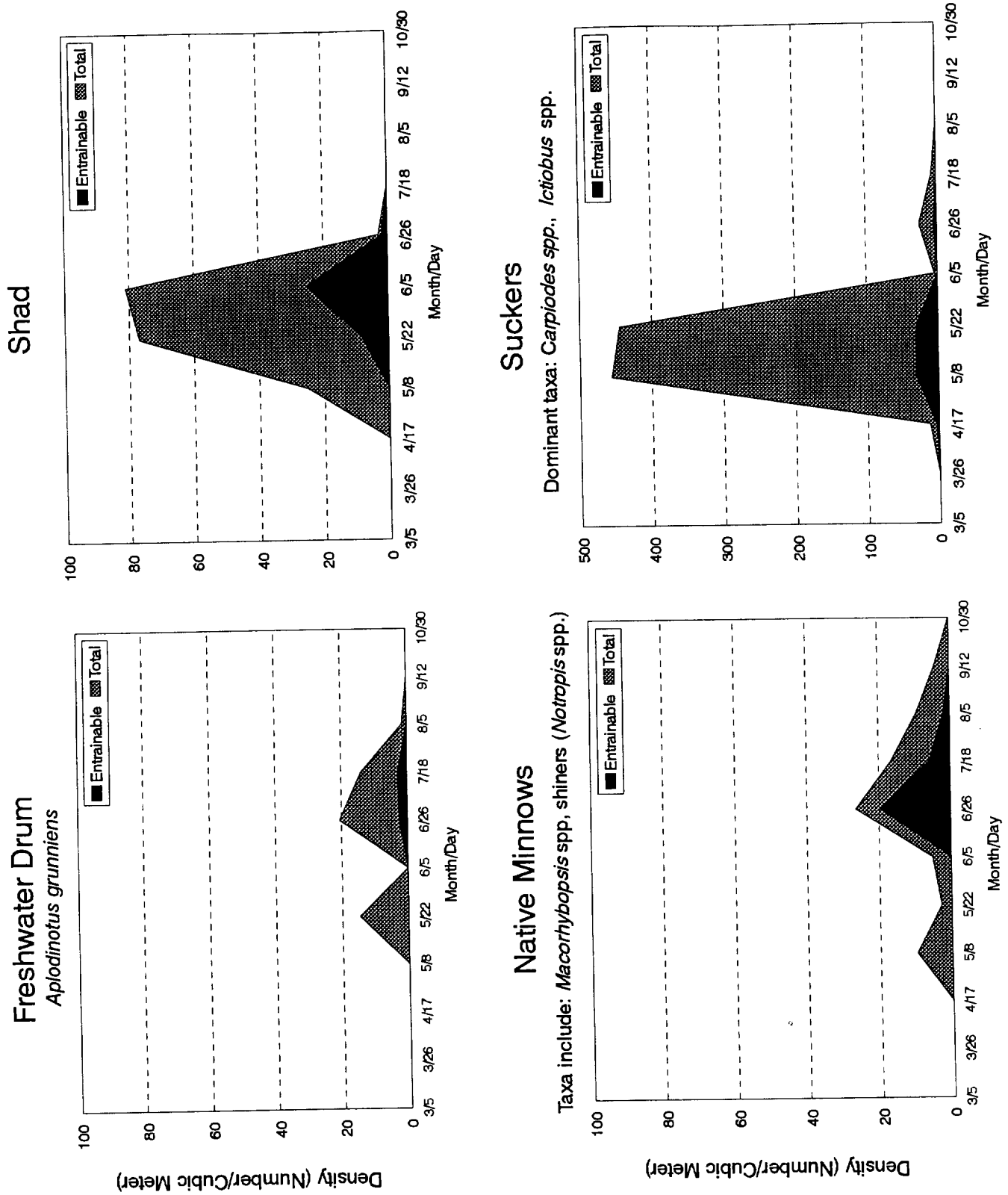

Figure 5. Relationship between number of larval fish in the river at DeValls Bluff to those potentially entrainable.

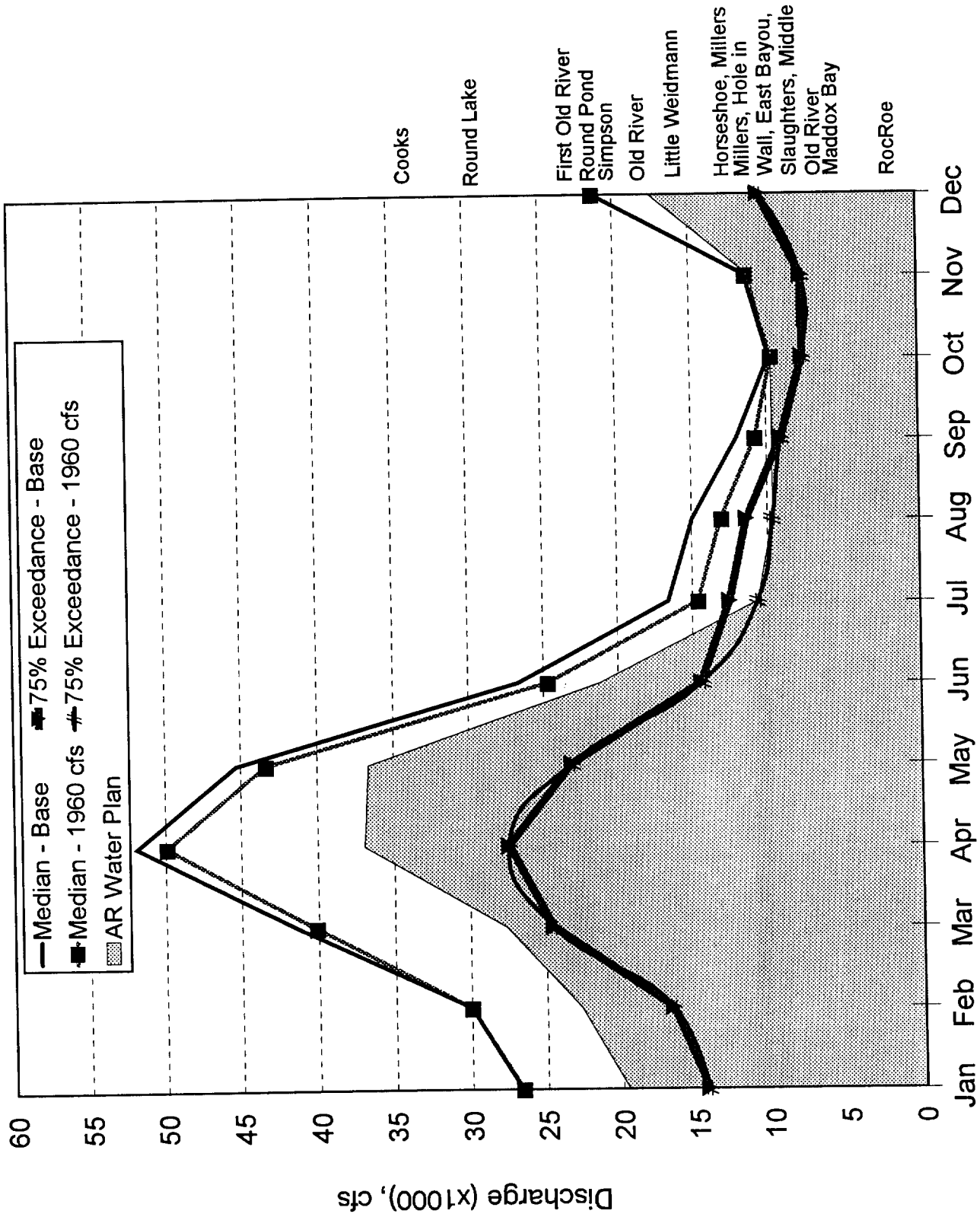

Figure 6. Median and 75% exceedance discharge in the White River at Clarendon for base and 1960 pump alternative. Shaded area represents minimum flows according the Arkansas State Water Plan. Oxbow lakes are arranged at approximate location of their controlling discharge.

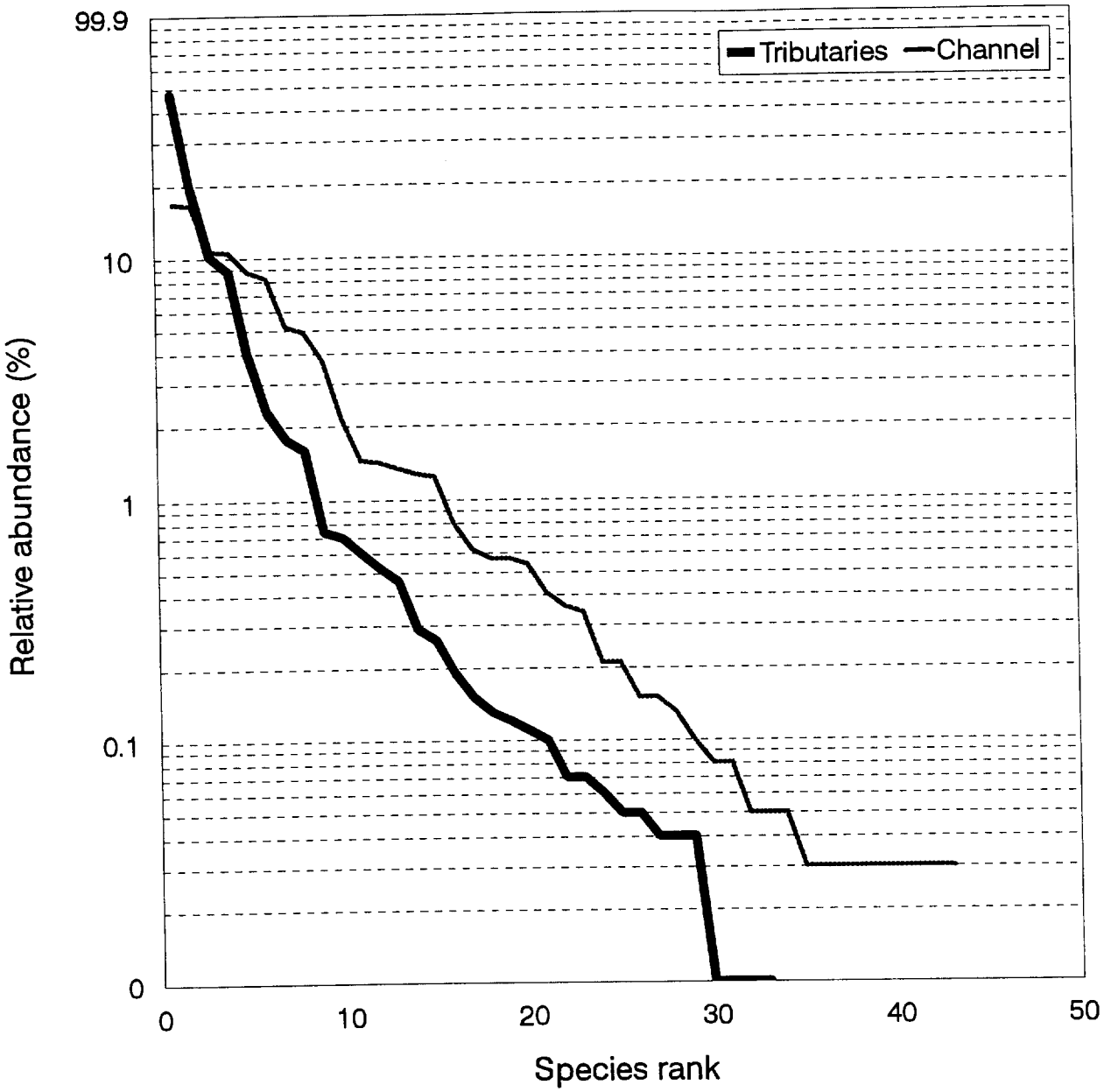

Figure 7. Dominance-diversity curves for fish communities from the main channel and tributaries of the White River, Arkansas.

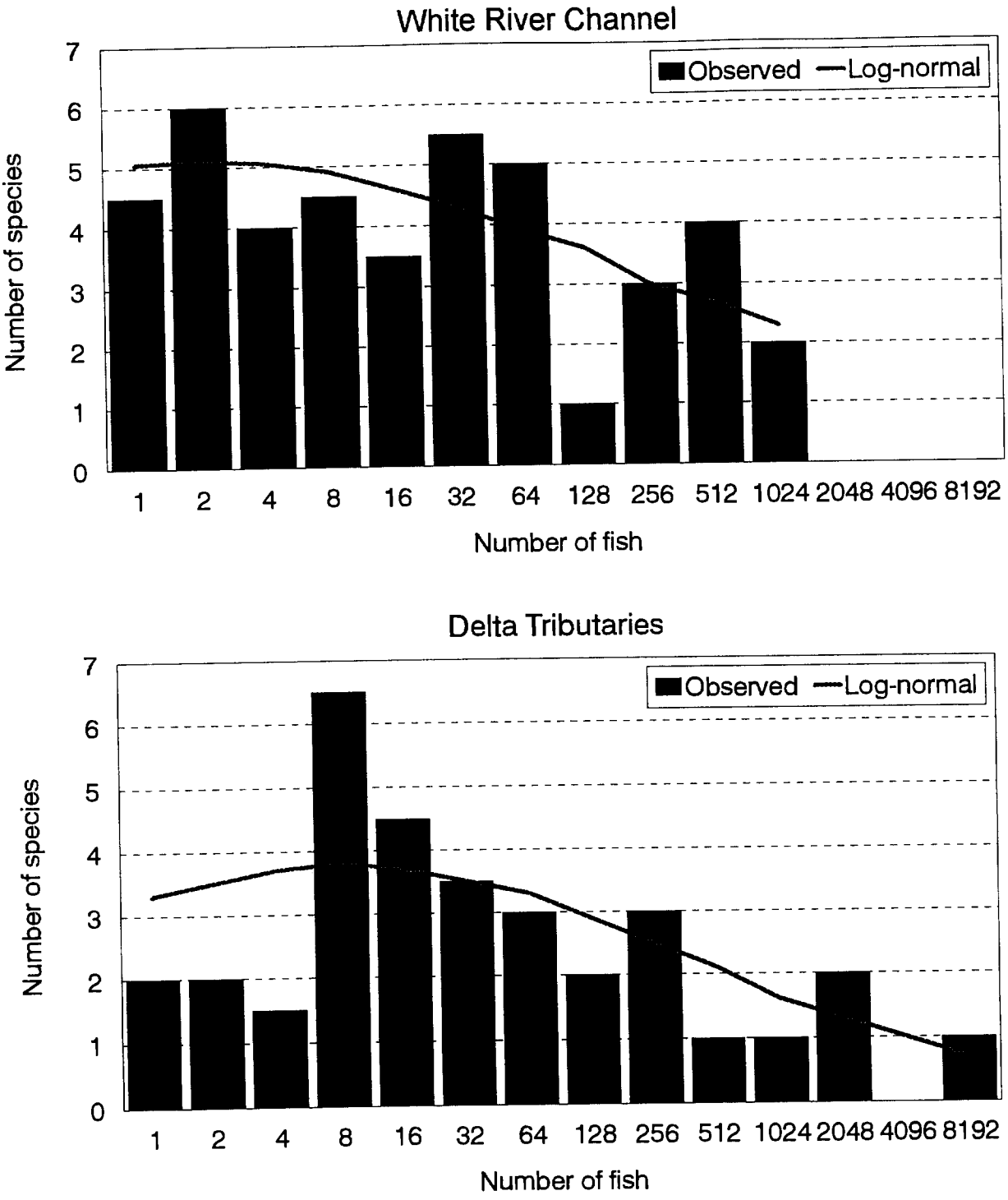

Figure 8. Species-abundance distribution. Number of species occurring in progressively doubling ranges of abundance as observed (bars) and as predicted by a best-fit log-normal model (curve). a) Channel fish community b) Tributary fish community

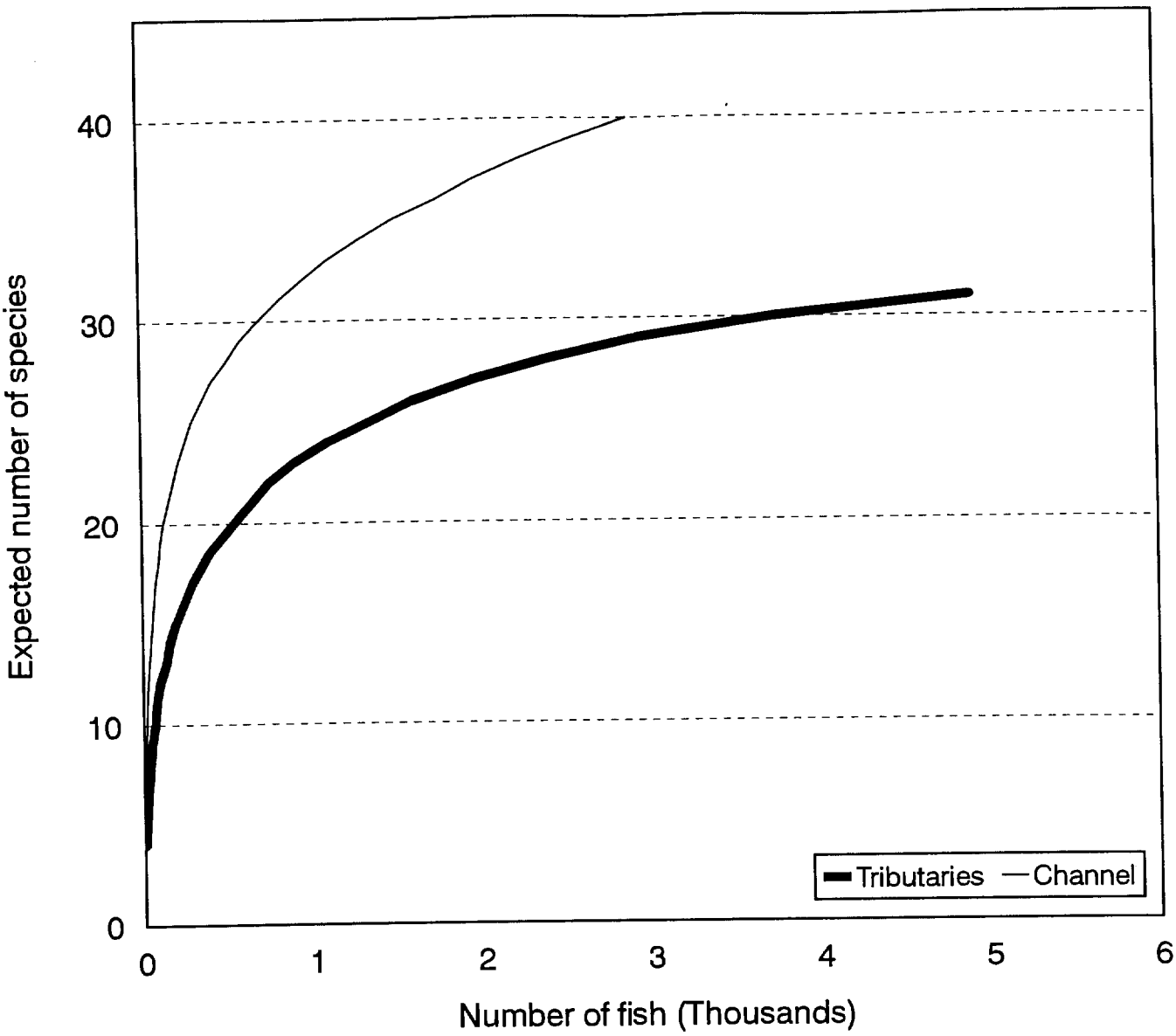

Figure 9. Rarefaction curves for main channel and tributary fish communities of the White River, Arkansas.

SECTION VI. COORDINATION

PART A. FISH AND WILDLIFE

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT CORPS OF ENGINEERS
167 NORTH MAIN STREET B-202
MEMPHIS TN 38103-1894

Reply to
Attention of:

October 12, 1999

Planning, Programs and Project Management Division
Project Management Branch

Mr. Allan J. Mueller
Field Supervisor, Arkansas Field Office
U.S. Fish and Wildlife Service
1500 Museum Road, Suite 105
Conway, Arkansas 72032

Mr. William B. Hathaway
U.S. Environmental Protection Agency
Region 6, Director,
Water Quality Protection Division

Dear Sirs:

This is in response to your letter of September 7, 1999, in which you requested that we evaluate a proposal, developed by Mr. Jerry Lee Bogard, presented in the "Agricultural and Industrial Partnership for the Preservation of Arkansas Groundwater".

The only new idea is the proposal from International Paper. The U.S. Fish and Wildlife Service has participated in the Eastern Arkansas Regional Comprehensive Study and the Grand Prairie Area Demonstration Project since 1982. During the study period, the relative merits of various conservation measures were fully considered. The conservation features have been fully optimized and included in the Grand Prairie Area Demonstration Project. The studies concluded that conservation features alone could not provide for protection of the Sparta and alluvial aquifers, prevent great losses to the area's economy, or provide the many environmental benefits included in the recommended plan. All potential sources of excess surface water were considered. Areas better served by the Arkansas River were included in the Bayou Meto study area, and the area south of DeWitt, Arkansas, was later removed from the project area when studies indicated that this area could better be served from the Arkansas River. Multiple withdrawal points were also considered on the White River, but not recommended because of engineering and environmental considerations.

International Paper switching to surface water would only effect the Sparta aquifer. The Grand Prairie report stated that this aquifer, because of its purity but relatively low safe yield, should be used for municipal and industrial supply and not used for agricultural irrigation water. A cone of depression is developing in the Stuttgart area separate from the cone at Pine Bluff due primarily to use of the Sparta for irrigated agriculture. In addition, recent observed well data shows that the depletion of the Sparta is occurring rapidly as the alluvial is depleted and more farmers are turning to the Sparta with greater and greater water demands. This clearly shows the need for rapid construction of the Grand Prairie Area

Demonstration Project to protect both the Sparta and alluvial aquifers. International Paper's use of the Sparta likely has minimal effect on the Sparta in Grand Prairie area compared to irrigated agriculture and no effect on the alluvial aquifer. However, this portion of the proposal appears to have merit for aquifer protection and may be considered in the study of the Bayou Meto Basin, which is located adjacent to Pine Bluff and would likely rely on the Arkansas River for excess water, or in the study of additional features for ground water protection and the environment for the Grand Prairie. Regardless, International Paper switching from the Sparta aquifer to using Arkansas River water would have no effect on the formulation and optimization of the recommended plan for the Grand Prairie.

Mr. Bogard's plan includes the transfer of $50 million in Federal funding to an irrigation district that has yet to be formed. The Corps has no authority for this transfer.

I agree that careful and complete consideration should be given to all serious proposals. I have carefully and completely considered Mr. Bogard's proposals. These proposals represent relatively minor deviations from plans previously analyzed and used in the formulation and optimization of the recommended plan. Mr. Bogard's proposals have been considered and found that they do not warrant additional development under this project.

I invite you to meet with members of my staff either in our offices or in the project area to review the planning process that your agency participated in and the plans that we together formulated and evaluated. Please contact Jim Bodron of my staff, the Project Manager, at 901-544-3639 for additional information.

Sincerely,

Daniel W. Krueger
Corps of Engineers
District Engineer

Copies Furnished:

Mr. Sam Hamilton, RD, FWS, Atlanta GA
Mr. Greg Cook, RA, EPA, Dallas, TX
Arkansas Soil and Water Conservation Commission
White River Irrigation Water Distribution District

United States Department of the Interior

FISH AND WILDLIFE SERVICE
1500 Museum Road, Suite 105
Conway, Arkansas 72032

IN REPLY REFER TO:

September 7, 1999

Colonel Daniel Krueger
District Engineer
Memphis District, U.S. Army Corps of Engineers
167 North Main Street, Suite 590
Memphis, TN 38103-1894

Dear Colonel Krueger:

Our agencies have recently become aware of a groundwater conservation proposal, entitled "Agricultural and Industrial Partnership for the Preservation of Arkansas Groundwater", developed by a coalition of Arkansas County Farmers and the International Paper Company. The proposed plan was submitted to the White River Irrigation Water Distribution District and the Arkansas Soil and Water Conservation Commission at a meeting in Stuttgart, Arkansas on August 9, 1999. Though not accepted by the Irrigation District, this plan has drawn a great deal of attention and support from local farmers and other conservationists.

The preliminary water conservation plan developed by the group addresses groundwater conservation through a partnership between agriculture and industry. The group's three phase approach begins with a reduction in the amount of water withdrawn from the Sparta aquifer by the International Paper Company. It includes reduction in the amount of water withdrawn from the alluvial and Sparta aquifers by farmers through on-farm water recycling and conservation, and finally addresses potential diversion of surface water from both the Arkansas and White Rivers.

The proposal is conceptual and lacks detail, however, the ideas presented warrant further evaluation. We request, therefore, that the Corps include this proposal in the suite of alternatives for the Grand Prairie Area Demonstration Project currently being evaluated through the NEPA process. We recommend that this new alterative receive a complete evaluation of costs, benefits, and impacts.

The citizen involvement that generated this proposal demonstrates the level of interest in water resource development issues in eastern Arkansas. It is appropriate that we respond to this interest with a careful and complete consideration of all serious proposals.

Sincerely,

Allan J. Mueller
U.S. Fish and Wildlife Service
Field Supervisor, Arkansas Field Office

William B. Hathaway
U.S. Environmental Protection Agency
Region 6, Director,
Water Quality Protection Division

c/Mr. Sam Hamilton, RD, FWS, Atlanta, GA
Mr. Greg Cook, RA, EPA, Dallas, TX
General Phillip Anderson, DE, USCE, Vicksburg, MS

J. Randy Young, P.E.
Executive Director

Arkansas Soil and Water Conservation Commission

101 EAST CAPITOL
SUITE 350
LITTLE ROCK, ARKANSAS 72201

PHONE 501-682-1611
FAX 501-682-3991

Statement by

J. Randy Young, Executive Director

Arkansas Soil and Water Conservation Commission

on

Bogard Proposal

I am encouraged in the recognition of Arkansas County's groundwater depletion problem by Arkansas county farmers and by International Paper's acknowledgement of the Sparta Aquifer depletion problem in Jefferson County and the willingness of these individuals to discuss these problems and potential solutions.

However, I'm struck by the lack of detail in the agriculture portion of the proposal presented by Mr. Bogard to the White River Regional Irrigation Water Distribution District (WRRIWDD) on August 9, 1999. While many of the concepts are similar to those developed by Memphis District U.S. Army Corps of Engineers in conjunction with WRRIWDD, the proposal contains no specifics on how its goals are to be met, no geographic boundaries can be determined, no detailed description on how groundwater savings is to be accomplished, and no estimates of the costs. The proposal envisions "50% of irrigation needs for designated crops from ground water" with expectations "that at least 25% of rice acres would be potentially benefited by use of excess surface water". The result would be either continued overdraft of both the alluvial and Sparta aquifers or reduced irrigated acreage. Neither is acceptable.

August 13, 1999

J. Randy Young, Executive Director

gricultural and ndustrial

artnership for the reservation of

rkansas roundwater

rkansas County Farmers

and

nternational aper

for

reservation of rkansas roundwate

August 9, 1999

Project Proposal

Executive Summary

Project Phase Descriptions

Executive Summary

- Upon approval International Paper Pine Bluff Mill (IP) joins a water district, to be formed, that will also include all or part of Arkansas County.

- The purpose of the new water district will be to conserve ground water and to implement business strategies, pertaining to the use of water, that will increase the competitive abilities to International Paper and Arkansas County farmers, in addition to, insuring the long term availability of Sparta Aquifer water to the citizens of Arkansas.

The proposed new water district will implement its plan for PRESERVATION OF ARKANSAS GROUNDWATER, (PAG), in three phases.

The implementation plan is anticipated to be completed within ten years from the date of the proposed water district being legally formed.

The successful implementation of the plan for PRESERVATION OF ARKANSAS GROUNDWATER being proposed by IP and Arkansas County farmers is contingent upon two significant events occurring prior to actual implementation.

1. The proposed White River Irrigation District MUST agree to Removing Arkansas County, now and forever more from its proposed current Irrigation District Plan.

2. Public funding amounting to fifty million dollars shall be secured and designated to be spent as set forth in the plan presented by the proposed but yet to be formed water district.

The public funding for the PLAN FOR PRESERVATION OF ARKANSAS GROUNDWATER should come from a portion of the money that has been appropriated for the proposed White River Irrigation District Plan earmarked for use in Arkansas County.

Upon removal of Arkansas County from the proposed White River Irrigation Districts' Plan, a cost savings amounting to approximately equal to that which would be required to fully implement the "PAG" would be realized by the proposed White River Irrigation District. Thereby, completely justifying a redirection of a portion of the proposed White River Irrigation District's federally appropriated funding.

If, for reasons presented by Congress, it is determined to be unfeasible that funding for the "PAG" cannot come from the proposed White River Irrigation District's authorized appropriation, those proposing the PLAN FOR PRESERVATION OF ARKANSAS GROUNDWATER will seek funding through other currently authorized spending bills.

NOTE: The funding formula for the implementation of PAG will be on a dollar for dollar cost share basis. Example: One dollar public funds matched by one dollar of private funds.

Organization Structure

In order to pursue a segregation of the Arkansas County agricultural irrigation water users interests in association with the Jefferson County industrial users it will be necessary to use one or more entities authorized under Arkansas statutory law to either create a new governmental entity or a furtherance of an existing entity.

Parts of Arkansas County and Jefferson County are within the bounds of districts already established under the Regional Water Distribution Act, A.C.A. S 14-116-10, et seq. Both counties also are within Soil and Water Conservation Districts established under the Conservation districts Law, A.C.A. S 14-125-10, et seq. Both of these statutory laws provide for an entity to accomplish the objectives of the proposed project and the fact that these districts already exist do not preclude creation of a new district for the project being considered.

As a result, in order to establish an entity through which the Arkansas County agricultural irrigation users can join with the Jefferson County industrial users to pursue their objective it would be necessary to:

First, remove the area from existing water Districts.

Second, establish a new District under either of the above laws for the project area

While the requirements for creation for each are a little different, generally, a minimum number of landowners will be required to petition either the Circuit Court or Arkansas Soil and Water Conservation Commission ("ASWCC") for creation. Even if the petition is filed with the court, ASWCC must approve of the creation of any such entity.

In Conclusion, the proposed compromise and cooperative arrangement will require:

1. Approval by ASWCC and existing Districts within which the project lies.
2. Approval by minimum number of landowners as well as ASWCC for creation of the new district.
3. Approval by the appropriate court of 1 and 2 which is usually only clerical provided all other agree with notice requirements depending upon the type of entity created.

PHASE I: PLAN FOR COMPETITIVE WATER CONVERSATION

- Upon project approval, International Paper agrees to implement a water conversation plan that will reduce IP's annual Sparta aquifer water withdraw by up to 90%.

- International Paper will, upon formation of the newly proposed water district, endeavor to complete the implementation of its conservation plan within two years.

- International Paper will receive, from the newly proposed district, funding based on a dollar for dollar cost share basis as set forth in the implementation plan presented by International Paper subject to the approval of the proposed and yet to be formed water district board.

- International Paper will share, on a percentage basis, 65% of funding derived from the public on an annual basis until such time that IP's portion of PAG has been fully implemented and IP has received funding from the proposed water district amounting to a dollar for dollar cost share.

- Landowners within the geographic boundaries of the proposed but yet to be formed water district that may or may not include all of Arkansas County will voluntarily participate in PAG.

- Said landowners will develop surface water storage impoundments equal to twenty acre feet of water or greater with tail water recovery capabilities or, implement a plan approved by the yet to be formed Water District, in return for which they will receive funding from the proposed but yet to be formed water district on a dollar for dollar cost share basis.

- All plans for the construction of PAG must be approved by the appropriate State and or Federal agencies that may or may not issue permits for projects involving water conservation prior to receiving approval from the proposed but yet to be formed water district seeking to implement PAG.

  Landowners within the proposed but yet to be implemented water district seeking to implement PAG will receive cost share funding on a first come first serve basis.

- The overall conservation goal of phase one of THE PLAN FOR PRESERVATION OF ARKANSAS GROUNDWATER is to reduce the annual withdraw of underground water within the geographic boundaries of the proposed but yet to be formed water district by thirty-five percent.

PHASE II: SUPPLEMENT SURFACE WATER FEASIBILITY STUDY

feasibility study will be required to best determine the most economic and environmentally friendly approach with which to take advantage of existing surface water supplies. It is the intent of the plan for the Preservation of Arkansas Groundwater, (PAG), to supplement existing surface water to areas of Arkansas county, as deemed feasible, by this study for use in production of rice and other crops requiring irrigation. The time estimated for the phase two study: One year.

NOTE: Refer to overview Process Phase III

PHASE III: EXCESS SURFACE WATER DEVELOPMENT

A. PURPOSE

Water conservation measures are generally considered to be more economically advantageous than the transportation of excess surface water due to the costs associated with transportation and due to the lack of reliable sources of excess surface water during times of use. However, there are some areas within the project which are close enough in proximity to sufficient sources of excess surface water to justify the construction and implementation of a transportation system to use excess surface water as a alternative to or supplement for water conservation measures.

B. OVERVIEW OF PROCESS

1. Identify all potential sources of excess surface water within or adjacent to project area within existing regulatory scheme. This should include both Arkansas and White River as well as their tributaries.
2. Develop cost estimate per acre foot transportation of excess surface water per .25 mile of transportation.
3. Comparison of costs of water conservation measure to costs of excess surface water transportation to identify areas within project that can use excess surface water at lower price than water conservation measures to develop target area for excess surface water on cost basis.
4. Comparison of available supply to usage by target area of project for refinement of target area due to supply limitations.
5. Further refine target area after reduction for supply limitations by combining use of excess surface water calculations with water conservation measures based upon cost-to-benefit analysis.
6. Finalize definition of target area within project by overlaying current regulatory scheme and topographical limitations where applicable.
7. Pursue necessary permits and land owner approval to permit transportation of excess surface water within target area.
8. Construction of excess surface water transportation system on a cost share basis in agreement with landowners within target area.

C. EXPECTATIONS

Based upon preliminary calculations within the project it is expected that at least 25% of rice acres would be potentially benefited by use of excess surface water. This would be expected to decrease water use 35,938 acre feet annually.

Estimated Groundwater Conservation Projections

Impact on All Groundwater

Impact on Sparta Aquifer

PLANNED WATER DISTRICT REGION

Groundwater Conservation Projections

Total Projected Groundwater Impact

USER GROUP	PRESENT Ground Water Usage	PLAN MATURITY Ground Water Usage
	Numbers in Billion Gallons	Numbers in Billion Gallons
International Paper Pine Bluff Consumption	12.92	1.29
Rice Farming Ground Water Needs	48.54	36.65
Other Crop Ground Water Needs	36.7	27.7
Net Impact on Groundwater Usage in the Plan District	0	-32.52
Total Annual Groundwater Usage	98.16	65.64

33% Reduction of Proposed Disctrict Groundwater Dependency from Partnership Projects!

Assumptions:

- Numbers represent 50% of irrigation needs for designated crops from groundwater
- 70% of farmers in the district participate in the PLAN

Note: Funding under the PLAN is not restricted to rice farming. Projects are subject to approval of the District Board.

PLANNED WATER DISTRICT REGION

Groundwater Conservation Projections

SPARTA AQUIFER IMPACT

USER GROUP	PRESENT Ground Water Usage	PLAN MATURITY Ground Water Usage
	Numbers in Billion Gallons	Numbers in Billion Gallons
International Paper Pine Bluff Consumption	12.92	1.29
Rice Farming Ground Water Needs	24.27	18.32
Other Crop Ground Water Needs	18.35	13.85
Net Impact on Groundwater Usage in the Plan District	0	-22.08
Total Annual Groundwater Usage	55.54	33.46

40% Reduction of SPARTA AQUIFER Groundwater Dependency from Partnership Projects!

Assumptions:

- Numbers represent 50% of irrigation needs for designated crops from groundwater
- 50% of all groundwater is Alluvial, 50% Sparta
- 70% of farmers in the district participate in the PLAN

Note: Funding under the PLAN is not restricted to rice farming. Projects are subject to approval of the District Board.

IN REPLY REFER TO:

United States Department of the Interior

FISH AND WILDLIFE SERVICE
1500 Museum Road, Suite 105
Conway, Arkansas 72032

1849-1999

May 13, 1999

Colonel Daniel W. Krueger
District Engineer
U.S. Army Corps of Engineers
167 North Main St., Room B202
Memphis, TN 38103-1894

Dear Colonel Krueger:

The Fish and Wildlife Service (Service) has reviewed the Eastern Arkansas Region Comprehensive Study, Grand Prairie Area Demonstration Project (GPADP), Draft General Reevaluation Report (GRR) and Environmental Impact Statement (EIS), dated July 1998. As agreed between Mr. Edward Lambert and members of our Vicksburg office, the Memphis District presented endangered/threatened species impact assessments in the body of the draft EIS, not in separate biological assessments. In these assessments the Memphis District concluded that the proposed project plan should not adversely affect any threatened or endangered species, or their critical habitat. Our comments are submitted in accordance with the Endangered Species Act (ESA) (87 Stat. 884, as amended 16 U.S.C. 1531 et seq.).

Threatened (T) or endangered (E) species that could be impacted by, or be present in, the GPADP area are as follows:

T: bald eagle (*Haliaeetus leucocphalus*): The eagle is a winter resident and nests in some areas along the White River.

E: pallid sturgeon (*Scaphirhynchus albus*): A far ranging fish that could potentially occur within the White River.

E: Curtis' pearly mussel: (*Epioblasma flotentina curtisi*) and fat pocketbook pearly mussel (*Potamilus capax*): Though known to historically occur in the White River, these mussels have not been collected in recent mussel surveys on the White.

E: least tern (*Sterna antillarum*): Though the tern is known to nest on sandbars in the river, no colonies are known to be in the study area.

E: pink mucket pearly mussel (*Lampsilis abrupta*): Has been known to inhabit the study area reach; Christian (1995) collected this species at Lambert's Landing Bend (river mile 63.5) and near Clarendon (river mile 99.0).

In the draft EIS, the Corp states that because "the pink pearly mussel does not occur at depths less than approximately 10 feet below the water surface at low water....no adverse impacts to this mussel should occur as a result of this plan. Prior to construction of the pump station inlet channel, mussels would be removed from the portion of the White River within the construction impact zone and released in other areas of the river with suitable habitat." (EIS-75) The Service disagrees with the finding of no adverse impacts for this mussel. The pump station inlet channel would be located between river mile 122 and 123. Pink mucket pearly mussles have been found both upstream and down stream of this area. Therefore, we recommend that a biological assessment be made for the endangered pink mucket pearly mussel. As part of the biological assessment, the Service recommends that a mussel survey be done in and around the proposed intake to allow an evaluation of the habitat and to locate all mussel beds.

With the exception of the pink mucket pearly mussel, the Service concurs with your determination that the proposed project would not adversely affect the aforementioned endangered or threatened species. We appreciate the opportunity to comment and look forward to working with you on the GPADP.

Sincerely,

Allan J. Mueller
Field Supervisor

cc:

Arkansas Game and Fish Commission, Little Rock, Arkansas
Attn: Bob Leonard
Arkansas Soil and Water Commission, Little Rock, Arkansas
Attn: Joseph Krystofik
Arkansas Department of Environmental Quality
Attn: Steve Drown
Arkansas Natural Heritage Commission, Little Rock, Arkansas
Attn: Cindy Osborne
Environmental Protection Agency, Dallas, Texas
Attn: Laura Talbot

IN REPLY REFER TO

United States Department of the Interior

FISH AND WILDLIFE SERVICE
2524 South Frontage Road, Suite B
Vicksburg, Mississippi 39180-5269

May 8, 1998

Colonel Gregory G. Bean
District Engineer
167 North Main St., Room B-202
Clifford Davis Federal Building
Memphis, Tennessee 38103-1894

Dear Colonel Bean:

This is the U.S. Fish and Wildlife Service's final report prepared in response to the Memphis District's Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area). Our report assesses the impacts of the proposed project on fish and wildlife resources, identifies measures to adequately mitigate resource losses, and outlines conservation measures to address fish and wildlife resource concerns. Our report has been prepared in accordance with the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661-667e.). In keeping with the requirements of the FWCA, this report should be attached to and made an integral part of any report released for public review or forwarded to Congress for consideration.

Sincerely,

Allan J. Mueller
Field Supervisor

cc. Arkansas Game and Fish Commission, Little Rock, AR
Arkansas Natural Heritage Commission, Little Rock, AR
Natural Resources Conservation Service, Little Rock, AR
FWS, Regional Office, Atlanta, GA
White River National Wildlife Refuge, DeWitt, AR
Cache River NWR, Augusta, AR
Environmental Protection Agency, Dallas, TX
Arkansas Field Office, FWS, Little Rock, AR
Norfork National Fish Hatchery, Mountain Home, AR
Greers Ferry National Fish Hatchery, Heber Springs, AR
Mammoth Springs National Fish Hatchery, Mammoth Springs, AR

A Fish and Wildlife Coordination Act Report

on the

General Reevaluation of the Grand Prairie Subarea Eastern Arkansas Region Comprehensive Study

Prepared by

Daniel Gregg and Larry Marcy
U.S. Fish and Wildlife Service
Vicksburg Field Office
Vicksburg, Mississippi

May 1998

Executive Summary

This Fish and Wildlife Coordination Act (FWCA) report contains the findings and recommendations of the U.S. Fish and Wildlife Service (Service) pertaining to the Memphis District, U.S. Army, Corps of Engineers' (Corps) Grand Prairie Subarea, Eastern Arkansas Region Comprehensive Study Reevaluation. It has been prepared and is submitted in accordance with the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661-667e). This report discusses the impacts of the authorized project on the fish and wildlife resources, outlines conservation measures to address fish and wildlife resource concerns, and recommends mitigation measures to offset unavoidable fish and wildlife resource losses. This report constitutes the report of the Service as required by Section 2(b) of the Act.

The study area is located within Arkansas, Prairie, Lonoke, and Monroe Counties, Arkansas within the White River drainage basin. The aquatic system of the White River, its tributaries, and oxbow lakes is diverse and includes approximately 150 species of endemic fishes and freshwater mussels. Principal game, commercial, and important species inhabiting these water bodies include white crappie, channel and flathead catfish, largemouth bass, bluegill, big and smallmouth buffalo, paddlefish, shovelnose sturgeon, shorthead redhorse, alligator gar, blue sucker, sauger, crystal darter, and black shiner.

Important wildlife habitats within the 362,660 acre study area consist of 19,930 acres of bottomland hardwood forests and 14,940 acres of forested uplands. In addition to the bottomland hardwoods, flooded rice and soybean fields provide important feeding and resting areas for wintering waterfowl. Both migratory and resident waterfowl are present in the study area. Wood ducks, although migratory, are also permanent residents, since they nest and raise their young in the study area. The mallard is the most numerous waterfowl species in the area, but other important waterfowl species dependent upon this area for food and cover include northern pintail, teal, gadwall, American wigeon, black duck, canvasback, ring-necked duck, and snow and Canada geese. The forested wetlands and uplands within the project area also provide essential habitat for game, nongame, and furbearing species including eastern wild turkey, white-tailed deer, fox and gray squirrel, swamp and cottontail rabbit, hawks and owls, mourning dove, migratory songbirds, raccoon, opossum, beaver, mink, and muskrat.

The Eastern Arkansas Region Comprehensive Study was conducted jointly by the Corps of Engineers' Memphis District and the Natural Resources Conservation Service. The reconnaissance phase report and the feasibility report indicated that several agricultural water supply and conservation plans were feasible. However, the study was terminated because Corps policy does not consider agricultural water supply a high priority mission. The Corps was directed by Congress to select and develop implementation plans for one area to serve as an agricultural water supply demonstration project. The Grand Prairie subarea was selected because alluvial aquifer depletion is comparably more severe within this area of eastern Arkansas. The General Reevaluation will evaluate alternative measures to provide a plan for agricultural water

supply, water conservation, and fish and wildlife habitat restoration. Preservation and protection of groundwater resources is a major objective of the project.

Four alternative plans were investigated in detail. All plans incorporate water conservation measures and on-farm water storage with an irrigation water import system. The plans include features for restoring native prairie and providing additional waterfowl foraging habitat. The tentatively selected plan (Alternative 7B) is also the National Economic Development (NED) Plan and includes a water import system to divert approximately 258,381 acre-feet of water per year from the White River via a 1,640 cubic feet per second (cfs) pumping plant located north of DeValls Bluff. A system of new canals (184 miles), pipelines (177 miles), existing channels (291 miles), and associated structures [weirs (120), diversion structures (165), inverted siphons (28) and lift stations] would be used to transfer water to 8,849 acres of new on-farm irrigation reservoirs and tail-water recovery systems.

Construction of the water distribution system would result in the loss of approximately 124 acres of forested uplands (54 permanently and 70 temporarily) and approximately 122 acres of forested wetlands (62 permanently and 60 temporarily). In order to offset these losses, the Corps proposes to acquire and reforest approximately 243 acres of farmed wetlands and 193 acres of prior converted croplands. Based on the Habitat Evaluation Procedures (HEP) analysis (a methodology for evaluating impacts on fish and wildlife resources), approximately 245 acres of farmed wetlands and approximately 200 acres of prior converted croplands would have to be acquired to compensate for the loss of forested wetlands and uplands. The Corps mitigation plan would adequately mitigate for the loss of forested wetlands and forested uplands. Specific mitigation areas will be coordinated with the Service and the Arkansas Game and Fish Commission.

Additionally, the Corps proposes to flood 38,529 acres of harvested rice fields each winter as a waterfowl management component of the project. Based on waterfowl methodology developed by the Service to quantify the impacts to waterfowl, the flooding of this acreage would provide 22,385,349 duck-use-days (DUDs)(38,529 acres x 581 DUDS per acre = 22,385,349 DUDs). It is estimated that the project area would annually provide 10,109,400 DUDs (17,400 acres of rice fields flooded x 581 DUDs per acre) under future without-project conditions. Therefore, the Corps proposal would provide an additional 12,275,949 DUDs per year (22,385,349 minus 10,109,400 = 12,275,949 DUDs). Based on the above information, the project would provide additional benefits to waterfowl. Shorebirds would also benefit from flooded crop fields and on-farm reservoirs. The Service compliments the Corps for including this feature in the tentatively selected plan.

Construction of the project right-of-way would result in the loss of two acres of natural prairie habitat. However, as an environmental design feature, the Corps proposes to acquire remnant prairie areas in fee title. Acquisition efforts will be coordinated with the Arkansas Natural Heritage Commission to identify high priority acquisition sites. The Corps also proposes to restore vegetation within approximately 300 miles of canal right-of-way (ROW) on an area of

3,000 plus acres. More information needs to be provided about the long term management and assessment of prairie restoration. It will be important to develop objective, quantitative criteria for the long term goals of the project rather than to evaluate the project based on initial effort. In order for the proposal to result in significant benefits to wildlife, prairie habitat should be restored on land adjacent to remnant prairies rather than spread out over 300 miles of canal ROW.

Water withdrawals from the White River would have minor impacts on the connectivity of four oxbow lakes to the White River when pumping occurs during median flows. Pumping could reduce discharge below the 75 percent exceedance baseline value but remain above minimum flows during July and August. However, the Arkansas State Water Plan (Arkansas Soil and Water Conservation Commission 1988) would prohibit pumping at low flows (75 percent exceedance value) so connectivity of lakes would not be affected during summer and fall months. During low flow conditions, differences between the Arkansas State Water Plan minimums and post project flows should be monitored to insure that state minimums are maintained and suitable depths exist for fish passage. To protect the fisheries of the White River, the Service believes a modified habitat evaluation procedure or similar instream flow study using existing data should be conducted for the White River. The pumping plant should be operated in compliance with the minimum flow needs identified by the study. The Service also believes that water withdrawal rates should be in compliance with water allocation levels proposed by the Arkansas Soil and Water Conservation Commission (1988) in order to protect the fisheries of the White River.

Pumping water from the White River would also result in entrainment of larval fish drifting in the water column of the inlet canal. Entrainment is projected to be 1.2 percent of larval fish during May up to 12.4 percent in July. However, a post construction monitoring program should be designed and implemented to more accurately estimate entrainment of larval fishes.

Smith *et al.* (1996) found that, in general, surface water from the White River is similar in quality to the ground water. They concluded that diversion of surface water for irrigation should not adversely impact fish and aquatic life and that water quality should be monitored after the project is implemented. However, since irrigation water may be recovered (tail water recovery systems would be installed on those farms with reservoirs) from cropland and reused, we are concerned that irrigation water may accumulate elevated levels of contaminants. Conducting contaminant surveys before and after project completion are necessary to insure that contaminant levels are kept at low levels in the irrigation water.

Pumping water from the White River would likely introduce zebra mussels into other streams and bayous of the area. The Corps should examine alternative water supply sources that are free from zebra mussels.

We have identified several serious existing fish and wildlife resource concerns in the project area. These include: (1) declining productivity of stream fisheries; (2) pollution from point and non-point sources; (3) reduction in wintering waterfowl habitat; (4) reduction of forested areas used by neotropical migrants; (5) declining grassland habitat and grassland birds; (6) preservation and

enhancement of shorebird habitat; and (7) spread of non-native zebra mussels. We believe that several specific conservation measures should be incorporated into the selected plan to address these concerns. These specific conservation measures include: (1) design on-farm reservoirs to benefit shorebirds; (2) install best management practices on agricultural land; (3) install weirs and grade control structures in the new canals, properly design canals, and provide access to the new canals; (4) install overfall pipe structures at the mouth of small streams and field ditches; and (5) revegetate the channel rights-of-way.

Although the Grand Prairie Demonstration project is the only authorized project, it is only one of five irrigation projects proposed as part of the overall Eastern Arkansas Project. Two other irrigation projects would withdraw water from the White River in addition to the Grand Prairie Demonstration project, one would withdraw water from Bayou Meto, and one would withdraw water from the Little Red River. Impacts associated with the other segments have not been addressed. If future projects withdraw water from the White River, and have similar construction requirements, cumulative, adverse impacts on fish and wildlife resources could result. Therefore, cumulative impacts from all five projects should be addressed.

To protect and improve fish and wildlife resource values of the Grand Prairie area, the Service recommends the following mitigation measures:

1. Conduct a proportional analysis study, instream flow incremental methodology, or similar instream flow study to determine minimum instream flows to protect the fisheries of the project area streams and oxbow lakes, and manage water withdrawal in compliance with minimum flow needs.

2. Operate the project to comply with the water allocation levels proposed by the Arkansas Soil and Water Conservation Commission:

3. Institute a larval fish monitoring program to more accurately measure entrainment of larval fishes.

4. Explore alternative sources of water supply that are not infested with zebra mussels.

5. Acquire in fee title and intensively reforest 245 acres of farmed wetlands and 200 acres of prior converted croplands. Management of mitigation lands should be at project expense over the 50 year life of the project.

6. Conduct contaminant surveys before and after project completion to insure that contaminant levels do not become elevated in the irrigation water.

7. Locate irrigation canals and on-farm reservoirs away from wetlands and natural heritage sites.

8. Develop objective, quantitative criteria for the long term goals of prairie restoration, rather than evaluate the project based on initial effort, and monitor restoration efforts.

The Service also recommends the following specific conservation measures be implemented to address the fish and wildlife resource concerns:

1. Design on-farm reservoirs to benefit shorebirds.

2. Install BMPs on agricultural land to reduce channel maintenance and improve water quality.

3. To increase fish and wildlife habitat and use of the resources, install weirs and grade control structures in the new canals, properly design canals, and provide public access to the new canals.

4. Install overfall pipe structures at the mouth of small streams and farm ditches to improve water quality and reduce channel maintenance.

5. Revegetate the channel ROW to increase wildlife habitat and opportunities for recreational pursuits.

6. Restore prairie habitat by acquiring remnant prairie and increase the acreage of prairie habitat by revegetating adjacent land with prairie species.

7. Address cumulative impacts of all five irrigation projects proposed in the Eastern Arkansas Project.

The Service has no objections to the continuation of the Grand Prairie Subarea, Eastern Arkansas Region Comprehensive Study provided that the previously discussed compensation measures are incorporated into project planning. Inclusion of our planning objectives and incorporation of our specific conservation measures are essential for addressing the serious fish and wildlife resources concerns outlined in this report.

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INTRODUCTION

This is the U.S. Fish and Wildlife Service's (Service) draft Fish and Wildlife Coordination Act (FWCA) report on the Grand Prairie subarea of the Eastern Arkansas Region Comprehensive Study (EARCS). The Comprehensive Study has been divided into five subareas which correspond to the five project areas identified by the Memphis District during feasibility studies. These five areas encompass all or parts of 24 counties in Eastern Arkansas and include: (1) Grand Prairie, (2) Bayou Meto, (3) White River, (4) Little Red River, (5) and the Black River subareas This report describes fish and wildlife resources, concerns, and planning objectives in the study area; evaluates alternative plans; discusses adequate mitigation measures; and discusses potential fish and wildlife conservation measures. It has been prepared with the assistance of the Arkansas Game and Fish Commission (AGFC) and is submitted in accordance with the Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. 661-667e) and the Endangered Species Act (87 Stat. 884, as amended U.S.C. 1531 et seq.).

The Eastern Arkansas Region Comprehensive Study was conducted jointly by the Corps of Engineers' Memphis District and the Natural Resources Conservation Service (NRCS) under authority of a September 1982 resolution of the Committee on Public Works and Transportation of the U.S. House of Representatives. The reconnaissance phase report completed in March 1985 and the feasibility report indicated that several agricultural water supply and conservation plans were feasible. However, the feasibility study was terminated because Corps policy does not consider agricultural water supply a high priority mission. The General Reevaluation for the Grand Prairie subarea is being conducted in response to Congressional direction contained in FY 92, 93, 94, 95, 96, and 97 Energy and Water Development Appropriations Acts and the President's FY 97 budget. The Corps was directed to select and develop implementation plans for one area to serve as an agricultural water supply demonstration project. The Grand Prairie subarea was selected because alluvial aquifer depletion is comparably more severe within this area of Eastern Arkansas. The General Reevaluation will evaluate alternative measures to provide a plan for agricultural water supply, conservation, and fish and wildlife restoration. Preservation and protection of groundwater resources is a major objective of the project (U.S. Army Corps of Engineers 1992).

PRIOR REPORTS

Several reports have been written by the Service on the Eastern Arkansas Region Comprehensive Study. The findings of the most pertinent reports are summarized below.

1984 - FWCA Planning Aid Letter

The Service provided the Corps current and projected bottomland hardwood acreage for the counties in the study area.

January 1985 - FWCA Planning Aid Letter

The Service submitted to the Corps the current acreage in national wildlife refuges and state wildlife management areas as well as projected federal and state land acquisition in the study area.

May 1985 - FWCA Planning Aid Report

The Service identified data gaps relative to instream flows, water quality, and winter water. The letter recommended instream flow studies, a study to determine the feasibility of implementing best management practices to improve water quality, and a study to determine winter water needs for waterfowl.

January 1989 - FWCA Planning Aid Report
The Service identified fish and wildlife problems and needs for the Eastern Arkansas Region Reevaluation Study and discussed potential conservation measures.

March 1989 - FWCA Planning Aid Report
The Service identified fish and wildlife problems and needs for the Bayou Meto subarea and discussed potential conservation measures.

September 1990 - FWCA Report
The Service identified fish and wildlife problems and needs for the Eastern Arkansas Region Study and discussed potential conservation measures.

October 1993 - FWCA Planning Aid Report
The Service identified fish and wildlife problems and needs for the Grand Prairie segment of the Eastern Arkansas Region Study.

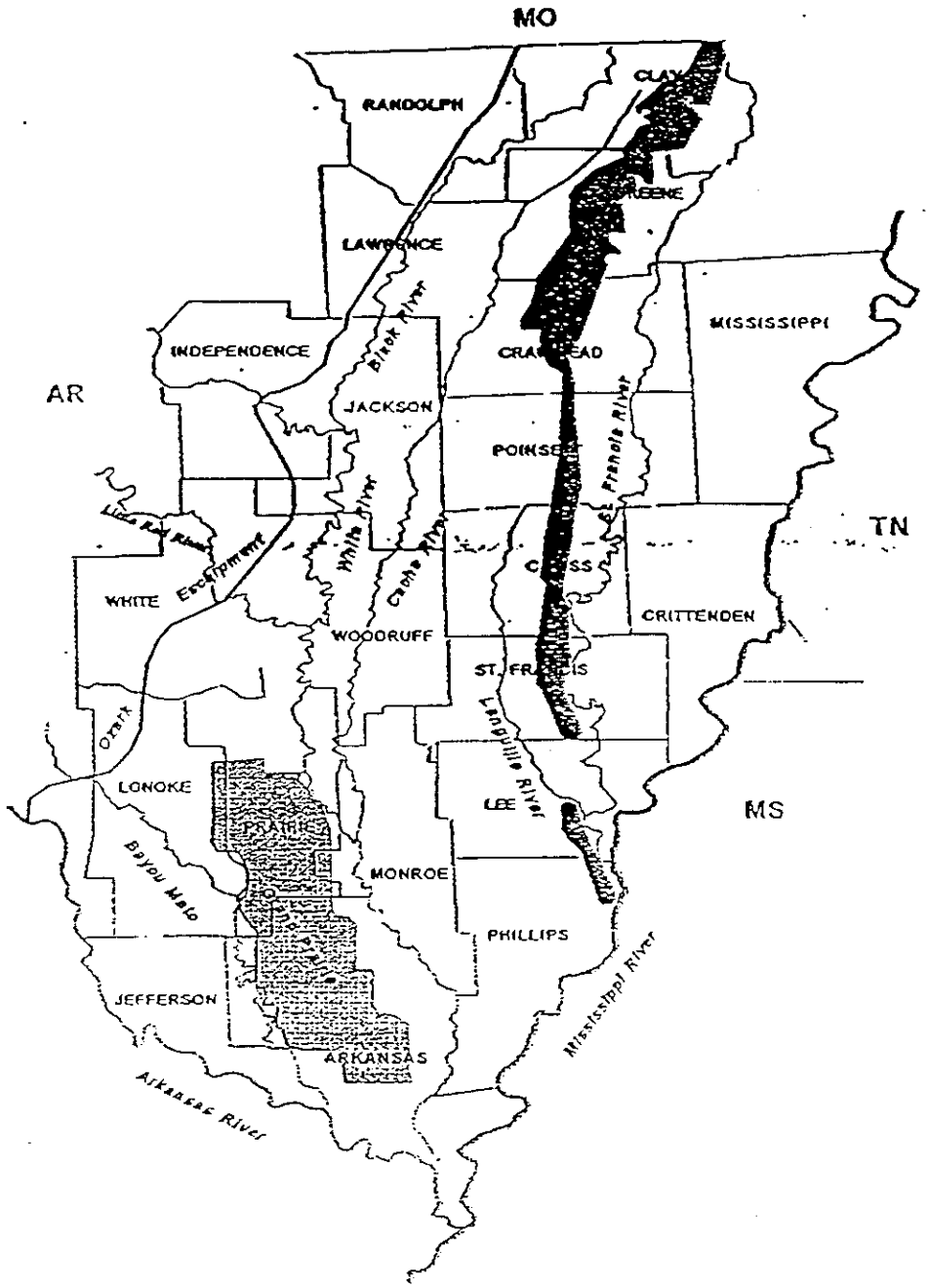
STUDY AREA DESCRIPTION

The Grand Prairie study area encompasses approximately 362,700 acres and is located within portions of Arkansas, Prairie, Lonoke, and Monroe Counties, Arkansas (Figure 1). Agricultural land comprises approximately 70 percent (254,406 acres) of the study area (Natural Resources Conservation Service 1992). This is a major rice and soybean producing area relying heavily on groundwater to irrigate crops. In addition to land in agricultural production, other important land uses include urban, water, and forest.

Most of the water acreage consists of the middle reach of the White River and its associated oxbow lakes, tributary streams, and reservoirs. The study area portion of the White River extends approximately 69.9 miles, from I-40 downstream to St. Charles. Major tributary streams include Hurricane Bayou, Honey Creek, Little LaGrue Bayou, LaGrue Bayou, Mill Bayou, and numerous smaller intermittent streams. Sixty to seventy percent of reservoirs in the project area are multipurpose irrigation reservoirs which are also managed for sportfish. Jacobs Lake and Peckerwood Lake, which are both multipurpose reservoirs for irrigation, are also managed for fishing and waterfowl hunting. Jacobs Lake is on the lower reach of Mills Bayou, and Peckerwood Lake is on the upper reach of LaGrue Bayou.

The forested land is composed of bottomland hardwoods, shrub swamps, brushy areas adjacent to streams, and upland hardwoods. The vast majority of bottomland hardwoods is found within the

Figure 1. ***GRAND PRAIRIE AREA DEMONSTRATION PROJECT***



19,596 acre Wattensaw State Wildlife Management Area (WMA), the 154,000 acre White River National Wildlife Refuge (NWR), and the 42,000 acre Cache River NWR. These public lands support a wide diversity of wildlife and provide opportunities for many outdoor recreational opportunities including hunting and fishing, bird watching, camping, and hiking. In 1989, public lands within the Cache/Lower White River were dedicated as "Wetlands of International Importance" under the auspices of the "Convention on Wetlands of International Importance Especially as Waterfowl Habitat," commonly referred to as the Ramsar Convention. In addition, large, privately owned wooded tracts are found along Mills Bayou and Little LaGrue Bayou.

Historically, the Grand Prairie of Arkansas was approximately 20 miles wide and 70 miles long, extending over 500,000 acres in portions of four counties. The vegetation of the prairie was typical of the vast tall grass prairie that extended north from portions of northeast Texas through Oklahoma, Kansas, Nebraska, northwest Missouri, Ohio, Iowa, and Illinois (Stolzenburg 1996). Today, only small, scattered pockets of prairie vegetation remain in the study area. Dominant prairie grasses include big bluestem (*Andropogon gerardi*), switchgrass (*Panicum virgatum*), Indian grass (*Sorgastrum avenaceum*), and little bluestem (*Schizachyrium scoparium*).

As mentioned previously, the Grand Prairie is a major rice and soybean producing area, which relies heavily on groundwater to irrigate crops. Ninety-four percent of the cropland in this area is presently irrigated (U.S. Army Corps of Engineers 1992). The extensive use of ground water for irrigation is depleting the Mississippi Alluvial Aquifer, the principal source of irrigation water for most farmers in the area. The present annual irrigation demand is 481,195 acre-feet, and approximately 408,007 acre-feet was removed from the alluvial aquifer in 1995 for agricultural purposes. The Eastern Arkansas Water Conservation Project (EAWCP) (NRCS 1992), the Arkansas State Water Plan (Arkansas Soil and Water Conservation Commission 1988), and several United States Geological Survey (USGS) studies have reported average annual ground water level declines of 0.5 to 0.7 feet per year (USGS 1984, 85, 86, 87, 89). The recharge rate has been as little as one inch or less per year. Under future without project conditions, it is estimated that only 8.7 percent of the water currently removed from the Mississippi Alluvial Aquifer will be available to farmers for irrigation by the year 2015. The proposed project would preserve the groundwater resource by using surface water sources to sustain the region's farm based, irrigation intensive economy. Under future with project conditions, at year 2015 and beyond, approximately 88 percent (209,046 acres) of the currently irrigated cropland would be irrigated. However, under future without project conditions, at year 2015 and beyond, only 26.6 percent (55,606 acres) of the currently irrigated cropland would be irrigated.

FISH AND WILDLIFE RESOURCES

Fisheries and Other Aquatic Resources

Fishery resources include single and multipurpose reservoirs, the White River, oxbow lakes, and tributary streams. Only a small portion of the White River and adjacent oxbow lakes are located in the study area; however, they are discussed in this report because the proposed plan could impact these important resources. The single purpose reservoirs contain minimal fishery values

due to shallow water depths, sediment deposition, and agricultural runoff. However, the fisheries of the multipurpose reservoirs (Jacobs and Peckerwood Lakes) are of good quality due to adequate water depths, less sediment deposition and agricultural runoff, and water level management.

The warmwater fisheries of the White River, oxbows, and tributaries vary from fair to excellent in quality. The ichthyofauna of these water bodies are extremely diverse and includes a great number of endemic fishes (Cross *et al.* 1986). The river basin has 150 recorded species, making this the most species rich fish fauna of the 18 drainages comprising the Western Mississippi Basin. The diverse taxa include minnows (39 species), darters (29 species), sunfishes (18 species), and suckers (17 species). Kilgore *et al.* (1997) collected 63 species of fish within the study area. These fish were represented by 16 species of minnows, 15 species of sunfish, and 8 species of darters. Approximately 47 species were observed in the White River channel, 34 in the tributaries, and 22 in the oxbow lakes. Fishes of these water bodies tolerate physical habitat alterations caused by varying degrees of sediment deposition and agricultural runoff (Jester *et al.* 1992). Principal game, commercial, and forage species inhabiting these water bodies include white crappie (*Pomoxis annularis*), channel and flathead catfish (*Ictalurus punctatus* and *Pylodictis olivaris*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), big and smallmouth buffalo (*Ictiobus cyprinellus* and *Ictiobus bubalus*), paddlefish (*Polyodon spathula*), shovelnose sturgeon (*Scaphirhynchus platorynchus*), shorthead redhorse (*Moxostoma macrolipidotum*), alligator gar (*Atractosteus spatula*), blue sucker (*Cycleptus elongatus*), crystal darter (*Ammocrypta asprella*), and blacktail shiner (*Notropis venustus*).

Thirty-four species of mussels, including the endangered pink mucket pearly mussel (*Lampsilis abrupta*), were collected during a recent mussel survey of the White River from the vicinity of Batesville, Arkansas, to its mouth (Christian 1995). This study identified numerous mussel beds within the study area reach of the river. Mussel densities in these beds range from one mussel per square meter to greater than ten mussels per square meter. These findings indicate that the White River could sustain a commercial harvest of mussels.

Service biologists also conducted surveys during 1996 on La Grue Bayou and its tributaries at over 15 bridge crossings for the presence of freshwater mussels and to evaluate habitat conditions. Mussels were encountered only in the mainstem La Grue Bayou at five locations below Peckerwood Lake. Live animals or fresh shells of 12 unionid mussel species, and a few shells of the Asian clam were collected (Table 1). There was no evidence of any endangered mussels occurring in the area. Virtually all tributary locations examined, including Little La Grue Bayou, were modified by channelization and/or by small impoundments for irrigation. Although there was suitable habitat, no mussels were found in these modified areas, apparently due to seasonally inadequate flows. Although mussels were once harvested commercially on LaGrue Bayou, the resource no longer supports this use. The primary factors currently limiting mussel fauna in the La Grue Bayou drainage include tributary modification, agricultural runoff, and periodic low flows.

Table 1. Mussel Species Observed in La Grue Bayou and Tributaries During Surveys in 1996.

Mussel Species	
*Pygadon grandis**	*Potamilus purpuratus**
*Quadrula quadrula**	*Truncilla truncata*
Lepotodea fragilis	*Ligumia subrostrata*
*Toxolasma texasensis**	*Lampsilis teres**
*Megalonaias nervosa**	*Plectomerus dombeyanus*
Fusconaia ebena	*Villosa lienosa*

* Live collections

During future without project conditions, the water quality of the water bodies in the middle and lower reach of the study area will likely increase. This prediction is based on the belief that a significant portion of the highly erodible land has, and will be, included in the U.S. Department of Agriculture's Conservation Reserve Program (CRP), and as a result, sediment deposition in the water bodies will be reduced. The Wetland Reserve Program (WRP) is also expected to protect water bodies by helping to preserve wetlands which filter out sediments and pollutants, thereby improving water quality for fish and wildlife. Minimal acreage is enrolled in CRP at the upper end of the project area. Therefore, fishery values for the streams in the upper reach of the study area will probably decrease because of continual deposition of sediment and agricultural chemicals in the streams.

Wildlife Resources

Before settlement by Europeans and Africans, the Mississippi River floodplain was an intricate maze of bottomland hardwood forests, swamps, and bayous, and historically, the largest forested wetland in North America. The transformation of this vast forest into agricultural use was gradual, yet deliberate. Most of the Mississippi Alluvial Valley (MAV), including Eastern Arkansas, was subject to periodic flooding by the Mississippi River and its tributaries. Hydrologic relationships in the MAV have been altered by federally funded water resources developments for flood control and agriculture (Goldstein 1988, Reinecke *et al.* 1988). The cumulative effect of these actions has reduced the original 24.9 million acres of bottomland hardwoods in the MAV to 5.2 million acres (Forsythe and Gard 1980), a loss of nearly 80 percent. In Arkansas, bottomland hardwoods comprised 9.8 million acres (29 percent of the surface area) in the early 1780's (Dahl, 1990). By 1980, 7.1 million acres had been converted to agricultural production (72 percent loss). An additional 210,000 acres of bottomland hardwoods were converted by the mid-80's (Hefner *et al.* 1994).

The remaining bottomland hardwoods interspersed with frequently flooded agricultural land in Eastern Arkansas constitute some of the most important waterfowl habitat in the state. The Grand Prairie region and associated White River bottoms is perhaps the most important wintering area in North America for mallards (*Anas platyrhynchos*) (Nichols *et al.* 1983). Of the 3,100,000 mallards that winter in the Mississippi Flyway, approximately 1,000,000 winter in Eastern Arkansas (Gamble 1997). The Eastern Arkansas region, including Grand Prairie, also provides breeding and wintering habitat for a large wood duck (*Aix sponsa*) population, which although difficult to census, may easily exceed one million birds in winter (Bellrose and Holm 1994). Other waterfowl species are also dependent upon the study area's forested wetlands and flooded agricultural fields for food and cover including northern pintail (*Anas acuta*), blue-and green-winged teal (*Anas discors* and *Anas crecca*), gadwall (*Anas strepra*), American wigeon (*Anas americana*), black duck (*Anas rubripes*), canvasback (*Aythya valisineria*), ring-necked duck (*Aythya collaris*), and snow and Canada geese (*Chen caerulescens* and *Branta canadensis*). The forested wetlands provide vital waterfowl resting areas. Mallards, wood ducks, and the other species use the wooded wetlands for foraging as well as for cover from inclement weather and predators. The isolation provided in wooded wetlands is critical for pair bonding (Reinecke *et al.*

1988). Further details on wintering waterfowl biology, behavior, and habitat requirements are found in Appendix A.

Carney *et al.* (1983) found that Arkansas has, for many years, consistently harvested more mallards than any other state in the nation. Arkansas County, within the Grand Prairie region, has had the highest mallard harvest of any county in the nation (Service 1995). Thus, the recreational aspects of waterfowl hunting in the study area are very important. Waterfowl hunting draws hunters from throughout the nation and makes a significant contribution to the economy of the study area.

A diverse assemblage of shorebirds breed, migrate, and winter throughout the Grand Prairie. Among the more common species of shorebirds are the killdeer (*Charadrius vociferus*), long and short-billed dowitchers (*Limnodromus scolopaceus* and *Limnodromus griseus*), common snipe (*Gallinago gallinago*), least sandpipers (*Calidris minutilla*), and lesser and greater yellowlegs (*Tringa melanoleuca* and *Tringa flavipes*). A more detailed discussion on the biology and habitat of shorebirds is found in Appendix B.

Forested wetlands are highly integrated, open systems with continuous inflow and outflow of sediments, nutrients, and aquatic and terrestrial species (Moulton 1990). Furthermore, bottomland hardwoods are extremely important as a component in the life cycle of many wildlife species (Glasglow and Noble 1971). Squirrels reach their highest densities in the habitat provided by mature mast trees. Both gray and fox squirrels (*Sciurus carolinensis* and *Sciurus niger*) are found in the study area. Furbearers such as mink (*Mustela vison*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), beaver (*Castor canadensis*), bobcat (*Felis rufus*), striped skunk (*Mephitis mephitis*), gray and red fox (*Urocyon cinereoargenteus* and *Vulpes vulpes*), and river otter (*Lutra canadensis*), are found in the bottomland hardwoods and riparian areas. White-tailed deer (*Odocoileus virginianus*) reach some of their highest densities in this diverse habitat. Black bear (*Ursus americanus*) and eastern wild turkey (*Meleagris gallopovo*) are found in the extensive wooded area along the White River. Many nongame species such as small mammals, neotropical migratory birds, songbirds, and raptors find ideal habitat in the forested wetlands and riparian areas. Although less productive, the agricultural lands of the study area also support small mammals, mourning dove (*Zenaida macroura*), and edge species.

The Service has determined that the bottomland hardwoods in the study area are Resource Category 2 habitat. Resource Category 2 habitat is of high value for evaluation species and is relatively scarce on a national basis or in the ecoregion. The mitigation goal for Resource Category 2 habitat is no net loss of in-kind habitat value. The Service anticipates that the extent and quality of bottomland hardwoods in the study area should increase due to the Wetland Reserve Program. Additionally, winter flooded cropland within the project area provides valuable winter foraging habitat for resident and migratory waterfowl.

Endangered and Threatened Species

The Endangered Species Act (87 Stat. 884, as amended U.S.C. 1531 et seq.) requires that an official list of endangered and threatened species be requested for any potential federal

construction project. The federally listed endangered pink mucket pearly mussel *(Lampsilis orbiculata)* occurs in the reach of the White River below DeValls Bluff. Two other endangered mussels, the fat pocketbook pearly mussel *(Potamilus capax)* and the Curtis pearly mussel *(Epioblasma florentina curtisi)* have been known to occur in the river system from historical records, however, they may no longer be present in the White River and its tributaries. The threatened bald eagle *(Haliaeetus leucocephalus)* occurs throughout the length of the White River and the endangered interior least tern *(Sterna antillarum)* occurs along the lower White River. Finally, the endangered pallid sturgeon *(Scaphirhynchus albus)* has been collected in the Mississippi River near the mouth of the White River and may be present in the White River. It is the responsibility of the Corps to determine if any proposed action would adversely impact any listed species.

FISH AND WILDLIFE RESOURCE CONCERNS AND PLANNING OBJECTIVES

Declining Productivity of Stream Fisheries in the Study Area

Major streams in the study area include Hurricane Bayou, Honey Creek, Little LaGrue Bayou, LaGrue Bayou, and Mill Bayou. Nearly all of the land drained by these streams has been cleared and converted to agricultural use. In many instances, the land has been cleared to the stream banks. Removal of bottomland forests and the vegetated riparian corridor, combined with poor soil conservation practices, has resulted in sheet erosion, sediment deposition, elevated turbidity levels, increased agricultural chemical runoff, and poor water quality (Inmon 1989). Compounding the problem is the fact that farming practices in the study area, like those throughout the Lower Mississippi Alluvial Plain, depend more heavily upon the use of chemicals than farming operations in other areas of the United States (Schmitt and Winger 1980). Additionally, practices such as land clearing and fall plowing, coupled with high winter rainfall and the soil types in the study area, contribute heavily to the transport of sediment and toxic chemicals into aquatic systems.

Pollution from Point and Non-Point Sources

Both non-point and point source pollution have contributed to the overall decline in water quality in the tributary streams of the project area. The former include agricultural runoff of farm chemicals such as pesticides, herbicides, and fertilizers. The latter include pollution from industrial companies and agro-industry. Many of the area's streams have been significantly degraded from these pollution sources. As a result, the fisheries have been adversely affected.

Reduction in the Amount of Flooded Habitat Available for Waterfowl

Recent and ongoing research on wintering waterfowl in the Lower Mississippi Valley (LMV) has revealed an integral relationship between hydrologic conditions in the LMV and the well-being of

mid-continent waterfowl populations. Reinecke *et al.* (1988) found a positive correlation between waterfowl and winter hydrology in the following six areas:

1. Population Size - during wet winters, the LMV winters a great percentage of the mid-continent waterfowl populations;

2. Distribution - winter water conditions affect the distribution of ducks during any particular winter and on a day-to-day basis;

3. Food Use - feeding behavior and selection of foods are related to water conditions;

4. Body Condition - wet winters produce higher average body weights than dry winters;

5. Survival Rate - wet winters produce a measurable increase in the survival rate, particularly among young-of-the-year; and

6. Reproduction - favorable winter water conditions in the LMV would likely result in more successful reproduction the following spring.

Because of the overall scarcity of winter water in the LMV, hunting clubs and the AGFC have constructed greentree reservoirs and installed water control structures to flood agricultural land and moist soil units for waterfowl. However, there is a need to flood additional land in the project area for waterfowl. The flooding of 38,529 acres of rice fields for waterfowl (Alternative 7b) would be in accordance with the North American Waterfowl Management Plan (NAWMP), which was developed jointly by the Service and the Canadian Wildlife Service (1986). This plan recognizes that reversal or modification of activities that destroy or degrade waterfowl habitat is necessary to successfully manage waterfowl. The plan states that all other efforts to manage waterfowl, such as harvest limitations, would be in vain if habitat trends are not reversed. One of the areas of high priority for waterfowl habitat protection and enhancement is the LMV, which includes the project area. Specific conservation strategies being pursued for the LMV include: (1) waterfowl habitat development on private lands, (2) increasing waterfowl carrying capacity on available public lands, and (3) incorporating waterfowl conservation into the planning, construction, and operation of water resource development projects. The LMV Joint Venture Project, a private, state, and federal cooperative effort, is implementing these strategies. Through this cooperative effort, 238,600 acres are being managed as winter waterfowl habitat.

Neotropical Migratory Bird Use Of Bottomland Hardwood Forests

Neotropical migratory birds breed in Canada and the United States and winter in Mexico, the Caribbean, Central America, and South America. Bottomland hardwood forests in the Mississippi Alluvial Valley are used extensively by these migrants during the nesting and migration seasons. Reduction in the acreage of forested habitat and associated changes in the quality and quantity of

the vegetation have caused a reduction in neotropical migratory bird populations (Pashley and Barrow 1992). Forest acreage reduction is not the only measure of loss. Because of changes in flooding and disturbance and varying histories of management, current tree species composition and age distribution are probably very different from pre-settlement conditions. Much of the remaining forest is extremely fragmented, which increases nest predation and parasitism. An analysis of Breeding Bird Survey data for the period from 1966 to 1990 found the Mississippi Alluvial Valley (MAV) was one of five physiographic areas in which notable declines occurred (Pashley and Barrow 1992). Seventy-seven percent of birds breeding in bottomland hardwoods of the MAV declined. Declining species include interior forest species such as the prothonotary warbler (*Protonotaria citrea)*, and also second growth or edge species such as the orchard oriole (*Icterus spurius*) and yellow-breasted chat (*Icteria virens*). The Mississippi Alluvial Valley Migratory Bird Conservation Initiative has made a preliminary determination of the amount and location of bottomland hardwood forest required for the conservation of neotropical migratory bird populations (Mueller *et al.* in press).

Declining Grassland Habitat and Grassland Birds

A large portion of the project area was originally in prairie interspersed with bottomland hardwoods. Today, only a small portion of the original tall grass prairie remains in eastern Arkansas. Within the project area, there are several relict prairie communities of special concern that have the potential to be affected by the project. The Arkansas Natural Heritage Commission has a conservation easement on or fee title to several of these native grassland communities including the Railroad Prairie State Natural Area. The following areas are privately owned: Halijan Prairie, Konecny Prairie, Auersperg Prairie, Beem Prairie, Gray Prairie, and Fairmount Prairie. Every effort should be made to avoid all native prairie areas.

Historically, grasslands evolved and were maintained by frequent disturbances, such as drought, grazing by native herbivores, and fire. The decline of the tallgrass prairie (estimated loss of 88-99 percent) exceeds that reported for any other major ecosystem in North America (Vickery *et al.* 1995). Throughout much of the area that once supported tallgrass prairies, agricultural crops have replaced grasslands. Grassland habitats are occupied by a small number of uniquely adapted bird species, selecting habitat features from a wide range of grass heights and densities. In North America, grassland birds have experienced steeper, more consistent and more widespread population declines over the last quarter century than any other avian guild. Some grassland bird species are neotropical migrants, however, most are short distance migrants that winter primarily in the southern U.S. and northern Mexico. Thus, there are opportunities for conservation on both breeding and wintering grounds. Winter survivorship is a critically important factor in the long term decline of grassland birds.

Habitat fragmentation and degradation of grasslands have been severe. Habitat loss has been caused by human development and forest succession, and includes subtle degradation such as unnatural grazing regimes, planting of exotic grasses, and succession to shrublands. Fire suppression and resultant woody encroachment are major tallgrass management problems that

influence grassland bird distribution patterns and nesting success. Early and mid-season cutting of agricultural grasslands have catastrophic impacts on nesting success of grassland birds.

Preservation and Enhancement of Shorebird Habitat

Several species of shorebirds migrate long distances between arctic and subarctic breeding grounds to Central and South America non breeding areas (Skagen and Knopf 1993). The tremendous energy demands associated with flights over several thousand miles require that birds be able to repeat the cycle of accumulating and using fat reserves (Morrison 1984, Myers *et al.* 1987). Because long-distance migrants cannot make the journey without periodically replenishing fat reserves, stopover sites become critical to the survival of many species (Myers 1983, Morrison 1984, Myers *et al.* 1987). Stopover sites in the central plains provide essential resources for long and intermediate distance neotropical migrants, such as white-rumped sandpiper (*Calidris fusciollis*), Baird's sandpiper (*C. bairdii*), pectoral sandpiper (*C. melanotos*), stilt sandpiper (*Micropalama bimantopus*), dunlin (*C. alpina*), Hudsonian godwit (*Limosa baemastica*), and semipalmated sandpiper (*C. pusilla*).

The occurrence of mudflats and shallow water habitats is highly variable yet is critical to refueling efforts of small shorebirds (Skagen and Knoph 1993). These ephemeral and dynamic habitats are perhaps some of the most endangered habitats in the continental U.S. because of the rapid loss of wetlands due to agricultural conversion (Tiner 1984, Dahl 1990) and extensive alterations of wetland hydrology (Fredrickson and Reid 1990). Approximately 22 species of shorebirds have been found using shallowly flooded agricultural fields in the MAV, including the study area (Twedt and Nelms 1995). Dowitchers (*Limnodromus* spp.), pectoral sandpipers, killdeer (*Charadrius vociferus*), and calidrid sandpipers ("peeps"; *Calidris* spp.) are the most abundant species. Killdeer and common snipe (*Capella gallinago*) are common throughout winter whereas yellowlegs (*Tringa spp.*) and calidrid sandpipers are present but less abundant (Loesch *et al.* in press).

Shallow water is the limiting factor in shorebird distribution. Shorebird habitat can be provided year round for wetland dependent birds by establishing water management capabilities on agricultural land (Loesch *et al.* in press). Shallow-flooded habitat must be present during spring, late summer, and fall. Shore birds feed on invertebrates found in the shallowly flooded crop fields, wetlands, and mudflats of reservoirs and other impoundments. However, it is estimated that under future without project conditions, only 26.6 percent of the currently irrigated cropland will be irrigated by the year 2015 due to continued aquifer depletion. This reduction in irrigated cropland would also substantially reduce a valuable food source for shorebirds. Depletion of the underground aquifer would also result in adverse impacts to shorebird habitat since less water would be available for reservoirs and other impoundments.

Spread of Non-native Zebra Mussels (*Dreissena polymorpha*)

The zebra mussel formed as a species millions of years ago in the huge saline water basin, which includes the present Aral, Caspian, Azov, Baltic, and Black Seas (Karnaukhov and Karnaukhov

1993). They were in the mouths of the rivers (Volga, Don, Dnepr, and Danube) that flowed into these seas, and there was a stable relationship between zebra mussels and other organisms in the areas. About 200 years ago, evidently in connection with the construction of canals and increased eutrophication of the water basins, zebra mussels began to increase their range into north European rivers that emptied into the Baltic Sea.

The zebra mussel has spread throughout several freshwater systems in the United States since being inadvertently released into Lake St. Clair, Michigan in 1986, when one or more transoceanic ships discharged ballast water (Miller *et al.* 1992). The mussel is expected to spread over much of North America (Strayer 1991). The mussel has now been documented in all of the Great Lakes and waterways in 21 states and provinces of Ontario and Quebec. Major river systems that now have zebra mussels include the St. Lawerence Seaway, and the Hudson, Illinois, Susquehanna, Mississippi, Ohio, Arkansas, White, and Tennessee Rivers (O'Neill 1992). Zebra mussels have been documented as far south as New Orleans (Snyder *et al.* 1994).

The zebra mussel is a prolific breeder and establishes dense populations once it invades an area. Unlike native mussels which burrow in the sand and mud, the zebra mussel spends its adult life attached to hard substratum. Because of this characteristic, native freshwater mussels are extremely susceptible to zebra mussel colonization, which may eventually lead to mortality of the host organism.

The species' rapid dispersal throughout the Great Lakes and major river systems is due to its ability to attach to boats navigating these waters (Benson 1996). Zebra mussels have an especially troubling characteristic: the ability to stay alive out of water for several days under moist and reasonably cool conditions. Thus, overland dispersal is another possible means of range expansion.

In 1991, a second species of *Dreissena* was discovered in North America but was only recently identified (Snyder *et al.* 1994). Quagga mussels (*Dreissena bugensis*) have been found in the St. Lawrence Seaway, Lake Ontario, Lake Erie, and Saginaw Bay in Lake Huron. This mussel can colonize much deeper habitats than the zebra mussel. The quagga mussel is the only species of *Dreissena* found below 100 meters. Unlike *D. polymorpha*, quagga mussels have been found on soft surfaces such as sand and mud.

Zebra mussels are excellent filter feeders; an adult zebra mussel has been documented as being able to filter up to one liter of water per day (Sprung and Rose 1977). This extremely efficient filtration rate may potentially result in food competition with other aquatic organisms, particularly young fish. Removal of significant proportions of plankton at the base of the food chain diminishes the energy available for fish production. Diatoms and rotifers, microscopic plants and animals, have been reduced by as much as 80 to 90 percent in some areas (Holland 1993, Kershner 1995). Since the invasion of zebra mussels, water clarity in Lake Erie has increased almost six-fold, allowing rooted aquatic plants to flourish and clog harbors (Holland 1993). Enhanced growth of aquatic weeds resulting from increased water clarity has led to taste and odor

problems in drinking water supplies, necessitating more expensive and aggressive water treatment procedures (Heath 1994). Inland lakes that support large populations of zebra mussels may experience a diminished fish yield, especially of fish feeding in open water. Direct impacts of consequence to humans include the clogging of water intake pipes of industrial and municipal water facilities and the fouling of boat hulls and fishing equipment. Zebra mussels may cause the decline or extirpation of native mussels. It is estimated that in the United States the zebra mussel could cause $5 billion in damage by the year 2000 (Miller *et al.* 1992).

Planning Objectives

The Service advocates that the following planning objectives be incorporated into any future planning studies in order to protect fish and wildlife resources in the area.

1. Protect and improve water quality and fishery resources in the project area.

2. Encourage implementation of erosion control measures.

3. Protect and increase forested bottomland hardwood wetlands in the project area.

4. Protect and increase wintering waterfowl habitat in the project area.

5. Protect natural prairie areas and other areas of special concern which contain rare natural communities and associated sensitive species including grassland birds.

6. Protect vegetated corridors along rivers and streams.

7. Maintain and enhance shorebird habitat by properly designing on-farm water storage reservoirs.

8. Reduce wildlife habitat fragmentation by properly constructing canals.

PROJECT ALTERNATIVES

Numerous structural and nonstructural measures were evaluated in the formulation of alternative plans. Plan formulation was initially conducted for a 394,475 acre project area. However, the majority of landowners in the southeastern section of the original project area decided not to participate in the project; this resulted in a 31,813 acre reduction in the size of the project area. Therefore, all alternatives are designed specifically for the 362,662 acre project area and include Alternatives 1 through 7. Alternative 1 is the no action alternative, which assumes that the amount of irrigation water stored, surface water captured, and irrigation water recovered would be significantly reduced due to the depletion of the aquifer. Alternatives 2 - 6 involved construction of additional irrigation reservoirs; water conservation measures; and a combination

of conservation measures, irrigation water storage, and increased water import. These alternatives were dropped from final consideration.

Alternative 7 consists of a major pumping station adjacent to Wattensaw Wildlife Management Area on the White River north of DeValls Bluff, which would import excess surface water from the White River to the other project area streams. Irrigation water from the pumping plant would enter a network of new or existing channels and pipelines and would be carried to water depleted areas. A system of new canals (184 miles), pipelines (177), and existing channels (291 miles), and associated structures [weirs (120), diversion structures (165), inverted siphons (28) and lift stations] would be used to transfer water to 8,849 acres of new on-farm irrigation reservoirs and tail-water recovery systems. No channelization would be required on any natural streams in the project area. Construction along natural streams would be limited to the clean out of minor blockages and the placement of low water weirs to maintain a year round wet system. Conservation measures and a water management plan would be implemented on all farms. The conservation measures include avoidance of wetlands, on-farm tail-water recovery systems, designing on-farm reservoirs to benefit wildlife, and flooding of winter rice fields for waterfowl. Their are four variations of Alternative 7, which are discussed below and are referred to as Alternatives 7A, 7B, 7C, and 7D. The major difference in these alternatives is the size of the pumping station or water import system.

Alternative 7A (1,480 cfs Import System)

This alternative would provide an average of 235,360 acre-feet of import water annually from the White River. Import water would be combined with conservation measures and groundwater withdrawals to meet initial irrigation demands. At year 2015 and afterwards, Alternative 7A would meet 85.8 percent of the irrigation demand.

Alternative 7B (1,640 cfs Import System)

Diversions from the White River would provide an average of 243,900 acre-feet of irrigation water annually. River diversions combined with groundwater withdrawals and conservation practices would initially meet the annual demand of 481,195 acre feet of irrigation water. Approximately seven percent of the water needs would come from available groundwater and result in a safe pumping rate. This plan would supply 87.6 percent of the irrigation demand at year 2015 and beyond. Alternative 7B has been identified as the tentatively selected plan.

Alternative 7C (1,800 cfs Import System)

This plan would divert an average of 250,227 acre-feet of water annually from the White River. Alternative 7C would supply 88.9 percent of the demand in 2015. Although this plan, like the

others, would not meet 100 percent of the irrigation needs, it would still furnish approximately 318,969 acre-feet more water at year 2015 than would be available under future without-project conditions.

Alternative 7D (1,960 cfs Import System)

This alternative would import an average of 256,368 acre-feet of water from the White River to the other project area streams. It would meet 90.2 percent of the annual irrigation demand in 2015, more than any other alternative; it would supply 325,110 acre-feet more water than future without-project conditions.

Management of pumping pools and pumping operation under Alternatives 7A - 7D would fall into two distinct seasons. The first season will begin on November 1 and go through March 30. During this period, the water import system will be used to fill on-farm reservoirs and to flood waterfowl habitat for feeding purposes. The second season is the cropping season, the period of heaviest water use, and extends from April 1 through September 30. During this season, water needs will be met through careful management of all water sources including rainfall runoff, import water, on-farm storage, and groundwater. The deliver system network will be managed to maintain minimum instream flows during both seasons.

PROJECT IMPACTS

Fishery Impacts

The tentatively selected plan (Alternative 7B) involves extensive canal construction and the installation of instream structures. The canals would provide an increase in low quality stream fishery habitat in the project area. Installation of weirs in area streams would require the removal of some streamside vegetation.

The proposed project would withdraw a large amount of water from the White River and transport the water to project area streams. Weirs would be installed in streams to increase water levels, especially on intermittent streams. Effects of water withdrawal from the White River and replenishment of streams in the project area on fish and riverine habitat were evaluated from field studies conducted during 1996 by personnel from the Corps' Waterways Experiment Station (WES). The 1997 WES study report indicates that Alternative 7B would have relatively minor adverse impacts on fishery resources of the White River (Kilgore *et al.* 1997). Additional water from the White River and the pooling effect of the weirs are projected to increase wetted area and habitat for fish in intermittent streams, many of which dry up during the summer months. The WES study projected an increase of 4,328 fish habitat units (HU) per month over existing conditions for project area streams. HU were determined by multiplying the habitat suitability index (ranging from .1 to 1.0) times the acres of useable habitat.

Potential adverse impacts on aquatic resources are associated with pump entrainment of larval fishes. The WES report indicated that these impacts would be minimal. Velocities in the pump station intake canal would range from approximately 0.2 feet/second when the river stage is near top bank, to one feet/second at lower stages. Larval fish drifting in the water column along the west bank of the White River would be drawn into the pump. Entrainment during the spawning season is projected to range from 1.2 percent of larval fish during May up to 12.4 percent in July for larval fish entering the inlet canal. Entrainment of larval fish would be less for the other months because most species spawn during March through July. The WES study indicated that the loss would be minor when considering the total numbers of larval fish that exist cumulatively in inlets and other backwaters of the White River and that 90 percent of the fish entrained are projected to be rough or forage fish. Non larval fish would not be a significant concern because these fish are strong enough to escape the velocities of the pump station intake.

Based on the WES study, pump-induced reductions in fish HU were less than three percent for any alternative. There were no effects in January, February, November, and December. The greatest reductions in HU occurred in April and May for all alternatives (1.9-2.4 percent). These results indicate that even with a maximum stage reduction of one foot during peak pumping, impacts on littoral fishes in the White River would be minimal.

The WES study evaluation of sixteen oxbow lakes along the White River indicates that the lakes would not be adversely impacted by pump stage reductions during median discharges, although four lakes could have there connectivity severed when discharge in the White River is at or below 75 percent exceedance flow during July and August. However, the Arkansas State Water Plan would prohibit pumping at low flows, i.e., below 75 percent exceedance value (Arkansas Soil and Water Conservation Commission 1996).

Smith *et al.* (1996) found that, in general, surface water from the White River is similar in quality to the ground water. Therefore, use of White River water for irrigation should not adversely impact fish and aquatic life. The Corps has stated that on-farm tail water recovery systems would not accumulate pesticides, since irrigation water would not be continuously reused to irrigate cropland. However, since a tail water recovery system is designed to recover and reuse irrigation water, the Service is concerned that pesticide and herbicide residues may still accumulate in the delivery system.

Pumping water from the White River would likely introduce zebra mussels into other streams and bayous. The mussels would adversely impact the native fisheries by removing plankton from the water. The plankton is the primary food source for larval fish

Wildlife Impacts

Alternative 7B would consist of a major pumping station and an elaborate water distribution system which would use approximately 291 miles of existing streams and channels, 184 miles of new canals, and 177 miles of new pipelines to provide inter-basin transfer of surface water from the White River to the project area. As a result of this project construction, approximately 124 acres of forested uplands and approximately 122 acres of forested wetlands would be adversely

impacted. The pumping plant at DeValls Bluff would be adjacent to AGFC's Wattensaw WMA and the water lines carrying water from the White River would cross the WMA and would therefore impact terrestrial habitat. Any additional habitat losses would further harm wildlife populations dependent upon forested resources.

Any reduction in forested wetlands would adversely affect wintering waterfowl by reducing foraging and resting areas. However, Alternative 7B would provide foraging benefits for waterfowl due to flooding cropland during November 1 through February 28. Based on waterfowl methodology (see Appendix A) developed by the Service to quantify the energy needs of waterfowl calculated in duck-use-days (DUD), Alternative 7B would provide an additional 12,275,949 DUD's per year (21,129 flooded acres of cropland x 581 DUD's per acre = 12,275,949 DUD's). A DUD is defined as the capacity of available forage to meet the energy needs of one duck for one day; harvested rice fields provide 581 DUD's per acre (Nelms and Twedt 1996).

Foti and Pagan (in press) evaluated the impacts of water withdrawals from the White River on wetlands and bottomland hardwood forest communities within the floodplains. They evaluated impacts to wetland zones as defined by Wharton *et al.* (1982) based on average river flows over ten day intervals. It was assumed that impacts of water withdrawals would occur when water levels dropped to a lower zone; if water levels remained within the same zone, it was assumed that vegetation within that zone could adapt to any minor changes in water elevation. This study revealed that under existing conditions, the amount of time flow is lowered below any given wetland zone boundary is projected to be ten percent or less, indicating minimal impacts.

Under Alternative 7B, some impacts are projected to occur from March through August. In most cases, the amount of time flow is lowered below any given wetland zone boundary is projected to be ten percent or less, indicating minimal impacts. Zone two levels (intermittently exposed black willow-water elm-water tupelo-bald cypress) would be reduced to Zone three flows (semipermanently inundated overcup oak-water hickory) approximately thirty percent of the time in July and twenty-five percent of the time in August. Although these reductions are significant, the study questioned the "naturalness" of existing flows of these magnitudes during mid-summer. The study concluded that these high flows apparently result from attempts to release water gradually from upstream reservoirs during wet years. A revised White River water control plan to modify releases from the upstream reservoirs is presently under consideration and impacts of the proposed plan are being evaluated.

Construction of the project would result in the loss of two acres of prairie habitat. We consider the loss of prairie habitat to be significant considering that native prairie habitat is rare in the project area.

AQUATIC AND TERRESTRIAL MITIGATION

The selected plan as discussed will result in several impacts to fish and wildlife resources. The impacts should be mitigated by implementing the measures discussed below. The measures comply with the Fish and Wildlife Service's Mitigation Policy. The policy applies to all activities

of the Service related to the evaluation of impacts of land and water developments and the subsequent recommendations to mitigate those adverse impacts (Service 1981). This includes five means of mitigation: (1) avoiding, (2) minimizing, (3) rectifying, (4) reducing, or (5) compensating for unavoidable adverse impacts.

Aquatic Mitigation

Establish Minimum Flows to Protect the Fisheries of the White River, Oxbow Lakes, and Tributary Streams

Since this project is the largest irrigation project ever proposed for the White River, and there is still uncertainty regarding downstream impacts, the Arkansas Game and Fish Commission has recommended (Craig Uyeda personal communication) that a proportional analysis study be conducted on the White River at DeValls Bluff. With this procedure, mean cross sectional values for stream width, depth, and velocity are related to total fish standing crop. These values can than be converted to habitat suitability indices (HSI) and multiplied by stream area to estimate fish habitat units (HU) at different discharges. This type of study would integrate existing hydrological and fish standing crop data, would identify flow needs for at least the most important and sensitive aquatic species in the river, and would be less costly than a standard instream flow study (Layher and Brunson 1992). This and future irrigation projects should be operated to comply with the flow needs identified by the study.

Water Withdrawal Rates Should not Exceed Proposed Allocation Levels

Because of increasing demands for water in the White River Basin coupled with impending major irrigation withdrawal projects, e.g. the Grand Prairie Demonstration Project, the Arkansas legislature directed the Arkansas Soil and Water Conservation Commission (ASWCC) to determine a water allocation plan for the White River. The Fish and Wildlife/Recreation/Water Quality Instream Flow (FWRWQIF) Committee (one of three committees formed to address water needs) reviewed existing instream flow data from several sources including data from the United States Geological Survey. Wetland vegetative and biological surveys were then conducted on the White River near DeValls Bluff to obtain adequate information to make flow recommendations for the White River. The FWRWQIF Committee submitted their report to the ASWCC in January 1996. The report recommended that allocation flows be set at a higher level than minimum stream flows so that water users could gradually and practically regulate from the allocation level to the minimum stream flow or shut off level. Table 2 gives a basic summary of the committee's recommendations for the White River at DeValls Bluff. The committee's recommendations also incorporate seasonality into the instream flow needs, since a single flow recommendation does not account for all the flow needs in the life cycles of fish and wildlife or their habitats found in Arkansas. Native fish species generally need high flows in the spring for spawning, lower flows in the summer and fall for growth and production, and high flows again in winter to flush spawning and nursery areas which also help recharge the groundwater table (Table 3).

TABLE 2. River Level, Recommended Instream Flows, and Justification for the White River near DeValls Bluff, Arkansas.

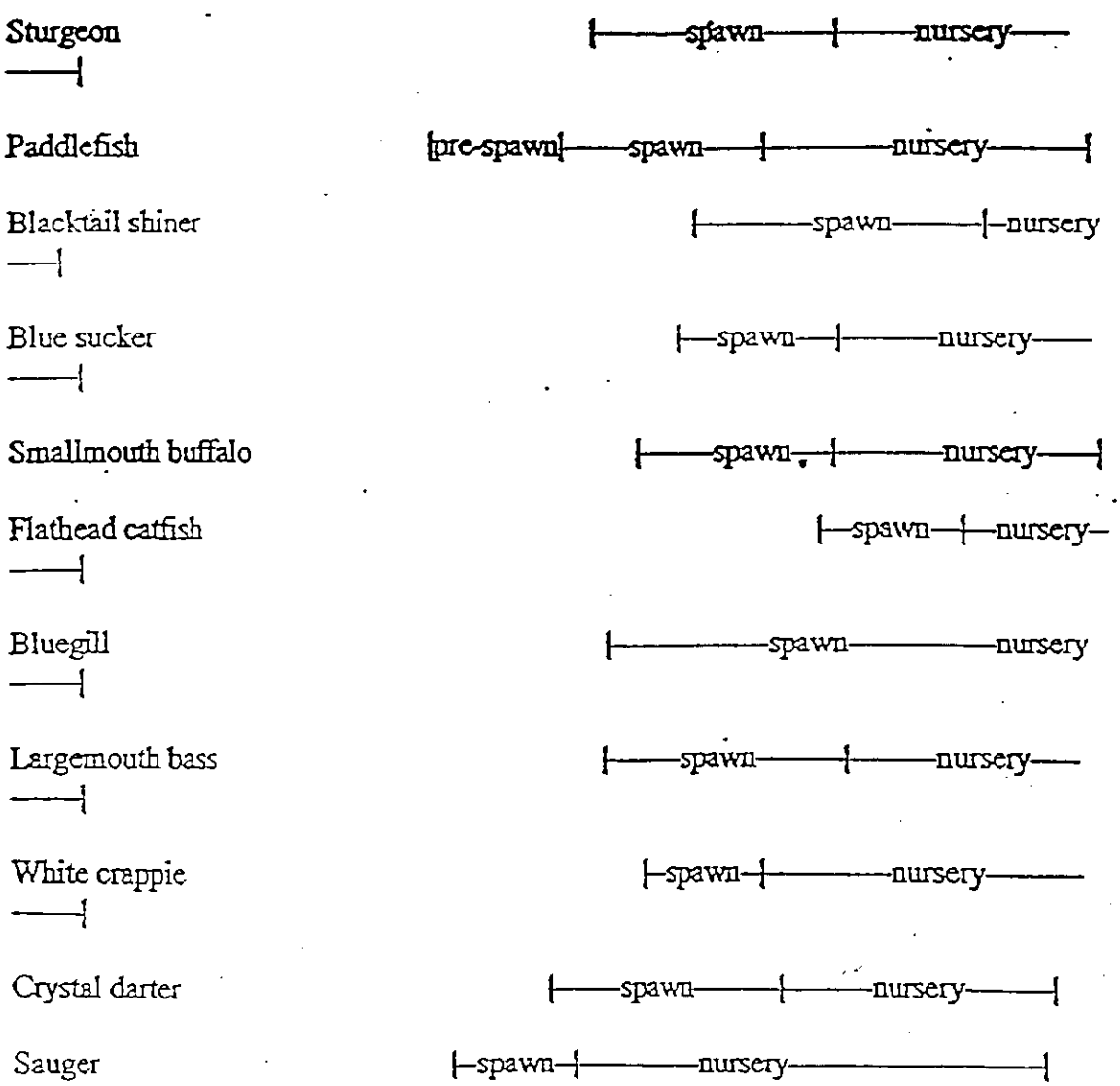
Gage Height	Level/Flow Recommendations	Justification
21'	174' msl/49,800 cfs Dec. 15-March 1 every year Dec. 15-April 1 2 of 3 years Dec. 15-May 15 1 of every 3 years	Needed to maintain wetland functions characteristic to zone V (swamp chestnut oak, cherrybark oak, etc.). Flow critical for paddlefish spawning. Important for foraging waterfowl
17'	170' msl/30,000 cfs March 1-May 15 2 of 3 years	Level critical to lower hardwood and medium hardwood wetlands, provides spawning habitat for nest building fish (bass, crappie)
11'	164' msl/16,400 cfs March 1-June 30 2 of 3 years	Levels at this stage are important for maintaining vegetative species tolerant to much flooding; critical for spawning of sunfish, minnows, catfishes
6.8'	159.8' msl/11,200 cfs July through November	Area usually wet, below this level the most aquatic habitat is lost per unit of gage ht. Exposure of mussel beds
4.7'	157.7' msl/8,700 cfs No diversion below this level at any time of the year	Bottom or shelf edge of shoreline wet area; critical level for fish, mussel, and invertebrate survival during low flow season

Source: Fish, Wildlife, Recreation, and Water Quality Instream Flow Committee (1996).

TABLE 3. WHITE RIVER SEASONAL FISH/FLOW RELATIONSHIPS

Discharge at DeValls Bluff in cfs (27 year period of record;x=mean,m=min,M=max)

	O	N	D	J	F	M	A	M	Jun	Jul	A	S
x	12160	15840	23790	32220	38050	40980	43650	44320	27070	20080	15910	13090
m	3715	3831	5260	6042	7974	14050	13230	10840	10110	7822	7112	4276
M	30100	48890	67180	110000	107100	73060	75360	90730	73590	48560	48900	36450



Source: Fish, Wildlife, Recreation, and Water Quality Instream Flow Committee (1996).

The ASWCC released a draft report on proposed water allocation levels of the White River in August 1996 and is now working on a final water allocation plan. Under the ASWCC plan, registered riparian and non-riparian users (riparian users refers to landowners adjacent to a stream while non-riparian users refers to non adjacent landowners) would be limited to the amount of water that could be withdrawn during low flow conditions (Tables 4, 5, and 6). Individuals or entities withdrawing more than one acre-foot of water per year are required to register their water use with the ASWCC. Although the proposed allocation levels do not always correspond to workgroup recommendations, the proposed plan recognizes the need for out-of-stream utilization and protection of instream resources.

Institute a Larval Fish Monitoring Program

A post-construction monitoring program should be designed and implemented in order to more accurately estimate entrainment of larval fishes. Since entrainment and impingement of fish are known to occur at pumping facilities, all precautionary measures should be taken to minimize adverse fishery impacts. Factors which should be considered during the planning stage include water velocity near the intake pipe, angle of the source canal, filter mesh size, and resting areas near the mouth of the canal.

The proposed monitoring plan should be developed and conducted during operation (at least two to three years) to determine the extent of fish mortality as well as the amount of compensation and/or mitigation required for any identified losses.

Investigate Alternative Sources of Water Supply

As previously mentioned, the project would likely introduce zebra mussels from the Whiter River into project area streams, which would adversely impact the native fisheries. Due to the presence of zebra mussels in the White River, the Service requests the Corps to investigate alternative sources of water supply. Likely sources of water could come from several Corps reservoirs located in the upper White River basin (Norfork, Bull Shoals, and Greers Ferry Lakes). These lakes have as authorized purposes power generation, flood control, recreation, and water supply. Approximately 7.53 million acre-feet of water is available for these purposes (White River Regional Irrigation Water Distribution District 1994). At this time, these lakes have not been infested with zebra mussels and precautions should be taken to educate recreational boaters about zebra mussels. These lakes could provide gravity fed water, via pipelines, to all five proposed irrigation projects.

Conduct Contaminants Surveys Before and After Completion of the Project.

As previously mentioned, collection of the irrigation water from cropland and reusing this water may result in concentrating contaminants in the irrigation water and sediments. Contaminant surveys conducted during the early stages of project planning would identify the existing level of contaminants in the water, sediment, and biota. Monitoring selected pollutants after the

Table 4. Proposed White River Allocation Plan

Clarendon Gage

SUMMER (June 1st - November 30th)

Registered riparian and non-riparian withdrawals rates will be adjusted during shortage conditions according to the table below. (Example: At 16 ft. stage - Individual non-riparian users (>200 cfs) will limit total pumping to 90% of registered daily withdrawal rate.)

PUMPING CAPACITY DURING ALLOCATION			Stage/Discharge	
Riparian	Non-Riparian <200 cfs	Non-Riparian >200 cfs		
100%	100%	90%	16 ft.	17,500 cfs
100%	100%	80%	14 ft.	14,350 cfs
100%	100%	70%	12 ft.	11,350 cfs
100%	50%	50%	11 ft.	9,875 cfs
50%	50%	20%	10 ft.	8,460 cfs
0%	0%	0%	9 ft.	7,125 cfs

The table below contains data compiled from flow frequency analyses and represent occurrence values that were averaged for the period 1965-1994. Data shown below is for illustration purposes only and does not guarantee specific allocation levels during any single year. (Example: During the month of August - Non-riparian diversion (<200 cfs) would have been shut-off <1 day on average during the period of 1965-1994.)

Average Number of Days per Month (1965-1994) with Reduced Withdrawal Rates

	Riparian		Non-Riparian <200 cfs		Non-Riparian >200 cfs					
Pumping Rate	50%	Shut-off	50%	Shut-off	90 %	80%	70%	50%	20%	Shut-off
June	<1	0	<1	0	3.1	3	1.5	<1	<1	0
July	<1	0	1.5	0	5.5	6.7	2.5	1.5	<1	0
Aug.	1.5	<1	4.1	<1	6.1	7.3	3.1	2.6	1.5	<1
Sept.	2.1	2	5.7	2	3.9	7.8	3.8	3.6	2.1	2
Oct.	2.9	3.7	6.9	3.7	4.4	5.3	4	4	2.9	3.7
Nov.	2.1	2.7	5.2	2.7	3.2	6.5	2.6	3.1	2.1	2.7

Source: Arkansas Soil and Water Conservation Commission (1996).

Table 5. # Proposed White River Allocation Plan

Clarendon Gage

WINTER (December 1st - February 28th)

Registered riparian and non-riparian withdrawals rates will be adjusted during shortage conditions according to the table below. (Example: At 20 ft. stage - Individual non-riparian users (>200 cfs) will limit total pumping to 70% of registered daily withdrawal rate.)

PUMPING CAPACITY DURING ALLOCATION			Stage/Discharge
Riparian	Non-Riparian <200 cfs	Non-Riparian >200 cfs	
100%	100%	90%	22 ft. — 29,900 cfs
100%	100%	80%	21 ft. — 27,600 cfs
100%	100%	70%	20 ft. — 25,400 cfs
100%	50%	50%	19 ft. — 23,300 cfs
50%	50%	20%	18 ft. — 21,200 cfs
0%	0%	0%	17 ft. — 19,200 cfs

The table below contains data compiled from flow frequency analyses and represent occurrence values that were averaged for the period 1965-1994. Data shown below is for illustration purposes only and does not guarantee specific allocation levels during any single year. (Example: During the month of February - Non-riparian diversion (<200 cfs) would have been shut-off 7.3 day on average during the period of 1965-1994.)

Average Number of Days per Month (1965-1994) with Reduced Withdrawal Rates										
	Riparian		Non-Riparian <200 cfs		Non-Riparian >200 cfs					
Pumping Rate	50%	Shut-off	50%	Shut-off	90 %	80%	70%	50%	20%	Shut-off
Dec.	<1	11	1.1	11	1.2	<1	1.1	1.1	<1	11
Jan.	<1	7.8	1.8	7.8	<1	1.5	<1	1.1	<1	7.8
Feb.	1.5	7.3	<1	7.3	<1	1.3	<1	<1	1.5	7.3

Source: Arkansas Soil and Water Conservation Commission (1996).

Table 6. Proposed White River Allocation Plan

Clarendon Gage

SPRING (March 1st - May 31st)

Registered riparian and non-riparian withdrawals rates will be adjusted during shortage conditions according to the table below. (Example: At 19 ft. stage - Individual non-riparian users (>200 cfs) will limit total pumping to 70% of registered daily withdrawal rate.)

PUMPING CAPACITY DURING ALLOCATION			Stage/Discharge
Riparian	Non-Riparian ≤200 cfs	Non-Riparian >200 cfs	
100%	100%	90%	20 ft. — 25,400 cfs
100%	100%	70%	19 ft. — 23,300 cfs
100%	50%	50%	18 ft. — 21,200 cfs
50%	50%	20%	17 ft. — 19,200 cfs
0%	0%	0%	16 ft. — 17,500 cfs

The table below contains data compiled from flow frequency analyses and represent occurrence values that were averaged for the period 1965-1994. Data shown below is for illustration purposes only and does not guarantee specific allocation levels during any single year. (Example: During the month of May - Non-riparian diversion (<200 cfs) would have been shut-off 4 days on average during the period of 1965-1994.)

Average Number of Days per Month (1965-1994) with Reduced Withdrawal Rates

	Riparian		Non-Riparian <200 cfs		Non-Riparian >200 cfs				
Pumping Rate	50%	Shut-off	50%	Shut-off	90%	70%	50%	20%	Shut-off
March	<1	2.5	1.6	2.5	1.2	<1	<1	<1	2.5
April	1	3.5	1.9	3.5	<1	<1	<1	<1	3.5
May	1.4	4	2.8	4	1	<1	1.2	1.4	4

Source: Arkansas Soil and Water Conservation Commission (1996).

completion of the project is necessary to insure that contaminants are kept out of the irrigation system or are at least mininized, and not released into the White River or its tributary streams.

Terrestrial Mitigation

Acquire Farmed Wetlands and Prior Converted Croplands

As previously discussed, the selected plan would result in the loss of 124 acres of forested uplands (54 acres permanently and 70 acres temporarily) and approximately 122 acres of forested wetlands (62 acres permanently and 60 acres temporarily). Based on the Fish and Wildlife Services' Habitat Evaluation Procedures (HEP, a methodology for evaluating impacts on fish and wildlife resources), the loss of forested wetlands and forested uplands would result in the loss of habitat value expressed as average annual habitat units (AAHU) for all evaluation species (Tables 7 and 8). To compensate for the loss of habitat value, approximately 245 acres of farmed wetlands and 200 acres of prior converted croplands would have to be acquired in fee title, reforested, and managed at project expense over the 50 year life of the project. Further details on the HEP analysis are available in Appendix C. The Corps proposes to compensate for the loss of forested wetlands and uplands by acquiring in fee title and reforesting 243 acres of farmed wetlands and 193 acres of prior converted croplands. The Service believes that the Corps' mitigation proposal would compensate for the loss of forested wetlands and forested uplands.

The Service will work with the Corps and AGFC to select appropriate mitigation sites. To assist the Corps in selecting potential mitigation sites, the Service has developed a hierarchy of criteria to be used to determine land type restoration potential and values. These criteria are divided into the following four categories: drainage basin location, restorable land type, rehabilitation methods, and specific land location (Table 9). These criteria are listed in ascending numerical order with number 1 being the most desirable. The Service believes that one of the primary mitigation sites should be adjacent to Wattensaw WMA. Wattensaw contains one of the largest blocks of forested areas within a largely agricultural area. Additionally, Wattensaw is the only area within the project area that contains substantial forested uplands, bottomland hardwoods, and is close to the White River. Therefore, there is a unique opportunity to reforest some of the cleared lands surrounding Wattensaw to provide a forested wildlife corridor to the White River.

Locate Irrigation Canals and On-Farm Reservoirs Away From Wetlands (Including Prior-Converted Wetlands) and Natural Heritage Sites.

Although Arkansas has lost over 80 percent of its bottomland hardwoods, there are still forested areas that offer food, cover, and shelter for waterfowl and other wildlife species. In addition, bottomland hardwoods and riparian forests provide beneficial nutrient input into the aquatic ecosystem and help control erosion. Trees also provide shade to streams thereby helping to buffer extreme water temperatures and interrelated dissolved oxygen fluctuations. In order to protect forested wetlands and riparian areas, the Service recommends that all new canals, pipelines, reservoirs, and weirs should be located in cleared agricultural lands to the maximum practical

Table 7. Average annual habitat units (AAHU) analysis for evaluation species (forested uplands).

Evaluation Species	AAHU With Project	AAHU Without Project	Net Change in AAHU
Barred Owl	12936	12998	-62
Gray Squirrel	12639	12699	-60
Pileated Woodpecker	5948	5976	-28
Carolina Chickadee	12193	12251	-58
White tailed Deer	7434	7470	-36

Table 8. Average annual habitat units (AAHU) analysis for evaluation species (forested wetlands).

Evaluation Species	AAHU With Project	AAHU Without Project	Net Change in AAHU
Barred Owl	16693	16742	-49
Gray Squirrel	14232	14274	-42
Pileated Woodpecker	10334	10364	-31
Carolina Chickadee	17289	17340	-51
Swamp Rabbit	17166	17228	-62

Table 9. Mitigation site selection criteria.

Drainage Basin Location Criteria

1. White River Basin south of DeValls Bluff
2. White River Basin north of DeValls Bluff
3. LaGrue Bayou
4. Mill Bayou

Existing Land Use Type Criteria

1. Degraded wetlands in riverine floodplains; actively farmed lands, pasture lands
2. Degraded upland forests in riverine flood plains
3. Cut over forested wetlands
4. Mature bottomland forest

Land Rehabilitation Methods Criteria

1. Wetland restoration including replacement of hydrology and woody vegetation
2. Wetland reforestation where hydrology is in place
3. Reforestation of uplands associated with riverine habitats
4. Preservation of a unique habitat, or a habitat important to a federally listed threatened or endangered species.

Specific Land Location Criteria

1. Sites within bird conservation areas identified by Mueller *et al.* (In press)
2. Sites adjacent to existing forested areas.
3. Sites adjacent to farmed areas that would provide corridors between wooded areas.

extent. It cannot be emphasized too strongly that on-farm reservoirs should be located on existing cropland areas away from wetlands as outlined in the Eastern Arkansas Region Comprehensive Study report (NRCS 1992). Furthermore, on-farm reservoirs should not be located on farmed wetlands as many of these areas still have hydrological functions and associated wetland values important to wildlife. In addition, the Arkansas Natural Heritage Commission has a conservation easement on or fee title to several areas of the last remaining native prairie found in Arkansas including the Railroad Prairie State Natural Area. Privately owned native prairie areas include Halogen Prairie, Konecny Prairie, Auersperg Prairie, Beem Prairie, Gray Prairie, and Fairmount Prairie. Every effort should be made to avoid all prairie areas. Reclamation of agricultural land adjacent to and in conjunction with preservation of existing native prairies should be considered as potential mitigation to offset project impacts on these sites.

Restore Prairie Habitat

The proposed project would result in the loss of two acres of native prairie habitat. However as an environmental design feature of the project, the Corps proposes to acquire remnant prairie areas in fee title. Acquisition efforts will be coordinated with the Arkansas Natural Heritage Commission to identify high priority acquisition sites. The Corps also proposes to restore vegetation within approximately 300 miles of canal right-of-way (ROW) on an area of 3,000 plus acres.

The proposed prairie restoration plan, as it currently stands, has both strengths and weaknesses. The chance to restore/create 3,000 plus acres of the Grand Prairie would be a positive benefit and should be a high priority for the study area. The use of a native seed source would also greatly increase the capacity to create actual prairie and infuse native genotypes into the process. Weaknesses of the current proposal include some aspects of what is proposed as well as a great deal that is not specified in this initial version. The establishment of prairie vegetation is expensive and labor intensive (Dr. James B. Grace, NBS, Southern Science Center, Lafayette, Louisiana, personal communication). Following construction of the canals and berms, soil erosion will be a major problem and a cover crop needs to be established quickly. Native prairie vegetation, which is perennial, takes years to become established due to competition from weeds and annual grasses (particularly Johnson grass). Since the slope of the berms is not natural to the Grand Prairie area, establishment of native assemblage of prairie plant species may be difficult.

The benefit of having the project serve as a corridor for migration is mentioned but insufficient information is presented to evaluate this proposed benefit. Revegetating a 300 mile long strip is less than ideal, especially as it affects the suitability for viable animal populations, particularly grassland birds. Additionally, the entire prairie will be edge habitat and very susceptible to invasion by exotic plants. Many species of grassland birds are edge and area sensitive and will not nest or feed in areas too narrow or small (Herkert *et al.* 1993). Habitat edges tend to be impacted by a number of forces from adjacent activities including neighboring non-native plant populations, pesticide drift, incidental soil disturbance, and elevated light penetration at the soil surface. To claim prairie restoration as a project feature, restored areas would have to have similar species diversity (a minimum 50 percent) and a species composition as the remaining relict prairies in the

area (Dr. James B. Grace, pers. comm.). The Corps has proposed to obtain the remaining relict prairies through fee title purchase or conservation easement. However, as an alternative to the proposed plan, serious consideration should be given to acquiring and replanting land adjacent to relict prairies to increase their size. Prairie tracts should be 250 contiguous acres or greater to facilitate the restoration and maintenance of prairie functions (Herkert *et al.* 1993). As proposed, 3,000 acres spread out over 300 miles would have little potential to restore prairie functions, whereas, 3,000 acres of restored prairie in one block would have great potential to restore prairie functions. Finally, more information needs to be provided about the long term management and assessment of prairie restoration. It will be important to develop objective, quantitative criteria for the long term goals of the project rather than to evaluate the project based on initial effort.

SPECIFIC CONSERVATION MEASURES

To address the fish and wildlife concerns and more fully achieve the planning objectives, the Service has formulated the following specific conservation measures. We believe that these measures could be included in project design without significantly increasing the cost of the project.

Design On-Farm Reservoirs to Benefit Shorebirds

The construction of on-farm reservoirs would benefit shore birds, waterfowl, and resident wildlife provided that they were constructed with sloping sides; this would expose additional mudflats during reservoir drawdowns. The NRCS, in conjunction with the AGFC, has developed a general design for a sloped reservoir which would be promoted to area farmers.

Install Best Management Practices (BMPs) on Agricultural Land

Serious sediment deposition problems exist in the project area streams which are caused by poor soil conservation practices on agricultural land such as fall plowing, clean tillage farming, and the growing of a single crop without a fall cover crop. BMPs such as minimum tillage, grassed waterways, filter strips, and strip cropping would greatly reduce sediment transport and deposition, improve water quality of the streams, and ultimately, reduce the need for channel maintenance. Further studies would be required to determine the following: 1) acres and location of agricultural land that require BMPs, 2) BMPs required on agricultural lands, 3) reduction in sediment yields as a result of implementing BMPs, and 4) whether restrictive easements would be required to implement and maintain BMPs on affected land. In addition, the technical assistance of the Natural Resources Conservation Service should be sought to aid in the study and implementation of the BMPs. The Farm Service Agency (formerly the Agricultural Stabilization and Conservation Service) administers the Conservation Reserve Program (CRP) which was reauthorized by the 1996 Farm Bill. Through financial incentives (annual payments), this program

encourages farmers to retire highly erodible cropland and/or land contributing to a serious water quality problem for 10-15 years. Major goals of CRP include reducing soil erosion and sedimentation, improving water quality, restoring fish and wildlife habitat, and establishing BMP's on cropland adjacent to streams and lakes.

Install Weirs and Grade Control Structures in the New Canals, Properly Design Canals, and Provide Public Access to the New Canals.

The weirs, which would be placed at strategic locations in the new canals, would increase normal water depths and thereby maintain the fisheries by ensuring that low dissolved oxygen levels and other problems associated with low summer water levels do not occur. Also, the weirs would benefit the fisheries of the new canals by creating standing pools or lake type environments and by reducing sediment movement and deposition. Grade control structures should be installed where the new canals connect to natural steams to prevent head cutting. All weirs should be located in areas that would have minimum impact to wetlands and bottomland hardwoods. Public access points should be developed along the new canals to ensure public use of the fishery resources. The AGFC and the Service should be consulted on placement of weirs and dams. Additionally, the Service recommends incorporating shallow canal side slopes (4:1 minimum) in the construction design or constructing facilities to allow wildlife movement across canals.

Install Overfall Pipe Structures at the Mouth of Small Streams and Farm Ditches.

Overfall pipe structures should be installed on small streams and farm ditches, which have high sediment yields and empty into the new canals and larger natural streams in the upper reach of the project area. These structures would reduce the need for channel maintenance by reducing sediment loading. They would also reduce the amount of contaminants entering these water bodies. Additionally, sufficient numbers of these structures with water control capability (stoplog structures to flood land from November through February) would increase wintering waterfowl habitat. This measure would be responsive to the objectives of the LMV Joint Venture of the North American Waterfowl Management Plan.

Revegetate Channel Right-Of-Way

The Service proposes that, during project construction, the spoil be spread and the ROW be revegetated with native grasses, particularly prairie species as proposed. The ROW would eventually provide habitat for various wildlife species, and offer opportunities for recreational pursuits. The reseeded ROW would also reduce sediment and pesticide transport into project area streams and reduce the need for channel maintenance.

Address Cumulative Impacts

Five irrigation projects are proposed in the Eastern Arkansas Project. Two other irrigation projects would withdraw water from the White River in addition to the Grand Prairie Demonstration Project, one would withdraw water from Bayou Meto, and one would withdraw water from the Little Red River. Impacts associated with the other segments have not been addressed. While the segments may be independent from a construction perspective, they are interdependent from an ecological perspective. If future projects withdraw water from the White River, and have similar construction requirements, cumulative, adverse impacts on fish and wildlife resources could result. Although the Grand Prairie Demonstration project is the only authorized project at this time, the Service recommends that cumulative impacts from all five irrigation projects be addressed at one time and mitigation planned accordingly.

RECOMMENDATIONS

To protect and conserve fish and wildlife resource values of the study area, the Service recommends the following mitigation measures:

1. Conduct a proportional analysis study, instream flow incremental methodology, or similar instream flow study to determine minimum instream flows to protect the fisheries of the project area streams and oxbow lakes, and manage water withdrawal in compliance with minimum flow needs.

2. Operate the project to comply with the water allocation levels proposed by the Arkansas Soil and Water Conservation Commission:

3. Institute a larval fish monitoring program to more accurately measure entrainment of larval fishes.

4. Explore alternative sources of water supply that are not infested with zebra mussels.

5. Acquire in fee title and intensively reforest 245 acres of farmed wetlands and 200 acres of prior converted croplands. Management of mitigation lands should be at project expense over the 50 year life of the project.

6. Conduct contaminant surveys before and after project completion to insure that contaminant levels do not become elevated in the irrigation water.

7. Locate irrigation canals and on-farm reservoirs away from wetlands and natural heritage sites.

8. Develop objective, quantitative criteria for the long term goals of prairie restoration, rather than evaluate the project based on initial effort, and monitor restoration efforts.

The Service also recommends the following specific conservation measures be implemented to address the fish and wildlife resource concerns:

1. Design on-farm reservoirs to benefit shorebirds.

2. Install BMPs on agricultural land to reduce channel maintenance and improve water quality.

3. To increase fish and wildlife habitat and use of the resources, install weirs and grade control structures in the new canals, properly design canals, and provide public access to the new canals.

4. Install overfall pipe structures at the mouth of small streams and farm ditches to improve water quality and reduce channel maintenance.

5. Revegetate the channel ROW to increase wildlife habitat and opportunities for recreational pursuits.

6. Restore prairie habitat by acquiring remnant prairie and increase the acreage of prairie habitat by revegetating adjacent land with prairie species.

7. Address cumulative impacts of all five irrigation projects proposed in the Eastern Arkansas Project.

SUMMARY OF FINDINGS AND SERVICE POSITION

The Service has determined that the tentatively selected plan could result in adverse impacts to larval fishes from entrainment during pumping operations. A larval fish monitoring program is needed to more accurately assess entrainment of larval fish. Oxbow lakes along the White River would not be adversely impacted by pump stage reductions during median discharges, although four lakes could have their connectivity severed when discharge in the White River is at or below 75 percent exceedance flow during July and August. However, the Arkansas State Water Plan would prohibit pumping at low flows, i.e., below 75 percent exceedance value. Providing water to existing canals and intermittent streams would provide some positive fishery benefits. A modified habitat evaluation procedure or similar instream flow study is needed to determined acceptable minimum flows necessary to protect the fishery resources of the White River. Construction of the water distribution system would result in the loss of approximately 124 acres of forested uplands (54 permanently and 70 temporarily) and approximately 122 acres of forested wetlands (62 permanently and 60 temporarily). The Service has determined that approximately

245 acres of farmed wetlands and approximately 200 acres of prior converted croplands would have to be acquired and reforested to compensate for unavoidable losses of forested upland and bottomland hardwoods. Wintering waterfowl would benefit under Alternative 7 D. Under this alternative, approximately 38,529 acres of harvested rice fields would be flooded for waterfowl during the winter months. Flooding of this acreage would provide 22,385,349 duck-use-days. Further information on this subject can be found in Appendix A. Although the proposed project is the only one authorized, the cumulative impacts of five irrigation projects in the Eastern Arkansas study area on fish and wildlife resources need to be considered as a whole instead of piece-mealing the separate components.

We support continuation of the project provided that our mitigation measures are incorporated into project planning. Inclusion of our planning objectives and incorporation of our specific conservation measures are essential for addressing the serious fish and wildlife resource concerns outlined in this report.

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APPENDIX A

WINTER WATERFOWL HABITAT AND BIOLOGY IN THE MISSISSIPPI ALLUVIAL VALLEY INCLUDING THE PROJECT AREA

WINTERING WATERFOWL BIOLOGICAL CHARACTERISTICS

Introduction

Historically, the Mississippi Alluvial Valley (MAV) including the project area served as a major wintering area for waterfowl. Waterfowl population numbers began to decline in the 1960's as the direct result of extensive droughts, loss of nesting habitat in the prairie pothole region of the North America, and the conversion of wintering areas in the MAV to agricultural production. The net effect has been that natural habitat is no longer sufficient to meet the needs of wintering waterfowl and other migratory birds. Clearing for grazing, timber harvesting, agriculture, and reservoir projects have all contributed to the decline of suitable waterfowl habitat in the region. Waste grain, rice, and soybeans are now the dominant food source of waterfowl in the MAV.

Both migratory and resident waterfowl use the area for resting, feeding, and roosting. Wood ducks (*Aix sponsa*), although migratory, are also considered permanent residents since they nest and raise their young in the study area. The mallard (*Anas platyrhynchos*) is by far the most numerous migratory waterfowl species occurring in the area. Of the 3,100,000 mallards that winter in the Mississippi Flyway, approximately 1,000,000 winter primarily in eastern Arkansas (Gamble 1995). Other waterfowl species are also dependent upon this area for food and cover. Northern pintails (*Anas acuta*), blue and green-winged teal (*Anas discors* and *Anas crecca*), gadwalls (*Anas strepera*), American wigeons (*Anas americana*), black ducks (*Anas rubripes*), canvasbacks (*Aythya valisineria*), and ring-necked ducks (*Aythya collaris*) use the area. Forested wetlands provide vital waterfowl resting areas.

Waterfowl wintering habitat (flooded woods and flooded cropland) is crucial to the well being of the mid-continent waterfowl populations, and is being rapidly diminished by federal flood control and water resource development projects. Because of its overall scarcity and importance in the project area, the Service considers waterfowl wintering habitat to be a Resource Category 2 as defined in the Service's Mitigation Policy (U.S. Fish and Wildlife Service 1981). Resource Category 2 habitat is of "high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section." The mitigation goal for Resource Category 2 habitat is "no net loss of in-kind value" and the Service is mandated to recommend measures to avoid losses of this habitat, or if unavoidable losses do occur, to recommend measures to replace that habitat value.

Several species of waterfowl, including mallards, are showing some signs of recovery approaching the population levels recorded in the 1950's. However, the northern pintail remains below the long term average. While the annual breeding waterfowl surveys are the most reliable estimates of waterfowl populations (Martin *et al.* 1979, Reynolds 1987), population estimates are also available from extensive surveys of wintering ducks as well as waterfowl harvest data. The midwinter waterfowl survey conducted by the Service and the states is not intended as a complete count or estimate of the total winter waterfowl population, but rather as total counts for

specific areas each year (Eggeman and Johnson 1989). The resulting population estimates are not considered of sufficient reliability to measure trends in abundance of most duck species because of the large area which must be surveyed and the difficulty of counting birds, especially in wooded habitats, and the lack of a valid statistical sampling scheme. Further, comparing the statewide numbers from year to year does not account for extremes of temperature or above or below normal rainfall; factors known to influence the arrival and departure of wintering waterfowl (Fredrickson and Heitmeyer 1988, Reinecke *et al.* 1992). Therefore, these surveys tend to count fewer ducks than are actually present, but the amount of undercount is unknown and is likely variable from year to year. These surveys do provide useful, general information for evaluating responses of wintering waterfowl populations to management programs and integrating regional waterfowl research and management data (Reinecke *et al.* 1992).

Waterfowl harvests have fluctuated since records have been kept, being lowest during the early 1960's when waterfowl populations, potential hunters, and days afield were low. In most years, harvests have tracked the fluctuation of these factors, especially waterfowl populations. In recent years, nationwide harvests of the heavily hunted mallard and of total ducks remained relatively constant, while hunter numbers declined and hunter success increased. It appears that fewer hunters have been increasingly successful at harvesting ducks.

In 1996, mallards comprised 63.4 percent of the ducks harvested in Arkansas, followed by gadwalls (12.8 percent), and wood ducks (6.6 percent) (U.S. Fish and Wildlife Service 1997). Hunters afield totaled 54,952 in 1996 (14 percent more than 1995) and total hunter days equaled 790,115 days (37 percent more than 1995). Total duck harvest in Arkansas (primarily eastern Arkansas) in 1996 was 1,227,739 ducks or 19.0 ducks per adult hunter. Twenty-one percent more ducks were harvested in 1996 than 1995.

Habitat Availability

The loss and degradation of waterfowl habitat has been identified as the major waterfowl management problem in North America (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1986). Habitat requirements for wintering waterfowl can be broken down into three components: availability, utilization, and suitability in meeting social behavioral requirements. Size of the migratory waterfowl population in the MAV is a function of these three components. Managed and unmanaged wintering waterfowl habitats are present in the MAV. Managed habitats, using structural measures and vegetation manipulation, are primarily found on federal and state lands, and represent the core wintering habitat during dry (below normal rainfall) years. Since 1988, Ducks Unlimited, the U.S. Fish and Wildlife Service, and the Arkansas Game and Fish Commission (through the Arkansas Partner's Program) have provided assistance to hundreds of private land owners, primarily in eastern Arkansas, to manage 238,600 acres as winter waterfowl habitat.

Unmanaged winter habitat (private lands) provides important forage to wintering waterfowl during years of normal or above normal rainfall. Periods of above normal rainfall show increases in available foraging habitat of up to 1,200 percent in Arkansas (Reinecke *et al.* 1988). The

increased availability of wintering habitat also effects the distribution of wintering waterfowl in the MAV. Proportionately more waterfowl have been found to winter in the MAV during periods of above normal rainfall and cold winters (Nichols *et al.* 1983, Reinecke *et al.* 1987).

In recent years, research has focused on relative waterfowl utilization and associated food availability in natural and agricultural foraging habitat. Utilization of agricultural fields differs among crops (Nelms and Twedt 1996). Dabbling ducks do not feed exclusively on agricultural seeds, but their diets are often dominated by such foods during autumn and winter (Jorde *et al.* 1983, Delnicki and Reinecke 1986, Miller 1987). Although agricultural seeds generally are available and relatively high in metabolizable energy, they may not satisfy the daily requirements of waterfowl for certain inorganic elements, amino acids, and vitamins (Baldassarre *et al.* 1983, Delnicki and Reinecke 1986). Bottomland hardwoods, especially red oak (*Quercus* spp. Subgenus *Erythrobalanus*) dominate hardwoods, are used for foraging to a certain extent, and roosting, loafing, and pair formation to a large extent (Bellrose 1980, Fredrickson and Heitmeyer 1988, Thompson and Baldassarre 1988, Reinecke *et al.* 1989, Heitmeyer and Fredrickson 1990). Availability of invertebrates in late winter in bottomland hardwoods is especially important to hens as a source of vital amino acids as they prepare for the breeding season (Wehrle *et al.* 1995). Caloric values, seed consumption, and seed decomposition rates of available waterfowl foraging habitat form the basis for determining project impacts to waterfowl and are discussed in detail in the Impact Assessment Methodology section of this appendix.

Habitat Utilization

Waterfowl are mobile and opportunistic, and their feeding habits have changed over time, presumedly in response to the large scale conversion of native wooded wetlands to small grain agriculture. The principal foods of mallards generally include agricultural grains; seeds and tubers of native plants; acorns; and invertebrates such as isopods, snails, and fingernail clams (Reinecke *et al.* 1987). Heitmeyer (1985) and Combs (1987) found that pin oak (*Quercus palustris*) and cherrybark oak (*Quercus falcata* var. *pagodaefolia*) acorns dominate the mallard diet during years of good mast production and favorable water conditions in southeastern Missouri. Nuttall oak (*Quercus nuttalli*) fills the same ecological niche in eastern Arkansas as pin oak in Missouri.

In early fall, mallards concentrate in shallowly flooded openings of bottomland forests. Shortly after arrival, mallards complete prealternate (breeding plumage) molt and consume primarily aquatic insects and moist soil seeds. Following molt, mallards begin courtship and by early January, 90 percent of the birds are paired (Bellrose 1980). During pairing, mallards forage intensively in flooded forests or agricultural fields, where they consume acorns and cereal grains. After pairing, mallards readily use shallowly flooded forests and continue to consume acorns, but increase consumption of macroinvertebrates (Fredrickson and Batema 1992).

The MAV also provides breeding and wintering habitat for a large wood duck population, which although difficult to census, may easily exceed one million birds in winter (Bellrose and Holm

1994). Wood ducks feed primarily on a variety of natural materials including hard mast (acorns of pin oak, water oak, Nuttall oak, and willow oak), invertebrates, weed seeds, aquatic tubers, and other fruits. Stream overflow is an important adjunct to food productivity. Small streams overflow frequently and briefly, sweeping organic matter and nutrients into the channel. Large streams do so less frequently, but their overflows cover the flood plain longer, often permitting wood ducks to take advantage of newly but temporarily created overflow habitat. Such habitat reaches maximum expansion on the alluvial plain of the Mississippi River. When possible, wood ducks exploit this bonanza as they prepare for the energy demands of breeding (Heitmeyer and Fredickson 1990).

Wood ducks use overcup oak/cypress/tupelo forest types and scrub/shrub habitats during fall courtship and pairing (Bellrose 1980). Paired wood ducks primarily use wetland areas that provide an interspersion of inundated shrubs, water-tolerant trees, and small areas of open water. Watercourses and their forested borders provide important corridors for movement of wood ducks between habitats (McGilvery 1968).

Waterfowl use large areas of flooded rice and soybean fields (Wright 1961, Delnicki and Reinecke 1986). Seeds and tubers of grasses, sedges, and other moist soil plants are also important components of the diet (Wright 1961, Wills 1970, Heitmeyer 1985, Delnicki and Reinecke 1986, Combs 1987). Invertebrates generally provide less than 10 percent of the diet in agricultural (Delnicki and Reinecke 1986) and moist soil (McKenzie 1987) habitats, but may be more important in forested wetlands (Heitmeyer 1985, Wehrle *et al.* 1995). Invertebrates, primarily snails, are a good source of essential amino acids, nitrogen, and minerals which are lacking in agricultural seeds (Natl. Res. Coun. 1977).

The nutrition of wintering waterfowl is not well understood (Fredrickson and Drobney 1979). It is, however, increasingly clear that nutrition affects dietary energy and protein intake, and that meeting these dietary requirements is positively related to winters with normal or above normal rainfall. Studies conducted in Mississippi during the wet winter of 1982-83 show increased mallard body weights while the dry winter of 1980-1981 show decreased mallard body weights (Delnicke and Reinecke 1986). Similar results in Missouri indicated that mallard body weights increased when water conditions and mast production were favorable, or when rainfall was sufficient to flood low lying cropland (Heitmeyer 1985, Combs 1987). The condition in which waterfowl return to the breeding grounds has been shown to have a major impact on their breeding success and survival (Bellrose 1980, Reinecke *et al.* 1989). Poor feeding conditions are positively correlated with winter precipitation (Heitmeyer and Fredrickson 1981, Kaminski and Gluesing 1987, Raveling and Heitmeyer 1989) and could potentially reduce recruitment in waterfowl (Dubovsky and Kaminski 1994).

Waterfowl Behavior

During winter, courtship and pair formation dominate the social behavior of dabbling ducks. Most of the project area is agricultural land, replacing forested wetlands as the primary foraging habitat. The forested wetlands and associated shrub swamps, beaver ponds, riparian habitat, and

other deep water habitat are used as resting or roosting areas and provide isolation from human disturbance, protection from predators, and a location for courtship and other social activities where pairs are visually isolated. Whereas much of the foraging and nutritional requirements can be met by flooded agricultural lands, a variety of habitats is needed to satisfy the total biological requirements of wintering waterfowl, because members of the population may differ in their habitat needs at any particular time or location (Reinecke *et al.* 1987). Examples include the likelihood of juvenile or unpaired mallards feeding in agricultural lands, to avoid harassment from courting parties, and adults and pairs seeking the isolation of shrub swamps (Heitmeyer 1985). Natural forested wetland complexes, where flooding regimes resemble historical water fluctuations, are necessary to meet all habitat requirements of wintering waterfowl (Fredrickson and Heitmeyer 1988).

WATERFOWL IMPACT ASSESSMENT METHODOLOGY

In this section, the term wintering waterfowl includes primarily puddle ducks consisting of the mallard, northern pintail, American wigeon, gadwall, green-winged teal, northern shoveler, and blue-winged teal. Impacts to waterfowl may be determined using a methodology that considers available food (energy) as an index of the carrying capacity of winter foraging habitat for dabbling ducks in the MAV. This methodology was developed in 1992 by Mr. Robert Barkley (U.S. Fish and Wildlife Service, Vicksburg Field Office) and Dr. Kenneth J. Reinecke (U.S. Geological Survey, Biological Resources Division, Mississippi Valley Research Field Station). This method has been used on several Vicksburg District Corps of Engineer flood control projects to quantify the impact of altering hydrology on traditional waterfowl wintering areas and for designing appropriate mitigation measures (U.S. Army Corps of Engineers 1991, 1993). This method has also been used in setting habitat management goals for wintering waterfowl habitat in the MAV (Loesch *et al.* 1994, Reinecke and Loesch In Press).

Project impacts may be determined by quantifying changes in the amount and quality of available wintering waterfowl foraging habitat resulting from project implementation. These changes are derived from hydrological and geographical information. To determine carrying capacity in terms of numbers of duck-use-days, data requirements include land use, hydrology, and available food during the 120 day (November 1 to February 28) waterfowl wintering period. The data are specific to those habitats and food resources that are available and used by foraging waterfowl. For a determination of baseline and future carrying capacities, land use is broken down into available acres of foraging habitat having food of value to wintering waterfowl under baseline conditions and future conditions without project. The data are broken down into acreage of soybeans, rice, moist soil, bottomland hardwood forested wetlands, and other (includes pasture, open water, etc.). Waterfowl foraging habitat, regardless of food value, is only of use to wintering waterfowl if available. Waterfowl use relatively shallow water areas, eighteen inches or less, for feeding (Fredrickson and Drobney 1979, Allen 1980, Heitmeyer 1985, Fredrickson and Heitmeyer 1988, Kaminski *et al.* 1993). Seasonal acres flooded (November 1 through February 28) for each habitat type eighteen inches or less are required. The land use data required for the

study area are specific to those acres inundated and represent only potential available foraging habitat. The amount of food available on a unit area was determined by Reinecke (1989) and McAbee (1994). Small grain crop residues, moist soil native weed seeds, acorns, and invertebrates in forest stands with more than 30 percent red oaks represent the available winter waterfowl food. The methodology was further refined to include information on seed deterioration rates and seed abundance, invertebrate abundance, as well as depth and duration of flooding (Nelms and Twedt 1996). By including these factors, the methodology more closely models winter waterfowl foraging habitat.

The index of carrying capacity for wintering waterfowl foraging habitat is expressed in duck-use-days (DUD) per acre which represents the capacity of the available forage to meet the energy requirements of one duck for one day. The information requirements to estimate DUD per acre are: (1) current land use, including crop type, (2) extent, duration, and depth of flooding, (3) amount of winter food present by land use, (4) energy of food items, (5) deterioration rates of food items, (6) energy requirements of waterfowl, and (7) estimated density of waterfowl. The equation for this is as follows:

$$DUD/Acre = \frac{Food\ X\ Energy}{Duck\ Energy\ Needs}$$

The equation used to estimate DUD per acre was further refined by factoring in the amount of seed deterioration that occurs over time because seed deterioration has a significant impact on DUD per acre. Deterioration rates were estimated from experimental data using the best fitting regression model (Nelms and Twedt 1996). Daily seed consumption estimates were also incorporated into the equation to preclude overestimating the influence of seed deterioration because foods consumed by ducks are not subject to deterioration. Since DUD per acre are a function of the weight of the food available and food is easily converted to calories, calculations are in terms of the weight of food. The equation for food available to ducks on a given day when seed consumption and deterioration are taken into account is:

$$Food_j = Food_0 - \sum_{i=0}^{j} (Food_{consumed_i} + Food_{deteriorated_i})$$

where:

$$Food_{consumed} = \frac{Mean\ duck\ density\ X\ Kcal\ \ consumed/duck/day}{Kcal/kg\ of\ food}$$

and

$$Food_{deteriorated} = Food\ X\ Deterioration\ rate\ X\ Days_{i}$$

where i and j are days to exhaustion.

DUD per acre, adjusted for deterioration, is calculated by multiplying the number of DUD per acre times the projected density of ducks (20.2 ducks per hectare). By converting to DUD per acre, units are comparable across habitats, which facilitates both wetland mitigation efforts and management decisions. This is particularly useful when the loss of one habitat must be mitigated with another habitat type due to practical constraints or the need to meet multiple ecosystem management goals. DUD per acre provide an objective index of the relative value of different habitats for dabbling ducks as winter foraging habitats.

To facilitate calculation, food item densities, deterioration rates, and energy values are aggregated within a given habitat type. Weighted averages based on weights of food items are used to calculate the aggregate values. Aggregate values are representative of any generic unit of food in the habitat of interest (Table 1).

Once aggregate values are calculated, the density of ducks feeding in the habitats of interest is projected so that daily consumption can be estimated. An overall average of systematic observations of waterfowl in flooded moist soil, rice, and soybean fields in the MAV is used to estimate duck density. The estimated diurnal density of ducks in flooded rice, soybean, and moist soil fields in the MAV from data collected by McAbee (1994) and Dan Twedt (U.S. Geological Survey, Biological Resources Division, Mississippi Valley Research Station) and Mr. Curtis Nelms (U.S. Fish and Wildlife Service, Vicksburg, Mississippi) (unpublished data) is 10.1 ducks/ha. No empirical estimates of waterfowl density in flooded bottomland hardwoods (BLH) in the MAV are known to exist, so estimates from croplands and moist soil are used for BLH also. Little information is available on nocturnal feeding densities of waterfowl, although this has been shown to be an important phenomenon (Paulus 1980, Reinecke unpublished data). To adjust for nocturnal foraging, the estimate of diurnal density is doubled to 20.2 ducks/ha. The role of the projected density and subsequent consumption estimates is to dampen the effects of seed deterioration on food availability. If the average daily consumption estimates are not included in the model then the influence of seed deterioration would be overestimated because foods consumed by ducks are no longer subject to deterioration. From these calculations, DUD/ha (or acre) and days to exhaustion (DTE) can be generated (Acres flooded X Weighted Ave. DUD/Acre = Total DUD) (Table 2).

Reasonable estimates are generated for the number of days of flooding until exhaustion of food resources occur at an average duck density. This density is assumed to be the point where declining foraging efficiency causes ducks to abandon a field. Reinecke *et al.* (1989) found this threshold foraging efficiency to be 50 kg/ha. The estimated DTE of food resources are useful for determining the impact of the length of inundation on habitat values. DTE allows the inclusion of data on flood duration and is useful in determining the impacts of projects on wintering waterfowl foraging habitat (Nelms and Twedt 1996).

Table 1. Food Densities and Metabolizable Energy Content of Foods in the MAV.

Food density in kg/ha (metabolizable energy content in Kcal/kg)[1]				
Foraging Habitat	Acorns	Grain	Weeds	Invertebrates
Moist Soil			450 (2500)	0.69 (2500)[2]
Harvested Cropland				
Corn		250 (3670)		
Milo		200 (3500)	25 (2500)	
Rice		166 (2933)[1&2]	32 (2500)[1&2]	3.96 (2500)[2]
Soybean		86 (1871)[1&2]	54 (2500)[2]	0.44 (2500)[2]
Bottomland Hardwoods				
30% red oaks	27 (3500)		22.5 (2500)	23.6 (2500)
50% red oaks	44 (3500)		22.5 (2500)	23.6 (2500)
70% red oaks	62 (3500)		22.5 (2500)	23.6 (2500
90% red oaks	80 (3500)		22.5 (2500)	23.6 (2500)

[1] All information from Reinecke *et al.* (1989) unless indicated
[2] McAbee (1994)

Table 2. Duck-Use-Days Per Hectare and Days to Exhaustion of Food Resources In Winter for Flooded Moist Soil, Rice, Corn, Soybean, and Bottomland Hardwood Forests. [1]

Habitat	Duck-use-days/hectare	Duck-use-days/acre	Days to Exhaustion
Moist Soil	2,563	1,037	126
Rice	1,434	581	71
Corn	970	392	48
Milo	849	344	41
Soybean	626	253	31
Bottomland Hardwoods 30% red oaks[2]	222	90	11
50% red oaks	384	155	19
70% red oaks[3]	566	229	28
90% red oaks	747	302	37

[1] Nelms and Twedt 1996

[2] 30% red oaks is used as the average composition in a natural stand.

[3] 70% red oaks is used in this waterfowl appendix as the average seedling survival rate.

RESULTS

Based on our assessment, the Corps proposal would provide benefits to waterfowl wintering in the project area. The Corps proposes (Alternative 7D) to annually flood 38,529 acres of harvested rice fields. As mentioned previously, DUD per acre provide an objective index of the relative value of different habitats (in this case harvested rice fields) for dabbling ducks as winter foraging habitat. Since DUD per acre are a function of the weight of the food available and food is easily converted to calories, calculations are in terms of the weight of food. Therefore, the relative value of harvested rice fields would be 581 DUD per acre of flooded habitat (see Table 2). Flooding of this acreage would provide 22,385,349 duck use days (DUDs) (38,529 acres flooded x 581 DUDs per acre = 22,385,349 DUDs). The project area would annually provide 10,109,400 DUDs (17,400 acres flooded x 581 DUDs per acre = 10,109,400 DUDs) under future without project conditions. Therefore, Alternative 7D, the tentatively selected plan, would provide an additional 12,275,949 DUDs per year (22,385,349 - 10,109,400 = 12,275,949).

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APPENDIX B
SHOREBIRDS HABITAT AND BIOLOGY

SHOREBIRDS

Introduction

Wetland management efforts have historically been focused primarily on waterfowl, but in the 1990's, shorebirds (Aves: Charadriiformes) and other nongame waterbirds have become increasingly appreciated by the public and subsequently wetland management efforts have expanded to include them (Helmers 1992). Although data are limited, significant population declines in most shorebird populations are evident (Helmers 1993). The North American Waterfowl Management Plan, a large scale multi-organization wetland management effort, has incorporated shorebirds into its management strategies (Helmers 1992, 1993, Streeter *et al.* 1993). The study area falls within the review of the Mississippi Alluvial Valley Migratory Bird Initiative, which identifies habitat goals for migratory birds including shorebirds (Loesch *et al.* in press). The well being of shorebirds has been compromised by wetland losses, hydrologic alterations due to stream channelization and flood control efforts, human development, and environmental contaminants. Shorebirds include a diverse assemblage of birds that breed, migrate, and winter throughout the Grand Prairie. Thirty-six species of shorebirds occur in Arkansas on a regular basis, nearly all of which have been observed in the project area, and several more species have been observed in isolated instances (James and Neal 1986).

Woodcock (*Scolopax minor*) and the black-necked stilt (*Himantopus mexicanus*) may breed in the project area. However, the only species of shorebird that has been documented to breed in the project area is the killdeer (*Charadrius vocerifus*). This species is thriving in the area and has adapted well to modern land uses. Killdeer are anticipated to maintain relatively stable populations in the foreseeable future.

Killdeer and common snipe are common throughout the winter whereas yellowlegs (*Tringa* spp.) and Calidrid sandpipers (*Calidris* spp.) are consistently present, but less abundant. Shorebird densities were greater in soybean fields than in rice fields and moist soil units from November to January (Twedt *et al.* in press). During February and March, shorebird densities in soybean and rice fields were similar, but greater than in moist soil units.

Seasonal Movements

Spring--It is usually wet during spring and flooded habitat is abundant. Shorebirds are most often observed on mudflats and on rice fields with little cover. More than 70 percent of shorebirds are associated with areas having water approximately 2 inches deep. Black-necked stilts and yellowlegs (*Tringa flavipes* and *T. melanoleuca*) are associated with water deeper than 2 inches. Whereas, killdeer and pectoral sandpipers (*Calidris melanotos*) were commonly observed on mudflats. In northeast Louisiana, Ouchley (1992) observed shorebirds most often on shallow flooded areas with little cover, such as rice fields with little post-harvest residue.

Flooding fields with about 2 inches of water is most beneficial to shorebirds, but deeper flooding is also beneficial if shallow water edge habitat is associated with the flood regime.

Summer--Suitable shorebird habitat in late summer is limited, with most of the habitat being provided by moist soil areas on National Wildlife Refuges. High species diversity and abundance of shorebirds during July, August, and early September underscore the need for shallow flooded habitat during summer. However, excess summer water is usually not available and flooding is not compatible with agricultural practices during this time. Suitable stopover habitat, particularly during the late summer is likely a limiting factor for shorebird populations that migrate through the Mississippi Alluvial Valley (Helmers 1992).

Fall/Winter--Intensive management of small areas can provide valuable fall and winter shorebird habitat. Rice fields and plowed fallow fields provide shorebird habitat from early fall through early winter. Rolling or lightly discing rice fields tends to break down stubble, increasing their value to shorebirds. Drawn-down impoundments, with exposed mud flats and little cover, seem to attract more fall migrants than disced fields on managed lands. Higher shorebird use of flooded soybean fields may be due to sparse vegetation cover and looser textured soil surface; these characteristics probably increase invertebrate productivity. Soybean is one of the most widely planted crops in the MAV, but soybean fields are not usually artificially flooded during winter. The opportunity exists to greatly increase shorebird winter habitat by artificially flooding soybean fields.

Many species of shorebirds migrate from Arctic breeding grounds to Central and South American wintering grounds with a major migration corridor passing through the Mississippi Alluvial Valley (MAV) (Helmers 1992). Some shorebirds migrate up to 7,500 miles between their breeding and wintering areas. To migrate successfully, shorebirds require highly productive stopover sites where they can efficiently forage to replenish fat reserves. They typically require habitat with an abundance of invertebrates that is either shallowly flooded (<10 cm) or comprised of mudflats. This habitat can be provided by impounding water on agricultural fields and moist soil units and by drawing down reservoirs in a timely fashion (Twedt *et al.* in press). Most species of shorebirds avoid wooded wetlands although they may use suitable openings in them occasionally.

Shorebird Behavior

Cotton, soybean, and rice are the three most common crops within the MAV (Bellow and Graham 1992). Flooded cotton fields offer only limited benefits to shorebirds; however, rice and soybean are used extensively by wintering and migrating shorebirds (Nelms and Twedt 1995).

Diurnal observations were made of behavior of flocks of birds using rice, soybean, and moist-soil habitats in Arkansas and Mississippi (Twedt and Nelms 1995). Specifically, behavior of flocks of common snipe and yellowlegs were compared among habitats and among seasonal periods during winter and early spring. Study areas included the Lower Yazoo River Basin in Mississippi and the Grand Prairie in Arkansas. During the winters of 1991-92 and 1992-93, sixty fields, 20 of each habitat type, were selected from landowners enrolled in cooperative "private lands" projects

supplemented with eight moist-soil habitats which were not under cooperative agreements but on which water was managed during winter.

Beginning November 15 of both winters, flocks of specific bird species were observed on selected fields twice during each of nine consecutive two-week periods and once during each of three additional consecutive two-week periods. If the selected fields did not have bird flocks present, the next flock of birds was observed in the appropriate habitat encountered. THU, the experimental unit employed in statistical analyses is the flock. Observations were made systematically on randomly selected dates (within each period) beginning at randomly selected times, but all observations were diurnal. During each visit scan-sampling was used to record the behavior of all individuals within small flocks (six bird minimum flock size) or the first 200 individuals encountered in large flocks. Behaviors were recorded as: feeding, moving, resting, flying, alert, social, and other. Before statistical analysis, the proportions of the four primary behaviors; feeding, resting, moving, and alert; within each flock were subjected to arcsine transformation (Zar 1984). Also the twelve two-week observation periods were equally grouped in four seasons: early winter, mid winter, late winter, and spring. For common snipe and yellowlegs, a separate multivariate analysis of variance (MANOVA) was performed on the transformed behavioral proportions of flocks to examine differences among habitats and seasons. Because flocks of each species were not consistently observed in all habitats or in all seasons, comparisons were only made where representative data were available. Seasonal comparisons for snipe and yellowlegs were between the aggregate of all winter periods and spring. Additionally, snipe behaviors were only compared between rice and soybean habitats.

Thirty-three common snipe flocks with a mean flock size of 24 birds and 29 yellowlegs flocks with a mean of 22 birds per flock were observed (Twedt and Nelms 1995). Preliminary analyses indicate that the interaction of habitat and season did not significantly impact the analyses for either common snipe or yellowlegs and was removed from these MANOVA. No significant differences were detected among habitats for either snipe or yellowlegs. However, significant differences in behavior were detected between winter and spring seasons for both snipe and yellowlegs in preliminary analyses. Greater proportions of both snipe flocks and yellowlegs flocks moved more during winter than during spring. Additionally, snipe flocks had a greater proportion of individual feeding during spring than during winter. Increased feeding behavior of snipe flocks during late winter and spring, may be the result of hyperphagia to develop fat deposits for northward migration and subsequent breeding. Alternatively, this increase in feeding behavior may be a response to diminished food resources on areas depleted earlier in the winter.

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APPENDIX C
HABITAT EVALUATION PROCEDURES
(TERRESTRIAL)

HABITAT EVALUATION PROCEDURES

Background and Objectives

The Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service 1980) were used to quantify the potential impacts of constructing a pumping plant adjacent to the Wattensaw WMA at DeValls Bluff as well as associated low water weirs, canals, and pipelines for irrigation purposes within the Grand Prairie subarea. HEP is a habitat-based evaluation system that estimates current habitat condition, predicts future condition, compares project alternatives, and devises mitigation strategies. The objectives of this work were (1) to determine pre-project (baseline) habitat conditions for selected wildlife species in the project area, (2) to estimate potential impacts to each species under project alternatives, and (3) to suggest mitigation measures or other design modifications to offset unavoidable habitat losses. Only direct impacts were evaluated. Direct impacts included land clearing, construction, and maintenance activities along the canal and pipeline rights-of-way.

An Overview of HEP

HEP is an accounting system for quantifying and displaying habitat suitability index (HSI) models that quantitatively describe the habitat requirements of a species or group of species. HSI models use measurements of appropriate variables to rate the habitat on a scale of zero (unsuitable) to 1.0 (optimal). In a typical HEP study, a number of evaluation species are chosen for each cover type of interest in the study area. Species may be chosen because of their ecological, recreational, or economic value, or because they represent groups of species (i.e., guilds) that have similar habitat needs (Roberts *et al.* 1985).

Baseline cover types were determined by the use of National Wetlands Inventory's (NWI) 1:24,000 quadrangle maps. Cover maps were then developed with the aid of Geographic Information System (GIS) software with the project area delineated by the Memphis District. Total acreage was then plotted and the average of the various habitat types determined. Habitat types were ground truthed during field evaluation and necessary modifications were made. The project area was divided into four cover types including upland hardwoods, bottomland hardwoods, forested swamp (cypress-tupelo), and scrub/shrub. Bottomland hardwoods include overcup, water, willow, Nuttall, and swamp chestnut oaks (*Quercus lyrata*, *Quercus nigra*, *Quercus phellos*, *Quercus nuttalli*, and *Quercus michauxii*), hickories, sugarberry (*Celtis laevigata*), cottonwood (*Populus deltoides*), American elm (*Ulmus americana*), sweetgum (*Liquidambar styraciflua*), pecan (*Carya illinoensis*), and green ash (*Fraxinus pennsylvanica*). Upland hardwoods include post, white, blackjack, and southern red oaks (*Quercus stellata*, *Quercus alba*, *Quercus marilandica*, and *Quercus falcata*), hickories, sugarberry, and blackgum (*Nyssa sylvatica*).

Evaluation Team

The interagency evaluation team consisted of professional biologists and included Mr. Daniel Gregg (U.S. Fish and Wildlife Service [FWS]), Mr. Edward Lambert (U.S. Army Corps of

Engineers, Memphis District [COE]), Mr. Robert Price (Natural Resources Conservation Service, Little Rock [NRCS]), and Mr. Craig Uyeda (Arkansas Game and Fish Commission [AGFC]). A team concept was use to evaluate habitat. For example, although more than one biologist from an agency was occasionally present during the early planning and the evaluation, each agency's opinion received equal weight in the decision making process.

Evaluation Species

With the consensus of the HEP Team members, six species were selected for the habitat evaluation. The combined habitat requirements of these species were believed to reflect the important wildlife values of the various habitats in the study area. These six species -- barred owl (*Strix varia*), gray squirrel (*Sciurus carolinensis*), Carolina chickadee (*Parus carolinensis*), pileated woodpecker (*Dryocopus pileatus*), swamp rabbit (*Syvilagus aquaticus*), and white-tailed deer (*Odocoileus virginianus*), inhabit upland forests and forested wetlands in the study area. Barred owls prefer mature forests with closed canopies and large trees; gray squirrels also prefer mature forests, but with a variety and abundance of mast-bearing trees such as oaks and hickories. Pileated woodpeckers choose habitats that contain high densities of large trees and snags, dense canopies, and tall shrub cover. Carolina chickadees nest in small cavities in live trees or snags and forage in densely wooded forests with abundant tree foliage. Swamp rabbits use moist forested habitats with dense understory and fairly open canopy. White-tailed deer prefer early successional stages of deciduous forest and bottomlands, interspersed with permanent water, thickets, old fields and/or croplands. The HEP Team members agreed that the white-tailed deer model would be modified to represent a single cover user.

Assumptions

Based upon the best available information from the COE, NRCS, and AGFC, the following assumptions and decisions were made by the evaluation team using their combined professional judgment and expertise.

With and Without the Project

1. From 1994 (beginning of HEP planning) to target year 0 (start of project construction), there would be no significant change in habitat unit value of any of the habitat sampled.

2. Habitat types would remain constant from target year 0 to target year 50.

Without the Project

1. Normal land use trends and practices are expected to continue.

2. Acreage figures from the different land uses would remain relatively constant.

3. Timber harvests would remain the same and would not appreciably change the overall structure of the study area forests.

4. HSI values for the evaluation species would remain constant.

With the Project

1. Project construction would result in the loss of approximately 124 acres of forested uplands (54 permanently and 70 temporarily) and approximately 122 acres of forested wetlands (62 permanently and 60 temporarily)

2. Lands converted to grassed rights-of-way along the canals would remain in that habitat type due to regular maintenance.

3. The HSI values for evaluation species affected by forest clearing could be estimated over the 50 year life of the project.

4. Due to construction of the canals and on-farm reservoirs, there will be a significant increase in acres of water.

5. Compensation requirements to offset project-induced impacts would be determined by use of HEP.

With the Project-Management of Compensation Lands

1. Approximately 193 acres of prior converted croplands and 243 acres of farmed wetlands would be acquired in fee title and reforested by the Corps to offset project induced losses of terrestrial habitat. Mitigation lands would then be transferred to either the AGFC or the Service. In-kind replacement would be used to accomplish the compensation goal to offset bottomland hardwood losses as outlined within the FWS' Mitigation Policy Guidelines (Service 1981).

2. Out-of-kind equal replacement would be used to accomplish the compensation goal to offset upland forest losses as outlined within the FWS Mitigation Policy Guidelines.

3. Compensation lands would be acquired within the immediate study area.

4. Compensation lands would be managed at project expense over the 50 year life of the project so as to optimize potential for wildlife habitat value.

5. Forested habitat types would be selectively harvested for timber stand improvement.

6. Changes in cover types would occur due to management, but net habitat acreage would remain constant.

7. Normal land use trends would not occur on compensation lands due to maintenance of existing habitat conditions for the benefit of wildlife populations.

Sampling Methods

Habitat variables contained in the HSI models were measured during May 1994 by a single team composed of biologists from the FWS, COE, NRCS, and AGFC. The sampling scheme was designed to include all habitat types of concern within the project area. Habitat variables were measured within 1/5 acre plots at selected project impact sites. Prior to entry into a plot, a compass azimuth was selected and recorded on field sheets. Upon entry into the site, azimuth changes were made and recorded if necessary. A standard distance of 50 meters was adopted by mutual agreement and used upon stand entry. To avoid bias, a random pace count was identified by a watch second hand and paced to the appropriate count to establish point center.

Plots were first classified by cover type and then the tree layer was sampled. The tree layer consisted of all woody plants > 20 feet tall, excluding vines. Trees within the plot were classified visually as either overstory or understory, and identified to species. The DBH of each tree was measured to the nearest inch, and the average height of all trees was estimated visually and checked occasionally with a clinometer. Tree counts and DBH measurements were later used to calculate the mean DBH of overstory trees, density of trees > than 20 inches DBH, number of snags and logs > than six feet in height/length, and the number of hard mast species present.

Visual estimates of percent cover were made independently by each sampling team member, and determined by group consensus. In forested plots, percent cover was estimated separately for all trees and hard mast species. Percent of shrub and herbaceous ground cover was sampled within a 25 foot subplot once the interagency team had reached point center.

HEP Results

To calculate the average annual habitat units (AAHU) in the study area for with and without the project, the HSI for each species was multiplied by the annualized acreage of habitat available. Thus, a comparison can be made between the AAHU for with and without the project to determine losses or gains as a result of the project. Tables 1 and 2 present the AAHU for with and without project conditions. Also shown are the AAHU gained for evaluation species which would be obtained through reforestation and management of mitigation lands (Tables 3 and 4).

Table 1. Average annual habitat units (AAHU) analysis for evaluation species (forested uplands).

Evaluation Species	AAHU With Project	AAHU Without Project	Net Change in AAHU
Barred Owl	12936	12998	-62
Gray Squirrel	12639	12699	-60
Pileated Woodpecker	5948	5976	-28
Carolina Chickadee	12193	12251	-58
White tailed Deer	7434	7470	-36

Table 2. Average annual habitat units (AAHU) analysis for evaluation species (forested wetlands).

Evaluation Species	AAHU With Project	AAHU Without Project	Net Change in AAHU
Barred Owl	16693	16742	-49
Gray Squirrel	14232	14274	-42
Pileated Woodpecker	10334	10364	-31
Carolina Chickadee	17289	17340	-51
Swamp Rabbit	17166	17228	-62

Table 3. Net change in AAHU for evaluation species after reforestation of prior converted croplands.

Evaluation Species	AAHU With Planting	AAHU Without Reforestation	Net Change in AAHU
Barred Owl	68.4	19.0	+49.4
Gray Squirrel	83.6	34.2	+49.4
Pileated Woodpecker	62.7	26.6	+36.1
Carolina Chickadee	89.3	32.3	+57.0
White-tailed Deer	132.4	52.8	+79.6

Table 4. Net change in AAHU for evaluation species after reforestation of farmed wetlands.

Evaluation Species	AAHU With Planting	AAHU Without Reforestation	Net Change in AAHU
Barred Owl	69.6	55.2	+14.4
Gray Squirrel	107.4	55.2	+52.2
Pileated Woodpecker	64.8	48.0	+16.8
Carolina Chickadee	116.9	57.6	+59.3
Swamp Rabbit	142.8	88.1	+54.7

The Corps proposes to obtain 193 acres of prior converted croplands and 243 acres of farmed wetlands in fee title and reforest the areas. The cleared land would then be reforested. Land acquisition in fee title would be the most cost effective method for obtaining the necessary mitigation lands in the study area. Additionally, fee acquisition provides unlimited control, unencumbered management of fish and wildlife resources, and the assurance of public access for consumptive and nonconsumptive recreational use.

COMPENSATION ANALYSIS

Management Plan Scenarios

The Corps' mitigation proposal for management of reforested lands (193 acres of prior converted croplands and 243 acres of farmed wetlands) would result in gains in AAHU for all evaluation species and would adequately compensate for adverse impacts to terrestrial resources. Based on HEP analysis, approximately 200 acres of prior converted croplands and approximately 245 acres of farmed wetlands would be required to offset terrestrial impacts. Equal replacement was the compensation goal chosen to offset forested upland impacts and is used to offset HU losses through a gain of an equal number of HU. With this goal, a gain of one HU for any target species can be used to offset the loss of one HU for any evaluation species. The actual area chosen for compensation to achieve this goal was determined by the following mathematical formula:

$$\text{Compensation Area} = -A \left(\frac{\sum_{i=1}^{n} I_i}{\sum_{i=1}^{m} M_i} \right)$$

where A = Size of candidate compensation study area
M = Habitat Units gained through compensation for a target species
I = HU losses for same species
I = species number
n = the total number of target species
m = total number of impacted species

In-kind (no trade-offs) was the compensation goal chosen to offset forested wetland impacts and is used to precisely offset HU losses for each evaluation species. The ideal compensation plan will provide, for each individual species, an increase in HU equal in magnitude to the HU losses. An optimum compensation area (OCA) was selected to optimize the achievement of the in-kind goal. The OCA minimizes the total HU over-compensations and under-compensations for evaluation species by a sum of squares technique and is calculated by the following mathematical expression:

$$\text{Optimum Compensation Area} = -A\left[\frac{\sum_{i=1}^{n} M_i I_i}{\sum_{i=1}^{n} M_i^2}\right]$$

Mitigation lands should be acquired in fee title, replanted with site specific hardwood species, and managed at project expense over the 50 year life of the project to increase the carrying capacity for wildlife. The public should also be made aware of the opportunity for wildlife related activities on these lands.

Objective of the Management Plan

The objective of the management plan is to increase the productivity of targeted species such as barred owl, wood duck, mink, and Carolina chickadee to a realistic level while holding management costs to a minimum. The management plan employs biologically sound principals of wildlife management aimed at providing increased yields of wildlife without endangering the available food source.

Management Plan

Mitigation lands would be managed at project expense over the 50 year life of the project. Reforesting prior converted croplands and farmed wetlands would be the major tool used in order to benefit targeted species. Management lands would be planted in those tree species suited to the area and would provide food, cover, and resting sites for evaluation species as well as many other wildlife species. Timber management practices would be employed and their value to wildlife would be as follows:

1. Selective cutting in bottomland forests would be performed as needed. Selective cutting favoring mast producers would yield direct improvements. Selection would be aimed at providing a balance between the red and white oak groups, which would insure the availability of mast if one of these groups should experience a mast failure.

2. Selective cutting in upland forests. The techniques and objectives are the same as for bottomland hardwoods with emphasis placed on removal of undesirable species of little or no value to wildlife which compete with desirable mast producers.

3. During forest regeneration, there would be some open areas which would be allowed to grow up in weeds, grasses, and woody vegetation. Extensive food and cover would be available during early forest regeneration and would gradually develop into a productive mast producing area in later years.

Expected Results

The implementation of the previously mentioned management practices would enhance the habitat unit value of the acquired lands. A summary of the expected results at the specific target years follows:

Target Year 0 - The acreage has been acquired, however, no management has taken place.

Target Year 1 - Reforestation has begun. Mast producing species (red and white oaks) have been selected, based on site compatibility. The mitigation site has been disked prior to planting to reduce residue, control competing vegetation, and reduce cover for rodents. One year old seedlings (18 to 30 inches tall) have been selected for planting, instead of acorns, because of their greater survival rate. Site specific species, including mast producers, have been planted on 10 foot spacings or about 440 trees/acre. The survival rate must be 70 percent after three years or the area will receive supplemental planting.

Target Year 10 - Selective thinning allows mast producers to out compete less desirable trees. Ground vegetation is developing into a high quality food supply for various wildlife species. Open areas have reverted to early successional woody plants.

Target Year 25 - Selective cutting, on a regular basis, benefits oak species by increasing mast production while decreasing competition from other less desirable species. An optimum balance between red oaks and white oaks is occurring, offering a more dependable mast crop. The understory has developed into a high quality food supply.

Target Year 50 - Mast production is greatly increased. The mast producers have developed into more vigorous producers because of lack of competition. Dependable mast crops yield a more dependable food supply. Older trees are producing more den sites. Understory growth is offering optimum food and cover. Open areas have reverted to hardwoods and are now producing an additional mast supply. Gray squirrel production is at an optimum level. Large mature trees provide cavities suitable for security and reproduction for cavity nesters such as the barred owl and Carolina chickadee. The mature forest provides an abundance of large snags and dead and fallen trees; critical components for the pileated woodpecker.

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SECTION VI. COORDINATION

PART B. PRIME AND UNIQUE FARMLAND

March 10, 1998

Planning Division
Environmental Analysis Branch

Lambert/0707_____
CEMVM-PD-F

Mr. Kalven Trice
State Conservationist
Natural Resources Conservation Service
Federal Building, Room 3416
700 West Capitol Avenue
Little Rock, Arkansas 72201

Dear Mr. Trice:

This letter is in regards to the Eastern Arkansas Region Comprehensive Study, Grand Prairie Area Demonstration Project, General Reevaluation. The primary purpose of the general reevaluation is to develop a plan of improvement for the Grand Prairie region of eastern Arkansas that would (1) protect and preserve the alluvial aquifer through the provision of supplemental irrigation water and water conservation measures and (2) provide significant environmental benefits through the enhancement and restoration of significant resources within the project area. The Grand Prairie project area encompasses 362,662 acres (70.2% cropland) and includes significant portions of Prairie and Arkansas counties and small portions of Monroe and Lonoke counties.

The selected plan involves the construction of 184 miles of irrigation canals; these canals would permanently displace 3,724 acres of cleared agricultural land. Construction of the inlet channel and pump station would permanently displace an additional 71 acres of farmland. The project would also require the placement of 177 miles of irrigation pipelines. However, these pipelines would be buried deep enough to allow continued cultivation of the rights-of-way once the pipelines have been constructed. On-farm components of the project would include 8,849 acres of new irrigation reservoirs, tail-water recovery systems, and retrofit of existing farm irrigation systems. Although it is assumed that on-farm components would be built on cleared lands, specific locations for these structures have not been identified.

Recently, digital copies of both Natural Resources Conservation Service soil maps of the project area as well as irrigation canal, pump station, and inlet channel locations and rights-of-way dimensions were sent to Mr. Tony Stevenson of your Irrigation Team. Based on this information, please provide your agency's interpretation as to the applicability of the Farmland Protection Policy Act to the 3,795 acres of farmland that would be permanently displaced by construction of the canals, inlet channel, and pump station. Furthermore, please determine if any of this agricultural land is prime or unique farmland or farmland of statewide or local importance (Form AD-1006 enclosed).

Your assistance in providing this information is appreciated. If you have questions or need additional information, contact Mr. Edward Lambert at (901)544-0707.

Sincerely,

Donald M. Dunn, P.E.
Chief, Planning Division

Enclosure

Reece_____
CEMVM-PD-
Lartigue_____
A/CEMVM-PD-
Dunn_____
CEMVM-F

USDA

United States Department of Agriculture

Natural Resources Conservation Service

Room 3416 Federal Building
700 West Capitol Avenue
Little Rock, Arkansas 72201

MAR 2 4 1998

Mr. Donald M. Dunn
Chief, Planning Division
Memphis District, Corps of Engineers
167 North Main Street B-202
Memphis, Tennessee 38103-1894

Dear Mr. Dunn:

This letter is in response to your letter dated March 10, 1998, concerning the Eastern Arkansas Region Comprehensive Study, Grand Prairie Area Demonstration Project, General Reevaluation. As requested, we have made our evaluation of this project's impact on farmland as required by the Farmland Protection Policy Act and completed our portion of the "Farmland Conversion Impact Rating" form (Form AD-1006 enclosed).

Enclosed is the form for you to complete. The instructions are on the back of the form.

If you have any questions or if additional information is required, please contact Tony Stevenson at 501-324-6641 as soon as possible.

James W. Caudle Acting for
KALVEN L. TRICE
State Conservationist

Enclosure

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request: 10 March 1998
Name Of Project: Grand Prairie Area Demonstration Project	Federal Agency Involved: Memphis District Corps of Engineers
Proposed Land Use: Canals (3,724 ac)& Pump Sta/Inlet Chan (71ac)	County And State: Prairie, Arkansas, Lonoke, Monroe
PART II *(To be completed by SCS)*	Date Request Received By SCS: 3-12-98

Does the site contain prime, unique, statewide or local important farmland? *(If no, the FPPA does not apply – do not complete additional parts of this form).*	Yes	No	Acres Irrigated	Average Farm Size
	☒	☐	1,090,700	544 acres

Major Crop(s)	Farmable Land In Govt. Jurisdiction	Amount Of Farmland As Defined in FPPA
Soybeans, Rice	Acres: 1,837,520 % 91.6	Acres: 1,821,510 % 90.1

Name Of Land Evaluation System Used	Name Of Local Site Assessment System	Date Land Evaluation Returned By SCS
LESA		3-20-98

PART III *(To be completed by Federal Agency)*	Alternative Site Rating: Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly	3,795			
B. Total Acres To Be Converted Indirectly	0			
C. Total Acres In Site	3,795			
PART IV *(To be completed by SCS)* Land Evaluation Information				
A. Total Acres Prime And Unique Farmland	3695			
B. Total Acres Statewide And Local Important Farmland	77			
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted	.002			
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value	30.9			
PART V *(To be completed by SCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*	82			

PART VI *(To be completed by Federal Agency)* Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b)*	Maximum Points				
1. Area In Nonurban Use	15	15			
2. Perimeter In Nonurban Use	10	10			
3. Percent Of Site Being Farmed	20	20			
4. Protection Provided By State And Local Government	20	0			
5. Distance From Urban Builtup Area	15	15			
6. Distance To Urban Support Services	15	10			
7. Size Of Present Farm Unit Compared To Average	10	10			
8. Creation Of Nonfarmable Farmland	10	0			
9. Availability Of Farm Support Services	5	5			
10. On-Farm Investments	20	10			
11. Effects Of Conversion On Farm Support Services	10	0			
12. Compatibility With Existing Agricultural Use	**10**	**0**			
TOTAL SITE ASSESSMENT POINTS	160	95			
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100	82			
Total Site Assessment *(From Part VI above or a local site assessment)*	160	95			
TOTAL POINTS *(Total of above 2 lines)*	260	177			

Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☒

Reason For Selection:

(See Instructions on reverse side)

Form AD-1006 (10-83)

SECTION VI. COORDINATION

PART C. PERTINENT CORRESPONDENCE

BATES/JS/3857
CELMM-PD-R

April 7, 1993

Planning Division
Environmental Analysis Branch

Ms. Cindy Osborne
Arkansas Natural Heritage Commission
Suite 1500
Tower Building
Little Rock Arkansas 72201

Dear Ms. Osborne:

To facilitate proper planning for the Grand Prairie Demonstration Project, the U.S. Army Corps of Engineers, Memphis District, is requesting the names and maps of the Breeding Bird Survey routes, State Natural Areas and elements of diversity located within the project area. Enclosed is a map of the project area.

If you require further information on this request, please contact Scott Bates, Wildlife Biologist, Environmental Analysis Branch, (901) 544-3857.

Sincerely,

David W. Wolfe
Chief, Planning Division

Enclosure

MAUNEY
CELMM-PD-R
DUNN
A/CELMM-PD-A
WOLFE
CELMM-PD

United States Department of the Interior
FISH AND WILDLIFE SERVICE
900 Clay Street, Room 235
Vicksburg, Mississippi 39180
April 19, 1994

MEMO

TO: Ed Lambert and Richard Hite, Memphis District Corps of Engineers, Memphis, TN

Ken Price, Soil Conservation Service, Little Rock, AR

Craig Uyeda, Arkansas Game and Fish Commission, Little Rock, AR

FROM: HEP team leader

SUBJECT: HEP team meeting, Eastern Arkansas Demonstration Project

I would like to personally thank all the HEP team members who were able to attend the April 13 and 14 HEP committee meeting held at Vicksburg. I believe the meeting was highly productive and that we were able to define and agree on the HEP objectives during our project scoping session.

Listed below are the goals, objectives, and assumptions we agreed to at the meeting. Please let me know if I missed anything.

A. Consolidate cover types into the following categories.
   1. Bottomland hardwoods
   2. Cypress/tupelo (Forested swamp)
   3. Shrub/scrub
   4. Upland forest

B. We will be looking at direct impacts to wildlife habitat.

C. Do a separate HEP on Wattensaw WMA (5-7 sample sites) to reflect upland species habitat.

D. Do HEP and HES samples at the same time and location using 1/5 acre sample plots.

E. Document changes to sample sites on site forms while in the field.

F. We will take a closer look at the proposed pipeline site on the north side of DeVall's Bluff.

G. The field survey will be carried out from May 23 - 27. If additional survey days are needed, they will be performed May 31 - June 4.

H. The following species were selected to accurately reflect habitat values for bottomland hardwoods and uplands.

Bottomland hardwoods	Uplands
Gray squirrel	Gray squirrel
Barred owl	Barred owl
Carolina chickadee	Carolina chickadee
Pileated woodpecker	Pileated woodpecker
Swamp rabbit	White-tailed deer (single cover user)

If you have any questions contact me at (601) 638-1891.

Daniel T. Gregg

Daniel T. Gregg
HEP team leader

Hite/Corbett

United States Department of the Interior
FISH AND WILDLIFE SERVICE

900 Clay Street, Room 235
Vicksburg, Mississippi 39180

October 27, 1993

Colonel Clinton W. Willer
District Engineer
U.S. Army Corps of Engineers
B-202 Clifford Davis Federal Building
Memphis, Tennessee 38103-1894

Dear Colonel Willer:

The attached planning aid report constitutes the report of the U.S. Fish and Wildlife Service relative to the Memphis District's Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area). Our report assesses the impacts of the proposed project on fish and wildlife resources, identifies project modifications to minimize resource losses, and outlines conservation measures to reduce or eliminate fish and wildlife resource losses. Our report has been prepared in accordance with the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 40, as amended; 16 U.S.C. 661 et seq.), but does not constitute our final report as required by Section 2(b) of that Act. In keeping with the requirements of the FWCA, this report should be attached to and made an integral part of your General Reevaluation Report.

The Service appreciates the opportunity to provide these preliminary comments and recommendations and looks forward to working with you and your staff as the study progresses.

Sincerely,

Charles A. McCabe
Acting Field Supervisor

cc: COE, Little Rock District, Little Rock, AR.
EPA, Region VI, Dallas, TX
Attn: Jay Gamble
Arkansas Game and Fish Commission, Little Rock, AR
Attn: Dave Criner
Arkansas Dept of Pollution Control & Ecology, Little Rock, AR
Attn: Steve Drown
Arkansas Soil & Water Commission, Little Rock, AR
Attn: Tammy Avery
Arkansas Natural Heritage Commission, Little Rock, AR
Attn: Cindy Osborne
Soil Conservation Service, Little Rock, AR
Attn: Bob Price

Lambert/js/3857 _____
CEIMM-PD-R

June 30, 1994

Planning Division
Environmental Analysis Branch

Mr. Craig Uyeda
Arkansas Game and Fish Commission
2 Natural Resources Drive
Little Rock, Arkansas 72205

Dear Mr. Uyeda:

As part of the Eastern Arkansas Region Comprehensive Study, General Reevaluation (Grand Prairie Area), the Memphis District is requesting the Arkansas Game and Fish Commission (AGFC) to conduct a rotenone fish survey within an above-ground canal in Prairie County, Arkansas, during July or August 1994. This canal is located adjacent to Arkansas Highway 11, approximately 5.8 miles south of U.S. Highway 70, near LaGrue Bayou and Peckerwood Lake (see enclosed map). The owner of the canal, Mr. Dan Hooks, has given permission to conduct the survey. Personnel from our Environmental Analysis Branch would provide landowner coordination and sampling assistance to the AGFC.

Since this canal is similar in design to many of the canals under study for construction in the Grand Prairie, a rotenone survey could lend valuable insight as to the fish species diversity and productivity that could potentially exist in above-ground canals planned for future construction.

Please inform me whether or not the AGFC can perform this survey. If you have questions or need additional information, contact Mr. Edward Lambert, at (901) 544-3857.

Sincerely,

Mauney _____
CELMM-PD-R

Donald M. Dunn, P.E.
Acting Chief, Planning Division

Enclosure

Bodron _____
A/CELMM-PD-F
Mauney _____
A/CELMM-PD-A
Dunn _____
A/CELMM-PD

Steve N. Wilson
Director

Scott Henderson
Assistant Director

Arkansas Game & Fish Commission

March 30, 1995

Dr. Morris Mauney
U.S. Army Corps of Engineers
Memphis District
167 North Main St., B202
Memphis, TN 38103

Dear Morris:

Attached please find a copy of the rotenone sample that we conducted on the Hooks Farm ditch this past fall. As per the recommendations, if another sample is to be conducted to better characterize what kind of fishery a true flowing water canal would have, then Arkansas Game and Fish Commission fisheries biologists will be involved with selecting the sample site.

If you have any questions on any of this work, please feel free to contact me at (501) 223-6371.

Sincerely,

Steve Filipek

Steve Filipek
Fisheries Research Biologist

SF:kh

Attachment

2 Natural Resources Drive Little Rock, Arkansas 72205
(501) 223-6300

Lambert/js/3857 _____
CELMM-PD-R

June 30, 1994

Planning Division
Environmental Analysis Branch

Mr. Steve N. Wilson
Arkansas Game and Fish Commission
2 Natural Resources Drive
Little Rock, Arkansas 72205

Dear Mr. Wilson:

The Memphis District, Corps of Engineers, would like to brief you and/or your staff on the Eastern Arkansas Region Comprehensive Study, General Reevaluation (Grand Prairie Demonstration Project). This project has the potential to add many thousands of acres of habitat for both winter waterfowl and fisheries. However, it is our understanding that the Arkansas Game and Fish Commission staff (AGFC) has some concerns relating to water withdrawals from the White River and pump station/pipeline construction within Wattensaw Wildlife Management Area; these topics, among others, could be addressed.

If possible, we would like to hold this meeting at the AGFC building in Little Rock, Arkansas sometime in late July or August 1994. Please inform us whether or not you are able to provide facilities for the meeting. A draft agenda will be provided for your review and comment. Attendees from other organizations such as the Arkansas Natural Heritage Commission, and Nature Conservancy would be welcome to attend, if they are interested.

Dr. Morris Mauney will be point of contact for this meeting. Please call him at (901) 544-3857 if you have questions or need additional information.

Sincerely,

Mauney _____
CELMM-PD-R

Donald M. Dunn, P.E.
Acting Chief, Planning Division

Bodron _____
A/CELMM-PD-F
Mauney _____
A/CELMM-PD-A
Dunn _____
A/CELMM-PD

Arkansas Game & Fish Commission

2 Natural Resources Drive Little Rock, Arkansas 72205

David E. Miller
Chairman
Melbourne

Dr. James E. Moore, Jr.
Vice Chairman
Little Rock

Hal Hunnicutt
Conway

Kirk Dupps
Bentonville

Steve N. Wilson
Director

W.R. "Witt" Stephens, Jr.
Little Rock

Pat Stephens
Stuttgart

Bill Bridgforth
Pine Bluff

Professor Arnold Kaplan
University of Arkansas
Fayetteville

July 12, 1994

Mr. Donald M. Dunn
Acting Chief, Planning Division
Memphis District, USCE
167 No. Main Street, Rm. B-202
Memphis, Tennessee 38103-1894

Dear Mr. Dunn:

Thank you for your letter of June 30, 1994 concerning setting up a briefing session with our agency regarding the Eastern Arkansas Region Comprehensive Study, General Reevaluation (Grand Prairie Demonstration Project).

We look forward to the opportunity to meet with you and your staff to discuss fish and wildlife resource issues in connection with the study and would be pleased to provide a meeting place here at our Little Rock office. Please contact Craig Uyeda of my staff to arrange the meeting date.

By copy of this letter I will be informing appropriate members of my staff who I feel would have particular interest in the discussions.

Your cooperation in this matter is very much appreciated.

Cordially,

Steve N. Wilson/RSH

STEVE N. WILSON,
Director

SNW:CKU:ac

cc: U.S. Fish & Wildlife Service
Don Akers
Mark Wright
Sonny Thompson
David Long
Allen Carter
Steve Filipek

Jon Schneider
John Welch
Craig Uyeda
Levi Davis
Jeff Farwick
Scotty May

Arkansas Soil and Water Conservation Commission

J. Randy Young, P.E.
Executive Director

101 EAST CAPITOL
SUITE 350
LITTLE ROCK, ARKANSAS 72201

PHONE 501-682-1611
FAX 501-682-3991

September 30, 1994

Mr. Ed Lambert
Memphis District, USACE
167 N. Main, Room B202
Memphis, TN 38103-1894

Dear Mr. Lambert:

This letter is to confirm the arrangements we made for a meeting between the Corps of Engineers, Soil Conservation Service and Arkansas Soil and Water personnel regarding GIS data generated to support the Grand Prairie and Bayou Meto Irrigation Projects. Personnel attending the meeting will include Marcella Callahan and Alice Weeks, SCS, Little Rock; yourself and Steve Williamson, ACE, Memphis; and Ken Brazil and myself, ASWCC, Little Rock. We will meet in Steve's office, Room 563, at 10 a.m., October 19, 1994.

If you have any questions, please do not hesitate to contact me.

Thank you.

Sincerely,

Joe

Joseph Krystofik

cc: Ken Brazil

An Equal Opportunity Employer

Steve N. Wilson
Director

Scott Henderson
Assistant Director

Arkansas Game & Fish Commission

HAMPTON WATERFOWL RESEARCH CENTER
Rt. 1, Box 188A
Humphrey, AR 72073

December 12, 1994

Mr. Ed Lambert
U.S. Army Corps of Engineers
Environmental Analysis Branch
167 N. Main Street, B202
Memphis, Tennessee 38103-1894

Dear Ed:

Please find the below data you requested regarding waterfowl harvest and population data for Arkansas, Prairie, Lonoke and Monroe Counties. The harvest data is collected by the U.S. Fish and Wildlife Service from randomly selected hunters participating in post-season questionnaires and a parts (duck wings and goose tails) collection survey. The population data is drawn from aerial surveys flown by the Arkansas Game and Fish Commission. Surveys are flown in mid-November, mid-December, and early January. Although our aerial surveys are extensive they are still underestimates of the total number of waterfowl present in the state. I pulled population data from about 45 survey units that correlate quite closely to the boundaries of the 4 counties you were interested in. I've included the statewide totals for comparison. If you have any questions, or need additional information on geese or other data, feel free to contact me. Good luck on your analysis.

Sincerely,

Tim Moser
Waterfowl Biologist

ARKANSAS NATURAL HERITAGE COMMISSION
1500 TOWER BUILDING
323 CENTER STREET
LITTLE ROCK, ARKANSAS 72201

Harold K. Grimmett
Director

Jim Guy Tucker
Governor

Date: December 13, 1994
Subject: Descriptive Info.
Grand Prairie
ANHC No. F-COEM-94-064

Ed Lambert
Environmental Analysis Branch
U.S. Army Corps of Engineers
167 N. Main St., B202
Memphis, TN 38103-1894

Dear Mr. Lambert,

In response to your conversation with Tom Foti, descriptive material on the Arkansas Grand Prairie as well as information on prairie restoration is enclosed. It is our understanding that you will use the information to try to reestablish some native vegetation in conjunction with the Grand Prairie Irrigation Project. We applaud this approach and offer our technical assistance on the project.

The Grand Prairie Region has undergone dramatic changes. For this reason reestablishment of native species will not be an easy task. One of the big obstacles which will first be faced is finding appropriate plant material. The use of local genotypes is extremely important. Priority should to be placed on locating a local source of such material. The Arkansas Natural Heritage Commission owns several prairie remnants in this region. Depending on the quantity and type of material needed, these areas may be available as seed sources.

The reestablishment of native vegetation in this area should be viewed as experimental. As the project progresses adjustments will be required and failures encountered. Plans should be kept flexible to allow for modifications as needed. The region, as a whole, stands to gain much by this undertaking.

If you need additional information, please feel free to contact our Chief of Research, Tom Foti at (501) 324-9761 or me at (501) 324-9762.

Sincerely,

Cindy Osborne

Cindy Osborne
Data Manager

Enclosures:
Arkansas Natural Community Abstract
"The Grand Prairie"
"Composition and Net Primary Production of Native Prairies in Eastern Arkansas"
"Composition, Production and Management of Eastern Arkansas Prairies"
"Changes in Vegetation on a Restored Prairie at Pea Ridge National Military Park, Arkansas"
A Guide to Prairie Restoration
"Establishing Native Grasses"
County Element Lists - Prairie, Arkansas, Monroe, Lonoke Counties

ARKANSAS NATURAL HERITAGE COMMISSION

1500 TOWER BUILDING
323 CENTER STREET
LITTLE ROCK, ARKANSAS 72201

Harold K. Grimmett
Director

Jim Guy Tucker
Governor

January 10, 1995

Mr. Edward Lambert
Environmental Analysis Branch
U.S. Army Corps of Engineers
167 N. Main St., B202
Memphis, Tennessee 38103-1894

Dear Mr. Lambert,

Here are the citations for the articles on prairies you requested and page nine of Tom Foti's article THE GRAND PRAIRIE in The Ozark Society Bulletin.

Dale, Edward E., Jr. and Thomas C. Smith. 1983. CHANGES IN VEGETATION ON A RESTORED PRAIRIE AT PEA RIDGE NATIONAL MILITARY PARK, ARKANSAS. 7th North American Prairie Converence Proceedings. Box 148, Biology Department, Southwest Missouri State University. Springfield, Missouri 65804-0095.

Dale, Edward E., Jr. and James W. Gibbons. 1979. RE-ESTABLISHMENT OF PRAIRIE VEGETATION AT PEA RIDGE NATIONAL MILITARY PARK, BENTON COUNTY, ARKANSAS. First Conference on Scientific Research in the National Parks. Robert M. Linn, Ed. U.S.D.I., National Park Service Transactions and Proceedings Series Number 5, pp. 183-187.

Foti, Thomas. 1971. THE GRAND PRAIRIE. The Ozark Society Bulletin, Volume V No. 4, Autumn. The Ozark Society. P.O. Box 38, Fayetteville, Arkansas 72701, pp. 6-11.

If you need any additional information, don't hesitate to call (501)324-9765.

Sincerely,

Kelly Hitt
Assistant Data Manager

Lambert/3857_____
CELMM-PD-R

January 13, 1995

Planning Division
Environmental Analysis Branch

Mr. Lewis Decell
WOTS Program Manager
U.S. Army Waterways Experiment Station
Environmental Laboratory, CEWES-EP-L
3909 Halls Ferry Road
Vicksburg, Mississippi 39180-6199

Dear Mr. Decell:

The Memphis District is currently conducting the Eastern Arkansas Region Comprehensive Study, General Reevaluation (Grand Prairie Area). The primary purpose of this study is to develop a plan that will utilize the White River as a source of agricultural water supply for the Grand Prairie Area of Arkansas.

Concerns relating to fish entrainment at the pump station have emerged during recent discussions with natural resource agencies. Therefore, the Memphis District is requesting that Dr. John Nestler (CEWES-ES-Q) meet with members of our study team to discuss possible measures that may reduce fish entrainment. His expertise could be valuable in designing a pump station and inlet channel that would minimize impacts to the White River fishery. We request Dr. Nestler's assistance under the Water Operations Technical Support program.

Mr. Edward Lambert will be point of contact for scheduling this meeting. Please call him at (901) 544-3857, if you have questions or need additional information.

Sincerely,

Donald M. Dunn, P.E.
Chief, Planning Division

Mauney_____
CELMM-PD-R
Bright_____
CELMM-PD-F
Dunn_____
CELMM-PD

Arkansas Game & Fish Commission

2 Natural Resources Drive Little Rock, Arkansas 72205

Steve N. Wilson
Director

Scott Henderson
Assistant Director

HAMPTON WATERFOWL RESEARCH CENTER
Rt. 1, Box 188A
Humphrey, AR 72073

August 25, 1995

Mr. Ed Lambert
U.S. Army Corps of Engineers
Environmental Analysis Branch
167 N. Main Street, B202
Memphis, Tennessee 38103-1894

Dear Ed:

Please find the extended data you requested regarding waterfowl harvest and population data for Arkansas, Prairie, Lonoke and Monroe Counties. As I mentioned in my previous memo, the harvest data is collected by the U.S. Fish and Wildlife Service from randomly selected hunters participating in post-season questionnaires and a parts (duck wings and goose tails) collection survey. Keep in mind that the estimates on a county by county basis are subject to large sampling errors.

The population data is drawn from aerial surveys flown by the Arkansas Game and Fish Commission. I've included December and Janaury surveys from 1985-1994 and have included tallies by species for the 4 county area. The separate 8.5x11 print-out specifies statewide survey totals by species for comparison. Survey methodology was substantially different in the period prior to 1985. The 1982-84 period will take some more work to tease out the 4 counties you specified for the January survey, and I am not sure if data for only these counties is retrievable at all for the December survey. If these years are important to your analysis please give me a call and I will attempt to retrieve them.

Although our aerial surveys are extensive they are still underestimates of the total number of waterfowl present in the state. I pulled population data from 47 survey units that correlate quite closely to the boundaries of the 4 counties you were interested in. Feel free to contact me if you need help in interpreting these printouts, species codes or have other questions. I'd be very interested in seeing your compiled results.

Sincerely,

Tim Moser
Waterfowl Biologist

ARKANSAS NATURAL HERITAGE COMMISSION
1500 TOWER BUILDING
323 CENTER STREET
LITTLE ROCK, ARKANSAS 72201

Harold K. Grimmett
Director

Jim Guy Tucker
Governor

Date: August 29, 1995
Subject: Grand Prairie Irrigation Project
Sensitive Element update
ANHC No. F-COEM-93-008

Mr. Don Dunn
Planning Division
Environmental Analysis Branch
Memphis District, Corps of Engineers
B-202 Clifford Davis Federal Building
167 N. Mid-America Mall
Memphis, Tennessee 38103-1894

Dear Mr. Dunn,

I recently met with Bob Price of the Natural Resources Conservation Service to review sensitive species information for the Grand Prairie Irrigation project. During the course of our meeting it came to my attention that new information was available which might be important in your planning efforts for this project. Attached are copies of two maps developed from a mussel survey of the White River by Alan David Christian. Marked on the maps are major and minor mussel beds in the vicinity of DeValls Bluff. It is our understanding the water intake structure for the Irrigation Project is proposed for this area. The endangered pink mucket mussel (Lampsilis abrupta) has been found at River Mile 121 (marked as 121B on map). The rabbits foot mussel (Quadrula cylindrica cylindrica) has been found at river mile 113. Rabbits foot is under review by the Fish and Wildlife Service for possible listing as Endangered or Threatened (Category 2). Dr. John Harris has informed me that it is possible for Endangered mussels to be present in any of the major mussel beds. I am including a copy of the legend provided with the mussel maps to help you interpret the color codes on the maps. If you have questions on this material or need additional information, please feel free to contact me.

Sincerely,

Cindy Osborne

Cindy Osborne
Data Manager

Enclosures: maps,legend
CC: Bob Price, Natural Resources Conservation Service

Lambert/sm/3857_____
CLEMM-PD-R

October 3, 1995

Planning Division
Environmental Analysis Branch

Mr. Steve N. Wilson
Arkansas Game and Fish Commission
2 Natural Resources Drive
Little Rock, Arkansas 72205

Dear Mr. Wilson:

The Memphis District, Corps of Engineers, is currently conducting the Eastern Arkansas Region Comprehensive Study, General Reevaluation (Grand Prairie Area). The primary purpose of this study is to develop a plan that will utilize the White River as a source of agricultural water supply for the Grand Prairie area of Arkansas.

The Memphis District is inviting you, and members of your staff, to attend a meeting to identify/discuss potential impacts relating to White River withdrawals and to formulate possible solutions to avoid or minimize these impacts. This meeting has been coordinated with Mr. Allen Carter of your staff; and it is scheduled for October 18, 1995, 10:00 a.m., at the Clifford Davis Federal Building in Memphis. An agenda will also be coordinated with Mr. Carter and sent to all attendees.

Mr. Gene Ploskey, Army Waterways Experiment Station, will be attending this meeting to share his expertise regarding fish entrainment and his knowledge of Arkansas stream fisheries. In addition, members of other government agencies and private organizations will be present.

Please contact Dr. Morris Mauney or Mr. Edward Lambert at (901) 544-3857 if you or your staff have questions or need additional information concerning this meeting.

Sincerely,

Donald M. Dunn, P.E.
Chief, Planning Division

Mauney_____
CELMM-PD-R
Bright_____
CELMM-PD-F
Lartigue_____
AC/CELMM-PD-A
Dunn_____
C/CELMM-PD

Arkansas Game & Fish Commission
2 Natural Resources Drive Little Rock, Arkansas 72205

Steve N. Wilson
Director

Scott Henderson
Assistant Director

February 22, 1996

Mr. Ed Lambert
Environmental Division
Memphis District, USCE
167 No. Main Street, Rm. B-202
Memphis, Tennessee 38103-1894

Dear Ed:

This letter is responsive to our most recent meeting regarding the East Arkansas Region Comprehensive Study Grand Prairie Segment.

We appreciate the opportunity to meet with the Memphis District, Natural Resources Conservation Service and the U.S. Fish and Wildlife Service on numerous occasions to discuss various aspects of this large-scale (interbasin transfer) irrigation project and address our agency's fish and wildlife resource concerns.

Your agency is already aware of most of our concerns and/or comments regarding this project; however, at this time, we would like to take this opportunity to address some items that require additional discussion, as well as specific aquatic resource studies that would assist in a more comprehensive assessment of project-related impacts to fish and wildlife resources.

The pipeline right-of-way for this project is presently proposed to cross the AGFC Wattensaw WMA. This has been discussed in earlier planning meetings, at which time the pumping plant site and pipeline corridor were adjusted to minimize adverse impacts to the WMA. At some point in time, the pipeline and right-of-way design, as well as impacts, compensation and/or mitigation measures should be addressed in specific detail.

We have been participating in the general fish and wildlife restoration and enhancement features such as winter water for waterfowl, higher than normal water levels annually in the ditches and waterways for fisheries resources, etc.; however, consideration should be given to the possibility of creating more wildlife habitat as part of the project somewhere in the benefitted area - property set aside for wildlife management and public use. The same consideration should be given to fisheries resource features,

also including public access to the resource, which we feel is an important project feature based on public funds utilized on this project and other potential fish and wildlife resource restoration and enhancement opportunities, as well as mechanisms that would guarantee features such as winter water for waterfowl and other wildlife conservation measures based on irrigation water useage that would be put into place for the life of the project.

To fully evaluate project effects on wildlife and fisheries resources, a proposed operation plan for this project is needed. It should include withdrawal rates, times of withdrawal, as well as the specific changes in river stage levels (feet and inches as they relate to flow rates (cfs). This is important information when assessing long term impacts on backwater areas, river tributaries, natural lakes and wetlands dependent on natural high and low flows of such a complex river system.

Since this is the largest irrigation project ever proposed for the White River, it is imperative that a comprehensive instream flow evaluation or a comparable study be conducted on the White near DeValls Bluff to identify the flow needs for at least the most important and sensitive aquatic species in the river. These include the pink mucket (T&E spp.), paddlefishfish (Category 2 spp.), shovelnose sturgeon, shorthead redhorse, alligator gar, blue sucker, largemouth and spotted bass, white crappie, bluegill, sauger, flathead catfish, smallmouth buffalo, crystal darter, and blacktail shiner. Whether this instream flow evaluation is an IFIM (instream flow incremental methodology), a "Missouri River"-type evaluation, or some other methodology, a formal evaluation needs to be done because of the importance of the river to the overall state's aquatic biota, other similar cases in other states where projects of this size caused significant damage to the aquatic resources, and the magnitude/precedence of this project. It has been suggested that perhaps we could listen to a review by Dr. John Nestler on a "Missouri River" type project and we are certainly open to such a suggestion.

Key points are seasonal flow needs of key species or assemblages (guilds) during spawning, larval stages, juvenile (rearing), and adult.

A larval fish evaluation at DeValls Bluff is another necessity due to the planktonic nature of several of the riverine obligate larvae-stage species (paddlefish, sturgeon, suckers, etc.) Key points would include determination and monitoring of larval fish densities in the White River near DeValls Bluff including what species are present at what time of the year, how are they distributed in the water column and across the channel (bottom vs. top of water column), velocity of pump near pipe and also near

river, angle of incurrent or source canal, filter mesh size (more for juvenile fish), resting sites near mouth of canal, etc. Any other state-of-the-art avoidance techniques to exclude larvae should be pursued.

Since entrainment and impingement of fish is a known occurence with pumping facilities, all precautionary measures must be taken to minimize adverse fishery impacts. In addition, entrainment/impingement studies should be planned and conducted during operation to determine the extent of fish mortality as well as direct compensation and/or mitigation for any identified losses.

Linkages between the river and oxbow lakes should be surveyed to make sure that these extremely productive ecosystems are not short-circuited relative to spawning fish, aquatic nursery areas, waterfowl feeding and resting areas, etc.

Key points would be the hydraulic control point elevation that bridges the gap between the river and these old channel scar lakes. Obviously it would need to have a depth in excess (1-2') of the bare minimum for fish passage into and out of the lake.

Impact of supplemental water to sloughs and bayous (transmission lines) should be evaluated (is more water necessarily good in a natural feast and famine hydrograph?)

Key point is whether additional water going through sloughs and bayous from project operation would have a negative or a positive impact to a biota that has evolved to a particular flow regime. Also, impact of low-head weirs on bayou fish migration should be fully addressed (i.e. LaGrue).

Other issues of substantial importance include the impact of increased irrigation water and therefore its drainage on heavy metal and pesticide/herbicide concentrations on slough and river water. In addition, how does this project affect transportational vectors of zebra mussels and other exotic species? Will there be significant effects on furbearers such as beaver, muskrat, etc.?

Key points are that although the above may seem like sidebars to more important impacts, their significance could be much greater than we might imagine given the history, for example, of zebra mussels in the U.S. and the impacts of toxics in our water.

Please be advised that we very much appreciate the opportunity to work cooperatively with the U.S. Corps of Engineers, Natural Resource Conservation Service, U.S. Fish & Wildlife Service and other interests in the preliminary planning processes for the Grand Prairie Irrigation Project; however, as we mentioned in earlier discussions, the magnitude of potential project-related impacts are difficult to fully evaluate without adequate fish and wildlife resource assessments and studies being conducted to help identify the existing resource base and determine impacts of such a unique project involving the inter basin transfer of water from the White River, one of the most valuable rivers in Arkansas, to the Grand Prairie region of the delta.

We, therefore, hope these comments will assist you in organizing your planning and study efforts and we shall look forward to further discussions regarding wildlife and fisheries resource impacts in connection with the GPIP as the planning processes continue.

Yours very truly,

Craig K. Uyeda, Chief
River Basins Section

CKU:ac

cc: Gene Sullivan/Lori Walton - White River
Regional Irrigation Water District
Ken Bright, Memphis District, USCE
Scott Yaich - USFWS - St. Charles
Curtis Nelms - USFWS - Vicksburg, MS.
Jon Schneider
Don Akers
Allen Carter
Steve Filipek
Mark Wright
Jeff Farwick
Bob Price - NRCS
Tony Stevenson - NRCS
Scotty May
Levi Davis
Sonny Thompson
Larry Rider
John Sunderland
Jack Killgore, Waterways Exper. Station, Vicksburg, MS
Randy Young, Director
AR Soil & Water Conservation Commission

October 17, 1996

Planning Division
Environmental Analysis Branch

Mr. Harold Grimmett
Director
Arkansas Natural Heritage Commission
1500 Tower Building
323 Center Street
Little Rock, Arkansas 72201

Dear Mr. Grimmett:

Congressional appropriation acts for fiscal years 1992 through 1995 directed the Memphis District Corps of Engineers to select and develop an implementation plan for one of five critical groundwater shortage areas within eastern Arkansas to serve as an agricultural water supply demonstration project. The Grand Prairie was selected because alluvial aquifer depletion is comparably more severe within this area. Initiated in December 1991, a general reevaluation has continued to the present. The Grand Prairie Area Demonstration Project (GPADP) general reevaluation is scheduled to culminate in March 1997 with a draft report.

The GPADP study area encompasses 362,662 acres (70.2% cropland) and includes significant portions of Prairie and Arkansas counties and small portions of Monroe and Lonoke counties. The primary purpose of the GPADP general reevaluation is to develop a plan that provides supplemental irrigation water, water conservation, and groundwater preservation. However, existing resources and project features are being utilized for environmental enhancement and restoration purposes. Since the study area is within a region which historically contained a vast tallgrass prairie, the Grand Prairie, a major environmental project feature will be an attempt to restore native prairie vegetation within the study area.

The White River Regional Irrigation Water Distribution District (WRRIWDD) is the local sponsoring entity. The WRRIWDD is comprised of a 16-member board and equitably represents all counties within the project area. The WRRIWDD was established by court order in 1984; and it is empowered by Arkansas law, Act 114 of 1957 and subsequent amendments, which grants authorities to water distribution districts. It is mandated to provide local assurances, such as financial support, and plans to procure easements and rights-of-way. The WRRIWDD has final approval of all stages of the project and will also be responsible for operation and maintenance of the constructed project.

Although efforts have been made to avoid locating proposed water distribution features in existing prairie remnants, native prairie will be impacted at three locations (see enclosed maps). The alignment of the primary irrigation canal (1000) crosses the Railroad Prairie approximately 2.3 miles west of DeValls Bluff, Arkansas. This canal cannot be relocated due to topography; the proposed canal right-of-way is approximately 300 feet wide at this location. Canal 3200 will cross the Railroad Prairie approximately 2.0 miles west of Hazen, Arkansas; the proposed right-of-way at this site is approximately 155 feet wide. However, it is anticipated that adverse impacts to prairie will be minimal at this locale since Canal 3200 will be routed primarily through a highly disturbed portion of the old railroad right-of-way and will diagonally cross Hwy. 70 through an inverted siphon. Canal 4500 with a right-of-way width of approximately 90 feet will cross the privately owned Fairmount Prairie.

It is my understanding that the Arkansas Natural Heritage Commission (ANHC) used Land and Water Conservation Act funds to purchase the portions of the Railroad Prairie potentially impacted by the GPADP and that certain stipulations may apply as to the use of the land and also to any project measures undertaken to offset impacts to this prairie. Because of the dramatic decline of native prairie within the project area, the Memphis District considers remaining prairie fragments an important natural resource and intends to replace the environmental value lost as a result of the project. Therefore, the Memphis District is requesting assistance from the ANHC in selecting the appropriate method(s) for offsetting impacts to this unique resource.

The Memphis District will appreciate your assistance. Please contact Edward Lambert at (901) 544-3857 if you have questions or need additional information.

Sincerely,

Donald M. Dunn, P.E.
Chief, Planning Division

Enclosures

Watson
AC/CELMM-PD-R
Bright
CELMM-PD-F
Lartigue
AC/CELMM-PD-A
Dunn
CELMM-PD

ARKANSAS NATURAL HERITAGE COMMISSION
1500 TOWER BUILDING
323 CENTER STREET
LITTLE ROCK, ARKANSAS 72201

Harold K. Grimmett
Director

Mike Huckabee
Governor

June 30, 1997

Mr. Donald M. Dunn, P.E., Chief
Planning Division
Memphis District Corps of Engineers
167 North Main Street B-202
Memphis, Tennessee 38103-1894

Dear Mr. Dunn:

In February I wrote Mr. Bryan Kellar, Director of the Outdoor Recreation Grants Program of Arkansas State Parks, seeking his advice on how to deal with the projected impacts of the Grand Prairie Area Demonstration Project on our Railroad Prairie Natural Area. Mr. Kellar responded (a copy of his response is enclosed), describing the process for converting to other than outdoor recreation use, land purchased with the aid of the Land and Water Conservation Fund.

As Mr. Kellar describes, the first steps will be to obtain precise legal descriptions of the tracts involved and to obtain qualified appraisals of the tracts. As the conversion will be, on our part, involuntary, I understand that the Memphis District will be responsible for these steps. As to replacement property, there are a number of potential tracts that my office will be happy to assist the Memphis District in assessing. Here too, I understand that when replacement property has been chosen, the Memphis District will provide the precise legal description(s) and appraisal(s) required.

When I have received descriptions and appraisals of both the property to be taken and that proposed as replacement, I will submit a request permission to complete the conversion.

Sincerely,

Harold K. Grimmett

enc:

DEPARTMENT OF PARKS & TOURISM
One Capitol Mall
Little Rock, AR 72201
one: 501-682-7777
FAX: 501-682-1364
History Commission:
01-682-6900 (V/TT)
Personnel Section:
01-682-7742 (V/TT)
State Parks Division:
01-682-1191 (V/TT)
Tourism Division:
501-682-7777 (V/TT)
Internet Addresses:
p://www.ono.com/arkansas
http://www.state.ar.us
143.456@compuserve.com

Mike Huckabee
GOVERNOR

Richard W. Davies
EXECUTIVE DIRECTOR

STATE PARKS, RECREATION & TRAVEL COMMISSION:
Danny Ford
CHAIRMAN
Jane Christenson
VICE-CHAIRMAN
Bill Barnes
Polly Crews
Dan Dempsey
Jim Goston
Debra Hook
Billy Lindsey
Donna Kay Matteson
Montine McNulty
Billy St. James
Ness Sechrest
J.D. "Bud" Shamburger
Ovid Switzer
Wade Williams

DIVISION DIRECTORS:
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ADMINISTRATION
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Nancy Clark
GREAT RIVER ROAD
John L. Ferguson
HISTORY COMMISSION
Anita Middleton
KEEP ARKANSAS BEAUTIFUL

AN EQUAL OPPORTUNITY/ AFFIRMATIVE ACTION/ AMERICANS WITH DISABILITIES ACT EMPLOYER

Arkansas
THE NATURAL STATE

June 13, 1997

JUN 1 1997
NATURAL HERITAGE COMMISSION

Mr. Harold Grimmett, Director
Arkansas Natural Heritage Commission
1500 Tower Building
323 Center Street
Little Rock, Arkansas 72201

Dear Mr. Grimmett:

The following steps will be necessary, according to the Federal regulations that govern the Land and Water Conservation Fund (LWCF), if the Arkansas Natural Heritage Commission wishes to convert a portion of the Railroad Prairie Natural Area to other than outdoor recreation use.

You should write me a letter asking permission for the conversion. The letter should describe the location of the present property and state the acreage. You should describe the location of the proposed replacement property and state the acreage. You must describe how all practical alternatives to the conversion have been evaluated and rejected on a sound basis.

You must then secure an appraisal of both parcels of property, at your expense, conforming to the enclosed standards. After completing this process I will submit the appraisals to the National Park Service (NPS) for their review and approval. A NPS review appraiser will analyze the appraisals to determine if the fair market value of the property to be converted has been established, and the property proposed for substitution is of at least equal fair market value and reasonably equivalent usefulness. Depending on the situation and the discretion of the Regional Director, the replacement property need not provide identical recreation experiences or be located at the same site.

The review appraiser will make recommendations to the NPS Regional Director and ultimately to the Secretary of the Interior concerning approval or disapproval of the conversion. If the conversion is approved the exchange property can be secured and title to the converted property can be transferred.

I have enclosed a copy of the regulations found in the LWCF Manual (Chapter 675.9.3) describing the conversion process. My telephone number is 682-1301, if I can assist you in any way.

Sincerely,

Bryan Kellar, Director
Outdoor Recreation Grants Program

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT CORPS OF ENGINEERS
167 NORTH MAIN STREET B-202
MEMPHIS TN 38103-1894

Reply to
Attention of:

July 29, 1998

Planning Division
Environmental Analysis Branch

Mr. Randall Mathis
Arkansas Department of Pollution
Control and Ecology
Water Quality
P.O. Box 8913
Little Rock, AR 72219-8913

Dear Mr. Mathis:

The Eastern Arkansas Region Comprehensive Study, Grand Prairie Area Demonstration Project, Draft General Reevaluation Report (GRR) and Environmental Impact Statement (along with the environmental appendix) are enclosed for your review and comment; the Section 404(b)(1) evaluation is contained in Volume 9, Appendix C, Section IV.

The project as described in the draft GRR is designed for the purpose of agricultural water supply and conservation and groundwater preservation. The Water Resources Development Act of 1996 (WRDA '96) authorized the project as a multiple purpose project. To comply with WRDA '96, the project will be studied for revisions to produce substantial additional groundwater protection and waterfowl conservation benefits. The resulting report from that study will be considered by the Secretary of the Army, who will decide whether the revisions should be included in the project.

The project as described in the draft GRR has been included in the President's Budget for Fiscal Year 1999 for a new start construction. If the project receives construction funding in the Energy and Water Development Appropriation Act, 1999, the funding will be used to implement project features that are common to the purposes of agricultural water supply, groundwater protection, and waterfowl conservation.

The Memphis District is requesting water quality certification in accordance with Section 401 of the Clean Water Act. In addition to your review and comment on the draft reports, input on additional features for groundwater protection and waterfowl conservation would be appreciated. Please send the water quality certification and any comments and/or suggestions to the following address within one week after the close of the public review period which will end on September 21, 1998.

Commander
Memphis District Corps of Engineers
ATTN: CEMVM-PD-R
167 North Main Street, B-202
Memphis, TN 38103-1894

A public workshop will be held in Stuttgart, AR, in the Community Room of the Farmers and Merchants Bank, 7th and Main Streets, on September 15, 1998, during the hours of 5:00 p.m. to 9:00 p.m. The purpose of the workshop will be to answer questions and to receive input and comments from all interested individuals and organizations concerning the proposed project. The workshop will be informal, and you are invited to come in at anytime during the workshop period. Pursuant to Section 404 of the Clean Water Act, this meeting will also allow opportunity for public comment on the discharge of dredged and fill material into waters of the United States.

Your assistance with this project is appreciated. Please contact Edward Lambert, (901) 544-0707, if you have questions or need additional information.

Sincerely,

Donald M. Dunn, P.E.
Acting Chief, Planning Division

Enclosure

STATE OF ARKANSAS
DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY
8001 NATIONAL DRIVE, P.O. BOX 8913
LITTLE ROCK, ARKANSAS 72219-8913
PHONE: (501) 682-0744
FAX: (501) 682-0910

September 22, 1998

Colonel Daniel W. Krueger, District Engineer
Memphis District Corps of Engineers
167 North Mid America Mall
B-202 Clifford Davis Federal Building
Memphis, Tennessee 38103-1894

RE: **Eastern Arkansas Region Comprehensive Study, Grand Prairie Area Demonstration Project - Draft General Reevaluation Report and Environmental Impact Statement**

Dear Colonel Krueger:

The Arkansas Department of Pollution Control and Ecology has completed its review of the above referenced GRR and EIS for the purpose of agricultural water supply, conservation, and groundwater protection in eastern Arkansas.

The Department has several concerns that need to be addressed before a decision relative to §401 water quality certification can be made. Specifically:

1. What is the minimum flow in cubic feet per second that will be used for the pump cut-off level? The GRR gave a range of flows based on mean monthly flows in the State Water Plan. The Department needs an actual minimum flow number.

2. How will sediment transport and scour be controlled in the 184 miles of earthen canals?

3. What will be the impacts on water quality from six years of construction?

4. How will maintenance be performed and who is responsible for maintenance?

The Department looks forward to working with the Corps of Engineers on the project.

Sincerely,

Chuck C. Bennett, Chief
Water Division

cc: Roger Hancock
J. Randy Young
Craig Uyeda

SEP 24 199

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT CORPS OF ENGINEERS
167 NORTH MAIN STREET B-202
MEMPHIS TN 38103-1894

Reply to
Attention of:

July 15, 1998

Planning, Programs, & Project
Management Division
Environmental & Economic Analysis Branch

Mr. Chuck C. Bennett
Arkansas Department of Pollution
Control and Ecology
Water Division
P.O. Box 8913
Little Rock, Arkansas 72219-8913

Dear Mr. Bennett:

On July 29, 1998, the Memphis District requested water quality certification for the Grand Prairie Area Demonstration Project (GPADP) following your office's review of the draft general reevaluation report (GRR) and environmental impact statement. After review of the draft reports, you sent a letter (enclosure) requesting answers to four questions. These questions as well as our responses are provided below.

1. What is the minimum flow in cubic feet per second that will be used for the pump cut-off level?

   As stated in the GRR, the pump cut-off level is based on the Arkansas State Water Plan. The minimum flow will vary month to month as shown in Volume 3, Appendix B, Section I (Hydraulics and Hydrology), pages IV-3 and IV-4. Based on the referenced pages, 9,650 cubic feet per second in the months of August, September, and October is the minimum flow rate. All pumping from the White River will be stopped when this level is reached.

2. How will sediment transport and scour be controlled in the 184 miles of earthen canals?

   As stated in Volume 3, Appendix B, Section I, 5-B-03 Summary, the potential for deposition, as presented, represents "worst-case" conditions. Limited sediment data in the White River indicates suspended sediment concentrations of approximately 74 mg/l. Inlet channel deposition was predicted to remove virtually all of this material; therefore, water actually entering the canal system should be relatively sediment free. As such, deposition rates shown for concentrations of 40 mg/l and 60 mg/l would significantly overstate depositional tendencies. Actual deposition within the canal system should be minimal. Any scour potential should be limited by the cohesive nature of the canal banks (constructed to minimize seepage) and vegetative cover above the waterline. Additionally, the canal system will function as a series of pools, between check structures, except when at peak capacity. Average canal velocities at peak capacity will be 1.6 feet per second or less. With a limited sediment load being transported within the canal system, the potential for significant inflows into natural streams would be very minimal.

3. What will be the impacts on water quality from six years of construction?

   The project will be constructed in phases that should have little effect on existing water quality. Water quality will be monitored during project construction and operation. Erosion control measures will be incorporated as a construction practice.

4. How will maintenance be performed and who is responsible for maintenance?

   The White River Regional Irrigation Water Distribution District is responsible for operating and maintaining the project. Volume 1, the Main Report, provides the operating plan on page 82 and the operation and maintenance requirements on pages 83-85. The estimated annual maintenance costs are included in Table 10 on page 87.

I hope this information is beneficial to you. Please proceed with the processing of water quality certification for the GPADP. If you have other questions or need additional information, contact Edward Lambert at (901) 544-0707.

Sincerely,

Daniel W. Krueger
Colonel, Corps of Engineers
District Engineer

Enclosure

CF:
Mr. Steve Drown, ADPCE

Judy

ADEQ
ARKANSAS
Department of Environmental Quality

July 21, 1999

Colonel Daniel W. Krueger, District Engineer
Memphis District Corps of Engineers
167 North Mid America Mall
B-202 Clifford Davis Federal Building
Memphis, Tennessee 38103-1894

RE: **Eastern Arkansas Region Comprehensive Study, Grand Prairie Area Demonstration Project - Draft General Reevaluation Report and Environmental Impact Statement**

Dear Colonel Krueger:

The Arkansas Department of Environmental Quality ("ADEQ") has completed its review of the above referenced project; and your July 15, 1999, correspondence providing claification to our earlier concerns and your request for water quality certification.

ADEQ has determined there is a reasonable assurance this activity will be conducted in a manner which, according to the Arkansas Pollution Control and Ecology Commission's Regulation No.2, will not physically alter a significant segment of the waterbody and will not violate the water quality criteria.

Pursuant to §401(a)(1) of the Clean Water Act, ADEQ hereby **issues** water quality certification for this project, contingent upon the following condition:

> The applicant shall obtain a General Storm Water Permit from the NPDES Branch of the Water Division of ADEQ, prior to project commencement.

Sincerely,

Randall Mathis

Randall Mathis
Director

RECEIVED
AUG 18 1999

cc: Roger Hancock, Region VI, Environmental Protection Agency
J. Randy Young, P.E., Chairman, Technical Review Committee, AS&WCC
Craig Uyeda, Chief, River Basins Section, Arkansas Game and Fish Commission

ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY
8001 NATIONAL DRIVE / POST OFFICE BOX 8913 / LITTLE ROCK, ARKANSAS 72219-8913 / TELEPHONE 501-682-0744 / FAX 501-682-0798
www.adeq.state.ar.us

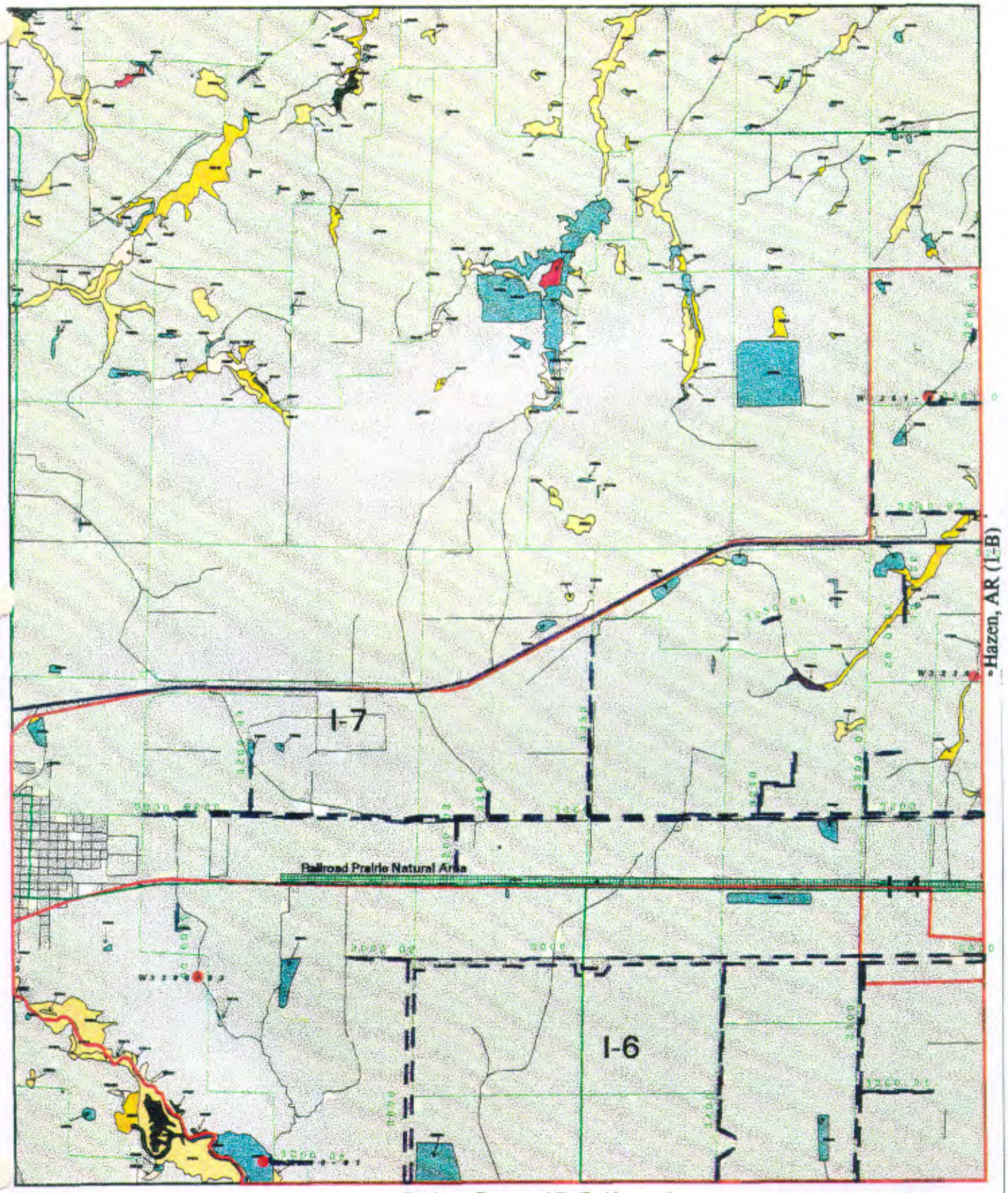
SECTION VII

HABITAT (WETLAND) MAPS

- Bottomland Hardwood
- Dead Timber
- Forested Swamp
- Impoundments
- Marsh
- Riverine
- Scrub/Shrub Swamp
- Unclassified
- Upland Hardwoods
- Prairies
- Unique Woodlands
- Interstates
- US Highways
- State Highways
- Other Roads
- Weirs
- Canal and Pipeline Right of Way Boundaries
- Item Reach Boundaries

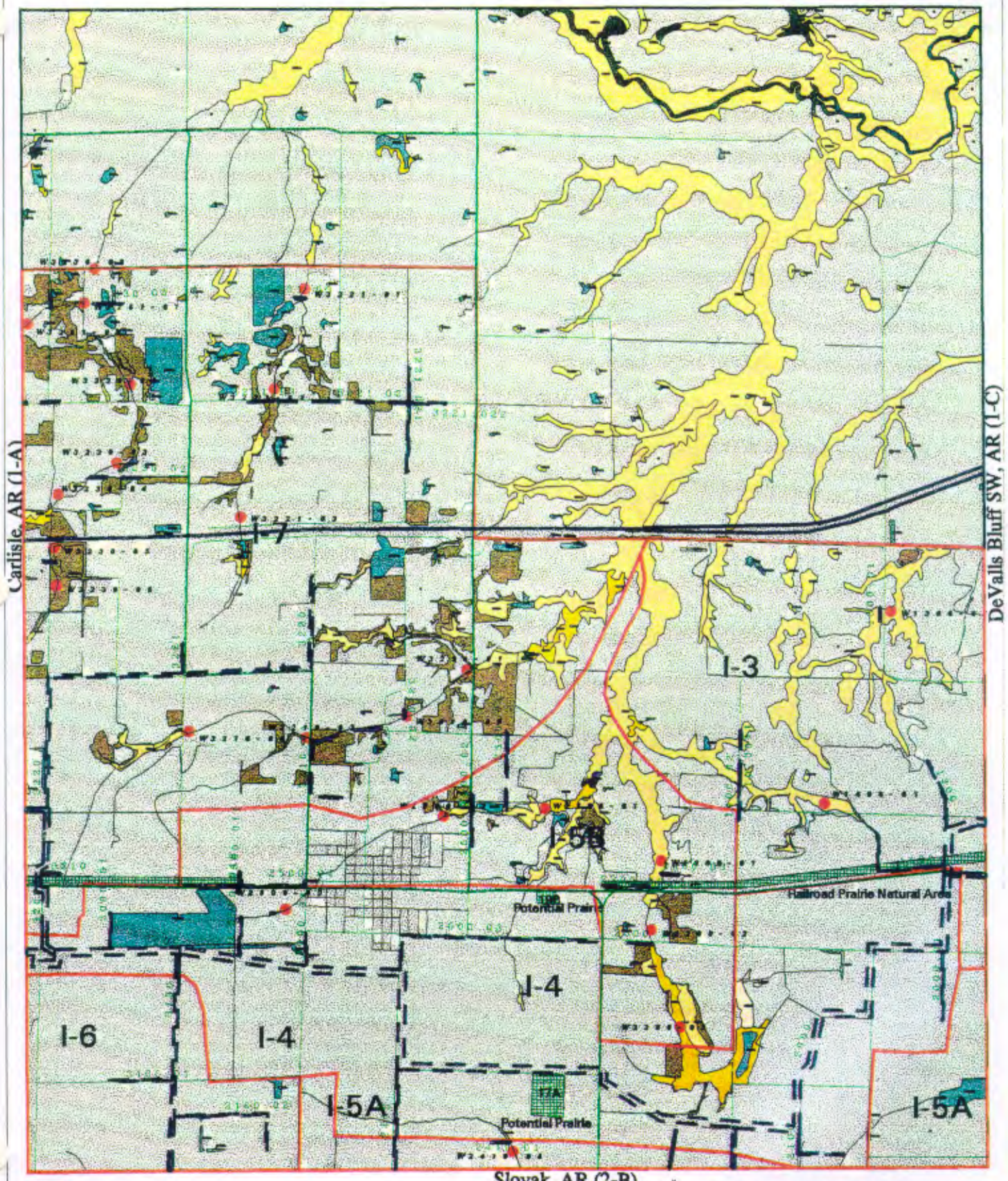
US Army Corps
of Engineers
Memphis District

Wetlands Index



US Army Corps of Engineers Memphis District

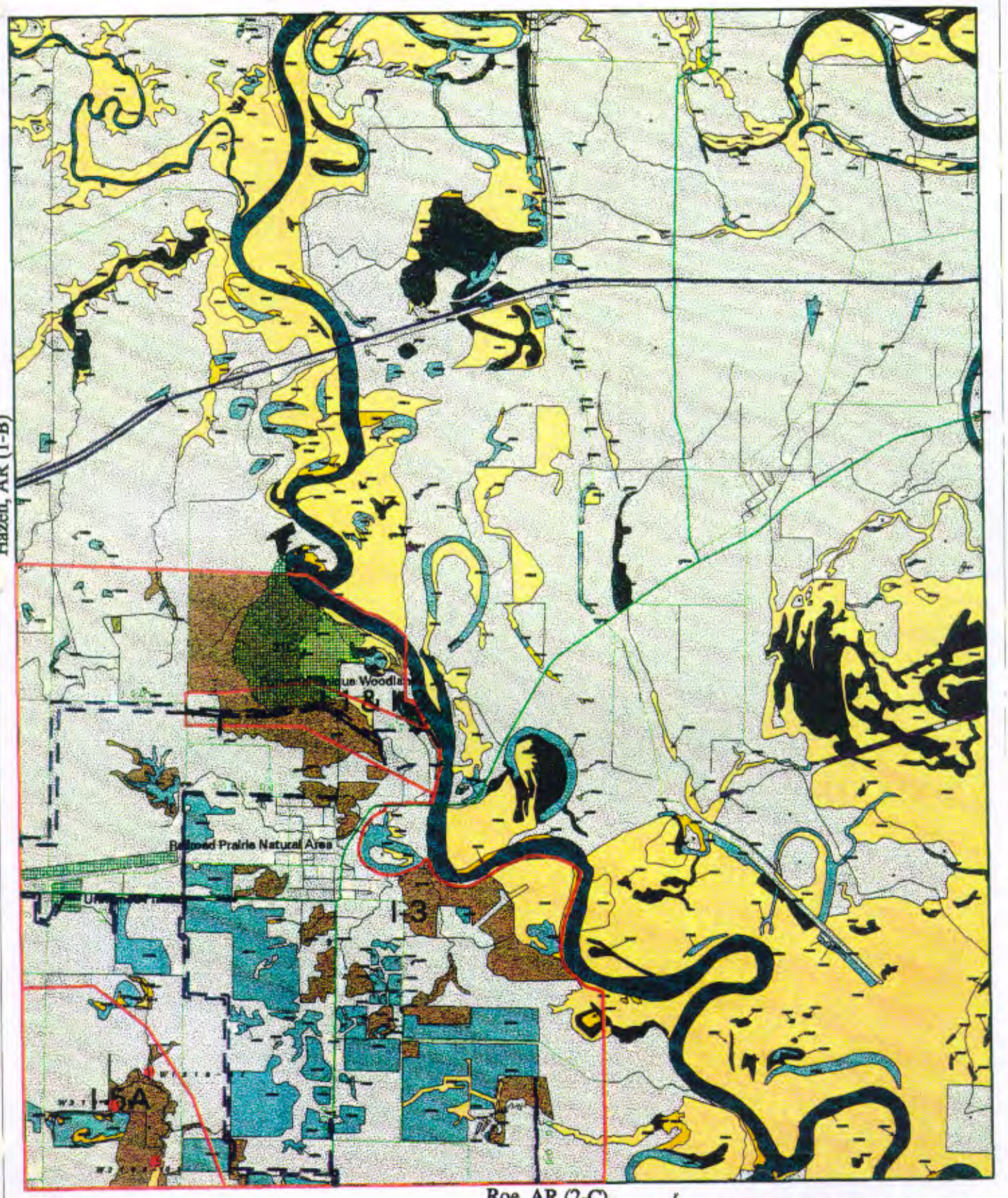
GROUND WATER INSTITUTE The University of Memphis

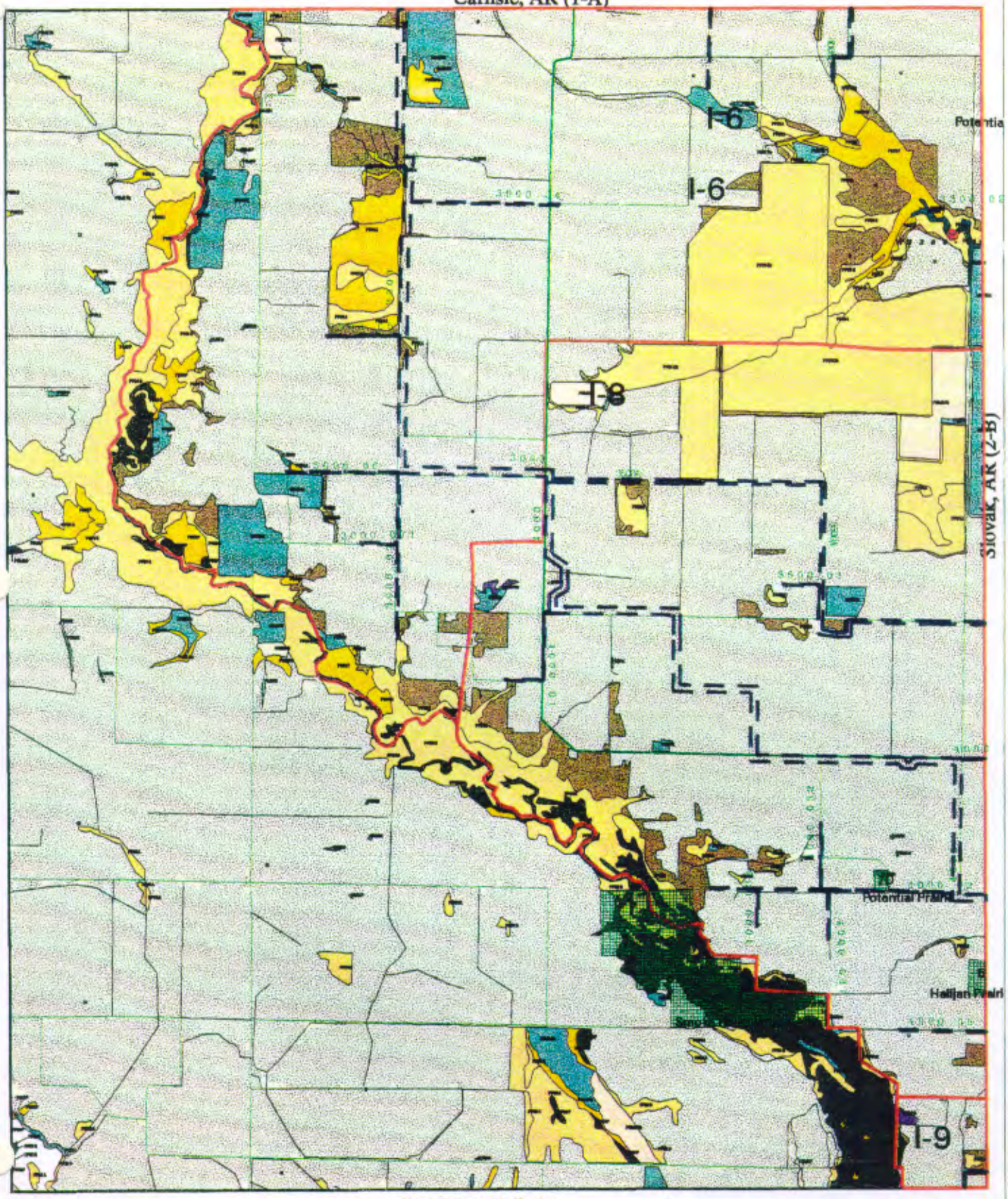


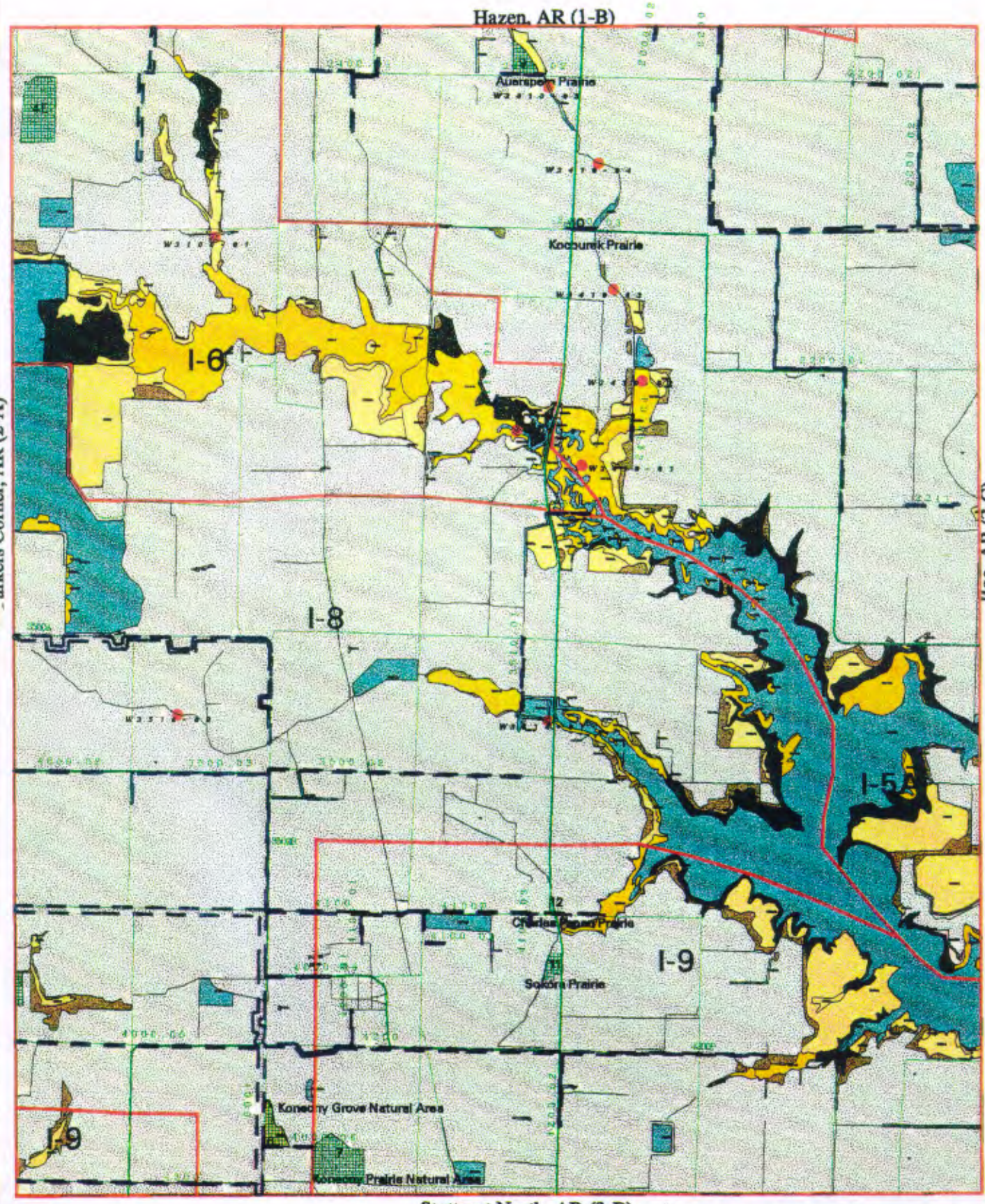
US Army Corps of Engineers Memphis District

GROUND WATER INSTITUTE The University of Memphis

Hazen, AR (1-B)
Wetlands


Hazen, AR (1-B)
Roe, AR (2-C)
Devalls Bluff SW, AR (1-C)
Wetlands
Railroad Prairie Natural Area
I-3
I-5A
GROUND WATER INSTITUTE
The University of Memphis

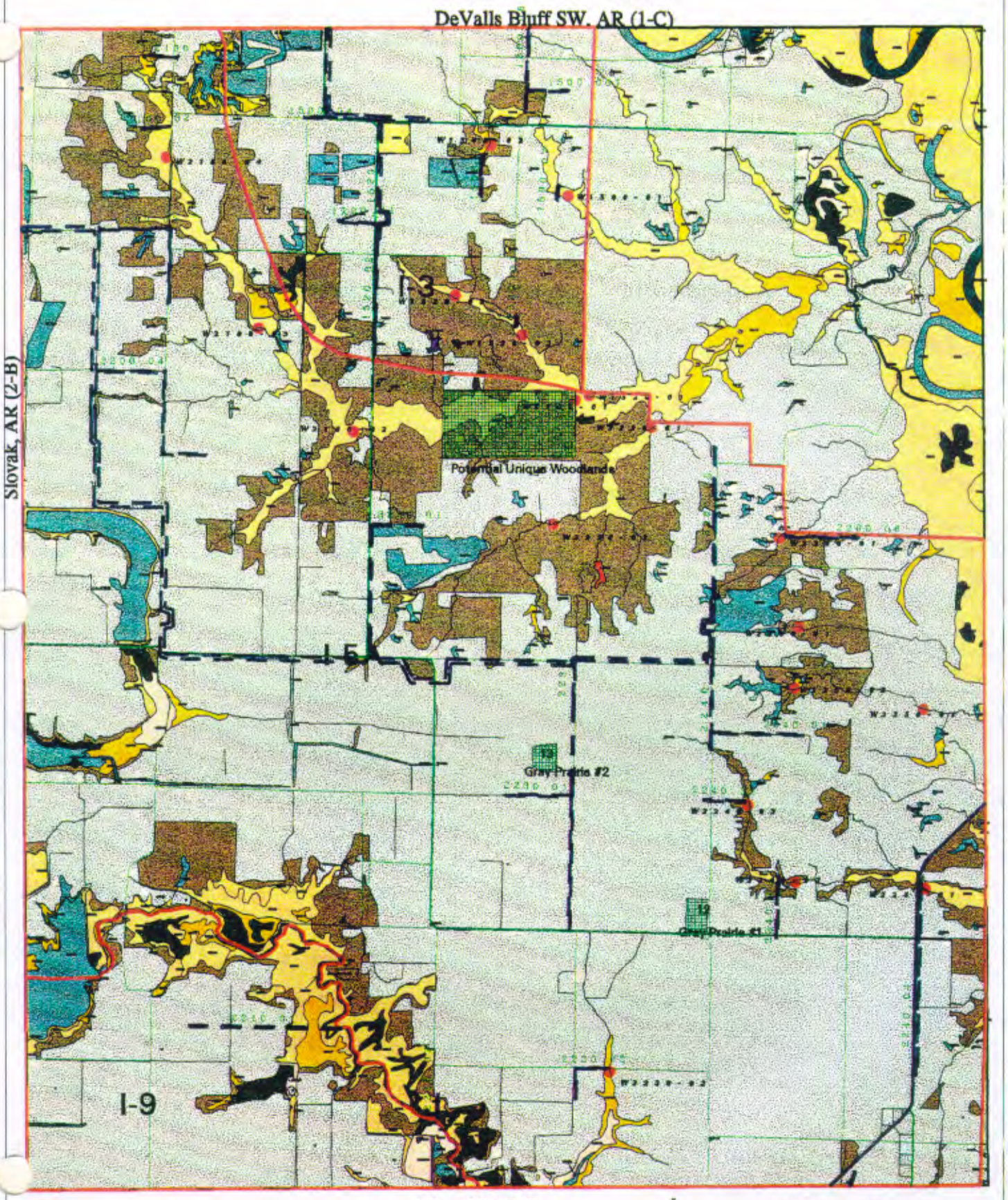

Carlisle, AR (1-A)
I-6
I-6
I-8
I-9
Potentia
Slovak, AR (2-B)
Potential Prairie
Halljan Prairi
Geridge, AR (3-A)
Parkers Corner, AR (2-A)
Wetlands
GROUND WATER INSTITUTE
The University of Memphis

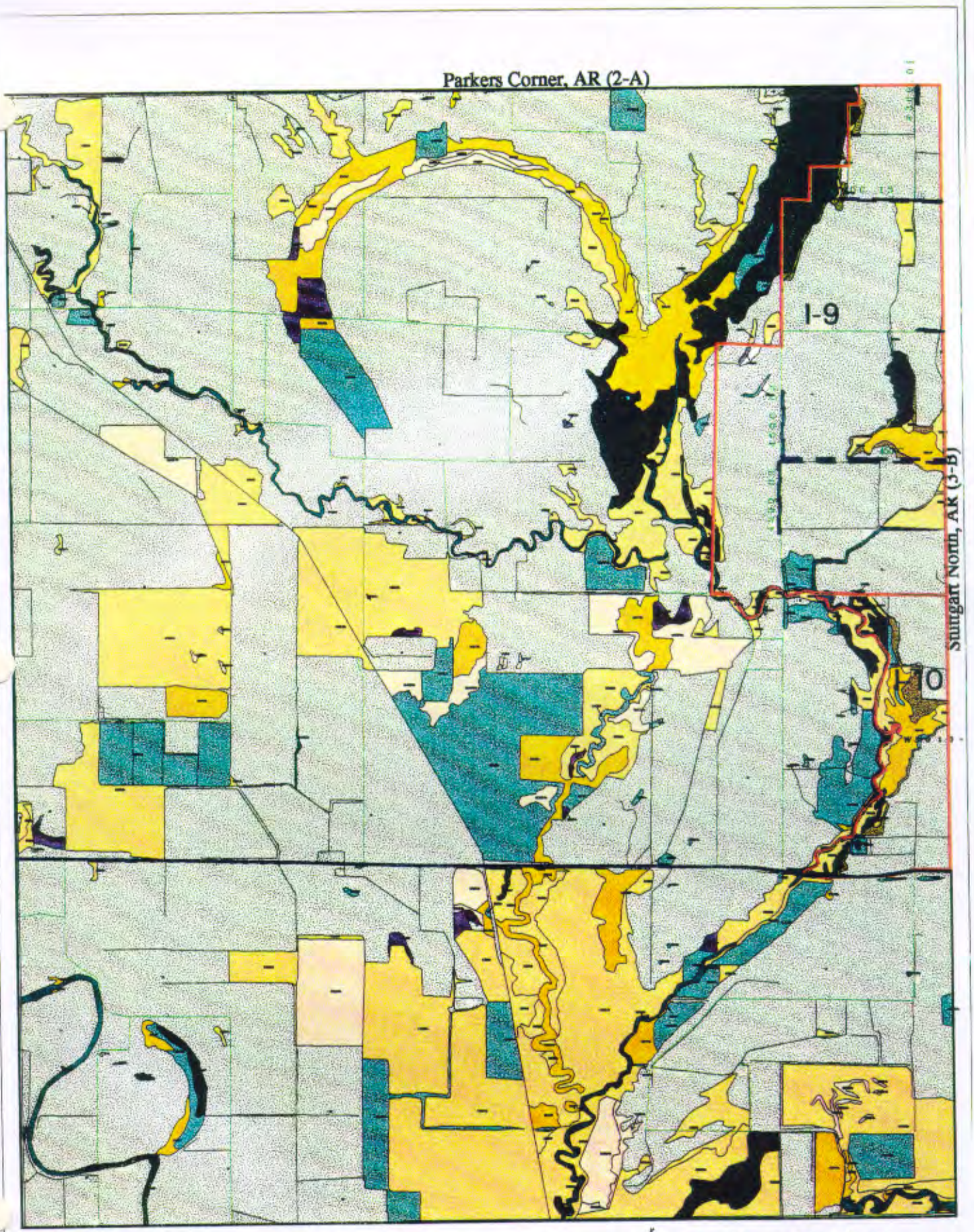


Slovak, AR (2-B)
Wetlands

US Army Corps of Engineers Memphis District

GROUND WATER INSTITUTE
The University of Memphis


DeValls Bluff SW, AR (1-C)
Slovak, AR (2-B)
I-3
I-5
I-9
Potential Unique Woodlands
13
Gray Prairie #2
12
Gray Prairie #1
Ulm, AR (3-C)
Roe, AR (2-C)
Wetlands
1:40,000



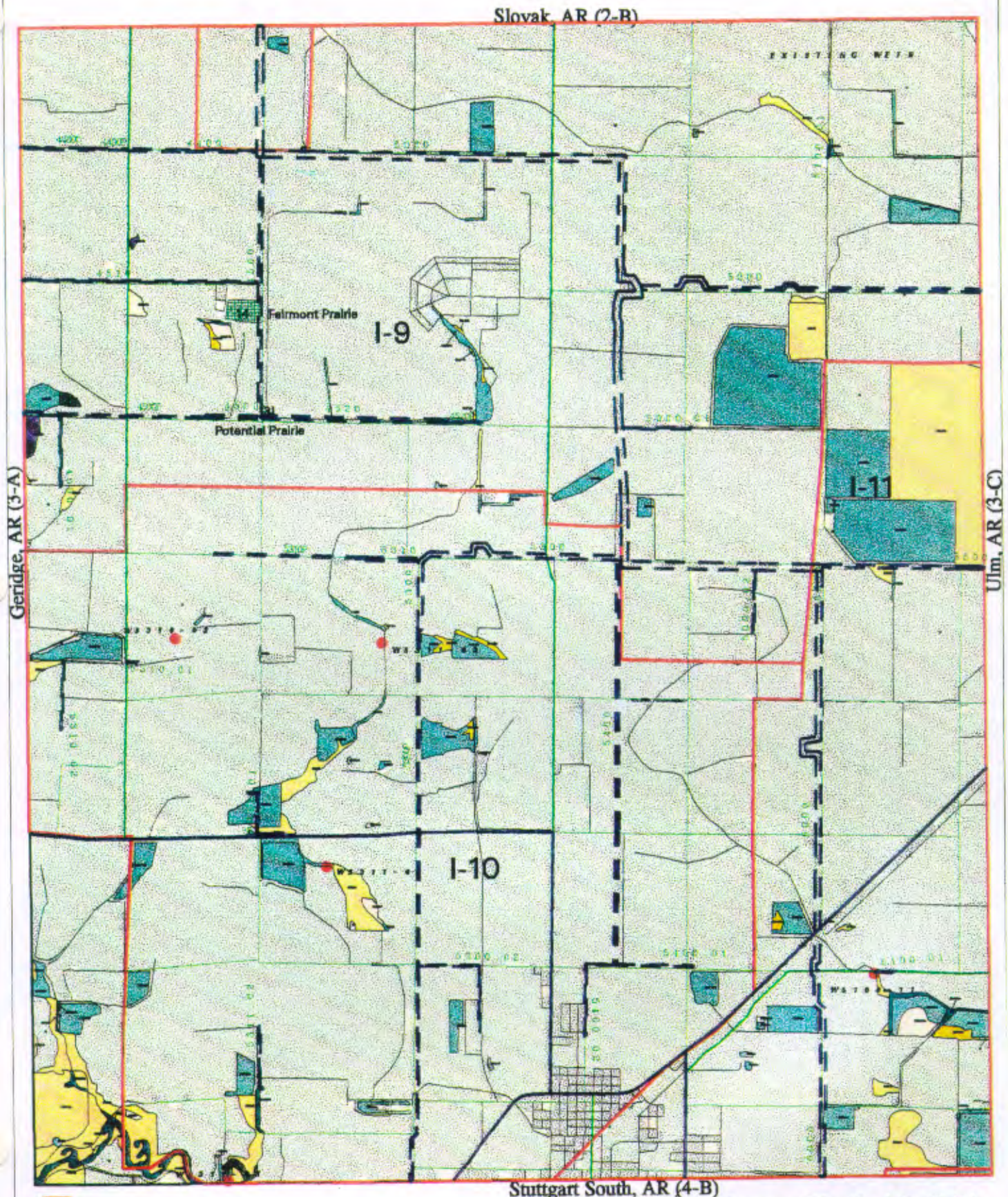
US Army Corps of Engineers Memphis District

GROUND WATER INSTITUTE The University of Memphis

1 : 48,000

Geridge, AR (3-A)

Wetlands



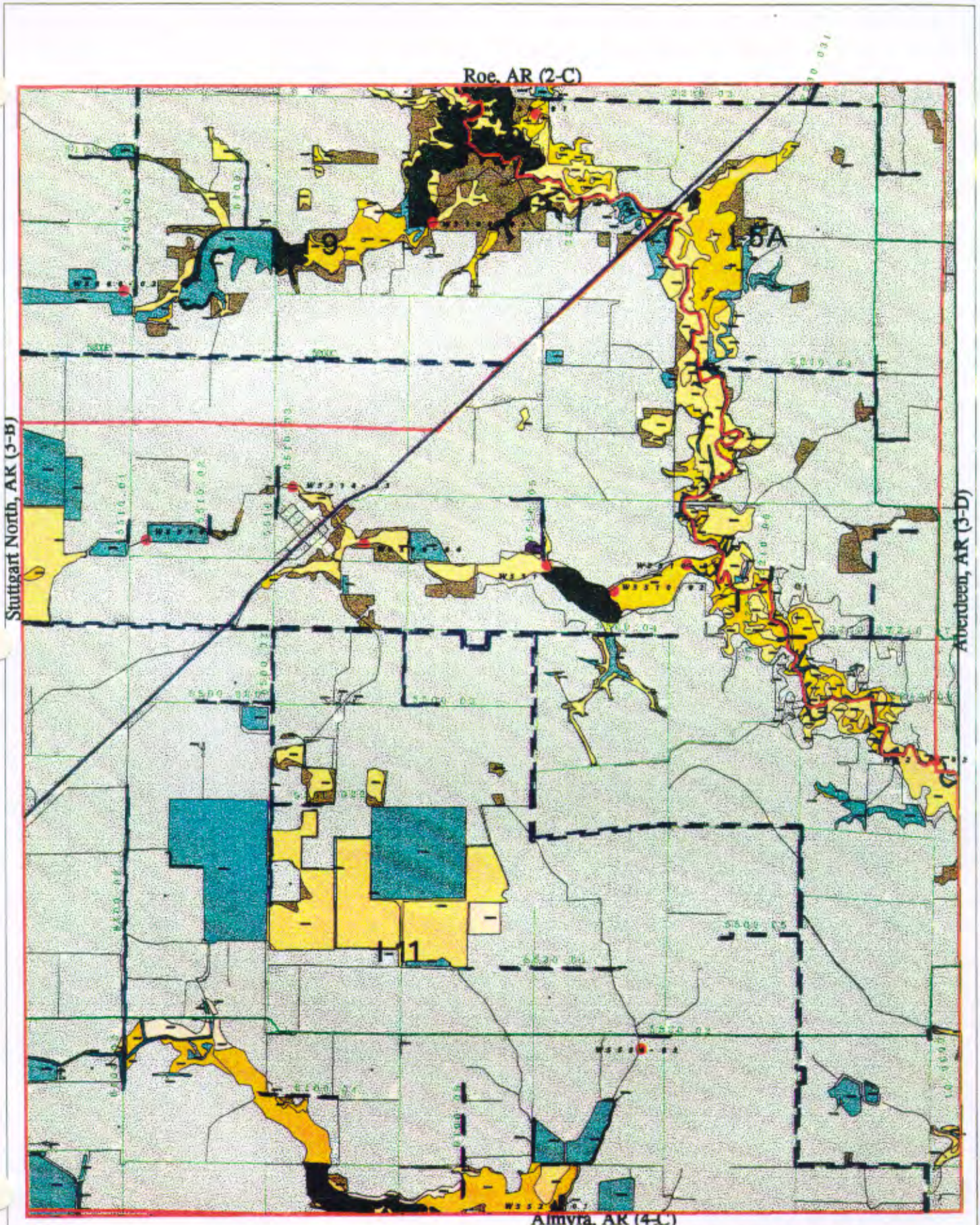
Stuttgart North, AR (3-B)

Wetlands

1 : 42,500

US Army Corps of Engineers Memphis District

GROUND WATER INSTITUTE The University of Memphis

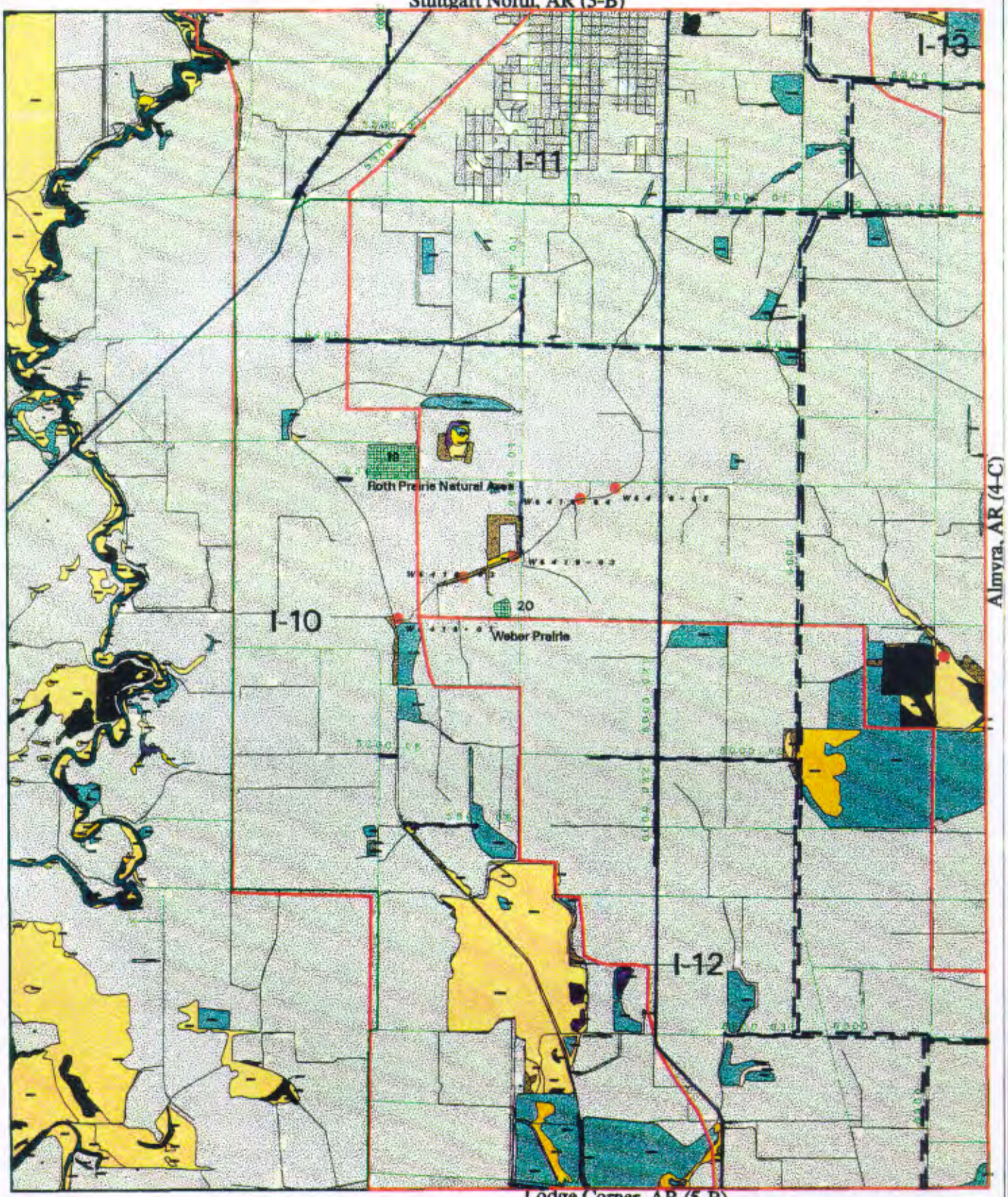


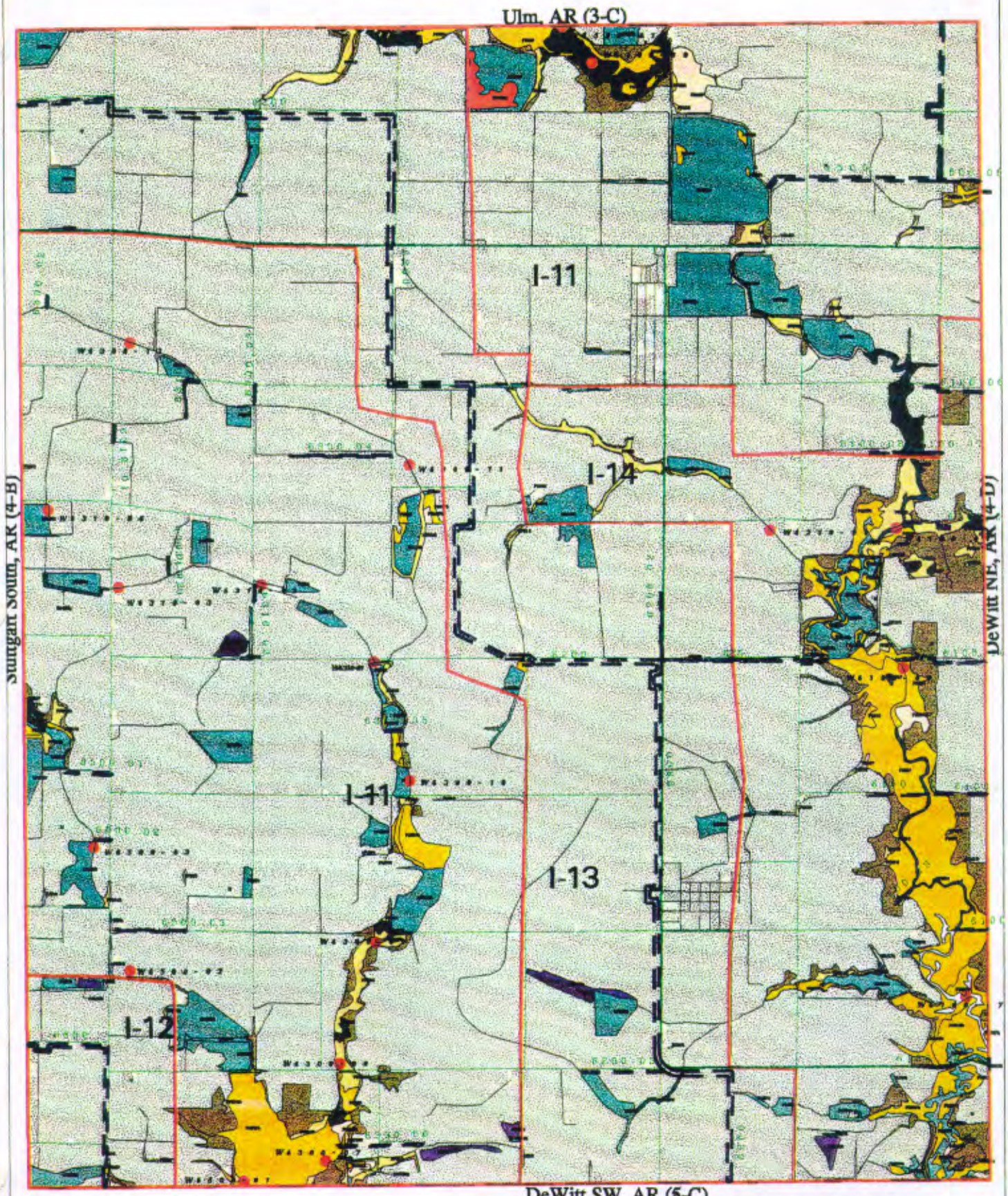
US Army Corps of Engineers Memphis District

GROUND WATER INSTITUTE The University of Memphis

Ulm, AR (3-C)
Wetlands

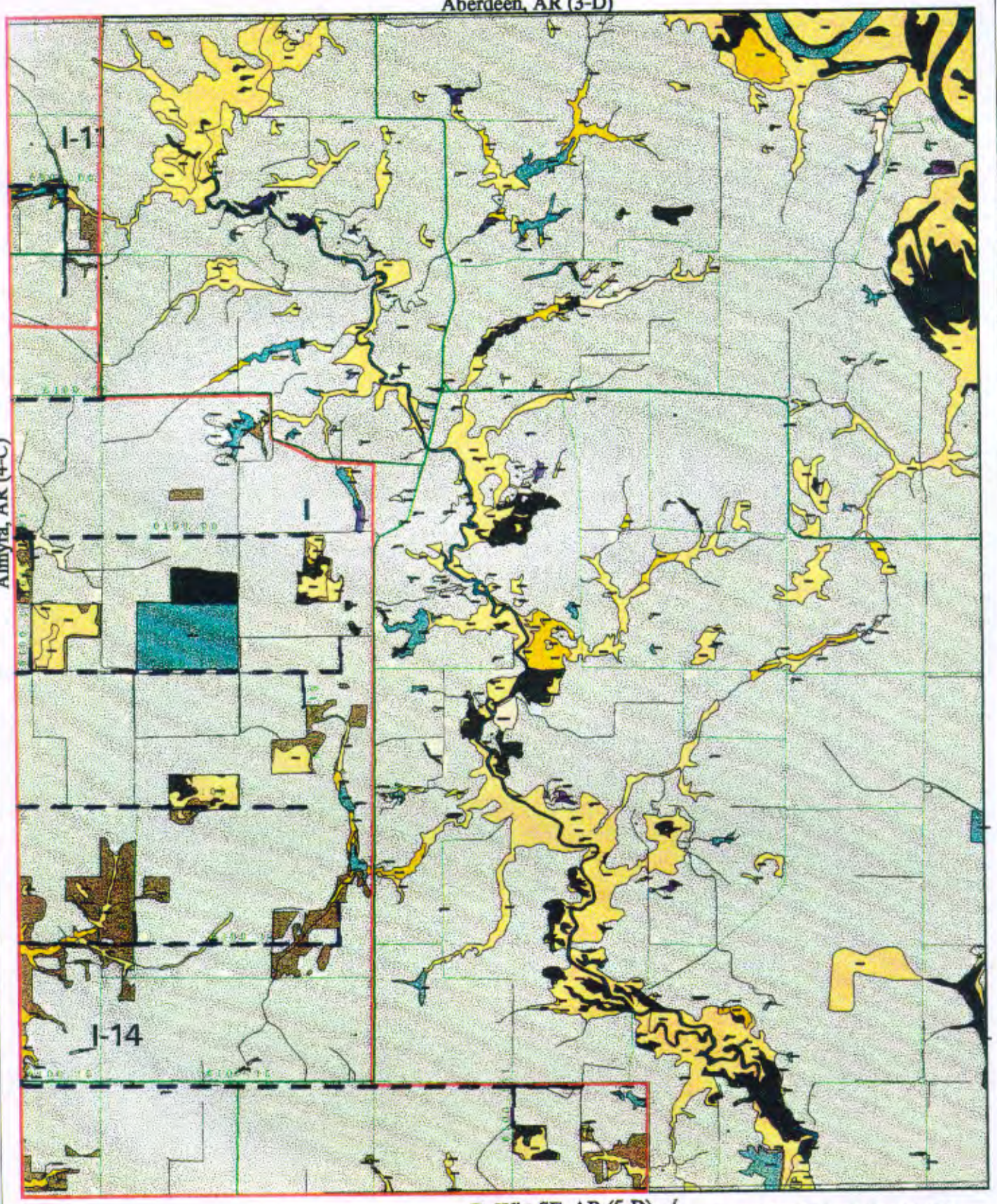
Ulm, AR (3-C)
DeWitt NE, AR (4-D)
Aberdeen, AR (3-D)
Wetlands
US Army Corps of Engineers Memphis District
GROUND WATER INSTITUTE
The University of Memphis


Stuttgart North, AR (3-B)
I-13
I-11
Roth Prairie Natural Area
I-10
Weber Prairie
I-12
Almyra, AR (4-C)
Lodge Corner, AR (5-B)
Stuttgart South, AR (4-B)
Wetlands


Ulm, AR (3-C)
Stuttgart South, AR (4-B)
DeWitt NE, AR (4-D)
I-11
I-14
I-11
I-13
I-12
DeWitt SW, AR (5-C)
Almyra, AR (4-C)
Wetlands

Aberdeen, AR (3-D)

Almyra, AR (4-C)



DeWitt SE, AR (5-D)

Dewitt NE, AR (4-D)

Wetlands

US Army Corps of Engineers Memphis District

GROUND WATER INSTITUTE The University of Memphis

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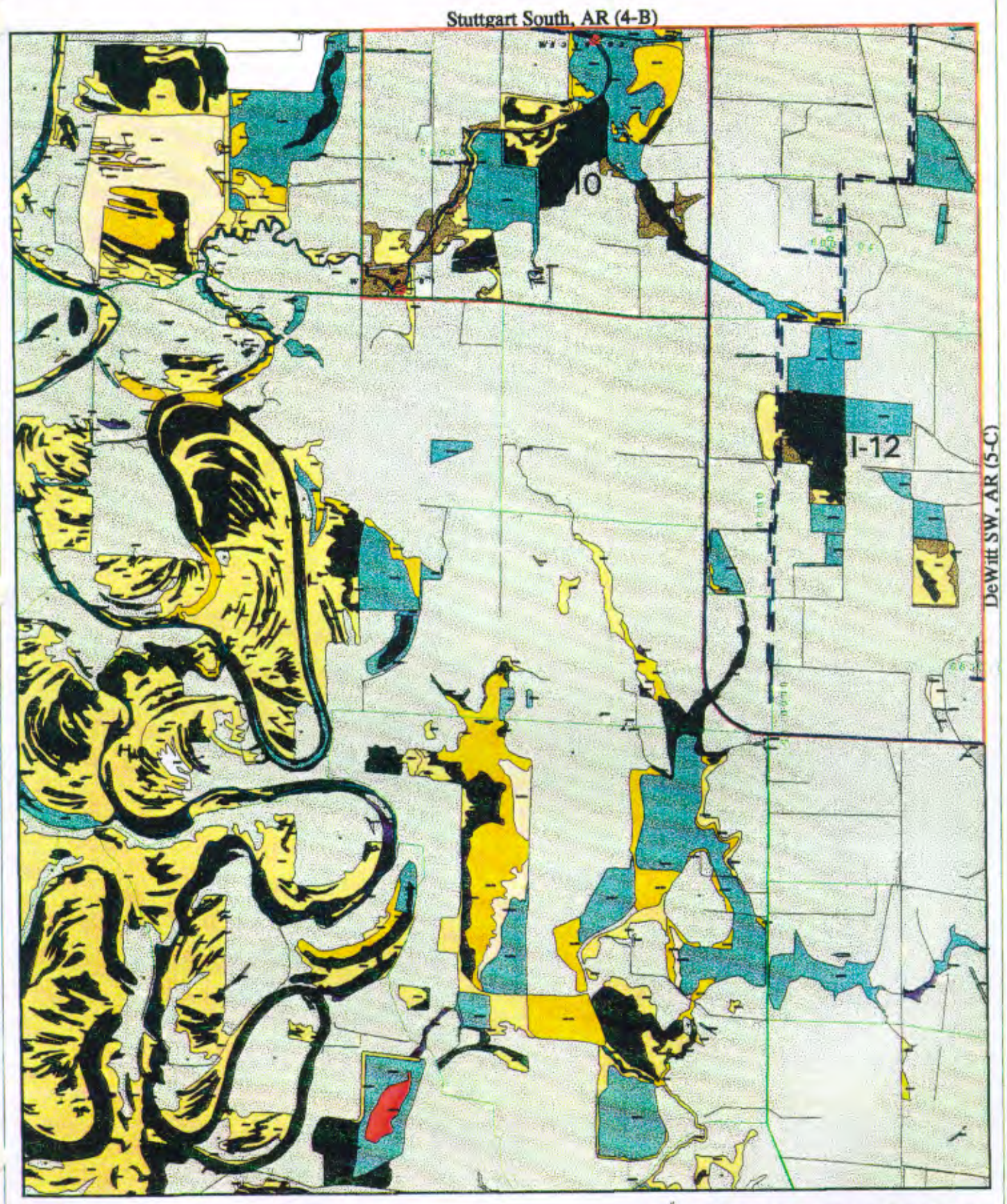
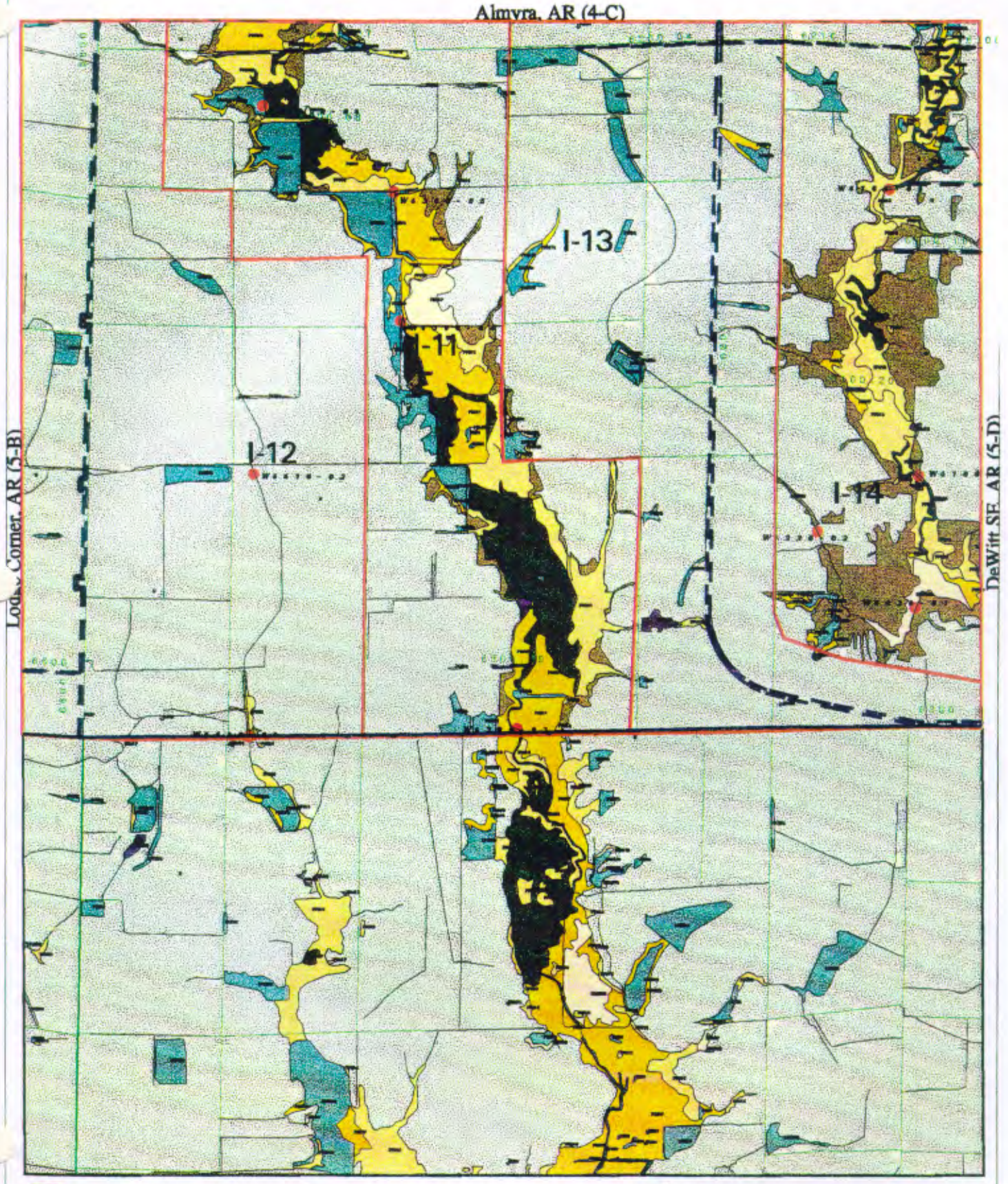


US Army Corps of Engineers Memphis District

GROUND WATER INSTITUTE The University of Memphis

1:40,000

Lodge Corner, AR (5-B)
Wetlands

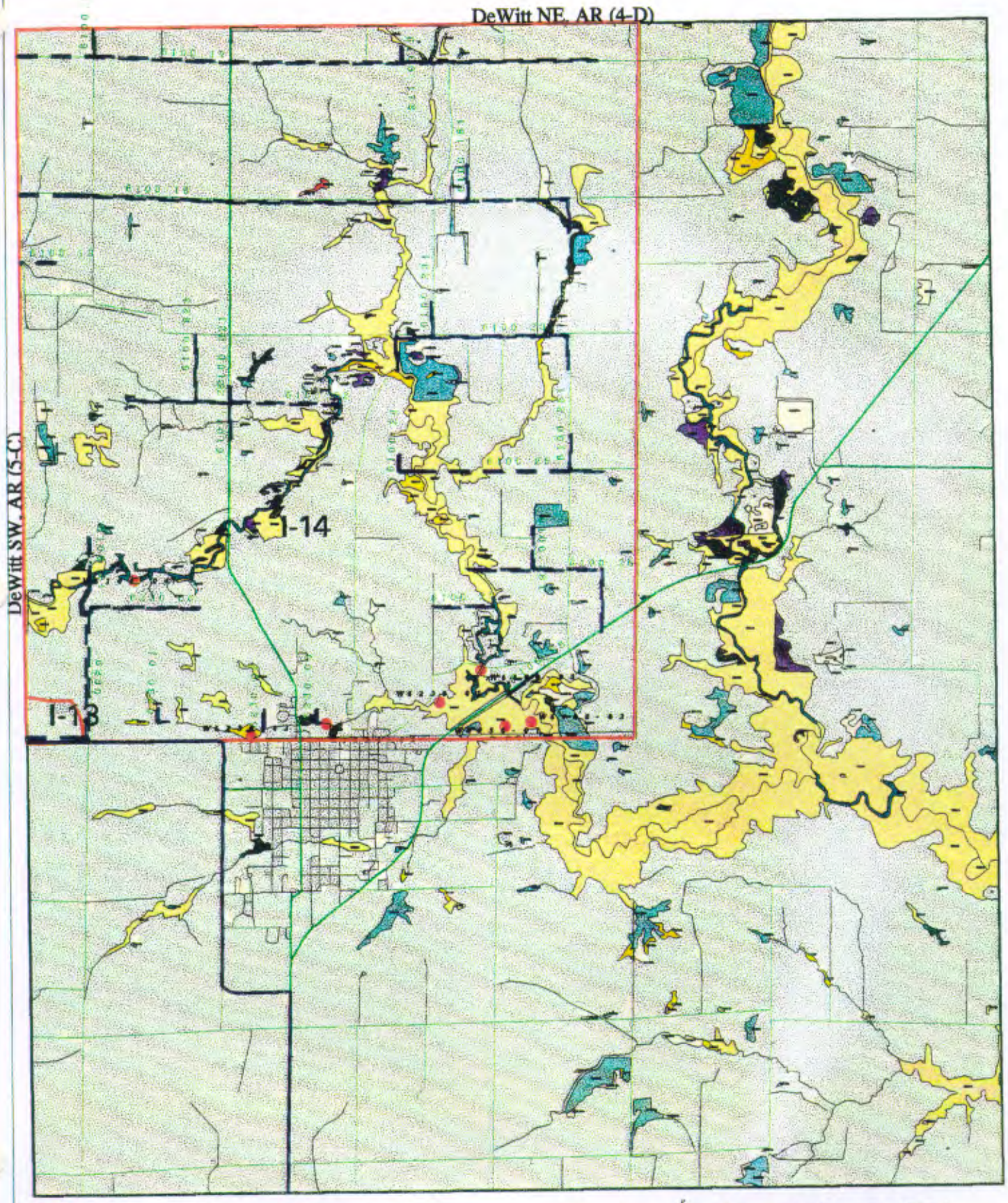


US Army Corps of Engineers Memphis District

GROUND WATER INSTITUTE The University of Memphis

1 : 62,500

Dewitt SW, AR (5-C)
Wetlands



US Army Corps of Engineers Memphis District

GROUND WATER INSTITUTE The University of Memphis

1:40,000

Dewitt SE, AR (5-D)
Wetlands

SECTION VIII

CULTURAL RESOURCES

SECTION VIII

GRAND PRAIRIE AREA DEMONSTRATION PROJECT
ARKANSAS

CULTURAL RESOURCES
Site Potential and Summary

THE CURRENT DATA BASE

State-maintained site forms for the project area and vicinity were examined in detail. Site plot data from these forms indicate that 122 sites are located in or within three kilometers of the overall project boundaries. Data from additional sites situated on similar landforms in the vicinity as well as all sites in Prairie County and the Grand Prairie Ridge were also examined.

Of the 122 sites situated in the immediate overall project area, 51 are located within one kilometer of individual, planned construction items. Thirty-one of these are located within 1000m of specific construction items, and 22 sites are plotted on site forms as being within 200m of planned construction activity.

Warnings about the bias of site file data have justifiably become standard caveats in archaeological technical reports. It is clear that a number of inherent biases in these data, principally from non-professional sources, are beyond analytical control. Even so, a number of categories of data, such as the various prehistoric periods of occupation, can be gleaned from the site records.

The land surfaces in most of the project area date from the Sangamon Interglacial Period from 18,000 to 130,000 years ago (*Saucier 1981:12*). It is, therefore, not surprising that site files reflect utilization of the project area in all major prehistoric time periods (Table 3) on a variety of soil types (Table 4). The earliest evidence of occupation in the project area consists of two Paleoindian projectile points—both from the Loess Hills Plains of Prairie County.

Fourteen Dalton period components have been recorded in the project vicinity and Ford and Redfield (*Redfield 1971*) reported the presence of a buried Dalton component at site 3PR3 on La Grue Bayou. Although not common, Early and Middle Archaic cultural items from the study area have been identified in site files.

Evidence of Late Archaic and Poverty Point sites are more common than that of previous periods but not nearly as plentiful as would be expected from other occurrence rates in adjacent regions. It seems likely that a large number of the recorded study area sites, with chronologically diagnostic but unanalyzed projectile points, are referable to this period.

As in other regions of the Central Mississippi Valley, Early Woodland sites seem to be rare in the project area; only three Early Woodland sites are noted on site forms. Middle Woodland components are only slightly better represented with five recorded sites. Baytown components (i.e., sites containing grog- or clay-tempered pottery) are the most numerous in the project area. It seems likely, however, that a number of the 38 sites containing grog-tempered ceramics relate to Early and Middle Woodland periods. Confident association with either period, absent ceramic decorative elements, is an abiding analytical problem across the Lower Mississippi Valley.

Table 3. Recorded Archaeological Components in the Grand Prairie Demonstration Project Area

Components	Loess Hills/Plains			White River Lowland	Ark. River Lowland	Unknown
	Uplands	Flats/ Terraces	Local Flood Plains			
Paleoindian		2				
Dalton		5	6	1	1	1
Early Archaic		1		1	1	
Middle Archaic			1		1	
Late Archaic		1	2	1	2	1
Lithic scatters*	6	9	1		5	4
Poverty Point					2	
Unknown Biface*		5	4	1	3	3
Early Woodland		1	1			1
Marksville		1	1			3
Unident. Ceramic Sites*		11	1	1	2	4
Baytown/Late Woodland	4	20	12	13	3	6
Coles Creek	1	3	5	7	3	
Early Mississippian			1			
Late Mississippian				1	2	1
Unknown Mississippian	4	9	4	9		2
Protohistoric	1			3		1
Historic	2	6		3		6
Small Mounds	1	10		2	1	5
Large Mounds		5		3		
Multiple Small Mounds		5			1	1
Multiple Large Mounds					1	1
Large and small mounds		1	1			

* "Lithic Scatters" are low density lithic sites without chronological diagnostics. "Unknown Biface" refers to sites with chronologically diagnostic but unevaluated bifaces. "Unident. Ceramics" are sites with unidentified ceramic artifacts.

Table 4. Recorded Archaeological Components and Soil Types in the Grand Prairie Demonstration Project Area

Area/Soil Types	Paleo	Dalton	Early Archaic	Middle Archaic	Late Archaic	Poverty Point	Lithic Scatter	Unknown Biface*
Loess Floodplains								
Tichnor Silt Loam		6		1	2		1	4
Loess Hills/Plains Uplands								
Loring Silt Loam (1-3% Slope)							1	
Loring Silt Loam (3-8% Slope)							1	
Loring Silt Loam (8-20% Slope)							4	
Muskogee Silt Loam								2
Loess Plains Flats/Terraces								
Calhoun Silt Loam		1					2	
Calloway Silt Loam							1	1
Crowley Silt Loam							1	
Loring Silt Loam (1-3% Slope)								
Loring Silt Loam (3-8% Slope)	1							
Muskogee Silt Loam		1					2	1
Stuttgart Silt Loam (0-1% Slope)	1	2			1		2	1
Stuttgart Silt Loam (1-3% Slope)								
Grenada Silt Loam (0-1% Slope)		1					1	
Grenada Silt Loam (1-3% Slope)			1					
Grenada Silt Loam (3-8% Slope)								
Amagon Silt Loam								
White River Lowlands								
Jackport Silty Clay Loam								
Commerce Silt Loam (0-1% Slope)								
Commerce Silt Loam (Freq. Flood)								
Dubbs Silt Loam (0-1% Slope)		1	1		1			
Dubbs Silt Loam (1-3% Slope)								1
Kobell Silt Clay Loam (0-1% Slope)								
Kobell Silt Clay Loam (Freq Flood)								
Sharkey Clay								
Gore Silt Loam (3-8% Slope)								1
Arkansas River Lowlands								
Calloway Silt Loam						1		
Perry Silty Clay (0-1% Slope)								
Perry Silty Clay (Freq. Flood)							1	
Rilla Silt Loam (level)		1	1	1	2	1	1	
Rilla Silt Loam (1-3% Slope)							2	1
Portland Silt Clay Loam							1	1
Hebert Silt Loam		1			1		4	3
Unknown	2	14	3	2	7	2	25	16
TOTAL								

Table 4. Recorded Archaeological Components and Soil Types in the Grand Prairie Demonstration Project Area (Continued)

Area/Soil Types	Unid. Ceramic*	Tchula	Marks-ville	Bay-town	Coles Creek	Unknown Miss.	Early Miss	Late Miss
Loess Floodplains								
Tichnor Silt Loam	1	1	1	12	5	4	1	
Loess Hills/Plains Uplands								
Loring Silt Loam (1-3% Slope)				1				
Loring Silt Loam (3-8% Slope)				3	1	2		
Loring Silt Loam (8-20% Slope)						2		
Muskogee Silt Loam								
Loess Plains Flats/Terraces								
Calhoun Silt Loam	2							
Calloway Silt Loam	1							
Crowley Silt Loam	3			6	3	4		
Loring Silt Loam (1-3% Slope)				1				
Loring Silt Loam (3-8% Slope)								
Muskogee Silt Loam	2							
Stuttgart Silt Loam (0-1% Slope)	1							
Stuttgart Silt Loam (1-3% Slope)	2	1		5		1		
Grenada Silt Loam (0-1% Slope)						1		
Grenada Silt Loam (1-3% Slope)				2		1		
Grenada Silt Loam (3-8% Slope)				6		2		
Amagon Silt Loam			1					
White River Lowlands								
Jackport Silty Clay Loam				2				
Commerce Silt Loam (0-1% Slope)				3	1	3		
Commerce Silt Loam (Freq. Flood)				1		1		
Dubbs Silt Loam (0-1% Slope)					2	1		
Dubbs Silt Loam (1-3% Slope)				2	3	2		
Kobell Silt Clay Loam (0-1% Slope)					1			
Kobell Silt Clay Loam (Freq Flood)	1			5		1		1
Sharkey Clay						1		
Gore Silt Loam (3-8% Slope)								
Arkansas River Lowlands								
Calloway Silt Loam								
Perry Silty Clay (0-1% Slope)				1				1
Perry Silty Clay (Freq. Flood)								
Rilla Silt Loam (level)					2			
Rilla Silt Loam (1-3% Slope)				1				1
Portland Silt Clay Loam	1			1	1			
Hebert Silt Loam	1			6		2		1
Unknown	4	1	3	58	19	28	1	4
TOTAL	19	3	5					

Table 4. Recorded Archaeological Components and Soil Types in the Grand Prairie Demonstration Project Area (Continued)

Area/Soil Types	Mound Sites	Proto-historic
Loess Floodplains		
Tichnor Silt Loam	1	
Loess Hills/Plains Uplands		
Loring Silt Loam (1-3% Slope)		
Loring Silt Loam (3-8% Slope)	1	
Loring Silt Loam (8-20% Slope)		1
Muskogee Silt Loam		
Loess Plains Flats/Terraces		
Calhoun Silt Loam	2	
Calloway Silt Loam	1	
Crowley Silt Loam	7	
Loring Silt Loam (1-3% Slope)		
Loring Silt Loam (3-8% Slope)		
Muskogee Silt Loam		
Stuttgart Silt Loam (0-1% Slope)		
Stuttgart Silt Loam (1-3% Slope)	1	
Grenada Silt Loam (0-1% Slope)	1	
Grenada Silt Loam (1-3% Slope)	3	
Grenada Silt Loam (3-8% Slope)	5	
Amagon Silt Loam	1	
White River Lowlands		
Jackport Silty Clay Loam		
Commerce Silt Loam (0-1% Slope)	1	
Commerce Silt Loam (Freq. Flood)	2	
Dubbs Silt Loam (0-1% Slope)	1	1
Dubbs Silt Loam (1-3% Slope)		2
Kobell Silt Clay Loam (0-1% Slope)		
Kobell Silt Clay Loam (Freq Flood)		
Sharkey Clay	1	
Gore Silt Loam (3-8% Slope)		
Arkansas River Lowlands		
Calloway Silt Loam		
Perry Silty Clay (0-1% Slope)		
Perry Silty Clay (Freq. Flood)	1	
Rilla Silt Loam (level)		
Rilla Silt Loam (1-3% Slope)		
Portland Silt Clay Loam	2	
Hebert Silt Loam		
Unknown	7	1
TOTAL	38	5

* Lithic scatters are low density sites without chronological diagnostics.
"Unknown Biface" refers to sites with chronologically diagnostic but unevaluated bifaces
"Unident. Ceramics" are sites with unidentified ceramic artifacts.

In addition to Baytown components, 19 sites were identified on site forms as Coles Creek, presumably based primarily on vessel neck decoration. Although a number of these Coles Creek sites were reported by amateurs, professional analysis has identified Plum Bayou phase material at sites in the project area. Like Baytown components, those identified as Coles Creek occur on all major types of landforms in the project area. Site forms for an additional 19 sites state only that ceramics occur at the loci without specifying tempering material or ceramic type.

Thirty-three recorded sites are described as having shell-tempered ceramics. Of these, only one, the Dumond Site (3AR40), was noted by site forms to contain an Early Mississippian component. However, House (*1982a:44*) has described this site as Middle Mississippian, and an excavation conducted by the University of Arkansas Museum (*Sholtz 1968*) disclosed both Mississippian and Woodland remains. Four sites are affiliated with Late Mississippian. The specific sub-periods of the remaining 28 recorded Mississippian sites is unknown.

Thirty-eight sites associated with mounds have been recorded in the project area. Twenty-one of these mound sites are located on Loess Plains Terraces, some distance from local streams and the Loess Uplands. One mound site was reported in a Loess Uplands area and another near a local Loess Terrace Stream floodplain. Eight mound sites were noted in or near project areas close to the White and Arkansas River Lowlands.

Site file data amply demonstrate House's (*1982a:44-45*) observation that most Mississippian sites were located on a variety of landforms (refer to Tables 3 and 4). If House is correct regarding the nucleation of area Mississippian settlements into a few central lowland niches after A.D. 1400, sites located on the Loess Uplands and Plains must precede that date. The five protohistoric sites noted on site forms are either in or adjacent to the White River Lowland.

PREHISTORIC SITE POTENTIAL EVALUATION

The purpose of data examined in previous sections is not simply *pro forma*. Among other purposes, it was intended to supply information to aid in survey design as well as to augment empirical data obtained in survey activities. Several basic questions could be asked of these data. Did substantive cultural activities likely take place in the project area and, if so, what was the likely nature of these activities? Were these activities likely to leave evidence and, if so, is the evidence likely to be apparent from intensive surface survey examination or obscured by overlying soil horizons or vegetation?

Desirable habitation locations were probably those which were well drained with ready access to abundant food, water, raw materials and transportation. The Loess Terraces and Uplands of the Grand Prairie Ridge, with the various rich Lowland habitats previously discussed and the adjacent Ozark border, would have provided access to a rich supply of food, water, raw materials and transportation opportunities from the project area.

Existing data indicate that archaeological sites are present in the project area from all major prehistoric time periods. The 22 sites currently recorded within 200m of proposed construction activity include components ranging from Dalton to protohistoric and include both individual mounds and mound groups. Additional sites are recorded within 1000m of proposed project construction. Furthermore, since only a small fraction of the extensive project area has been systematically examined by professionals, it seems likely that other, unrecorded, cultural resources are also present.

Habitats and resources of the project area, of course, were subject to shifts over time with geological and climatic changes. Unlike areas to the east, the basic current geological and hydrologic structure of the Grand Prairie Ridge area was in place well before Paleoindian times. The most dramatic climatic changes probably occurred during the Hypsithermal Interval from the latter part of the Early Archaic Period through the Middle Archaic Period. Whether populations abandoned adjacent lowland areas during this time, as suggested by some researchers, or changed to subsistence-settlement patterns resulting in lower archaeological visibility or buried components, as suggested by others, is unknown.

Following the Hypsithermal Interval, increases in precipitation and a return to moderate temperatures resulted in a return to the rich riverine lowland environment which remained essentially unchanged until about the beginning of the twentieth century. Given well-drained land, these landscapes would have been very attractive to prehistoric populations, although seasonal flooding may well have deterred permanent occupation in limited portions of the project area.

Analysis in the Cache River project suggested that certain landforms in the region are far more likely to be associated with prehistoric sites than others (*House 1975:153-155*). Throughout the Cache Basin, braided stream terraces overlooking low-lying areas along the river tended to have many sites, suggesting more intense occupation. Prominent points of terrace edges were found to be especially likely to contain sites.

These conclusions, of course, were not unexpected. Somewhat more surprising was House's finding that slightly elevated areas on the flood plain contained a relatively high rate of sites as did interfluvial areas of braided stream terraces containing natural levees and sand dunes.

Buried Site Potential

Taylor (*1975:199*) has discussed the potential for buried Paleoindian sites in the Cache River Basin and other portions of eastern Arkansas.

Archaeological remains associated with the loess soils of the Grand Prairie (which constitute most surfaces in the project area) can be expected to be found at the surface because of the age of the soils. There is some indication in site forms that in areas of the White River Lowland, archaeological materials have been buried by relatively modern natural levees. At Big

Lake, where braided stream terraces were covered by extensive natural levee deposits from the Little River, Lafferty et al. (*1987*) and Spears et al. (*1988*) found evidence of extensive buried, stratified Woodland deposits.

Locating such buried archaeological remains is a major problem in surveys throughout the United States and, although the problem has been noted frequently by researchers, systematic methods for locating and identifying localized buried components have seldom been successfully undertaken. It is apparent from the discussion above that the location of buried archaeological deposits is dependent on a myriad of natural and cultural variables including geological, hydrological and varying prehistoric subsistence-settlement systems.

Ironically, the activities most likely to yield information about buried archaeological sites are the construction of drainage canals or channel enlargement projects which, in addition to destroying sites, frequently bring buried cultural materials to the surface. For this reason, the careful examination of redeposited soils from previous construction activity is the most practical method currently available for detecting buried sites in survey activity.

HISTORIC SITE POTENTIAL

The background search and literature review of the Arkansas State site files revealed that 17 previously recorded historic archaeological sites are located in the general study area, with 10 located within one kilometer of the project area. No standing historic structures were previously recorded within the project area.

Of the 10 previously recorded historical sites located within one kilometer of the project area six were situated adjacent to the White River Valley and four were located along drainages in the eastern and southern portions of the Grand Prairie. The majority of these sites reflect earlier historical occupations based on access to waterborne transportation routes.

The review of the existing data indicated that archaeological sites from all historic time periods are present within the proximity of the project area. Several Contact, Colonial and Antebellum sites have been recorded in the vicinity; these are all located on the periphery of the Grand Prairie either along the White River drainage to the east or near the Arkansas Post along the Arkansas River to the south.

Within or adjacent the project ROW, seven of the previously recorded sites date from the 1860s. These sites date to the Civil War period when several engagements and the Union occupation of DeValls Bluff occurred. The Civil War sites include a Calvary depot (3PR37), remount camp (3PR29), defensive berms (3PR92) and other Federal installations constructed near the community of DeValls Bluff (3PR84) during the 1860s.

The remaining three sites date to the early 1900s when settlement patterns shifted to the interior of the Grand Prairie following the introduction of the railroads and rice cultivation.

Although one site, a sunken metal barge (3PR91), reflects the continued utilization of the White River for commercial transportation, the other sites represent a new pattern of settlement on the prairie terrace. Homesteads such as one located near Mill Bayou (3AR77) contained brick, ceramics, glass and metal dating to the period when whole ethnic communities such as Almyra were established by railroad speculators to enhance the commercial production of rice.

The historic overview indicates that the natural environment limited subsistence strategies and settlement patterns within the Grand Prairie area prior to the late 1800s. Environmental characteristics such as poorly drained soils and the proximity to water limited cultural perceptions about the area's natural resources during these earlier historic periods.

Later historical periods witnessed an increased utilization of the prairie terrace through extensive agricultural cultivation of the area. The introduction of rice production following the turn of the century shifted settlement patterns in the project area, and the number of homesteads established across the Grand Prairie greatly increased during this time.

In Colonial times the vast prairie grasses were used as cattle and sheep range by French and Spanish inhabitants. During this period occupation within the project area continued to reflect a settlement pattern based on access to water and timber and a subsistence strategy based on trapping and farming the easier plowed soils on the periphery of the Grand Prairie. The potential for sites dating to Colonial times is very limited.

Throughout most of the Territorial and Antebellum Periods Anglo-American immigrants avoided the eastern and southern lowlands of Arkansas including the prairie terrace of the Grand Prairie because of the fear of malaria and the lack of technology to effectively exploit the natural resources of the area. Most of these immigrants moved to the north and west of the project area, although a few isolated frontier settlements were established along the wooded streambeds of the Grand Prairie.

These homesteaders pursued a seasonal folklife style of ranging livestock on the prairies, subsistence farming and hunting until the 1850s when settlers in the area began to participate on a limited basis in the production of cotton. Dispersed communities arose in this rural setting based on a generalized grain and livestock economy. Communities such as Casscoe, Point DeLuce and DeWitt date to the later part of the period; the areas surrounding these communities offer the best potential for archaeological sites dating to this time period within the project area.

The impact of the ensuing hostilities during the Civil War Period on the project area was dramatic. Numerous expeditions and skirmishes throughout the Grand Prairie area exposed the project area to large numbers of people for the first time. Federal installations along the White River at St. Charles and DeValls Bluff and the completion of the Memphis and Little Rock Railroad through the Hazen and Carlisle areas significantly increased activity on the area affording the potential for sites dating to the Civil War period in the eastern and northern portions of the project area.

Immediately following the Civil War settlement patterns within the project area continued to be limited to Anglo-American homesteads located along the bottomlands of the numerous bayous that crossed the Grand Prairie. Farming communities such Tyler, Gum Pond and Clear Point developed in the central and southern portions of the project area during this period based on the production of cotton and corn.

The introduction of major railroads and several short lines across the interior portions of the Grand Prairie provided access to national markets for the commercial production of hay for the first time. Immigration into the area by German farmers from the Midwest and other Central Europeans significantly altered the methods of cultivation utilized for the production of rice and established new settlement patterns within the central and northern portions of the project area.

A unique rice culture based on the cultivation, processing and marketing of this agricultural product developed throughout the Grand Prairie. Extensive agricultural production within the Grand Prairie area may have impacted some of the homesteads established during this period, and the potential for locating archaeological sites and standing historical structures dating to this period within the project area is high.

SUMMARY

Most current study area land surfaces were available for occupation in all prehistoric and historic periods, and existing data confirm that the vicinity was utilized from Paleoindian times (ca. 11,500 B.P.) until the present. A number of cultural resources are known to exist close to areas of proposed construction and a number of these appear to be of great significance. Systematic examination seems likely to identify additional significant prehistoric sites in the project area.

Because much of the project area is close to local floodplains and the White River Lowland, and may have been subjected to extensive seasonal flooding at times, some prehistoric occupations and historic occupations prior to extensive drainage projects in the last quarter of the nineteenth century may well have been seasonal in nature. Isolated buried components could be located in some of these floodplain locations; however, archaeological deposits in the bulk of the project area should be surficial.

SECTION IX

HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

SECTION IX

HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE PHASE 1 ASSESSMENT

Grand Prairie Area Demonstration Project

9-01. SUMMARY

The Corps of Engineers, Memphis District (MD) has examined the study area for the East Arkansas Region Comprehensive Study, Grand Prairie Area Demonstration Project, General Reevaluation, in Arkansas, Lonoke, Monroe and Prairie counties, Arkansas, for the potential presence of hazardous, toxic, and radioactive wastes (HTRW). The assessment relies on site inspections, analysis of aerial videotapes and photographs, and document research. Based on these evaluations, it is reasonable to conclude that no hazardous or toxic waste will be encountered during construction of this project. No additional HTRW work is recommended, unless new information or HTRW is discovered during construction.

9-02. INTRODUCTION

The purpose of this initial assessment is to gather and evaluate data regarding the existence or potential for encountering HTRW at or near Corps civil works projects. Documentation is based on the analysis of aerial photography, historical records search, and site inspections. The assessment is intended to minimize liability of the Federal government, protect the health and safety of field personnel from undocumented HTRW sources during field investigations, and document the existence of sites that are in need of remediation.

This assessment was prepared under guidance of the Corps of Engineers Regulation ER 1165-2-132, Water Resources Policies and Authorities for Hazardous, Toxic, and Radioactive Waste (HTRW) for Civil Works Projects, June 22, 1992.

9-03. PROJECT DESCRIPTION

Purpose and Need. The purpose of this project is to identify the current and future water resource problems in the Grand Prairie region of eastern Arkansas and to provide supplemental water to this agricultural region of Arkansas. This project provides a solution to the problems caused by the current rate of withdrawal of groundwater used for irrigation.

Project Authority. Resolution adopted by the Committee on Public Works and Transportation of the U. S. House of Representatives on 23 September 1982 and the FY 1992, FY 1993, FY 1994, and FY 1995 Energy and Water Development Appropriation Acts. The Water Resources Development Act of 1996 reauthorized the Grand Prairie - Bayou Meto Project. The Grand Prairie-Bayou Meto Project was previously authorized by the Flood Control Act of 1950 and deauthorized in 1989 pursuant to Section 1001(b) of WRDA 1986.

Prior Project Documentation. The Eastern Arkansas Region Comprehensive Study Summary of Reconnaissance Study Findings was distributed for review in March of 1985. The Eastern Arkansas Region Comprehensive Study Feasibility Report was completed in August of 1990.

Project Action. The plan consists of pumping water from the White River down irrigation canals and through a distribution system of canals, pipelines, and existing natural streams through Prairie, Lonoke, Arkansas, and Monroe counties . Approximately 184 miles of irrigation canals will be built, and 177 miles of pipelines will be installed. Approximately 4780 acres of land would be converted into irrigation canals, canal levees, buffer zones along canal levees, and pipeline rights-of-way. All irrigation canals will contain structures to control hydraulic grades and maintain pools. Storage reservoirs will be constructed on existing cropland to prevent wetland losses. Water conservation measures, groundwater management strategies, and on-farm storage facilities are integral parts of the plan.

9-04. GENERAL ENVIRONMENTAL SETTING

Geologic Features. The underlying geology consists of a basement bedrock deposited as Paleozoic sediments. These are overlain by Cretaceous sediments of marine origin, and then Tertiary deposits divided into different groups that plunge gently southward toward the Gulf of Mexico. The surface veneer consists of Quaternary sand, gravel, and clay alluvium deposits ranging in thickness of 190 to 200 feet. The Grand Prairie was once a large prairie originally covering almost 500,000 acres, but now consists of 10 widely scattered remnants totaling approximately 500 acres.

Climate. The climate of the project area is temperate with long, warm summers and short, moderately cold winters. Average annual temperature is about 61 F with monthly averages ranging from 40 in January to 81 in July. Average annual precipitation is approximately 49 inches with March, April, and May having the highest rainfall, while August, September, and October have the lowest. Thunderstorms occur an average of 53 days of the year, and tornados have been known to occur in the area.

Hydrological Elements. The principal source of groundwater is the Quaternary alluvial aquifer, a sequence of clay, silt, sand, and gravel which underlies the project area. This is a large aquifer, capable of transmitting and storing large quantities of groundwater. Surface water is supplied by numerous streams, oxbow lakes, sloughs, and multipurpose reservoirs.

Vegetation and Wildlife. Construction of new canals will impact about 231 acres of wetlands and upland hardwood forests in Grand Prairie. To mitigate these losses, approximately 232 acres of cleared land will be acquired and planted in selected bottomland hardwood trees; and 198 acres of cleared land will be planted in upland hardwood tree species. Agricultural land impacted by canals, pumping stations and inlet channels are estimated to be 3753 acres. Prairie grasses will be planted on irrigation canal levees. One endangered fish species, pallid sturgeon (*Scaphirhynchus albus*), and one endangered mussel species, pink mucket pearly mussel (*Lampsilis abrupta*), occur within the study area portion of the White River. The threatened bald eagle (*Haliaeetus leucocephalus*) is a transient species, resting and feeding along the White River during its winter migration. However, no large concentrations of eagles have been observed along this portion of the river; and no nest sites are known to be located within the study area. No adverse impacts to these species, or their critical habitats, are expect to result from the project. All project-related matters concerning these species were coordinated with the U.S. Fish and Wildlife Service.

9-05. ENVIRONMENTAL CONCERNS

The objective of this investigation is to determine the existence or probability of locating historical waste disposal sites or other sites containing substances that could be injurious to workers or detrimental to wildlife. Many toxic chemicals possess half-lives that enable particular chemical forms to persist in the soil, creating a potential long term risk. The formation of a chemical metabolite over time can aid in the identification of the original organic contaminant. Several factors, such as soil characteristics (clay, mineral, or organic types), chemical concentration of the contaminant, residence time of the chemical within the soil, surface and groundwater interactions, and site-specific meteorological conditions determine whether a particular metabolite is ultimately released to the environment, causing containment problems.

Exposure to contaminated soil may pose both direct and indirect hazards to humans. The degree of exposure to toxic substances is primarily a function of concentration in the top several inches of soil. Exposure is induced by skin adsorption, ingestion, or inhalation of the contaminant. Within the soil's surface layer, such routes of exposure are facilitated because sunlight and air allow many chemicals to volatize rapidly or become metabolized to different forms by soil microorganisms. Chemicals can also leech into groundwater and enter streams in surface runoff, where they present a threat to fish, birds, and terrestrial wildlife species.

Undocumented underground storage tanks for petroleum products represent an additional source of concern. If undocumented waste sites are uncovered during the course of the proposed action, work delays, increased coordination with regulatory agencies, and escalating project costs could result, with the risk of potential worker exposure to HTRW.

9-06. ASSESSMENT METHODOLOGY

HTRW Objective. The objective of this assessment is to minimize, through early detection, exposure from any waste site or contaminated material during the construction of the project. The intent is to provide a reasonable assessment of the potential problem areas, so that project managers and local sponsors can make decisions on property transfers or future testing requirements. This preliminary assessment focuses on information that would identify known sites adjacent to or near the project area and determine the probabilities for potential contaminant release.

Aerial Photographic\Video Tape Analysis. Aerial photographs of the project area were reviewed to develop a land use history of the project site. Aerial photographs can reveal previously disturbed or cleared land, waste disposal sites, or commercial and industrial activities. However, due to the scale of the photography, only gross land disturbances can be detected. Photographs from 1991 at a scale of 1:24,000 were examined. The rights-of-way of canal alignments were video taped from an altitude of 125 feet and reviewed to determine the existence of any soil stresses or surface debris. These tapes could indicate the presence of any hazardous or solid waste disposal sites along the alignments.

Agency Coordination/ Historical Records Search. The U. S. Environmental Protection Agency (EPA), several divisions of the Arkansas Department of Pollution Control and Ecology (ADPCE), and various local officials were contacted regarding information about any known HTRW problems in the project area. Contacts are listed in Appendix (A).

Site Visits. Memphis District personnel have made numerous site visits to the study area to become familiar with the wildlife habitats and the overall land use. During the past several years, numerous field investigations have been conducted by Corps biologists and engineers.

9-07. ASSESSMENT RESULTS AND FINDINGS

The results of the aerial photography analysis, video tape review, records search, and site inspections are discussed below. Details of these analyses are contained in files at Memphis District.

Aerial Photographic\Video Tape Analysis. Existing conditions were examined on current aerial photographs (1991). No areas of stressed vegetation or degraded areas were apparent. No potential HTRW problems were indicated. Approximately 30 hours of aerial video tapes of canal

alignments including 150 foot rights-of-way on both sides were reviewed: no evidence of hazardous waste disposal sites or areas of soil contamination were observed.

Agency Coordination/Historical Records Search. A records search of potential sources of contamination within the project area was performed through contact with personnel from the EPA and ADPCE. Records listing Federal and state Comprehensive Emergency Response, Compensation, and Liability Information System (CERCLIS) and National Priorities List (NPL) sites were examined, and no sites are located within or bordering the study area. A Resource Conservation and Recovery Act (RCRA) list of the hazardous waste producers located within the vicinity of the four county project area was compiled; none occur within the project area or the American Society of Testing Materials (ASTM) recommended buffer zone. There are no RCRA Treatment, Storage, and Disposal facilities within the project limits. A list of underground storage tanks and the four county LUST (Leaking Underground Storage Tank) list was obtained, and none are located within the vacinity of proposed construction limits. The locations of known illegal dump sites was mapped, and none are located within the project limits.

A list of operating and closed landfills and transfer stations was obtained; none are located within the boundaries of the construction limits. One facility (Riceland landfill- closed in 1980 and now a transfer station) encroaches on the ASTM recommended half mile buffer zone. However, man made drainage ditches have been constructed along the periphery of this former landfill. These ditches are located closer to the landfill and were excavated to depths similar or greater than proposed for the new canal. The manager of the facility noted during a site visit that landfill material was encountered during excavation of the existing ditches. No records were available but he recalled this work occurring in the late 1970's time frame. Since the proposed canal is approximately one-half mile farther away than exiting ditches and does not have the apparent hydraulic connectivity to the landfill that the existing ditches do, the selected plan will not result in an increased risk of leachate generation.

Site Visits. The land use for the study area is rural agricultural with low density residential areas. A visual inspection of Riceland and two other landfill sites was conducted on 4 September 1996 to determine the adequacy of the buffer zone located between the sites and the project features. No discolored or contaminated soil lacking vegetation, stressed vegetation or wildlife, or irregularities of topography have been observed by Memphis District personnel. All rights-of-way for the canals have been visually inspected with no obvious signs of HTRW sites.

9-08. ASSESSMENT DISCOVERY

Site investigations, aerial photography and video tape reviews indicate the absence of apparent site-specific HTRW problems within the project rights-of-way. In addition, agency coordination has provided no substantial cause for further consideration of potential HTRW in the area.

9-09. RELATIVE RISK ASSESSMENT

Based on document verifications that no HTRW indications or existing support facilities exist within project rights-of-way and present land use, the potential for encountering hazardous or toxic wastes in the project area is unlikely.

9-010. CONCLUSION AND RECOMMENDATION

Based upon information gathered during the preliminary assessment for the study area, it is reasonable to assume that no hazardous, toxic, or radioactive wastes will be encountered during the construction of this project. No additional HTRW investigations are recommended. This assessment indicates no apparent risk of encountering hazardous wastes sites within the project area. No other analysis is required, unless new information is developed or HTRW is discovered.

APPENDIX A

COORDINATION LIST

FEDERAL

U.S. Fish and Wildlife

1. Curtis Nelms (901)629-6619
   Possible Landfill Site, April 5, 1996

Environmental Protection Agency, Region VI, Dallas, Texas

1. Rhonda Sharpe (214)665-6444
   Federal RCRA Sales, December 3, 1996

STATE

Arkansas Department of Pollution Control and Ecology

1. Jane Marsh (501)682-0984
2. Carla Graham, Records Technician
3. Heidi Love, Inspector Supervisor
   (501)682-0590
   Permitted LandfillList, June 24, 1996
4. Cyndi Harmon (501)682-0856
   Active HTRW Generators,
   January 26,1996
5. John Mitchell (501)682-0924
   Air Quality Standards
6. Constance Gwinn (501)682-0591
   Illegal Dump Program Coordinator
   Illegal Dump List, April 15, 1996

LOCAL

City of Hazen

1. T.A. Cowan (501)225-4521
   Administrative Assistant Transfer Station
   Legal Description, July 26, 1996

City of Stuttgart

1. Andrew Robinson (501)673-6481
   Landfill Information, June 10, 1996

Mehlburger Firm

1. Mike Johnson (501)375-5331
   Open Dump List Update, June 7, 1996