APPENDIX 12
WATER QUALITY

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A12-1 Introduction

Multiple reaches of the Mississippi River levees (MRL) within the Memphis, Vicksburg and New Orleans Districts are not built to the project design grade. For these levees to provide the approved level of flood protection for the areas within the lower Mississippi Valley, levee improvements must be made. These improvements include the raising of sections of the levees, raising or stabilizing sections of floodwall, flattening the slopes of certain levee segments to protect against levee slides, the creation or expansion of seepage control berms, or the installation of relief wells along the levee toe. These measures are implemented to restrict overtopping or to prevent seepage from undermining the levee. Many of the Work Items detailed in this report will require the acquisition of additional borrow areas (BA). Traditionally, material used to build the levees and the berms comes from BAs created on the riverside of the levee, and to reduce cost, these BAs are situated as close to the levee as is possible. However, in some instances Work Items require borrow material to be obtained from the landside of the levees. Much effort is made to locate BAs adjacent to Work Items in an effort to minimize hauling distances. When the closest available borrow would come from a forested site, alternate BAs both riverside and landside of the levee are considered to reduce the loss of bottomland hardwoods (BLH). In addition, alternative measures to seepage berms are employed through the use of relief wells to reduce the potential of levee failure due to seepage or uplift. This appendix will examine the water quality impacts associated with raising the levees, raising or stabilizing sections of floodwall, flattening the slopes of levee segments, construction of levee berms, and the installation and operation of relief wells.

Multiple studies have been conducted to determine the overall aquatic health of the Mississippi River. The passage of the Clean Water Act (CWA) in 1972 initiated slow improvements to the water quality of the streams flowing into the Mississippi River. Although the water quality in the Mississippi River is improved since the passage of the CWA, it still carries a high load of nutrients to the Gulf of Mexico. The Spatially Referenced Regression On Watershed attributes (SPARROW) model was constructed for the Mississippi/Atchafalaya River Basin (MARB) to help identify the major sources of nitrogen and phosphorus loads to the continental watershed. Catchments located in the middle Mississippi and Ohio River Basins were found to deliver the highest nitrogen yields, while the highest phosphorus yields were located throughout the central region of the MARB. Agricultural inputs from manure, fertilizer, and legume crops were the largest sources of nitrogen. High phosphorus inputs were found to come from areas with a high concentration of crop and animal agriculture and wastewater treatment plants. (Robertson and Saad, 2014, Robertson et al., 2014). Long-term sampling efforts have been conducted by the United States Geological Survey (USGS) for the last 50 years at many stations along the lower Mississippi River (LMR). This report will compare in situ water quality parameters, as well as nutrient conditions for six LMR stations over their respective periods of record (POR). In addition, water quality comparisons will be made for one of the Mississippi River stations by decade over the 50 year timeframe. This report will also present concentrations of trace metals from the 2010 decade at stations located at the upper and lower end of the LMR. Water quality of BAs adjacent to the Mississippi River were studied prior to the 1998 Supplemental Environmental Impact Statement (SEIS) report. A subset of these BAs were resampled to document current water quality conditions. This report will also address concerns brought about by local land owners over the mixing of relief well discharge, which have higher dissolved salt concentrations with local surface waters used for agricultural irrigation. Lastly, this report addresses the various alternatives considered for BA construction when material is needed to implement the proposed improvements.

A12-2 Mississippi River Water Quality

Water quality data from multiple stations along the LMR were retrieved from the USGS National Water Information System (NWIS), an online database. The stations include: Thebes, Memphis, Arkansas City, Vicksburg, St. Francisville, Baton Rouge, Luling, New Orleans and Belle Chase. After reviewing the data, the stations located at Thebes, Memphis, Arkansas City, Vicksburg, St. Francisville and New Orleans (composite of values collected from Luling, New Orleans and Belle Chase) provided the most comprehensive and representative sample sets for the period from 1970 through 2019. The data were analyzed using Statistical Analysis System (SAS) software (PROC MEANS). Due to the low number of samples collected in any given year, the data were sorted and analyzed by decade. The software provided the following statistics: the number of observations, the mean, the minimum, the maximum and 10, 25, 50, 75, and 90 percentile values for each time frame. The statistics generated were given for the decades of 1970, 1980, 1990, 2000 and 2010 as well as for the entire POR. Not all of the listed statistics are presented in this document, but all of the data retrieved and the results of the statistical analyses will be available in the MRL website (http://wwww.mvk.usace.army.mil/MRLSEIS/). The following water quality parameters collected are reported: temperature, pH, dissolved oxygen, specific conductivity, turbidity, alkalinity, total suspended solids, total organic carbon, total nitrogen (TN), total organic nitrogen (TON), ammonia (filtered or total), nitrate plus nitrite (filtered) (NOx), total phosphorus (TP) and orthophosphate (filtered). Many of the nutrient parameters can be measured as total or filtered, but generally one has many more values. In this report, we are generally reporting the form with the greatest number of samples. If the two forms have near equal numbers of samples, then the form reported for the previous decade was used. Although this is somewhat confusing, the collecting agency was not consistent in the form analyzed between stations or across time.

The mean value of in situ water quality measurements for the POR were compared as they move downstream from Thebes to New Orleans. All of these measurements (temperature, pH, dissolved oxygen, specific conductance, and turbidity) were within acceptable limits for the National recommended water quality criteria for fresh water published by the Environmental Protection Agency (EPA). These measurements can be seen in Tables A12-1 through A12-6.

Table A12-1. Thebes, Illinois Water Quality Data for the POR					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	1190	3.5	16.4	28	
		7.9	17.1	25.2	32 C (max) EPA
pH (Standard Units)	668	7.6	7.93	8.3	
		7.8	7.9	8.1	6.0-9.0 EPA
Dissolved Oxygen (mg/L)	597	5.6	8.71	13.2	
		6.4	8	10.7	5.0 (min) EPA
Specific Conductance (µs/cm)	679	397	511	620	
		451	510	571	1000 MS
Turbidity (NTU)	283	8.1	74.5	180	
		21	40	85	National Standard Undefined
Alkalinity (HCO3) (mg/L)	103	152	190	240	
		170	190	210	20.0 (min) FWC
Total Suspended Solids (mg/L)	88	34	205.3	520	
		75	137	257	National Standard Undefined
Total Organic Carbon (mg/L)	377	4.1	5.28	6.4	
		4.4	4.9	5.5	National Standard Undefined
Total Nitrogen (mg/L)	600	1.8	3.46	5.2	
		2.6	3.4	4.3	National Standard Undefined
Total Organic Nitrogen (mg/L)	580	0.43	0.97	1.6	
		0.61	0.86	1.2	National Standard Undefined
Total Ammonia (dissolved) (mg/L)	483	0.01	0.065	0.16	0.773 FWC (Fish Early Life Stages @ 30° C, 8.1 pH) (EPA, 1998)
		0.02	0.03	0.07	
Nitrate + Nitrite (dissolved) (mg/L)	135	1.22	2.46	3.75	
		1.81	2.42	3.03	National Standard Undefined
Total Phosphorus (mg/L)	611	0.18	0.34	0.59	
		0.22	0.28	0.4	National Standard Undefined
Ortho Phosphorus (mg/L)	462	0.067	0.1	0.14	
		0.08	0.1	0.12	National Standard Undefined

Table A12-2. Memphis Water Quality Data for the POR					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	87	3.6	13.8	28.3	
		6.9	9.9	21.1	32 C (max) EPA
pH (Standard Units)	49	7.3	7.67	8.1	
		7.4	7.7	7.9	6.0-9.0 EPA
Dissolved Oxygen (mg/L)	49	5.9	8.99	12.5	
		7.2	8.6	10.6	5.0 (min) EPA
Specific Conductance (µs/cm)	56	272	381	485	
		326	387	444	1000 MS
Turbidity (NTU)	-	-	-	-	
	-	-	-	-	National Standard Undefined
Alkalinity (HCO3) (mg/L)	15	83	122	165	
		95	122	149	20.0 (min) FWC
Total Suspended Solids (mg/L)					
					National Standard Undefined
Total Organic Carbon (mg/L)	4	3.6	4.25	4.8	
		3.8	4.3	4.7	National Standard Undefined
Total Nitrogen (mg/L)	17	1.1	2.38	4.3	
		1.9	2.1	2.8	National Standard Undefined
Total Organic Nitrogen (mg/L)	17	0.34	0.626	1	
		0.44	0.53	0.96	National Standard Undefined
Total Ammonia (dissolved) (mg/L)	11	0.04	0.058	0.09	0.773 FWC (Fish Early Life Stages @ 30° C, 8.1 pH) (EPA, 1998)
		0.04	0.05	0.07	
Nitrate + Nitrite (dissolved) (mg/L)	17	0.64	1.657	2.90	
		1.20	1.49	2.38	National Standard Undefined
Total Phosphorus (mg/L)	17	0.013	0.194	0.27	
		0.16	0.2	0.21	National Standard Undefined
Ortho Phosphorus (mg/L)	17	0.04	0.065	0.1	
		0.05	0.058	0.07	National Standard Undefined

Table A12-3. Arkansas City Water Quality Data for the POR					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	154	5	19	29.5	
		10.5	19.8	28	32 C (max) EPA
pH (Standard Units)	154	7.5	7.81	8.1	
		7.6	7.8	8	6.0-9.0 EPA
Dissolved Oxygen (mg/L)	120	6.1	8.27	11.7	
		6.6	7.7	9.4	5.0 (min) EPA
Specific Conductance (µs/cm)	154	307	404.3	481	
		363	410	469	1000 MS
Turbidity (NTU)	124	20	58.3	110	National Standard Undefined
		29	48	76	
Alkalinity (HCO3) (mg/L)	47	100	122.1	150	
		110	120	136	20.0 (min) FWC
Total Suspended Solids (mg/L)					National Standard Undefined
Total Organic Carbon (mg/L)	42	4.8	7.6	11	National Standard Undefined
		5.6	7.1	9.1	
Total Nitrogen (mg/L)	128	1.3	2.47	3.3	National Standard Undefined
		1.7	2	2.6	
Total Organic Nitrogen (mg/L)	94	0.38	0.85	1.5	National Standard Undefined
		0.5	0.73	1.1	
Total Ammonia (dissolved) (mg/L)	77	0.01	0.057	0.13	0.773 FWC (Fish Early Life Stages @ 30° C, 8.1 pH) (EPA, 1998)
		0.03	0.04	0.07	
Nitrate + Nitrite (dissolved) (mg/L)	74	0.65	1.366	2.30	National Standard Undefined
		0.92	1.30	1.70	
Total Phosphorus (mg/L)	134	0.11	0.205	0.31	National Standard Undefined
		0.15	0.19	0.24	
Ortho Phosphorus (mg/L)	52	0.03	0.062	0.1	National Standard Undefined
		0.05	0.06	0.07	

Table A12-4. Vicksburg Water Quality Data for the POR					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	156	5	16.64	28.5	32 C (max) EPA
		9	16.5	25	
pH (Standard Units)	158	7.3	7.65	8	6.0-9.0 EPA
		7.5	7.7	7.9	
Dissolved Oxygen (mg/L)	146	6.5	8.69	11.5	5.0 (min) EPA
		7.2	8.2	10	
Specific Conductance (µs/cm)	160	280	367	442	1000 MS
		322	370	415	
Turbidity (NTU)	152	12	64.4	120	National Standard Undefined
		30	60	90	
Alkalinity (HCO3) (mg/L)	26	100	131.6	164	20.0 (min) FWC
		110	129	151	
Total Suspended Solids (mg/L)	0				National Standard Undefined
Total Organic Carbon (mg/L)	50	3.8	6.7	10	National Standard Undefined
		4.7	6.3	8.2	
Total Nitrogen (mg/L)	142	1.3	2.12	3.1	National Standard Undefined
		1.6	2	2.6	
Total Organic Nitrogen (mg/L)	97	0.37	0.74	1.2	National Standard Undefined
		0.51	0.67	0.93	
Total Ammonia (dissolved) (mg/L)	75	0.01	0.051	0.13	0.773 FWC (Fish Early Life Stages @ 30° C, 8.1 pH) (EPA, 1998)
		0.02	0.04	0.07	
Nitrate + Nitrite (dissolved) (mg/L)	148	0.976	1.52	2.16	National Standard Undefined
		1.175	1.47	1.795	
Total Phosphorus (mg/L)	146	0.11	0.208	0.33	National Standard Undefined
		0.15	0.19	0.26	
Ortho Phosphorus (mg/L)	53	0.03	0.059	0.09	National Standard Undefined
		0.04	0.06	0.07	

Table A12-5. St. Francisville Water Quality Data for the POR					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	749	7	17.8	28.9	32 C (max) EPA
		9.8	18	26	
pH (Standard Units)	1132	7.2	7.65	8	6.0-9.0 EPA
		7.45	7.7	7.9	
Dissolved Oxygen (mg/L)	680	6.4	8.77	11.5	5.0 (min) EPA
		7.1	8.55	10.3	
Specific Conductance (µs/cm)	997	289	375.9	469	1000 MS
		323	376	424	
Turbidity (NTU)	441	25	64.5	100	National Standard Undefined
		37	56	76	
Alkalinity (HCO3) (mg/L)	330	100	130	163	20.0 (min) FWC
		113	127	145	
Total Suspended Solids (mg/L)	181	49	158.4	332	National Standard Undefined
		84	130	199	
Total Organic Carbon (mg/L)	252	4.3	6.53	9.1	National Standard Undefined
		5.1	6	7.4	
Total Nitrogen (mg/L)	525	1.5	2.14	3.1	National Standard Undefined
		1.7	2.1	2.5	
Total Organic Nitrogen (mg/L)	494	0.25	0.54	0.95	National Standard Undefined
		0.315	0.46	0.67	
Total Ammonia (dissolved) (mg/L)	490	0.005	0.029	0.06	0.773 FWC (Fish Early Life Stages @ 30° C, 8.1 pH) (EPA, 1998)
		0.01	0.02	0.03	
Nitrate + Nitrite (dissolved) (mg/L)	499	0.84	1.44	2.20	National Standard Undefined
		1.1	1.36	1.72	
Total Phosphorus (mg/L)	581	0.12	0.216	0.322	National Standard Undefined
		0.16	0.2	0.261	
Ortho Phosphorus (mg/L)	526	0.04	0.07	0.102	National Standard Undefined
		0.05	0.063	0.083	

Table A12-6. New Orleans Water Quality Data for the POR					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	898	7	18.4	29	32 C (max) EPA
		11	18.5	26.5	
pH (Standard Units)	1235	7.2	7.6	7.9	6.0-9.0 EPA
		7.4	7.6	7.8	
Dissolved Oxygen (mg/L)	829	6	8.4	11.4	5.0 (min) EPA
		6.7	8.1	10	
Specific Conductance (µs/cm)	1216	303	423	506	1000 MS
		338	398	456	
Turbidity (NTU)	600	10	58	110	National Standard Undefined
		26.5	55	80	
Alkalinity ($HCO3$) (mg/L)	179	102	131	164	20.0 (min) FWC
		114	131	148	
Total Suspended Solids (mg/L)	215	18	142	311	National Standard Undefined
		46	108	191	
Total Organic Carbon (mg/L)	329	3.6	6.6	10	National Standard Undefined
		4.5	5.8	7.5	
Total Nitrogen (mg/L)	493	1.3	1.8	2.9	National Standard Undefined
		1.7	2.1	2.5	
Total Organic Nitrogen (mg/L)	391	0.27	0.57	0.92	National Standard Undefined
		0.36	0.52	0.68	
Total Ammonia (dissolved) (mg/L)	356	0.005	0.04	0.08	0.773 FWC (Fish Early Life Stages @ 30° C, 8.1 pH) (EPA, 1998)
		0.01	0.02	0.04	
Nitrate + Nitrite (dissolved) (mg/L)	142	0.994	1.47	2.05	National Standard Undefined
		1.15	1.395	1.78	
Total Nitrite (mg/L)	394	0.002	0.014	0.03	1.0 mg-N/L EPA MCL Drinking Water
		0.005	0.01	0.02	
Total Phosphorus (mg/L)	712	0.13	0.24	0.37	National Standard Undefined
		0.18	0.23	0.3	
Ortho Phosphorus (mg/L)	406	0.05	0.098	0.15	National Standard Undefined
		0.062	0.084	0.11	

The mean value for the POR of the five highlighted nutrient concentrations were compared as they move downstream from Thebes to New Orleans. At the time this document was written, no standard criteria for rivers and streams (fresh water) for nutrients had been published by EPA or the representative environmental State agencies for Louisiana, Mississippi, Arkansas Missouri, Tennessee, Kentucky and Illinois. The following graphs are presented to show the spatial nutrient trends of the Mississippi River as the water moves downstream. The mean TN concentration decreased approximately 1.0 mg/L from Thebes to Memphis and continued to fall at a slower rate to New Orleans from 3.46 mg/L to 2.38 mg/L and then an average of 1.80 mg/L respectively. The mean NOx concentration of 2.46 mg/L at Thebes decreased slowly to a concentration of 1.37 mg/L at Arkansas City before increasing slightly to an average of 1.48 mg/L at the lower three stations. It should be noted that the slight increase in concentration between Arkansas City and Vicksburg can likely be attributed to the predominant time frame of sample collection. Approximately 75 percent of the samples for Arkansas City were collected in the 1980s and prior, while approximately 90 percent of the samples collected for Vicksburg were from the 2000 and 2010 decades. The mean concentration for TON demonstrated a more consistent downward trend from Thebes to New Orleans, except for the lower concentration at Memphis. The concentration for the TON parameter fell from 0.97 at Thebes to 0.57 mg/L at New Orleans. The TP mean concentration of 0.34 mg/L at Thebes decreased to 0.19 mg/L at Memphis and then slowly increased to 0.24 mg/l as flow moves to New Orleans. The mean concentration for orthophosphate decreased from 0.100 mg/L at Thebes to 0.059 mg/L at Vicksburg and then increased back to 0.100 mg/L at New Orleans. Graphs of the nutrient trends at each station can be seen in Figures A12-1 through A12-5.

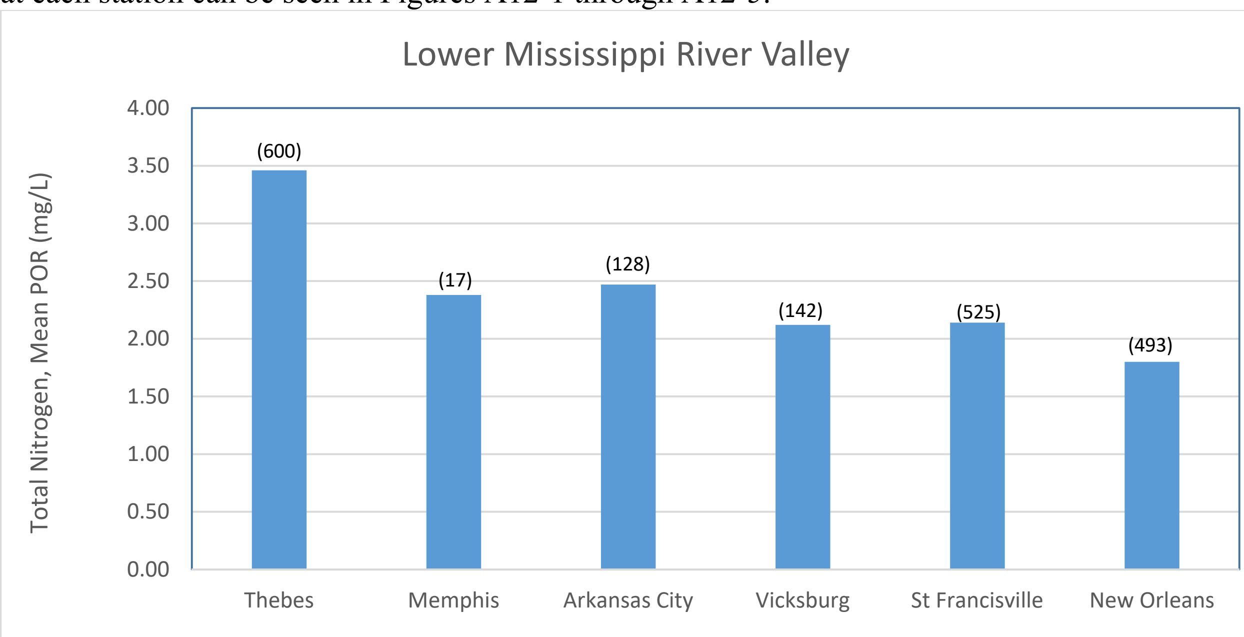

Figure A12-1. Water Quality Comparing Total Nitrogen over the POR from Thebes to New Orleans. The number of observations is provided in ( ) above the bar for each station.

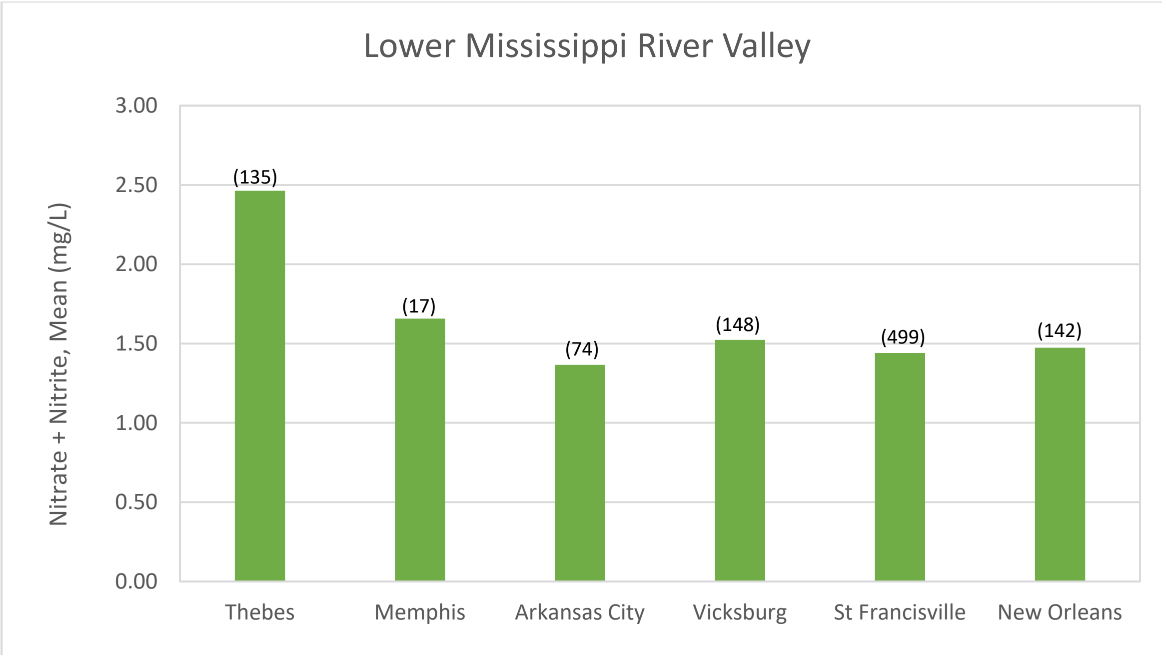

Figure A12-2. Water Quality Comparing Total Nitrate over the POR from Thebes to New Orleans

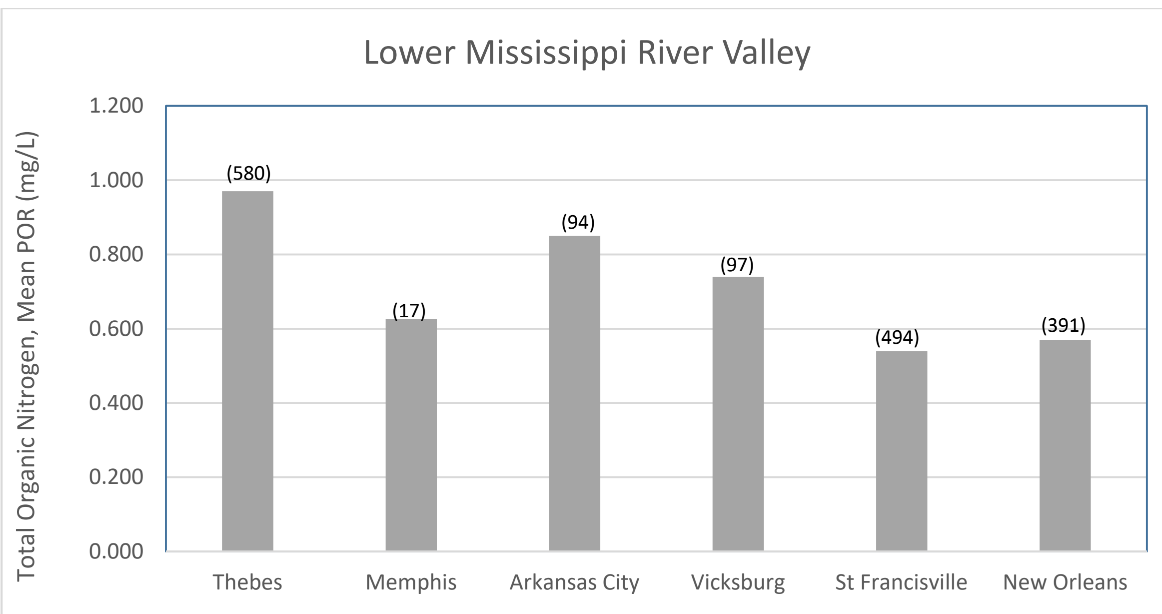

Figure A12-3. Water Quality Comparing Total Organic Nitrogen over the POR from Thebes to New Orleans

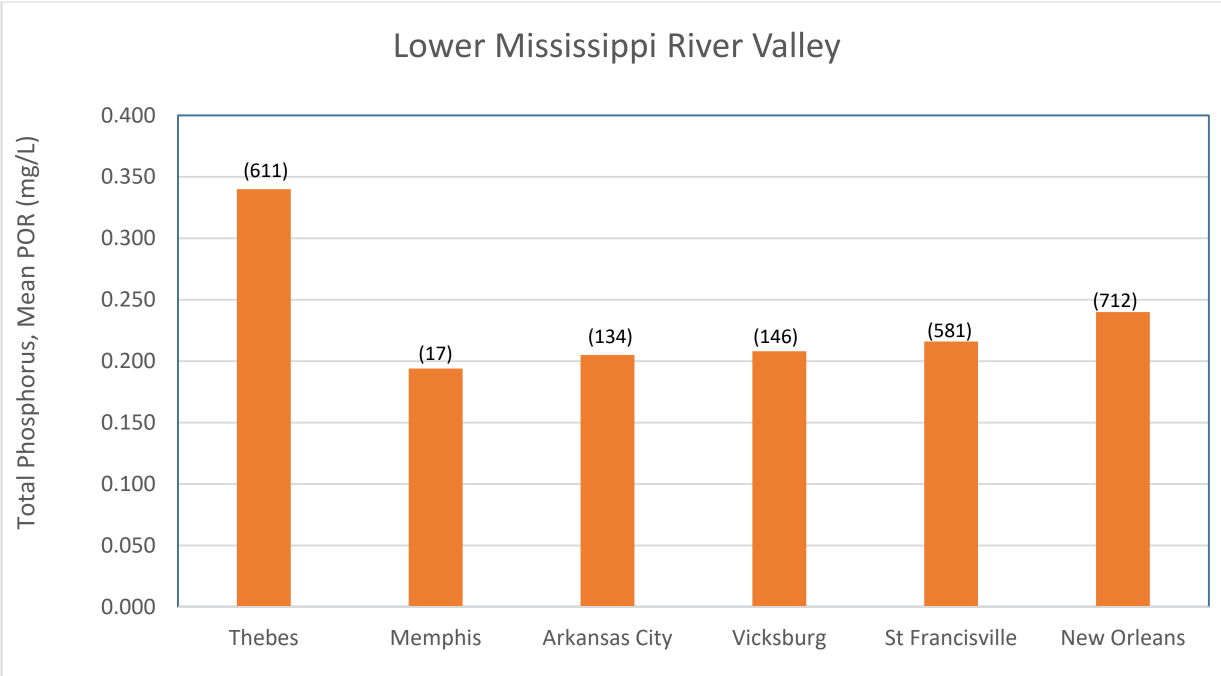

Figure A12-4. Water Quality Comparing Total Phosphorus over the POR from Thebes to New Orleans

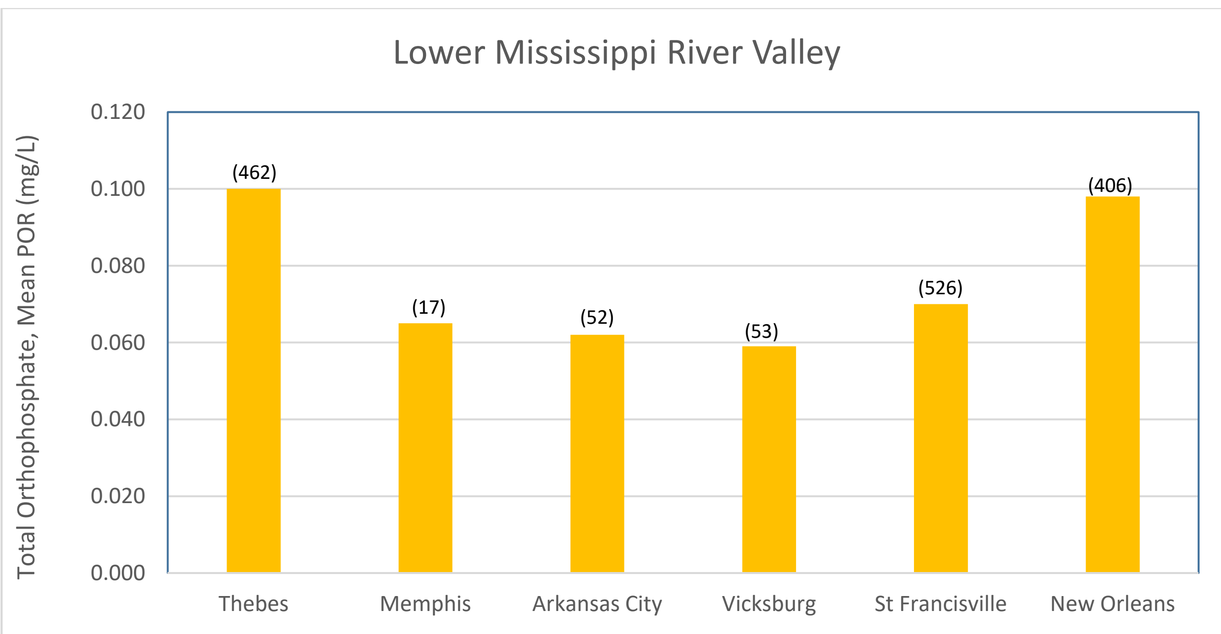

Figure A12-5. Water Quality Comparing Total Orthophosphate over the POR from Thebes to New Orleans

Of the six stations selected, the St. Francisville station has the most comprehensive data set. Data collection at this station started in the 1970s with the following parameters: temperature, pH, dissolved oxygen, specific conductivity, turbidity, alkalinity, total suspended solids, total organic carbon, TN, TON, ammonia (filtered or total), NOx, TP (filtered) and orthophosphate (filtered). The reported standard criteria for in situ ambient water quality conditions in Louisiana were compared against the data collected for each decade at St. Francisville. Most of the observations for in situ water parameters (temperature, pH, dissolved oxygen, specific conductance, and turbidity) were within acceptable limits. These results can be seen in Tables A12-7 through A12-11.

Table A12-7. St. Francisville Water Quality Data for the 1970 Decade					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	177	6.5	17.22	28.5	
		9.5	16.5	25	32.2 ˚C (max) LA
pH (Standard Units)	164	7.1	7.52	7.9	
		7.3	7.5	7.7	6.0-9.0 LA
Dissolved Oxygen (mg/L)	156	6.4	8.68	11	
		7.3	8.55	10	5.0 (min) LA
Specific Conductance (µs/cm)	179	285	356.1	437	
		305	352	404	Standard Undefined
Turbidity (NTU)	154	27	65	99	
		45	65	80	150 LA
Alkalinity (HCO3) (mg/L)	0				
					20.0 (min) FWC
Total Suspended Solids (mg/L)	5	113	183	296	
		133	174	199	Standard Undefined
Total Organic Carbon (mg/L)	77	4.5	7.42	11	
		5.4	6.8	8.4	Standard Undefined
Total Nitrogen (mg/L)	57	1.2	1.94	2.8	
		1.5	1.9	2.4	Standard Undefined
Total Organic Nitrogen (mg/L)	42	0.42	0.73	1	
		0.57	0.68	0.84	Standard Undefined
Total Ammonia (dissolved) (mg/L)	45	0.005	0.048	0.1	0.773 FWC (Fish Early Life Stages @ 30° C, 8.1 pH) (EPA, 1998)
		0.01	0.03	0.07	
Nitrate + Nitrite (dissolved) (mg/L)	25	0.28	1.05	1.40	National Standard Undefined
		0.98	1.20	1.30	
Total Phosphorus (mg/L)	64	0.11	0.205	0.32	
		0.15	0.205	0.27	Standard Undefined
Ortho Phosphorus (mg/L)	75	0.02	0.073	0.14	
		0.03	0.05	0.09	Standard Undefined

Table A12-8. St. Francisville Water Quality Data for the 1980 Decade					
Water Quality Parameter	# Obs	10% / 25%	Mean / Median	90% / 75%	Criteria
Temperature (Celcius)	119	6.5	18.06	29.5	
		9.5	18.5	27	32.2 ˚C (max) LA
pH (Standard Units)	120	7.2	7.56	7.9	
		7.3	7.6	7.8	6.0-9.0 LA
Dissolved Oxygen (mg/L)	119	6.5	8.87	11.8	
		7.3	8.6	10.3	5.0 (min) LA
Specific Conductance (µs/cm)	121	301	396.2	506	
		334	391	453	Standard Undefined
Turbidity (NTU)	117	26	63.4	120	
		36	55	80	150 LA
Alkalinity (HCO3) (mg/L)	0				
					20.0 (min) FWC
Total Suspended Solids (mg/L)	116	45	163.1	357	
		82	140	206	Standard Undefined
Total Organic Carbon (mg/L)	112	3.8	6.21	8.4	
		4.9	5.7	7.1	Standard Undefined
Total Nitrogen (mg/L)	75	1.5	2.42	3.5	
		2	2.3	2.8	Standard Undefined
Total Organic Nitrogen (mg/L)	66	0.54	1	1.5	
		0.72	0.93	1.1	Standard Undefined
Total Ammonia (dissolved) (mg/L)	38	0.02	0.07	0.17	0.773 FWC (Fish Early Life Stages @ 30˚ C, 8.1 pH) (EPA, 1998)
		0.04	0.06	0.09	
Nitrate + Nitrite (dissolved) (mg/L)	67	0.66	1.387	2.20	National Standard Undefined
		1.10	1.30	1.70	
Total Phosphorus (mg/L)	112	0.09	0.207	0.36	
		0.125	0.19	0.28	Standard Undefined
Ortho Phosphorus (mg/L)	48	0.04	0.069	0.11	
		0.05	0.065	0.08	Standard Undefined

Table A12-9. St. Francisville Water Quality Data for the 1990 Decade					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	128	7	18.42	28.5	
		11.75	18.5	26.25	32.2 ˚C (max) LA
pH (Standard Units)	130	7.4	7.75	8.1	
		7.6	7.8	8	6.0-9.0 LA
Dissolved Oxygen (mg/L)	117	6.4	8.78	11.8	
		7	8.4	10.2	5.0 (min) LA
Specific Conductance (µs/cm)	127	306	383.6	473	
		328	380	424	Standard Undefined
Turbidity (NTU)	119	20	55	90	
		32	46	70	150 LA
Alkalinity (HCO3) (mg/L)	43	99	129.5	162	
		117	127	141	20.0 (min) FWC
Total Suspended Solids (mg/L)	60	61	147.2	324.5	
		82.5	106	168	Standard Undefined
Total Organic Carbon (mg/L)	63	4.7	6.04	7.6	
		5.2	5.6	6.7	Standard Undefined
Total Nitrogen (mg/L)	97	1.2	2.11	3	
		1.7	2	2.4	Standard Undefined
Total Organic Nitrogen (mg/L)	97	0.24	0.54	0.88	
		0.34	0.51	0.67	Standard Undefined
Total Ammonia (dissolved) (mg/L)	110	0.01	0.03	0.05	0.773 FWC (Fish Early Life Stages @ 30˚ C, 8.1 pH) (EPA, 1998)
		0.01	0.03	0.04	
Nitrate + Nitrite (dissolved) (mg/L)	110	0.765	1.498	2.30	National Standard Undefined
		1.10	1.40	1.80	
Total Phosphorus (mg/L)	116	0.09	0.19	0.28	
		0.13	0.18	0.24	Standard Undefined
Ortho Phosphorus (mg/L)	104	0.04	0.06	0.095	
		0.05	0.06	0.08	Standard Undefined

Table A12-10. St. Francisville Water Quality Data for the 2000 Decade					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	139	7	18.2	29.1	
		10.6	18.6	26.6	32.2 °C (max) LA
pH (Standard Units)	134	7.4	7.75	8.1	
		7.6	7.8	8	6.0-9.0 LA
Dissolved Oxygen (mg/L)	131	6.5	8.79	11.5	
		7.3	8.6	10.2	5.0 (min) LA
Specific Conductance (µs/cm)	139	296	380	462	
		342	378	429	Standard Undefined
Turbidity (NTU)	51	35	88.3	160	
		44	61	85	150 LA
Alkalinity (HCO3) (mg/L)	138	101	127.7	159	
		113	128	143	20.0 (min) FWC
Total Suspended Solids (mg/L)					
					Standard Undefined
Total Organic Carbon (mg/L)	140	3	3.66	4.25	
		3.3	3.65	3.9	Standard Undefined
Total Nitrogen (mg/L)	138	1.5	2.14	3.3	
		1.7	1.9	2.5	Standard Undefined
Total Organic Nitrogen (mg/L)	138	0.25	0.41	0.66	
		0.28	0.345	0.48	Standard Undefined
Total Ammonia (dissolved) (mg/L)	139	0.01	0.022	0.04	0.773 FWC (Fish Early Life Stages @ 30° C, 8.1 pH) (EPA, 1998)
		0.01	0.02	0.02	
Nitrate + Nitrite (dissolved) (mg/L)	137	0.82	1.46	2.43	National Standard Undefined
		1.06	1.30	1.70	
Total Phosphorus (mg/L)	138	0.163	0.232	0.33	
		0.181	0.219	0.271	Standard Undefined
Ortho Phosphorus (mg/L)	138	0.041	0.067	0.094	
		0.05	0.069	0.081	Standard Undefined

Table A12-11. St. Francisville Water Quality Data for the 2010 Decade					
Water Quality Parameter	# Obs	10%	Mean	90%	Criteria
		25%	Median	75%	
Temperature (Celcius)	164	7.1	17.41	28.6	
		9.5	18.2	25.2	32.2 ˚C (max) LA
pH (Standard Units)	162	7.5	7.81	8.1	
		7.7	7.8	7.9	6.0-9.0 LA
Dissolved Oxygen (mg/L)	154	6	8.75	11.7	
		6.7	8.45	10.6	5.0 (min) LA
Specific Conductance (µs/cm)	164	290	376	472	
		323	373	436	Standard Undefined
Turbidity (NTU)	1		50		
					150 LA
Alkalinity (HCO3) (mg/L)	149	100	131	166	
		113	127	148	20.0 (min) FWC
Total Suspended Solids (mg/L)					
					Standard Undefined
Total Organic Carbon (mg/L)	158	3.1	3.72	4.4	
		3.4	3.6	4	Standard Undefined
Total Nitrogen (mg/L)	161	1.5	2.11	2.8	
		1.7	2.1	2.4	Standard Undefined
Total Organic Nitrogen (mg/L)	151	0.245	0.42	0.64	
		0.28	0.41	0.52	Standard Undefined
Total Ammonia (dissolved) (mg/L)	161	0.005	0.015	0.04	0.773 FWC (Fish Early Life Stages @ 30˚ C, 8.1 pH) (EPA, 1998)
		0.005	0.01	0.02	
Nitrate + Nitrite (dissolved) (mg/L)	160	0.985	1.465	1.99	National Standard Undefined
		1.15	1.42	1.775	
Total Phosphorus (mg/L)	151	0.15	0.225	0.317	
		0.176	0.214	0.266	Standard Undefined
Ortho Phosphorus (mg/L)	161	0.051	0.075	0.106	
		0.056	0.07	0.09	Standard Undefined

To more easily visualize how water quality has changed over time, some of the major nutrient constituents at St. Francisville were graphed by decade (Figures A12-6 through A12-10). These parameters were: total nitrogen, nitrate plus nitrite (filtered), total organic nitrogen, total phosphorus and orthophosphate (filtered). The concentration for TN increased from a mean value of 1.94 to 2.42 mg/L between 1970 and 1980 and then appeared to remain constant at a value around 2.12 mg/l for the next three decades. NOx concentration increased from 1.05 mg/L in the 1970's to approximately 1.45 mg/L for the next four decades. The mean concentration for TON experienced a surge in the 1980s, increasing from 0.73 mg/L in the 1970s to 1.00 mg/L, then back down to 0.54 mg/L in the 1990s. The TON concentration was relatively constant at 0.42 mg/L for the last two decades. TP remained relatively constant for the last five decades, ranging from 0.19 to 0.24 mg/L. Orthophosphate has also been relatively constant for the last five decades, ranging from 0.060 to 0.073 mg/L. The in situ water quality measurements reported for the St. Francisville station from the last decade were within acceptable limits established by the National recommended water quality criteria for fresh water published by the EPA. At the time this document was written, no standard criteria for the previously mentioned nutrients had been published by EPA or the Louisiana Department of Environmental Quality for rivers and streams (fresh water).

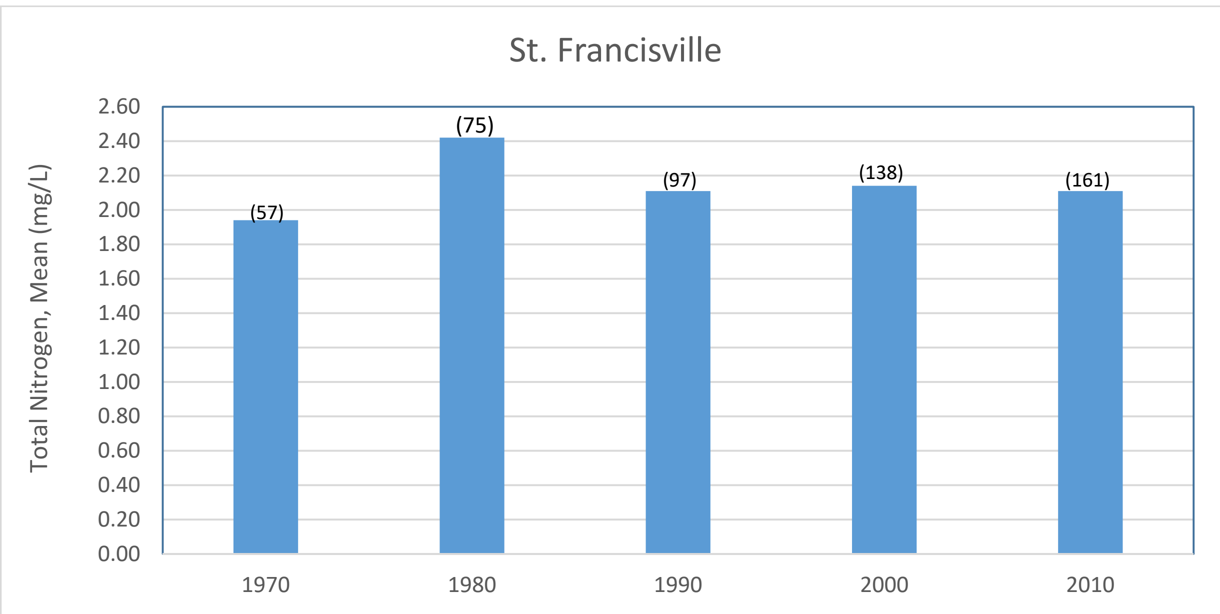

Figure A12-6. St. Francisville Water Quality Comparing Total Nitrogen for Decades 1970 – 2010. The number of observations is provided in ( ) above the bar for each decade.

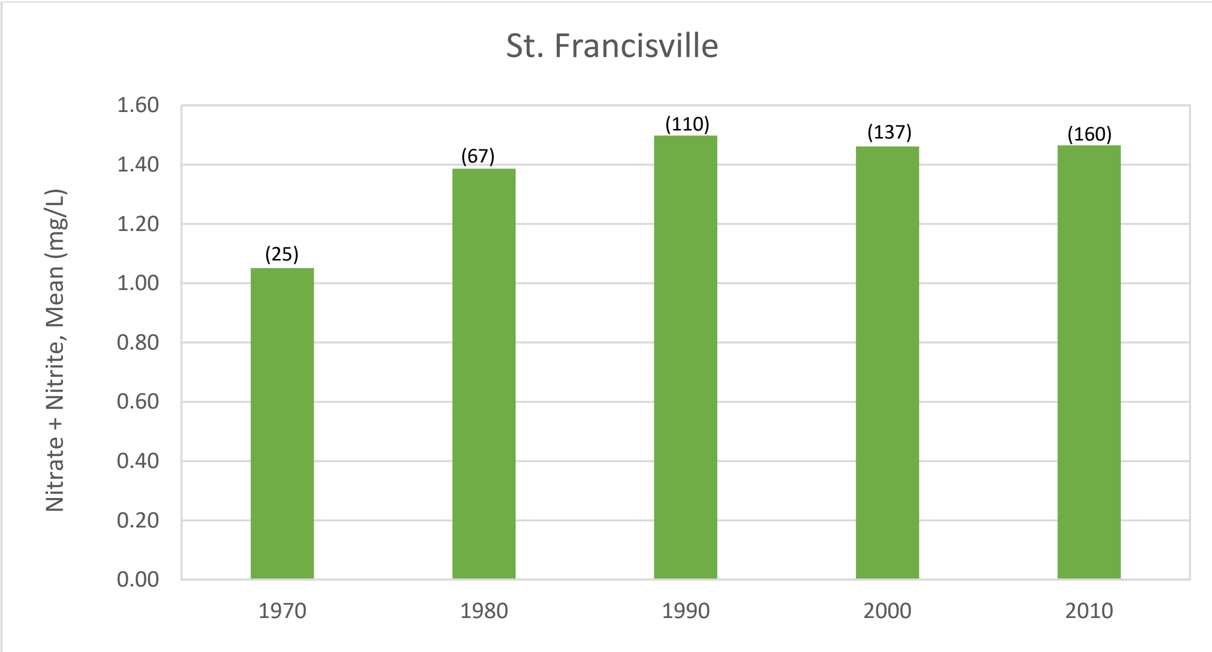

Figure A12-7. St. Francisville Water Quality Comparing Total Nitrate for Decades 1970 – 2010

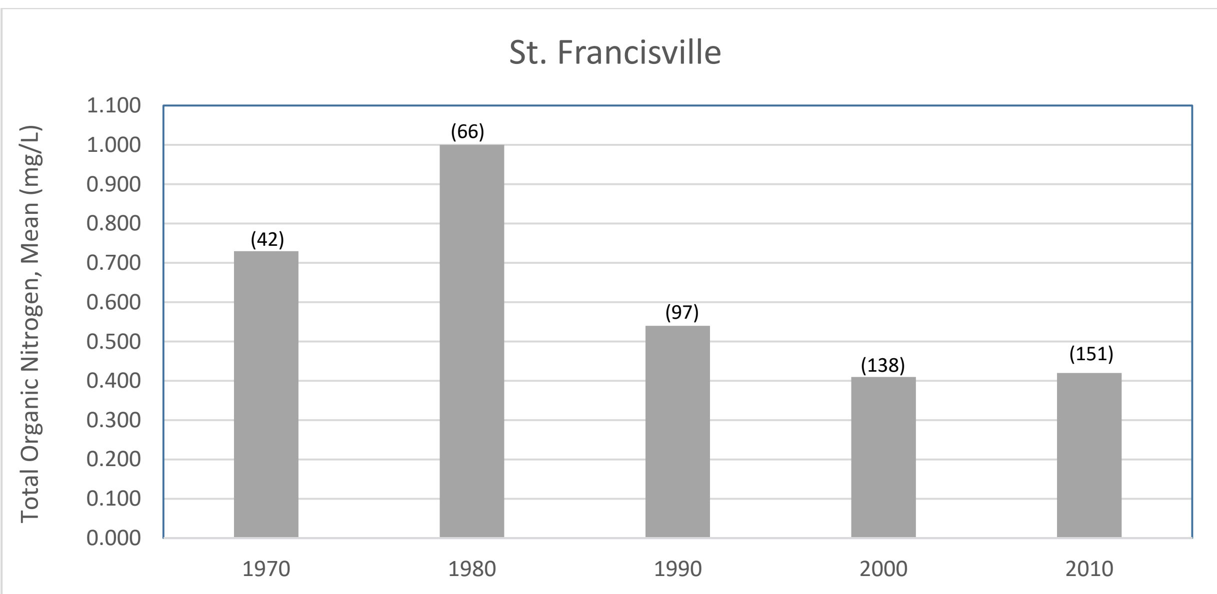

Figure A12-8. St. Francisville Water Quality Comparing Total Organic Nitrogen for Decades 1970 – 2010

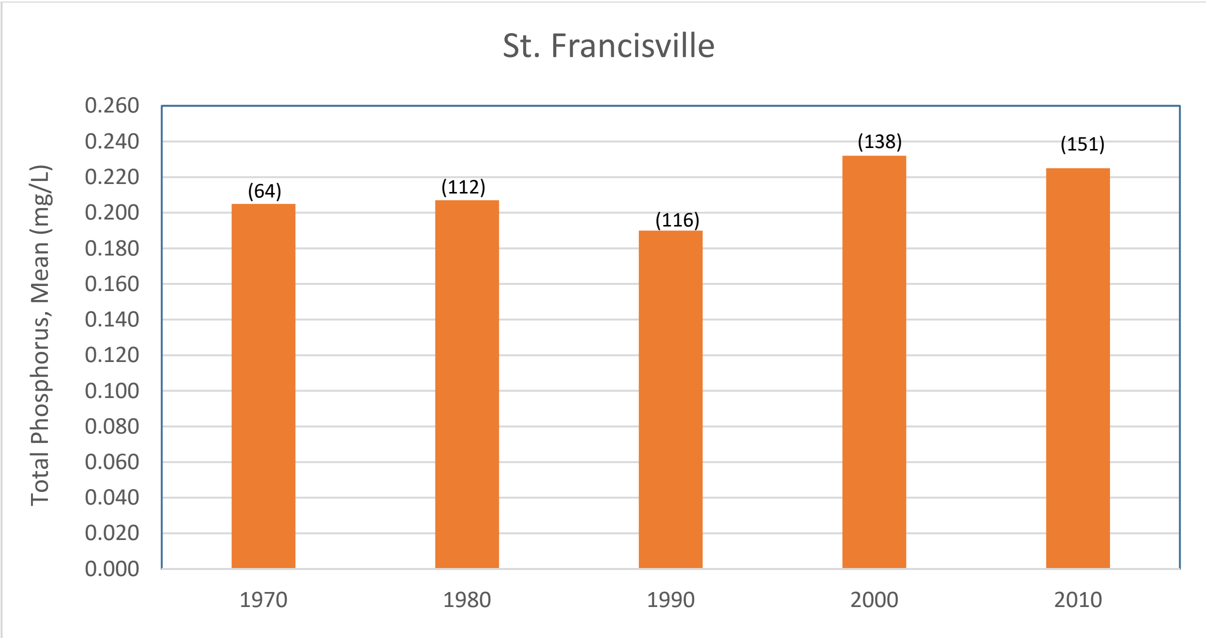

Figure A12-9. St. Francisville Water Quality Comparing Total Phosphorus for Decades 1970 – 2010

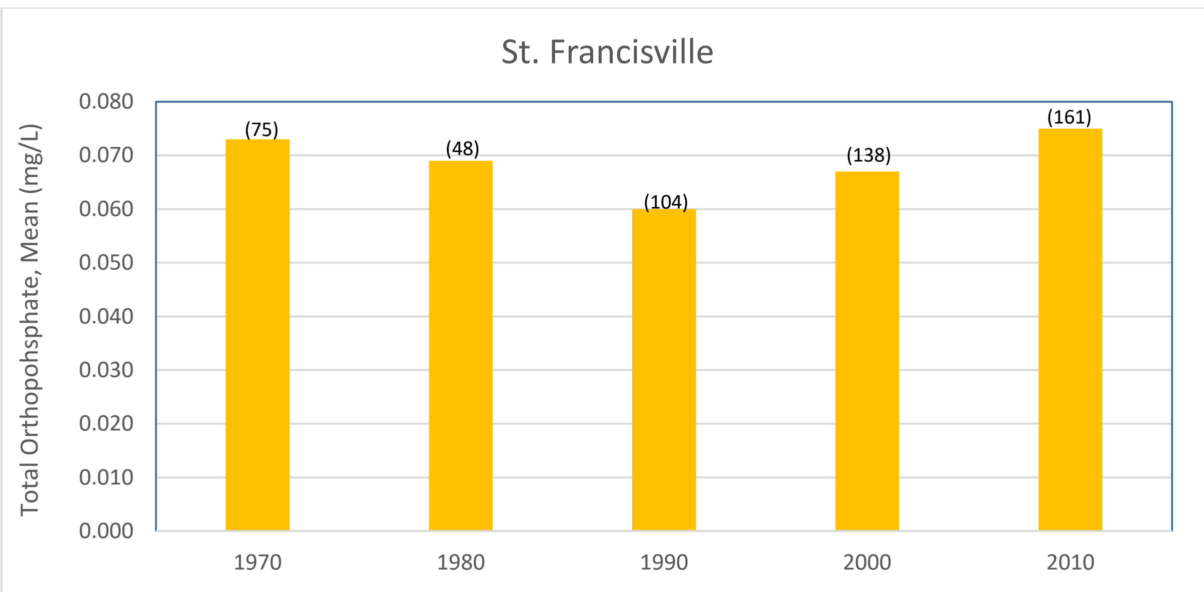

Figure A12-10. St. Francisville Water Quality Comparing Total Orthophosphate for Decades 1970 – 2010

Beginning in 2011, the USGS has maintained an in situ water quality probe that measures daily values for NOx in the Mississippi River at the Baton Rouge station. A graph produced using the USGS NWIS database shows the seasonal trends for concentration of two nutrients in mg/L. The daily values range from less than 0.5 to greater than 3.0 mg/L from 2011 to 2019. The approximate average value is 1.5 mg/L. This graph is displayed in Figure A12-11.

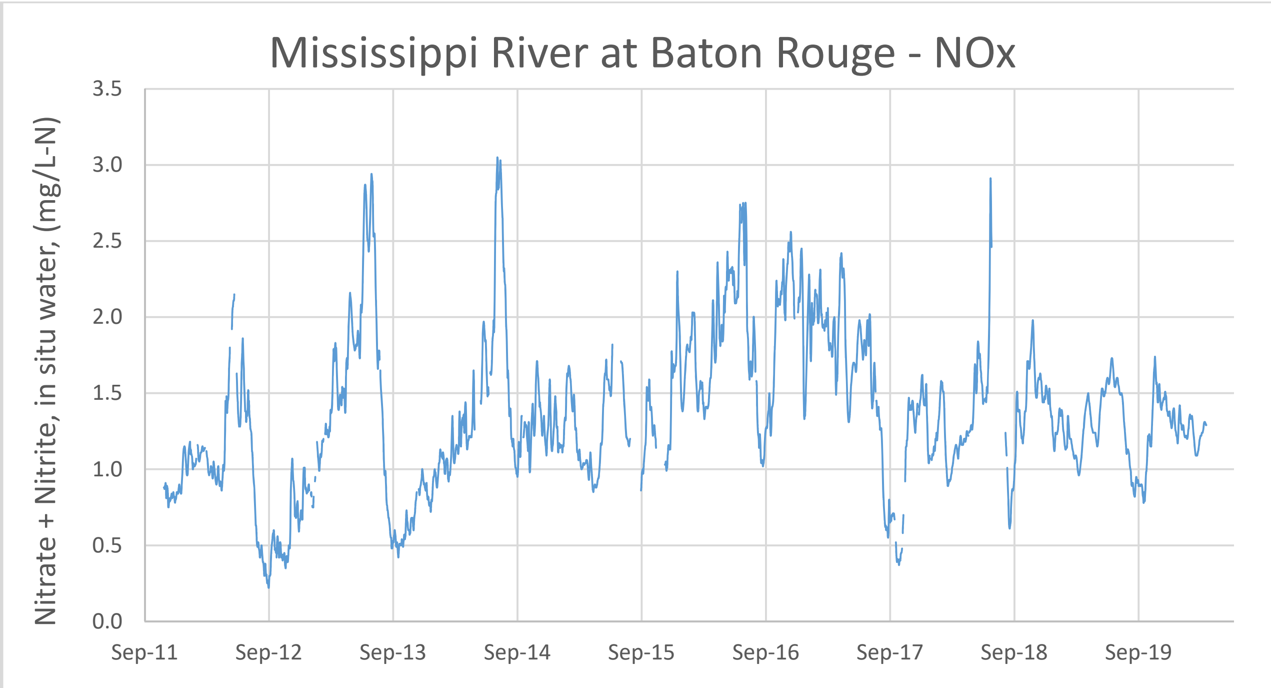

Figure A12-11. Daily nitrate plus nitrite concentrations from in situ water quality probe maintained by USGS in the Mississippi River at Baton Rouge.

As previously stated, at the time this document was written, no standard criteria for rivers and streams (fresh water) for nutrients has been published by EPA or the representative State environmental agencies for Louisiana, Mississippi, Arkansas Missouri, Tennessee, Kentucky and Illinois. However, in 2008, the Mississippi River Gulf of Mexico Watershed Nutrient Task Force published the Gulf Hypoxia Action Plan (2008). The task force included representatives from multiple Federal and State agencies directly influencing the nutrient concentrations in the Mississippi River. The ultimate goal for the task force was to reduce, mitigate, and control hypoxia in the Northern Gulf of Mexico, as well as improve water quality in the Mississippi River Basin. One of the primary goals of the plan was the reduction of the overall size of the hypoxic zone. This plan called for a dual nutrient strategy targeting the reduction of riverine TN and TP loads by 45 percent. This reduction would be based on the average initial nutrient loads measured from 1980 to 1996. Actual reduction percentages would be based on a rolling five year average starting in 2001. The annual nutrient flux was estimated by the adjusted maximum likelihood estimation (AMLE) method using LOADEST, a FORTRAN program used for estimating constituent loads in streams and rivers. The data is maintained by the USGS (USGS, 2016). A graph of the reduction in nutrient loading delivered to the Gulf of Mexico from the MARB can be seen in Figure A12-12.

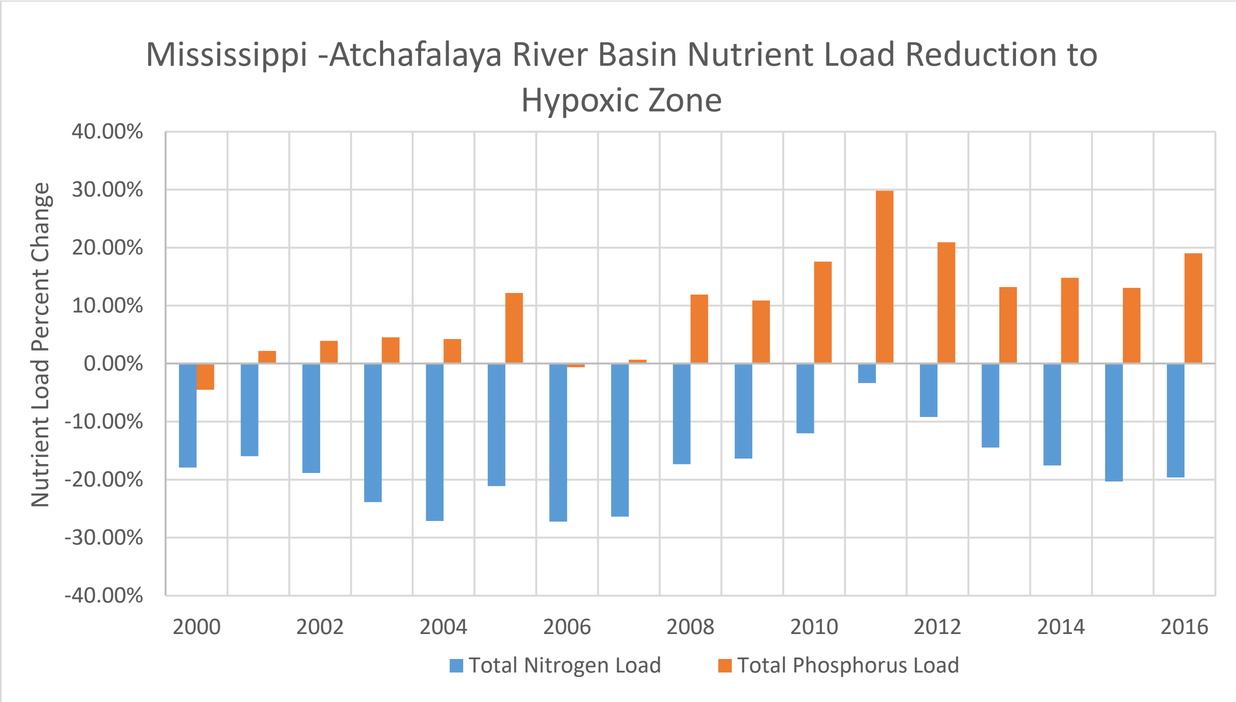

Figure A12-12. Percent Change of Total Nitrogen and Phosphorus Loading to the Gulf Hypoxic Zone.

The percent change of TN loading to the Gulf of Mexico was based on the base year average value (1980 to 1996) of 1,575,176 metric tons –TN. This value was compared to the five year rolling average TN load, which ranged from 3.3 percent in 2011 to 27.2 percent in 2006. The average reduction of TN loading to the Gulf of Mexico from 1997 to 2016 was 18.2 percent. The percent change of TP loading to the Gulf of Mexico was based on the base year average value (1980 to 1996) of 137,276 metric tons –TP. This value was compared to the five year rolling average TP load, which ranged from 4.5 percent reduction in 2000 to -29.8 percent increase in 2011. The average increase of TP loading to the Gulf of Mexico from 1997 to 2016 was -10.2 percent. The minimal reductions in TN load and major increase in TP for the 2011 water year can be attributed to the major flood experienced in the LMR basin.

A12-3 Trace Metals

Trace metal samples in the LMR were not collected as frequently in recent decades as they were in the earlier decades. The most substantial sets of trace metal concentrations were found at the Thebes and St. Francisville stations during the decade of 2000. These data included concentrations for arsenic, cadmium, chromium, copper, iron, lead, nickel, selenium, lithium, silver and zinc. The National recommended water quality criteria for fresh water published by the EPA was used for comparison. The mean hardness values from the 2000 decade of 202 and 144 mg/L for Thebes and St. Francisville, respectively, were used to compute hardness dependent criteria. No data was reported for mercury at either of these stations for the 2000 decade. The mean dissolved trace metal concentrations were within acceptable aquatic life limits for acute and chronic fresh water (FWA & FWC) for all metals. The temporary construction activity proposed for the 143 Work Items should not pose a significant impact to the trace metal concentrations in the Mississippi River. The trace metal concentrations for these two stations can be seen in Tables A12-12 and A12-13.

Mississippi River at Thebes, Illinois							
Table A12-12. Thebes, IL Water Quality Data – Trace Metals for the 2000 Decade							
Trace Metals (ug/L)							
Parameters	Abbrev	# Obs	Mean	10%	90%	Criteria	
						FWA	FWC
Arsenic	as	140	**1.90**	1.20	2.90	**340.00**	**150.00**
Cadmium	cd	38	**0.07**	0.02	0.08	**68.26**	**1.74**
Chromium III	cr	38	**0.34**	0.08	0.40	**1015.12**	**132.05**
Copper	cu	38	**2.15**	1.60	2.60	**35.81**	**22.44**
Iron	tfe	0	.	.	.	**N/A**	**1000.00**
Lead	pb	0	**.**	.	.	**137.89**	**5.37**
Mercury	0					**1.40**	**0.77**
Nickel	ni	38	**2.86**	1.42	4.32	**92.53**	**90.24**
Selenium	se	140	**1.06**	0.77	1.40	**N/A**	**1.50**
Lithium	li	140	**10.68**	4.99	18.25	**N/A**	**N/A**
Silver	ag	38	**0.21**	0.05	0.50	**3.20**	**N/A**
Zinc	zn	38	**3.47**	0.58	12.40	**88.83**	**189.95**

Mississippi River at St. Francisville							
Table A12-13. St. Francisville Water Quality Data – Trace Metals for the 2000 Decade							
Trace Metals (ug/L)							
Parameters	Abbrev	# Obs	Mean	10%	90%	Criteria (EPA)	
						FWA	FWC
Arsenic	as	139	**1.285**	0.760	2.000	**340.00**	**150.00**
Cadmium	cd	37	**0.068**	0.020	0.100	**47.22**	**1.35**
Chromium III	cr	37	**0.291**	0.060	0.400	**768.13**	**99.92**
Copper	cu	36	**2.297**	1.500	3.800	**25.98**	**16.78**
Iron	tFe	139	6.704	-10.000	21.900	**N/A**	**1000.00**
Lead	pb	37	**0.142**	0.050	0.400	**95.84**	**3.73**
Mercury	no recent data					**1.40**	**0.77**
Nickel	ni	37	**1.911**	1.300	2.700	**70.21**	**67.95**
Selenium	se	161	**0.560**	0.400	0.800	**N/A**	**1.50**
Lithium	li	160	**5.502**	2.850	9.850	**N/A**	**N/A**
Silver	ag	37	**0.189**	0.050	0.500	**3.20**	**N/A**
Zinc	zn	34	**3.256**	0.700	6.200	**66.78**	**142.35**

A12-4 Borrow Area Water Quality

In the period leading up to the 1998 SEIS Report, efforts were made to document water quality conditions from over 25 BA on both the riverside and landside of the levee scattered throughout all three districts of the LMR. The findings of this monitoring effort were documented in the 1998 SEIS report. Follow up studies were conducted in 2019 at five of the previously documented BAs where additional in situ water quality measurements were collected. These BAs were located on the both the riverside and landside of the levee. One additional BA named MODOC was added to the recent monitoring effort. The water quality parameters collected include: water temperature, specific conductivity, dissolved oxygen, pH and turbidity. The locations of these BAs are provided in Figure A12-12. Table A12-14 provides the location by State, county, and river mile of the BAs analyzed. The BAs are located throughout the project area from river mile 180 to river mile 733.

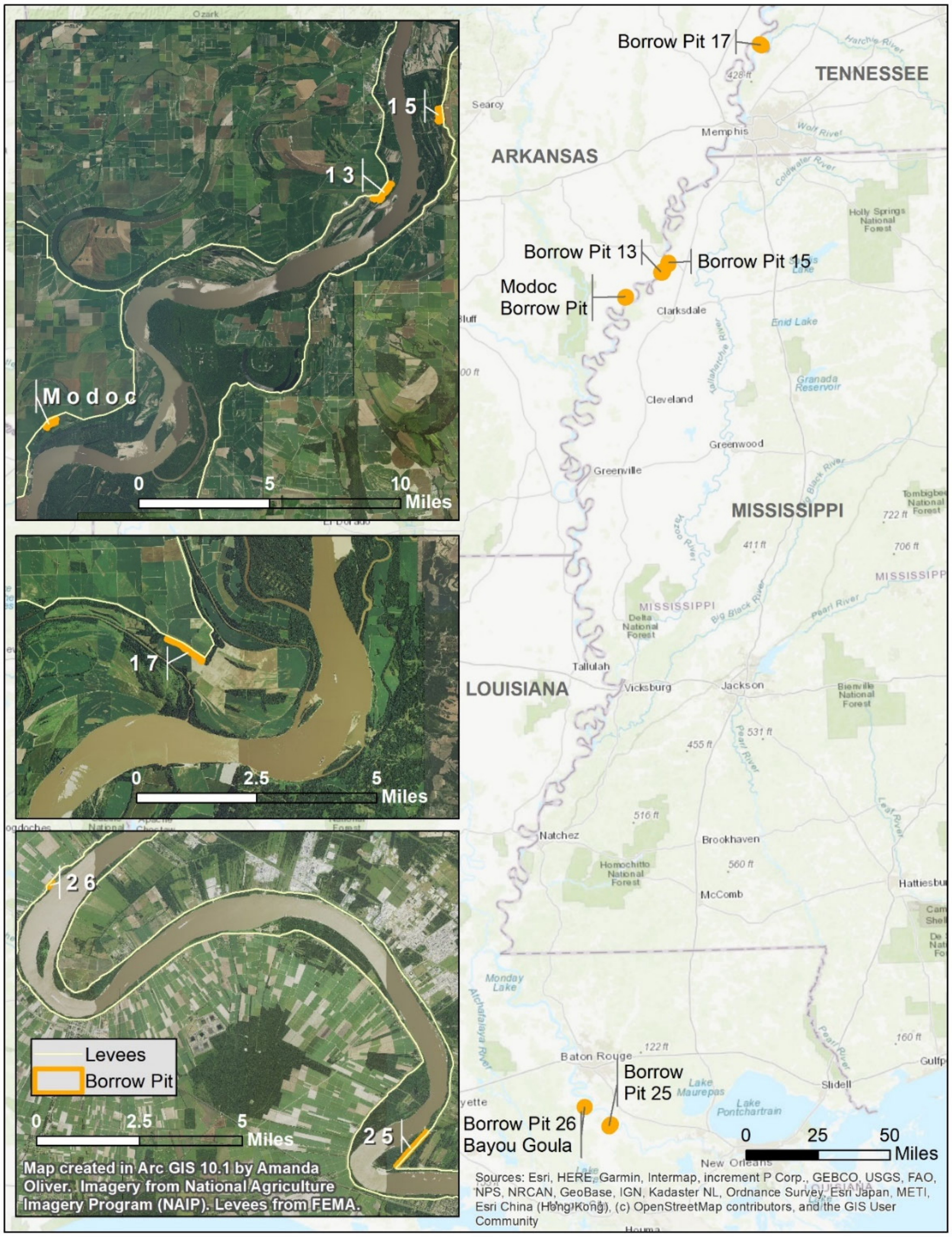

Figure A12-12. Map showing the locations of borrow areas with updated water quality measurements

Table A12-14. Borrow area Classification by State, County, and River Mile

Location	Identification #	River mile	River bank	County	State	District	Miles To Main Ch
Borrow_Pit_13	BA - 13	656	R	Phillips	Arkansas	MVM	0.3
Borrow_Pit_15	BA - 15	659	L	Coahoma	Mississippi	MVM	1.8
Borrow_Pit_17	BA - 17	733	R	Mississippi	Arkansas	MVM	2.3
Borrow_Pit_25	BA - 25	180	L	Ascension	Louisiana	MVN	0.1
Borrow_Pit_26	BA - 26	194	R	Iberville	Louisiana	MVN	0.1
MODOC	BA - 27	634	R	Phillips	Arkansas	MVM	0.8

In situ water quality was measured at five BAs in the project area. Water temperature varied both spatially and temporally among the five BAs. While depth appeared to influence the temperature measurements on many of the sample dates, all but one of the values were above 27.7 degrees Celsius. These measurements were consistent with the warmer southern climate during the summer months. Temperatures varied as much as 9 degrees Celsius at the surface between the three sample dates at BA-17. However, the water temperature range for Bas-13, 15, 25 and 26 was only 3 to 5 degrees Celsius at the surface over same time frame. Water temperature range between the surface and the bottom of the BAs went from 0.0 to 1.9 degrees for BA-15, 17, 25, and 26 where maximum depth was less than 4.5 feet. Temperature readings varied as much as 7.4 degrees Celsius in BA-13, where the maximum depth exceeded 11 feet. Many of the temperature readings exceeded EPA's national criteria for maximum temperature for freshwater aquatics of 32 degrees Celsius. The specific conductivity ranged between 279 and 536 µS/cm at the surface in BA-25 over the multiple measurement events. Specific conductivity varied less than 31 µS/cm between measurements taken at the surface and at the bottom. The dissolved oxygen concentration at the surface ranged from 3.14 to 12.2 mg/L for all of the BAs. Dissolved oxygen measurements ranged from 0.15 to 6.46 mg/L at the bottom of the BAs. All of the recent measurements were collected in August and September of 2019 from BAs-13, 15, 17, 25 and 26, and at least one of the two sites in each BA failed to meet the EPA minimum dissolved oxygen concentration for fresh water of 5.0 mg/L. These BAs likely suffered from excessive oxygen demand propagated by the concurrent backwater flood. Hydrogen ion concentrations (pH) ranged from a high of 11.96 at the surface of BA-25 to a low of 7.0 at the bottom of BA-13. The criteria range of 6.0 to 9.0 set by EPA's national standard was exceeded on the upper criterion from measurements taken at the surface from BAs-15, 17, 25, 26, MODOC. These high pH measurements are likely the result of primary productivity. Turbidity measurements taken at the surface ranged from 7.2 to 40.7 NTUs with one outlier reaching 68.9 NTU. The quiescent surface of most BAs allows for optimal settling conditions for many of the summer months. The water quality measurements reported from the selected BAs were collected during warmer summer months, allowing temperatures to exceed the national standard for fresh water. In some instances, dissolved oxygen concentrations were observed to fall below national standards and pH was observed above of the basic criteria set for aquatic health. The in situ water quality values for the six BAs can be seen in Table A12-15 and their location can be seen in Figure WQ-1.

Table A12-15. In Situ Water Quality Measurements collected from borrow areas from the LMR in 1980, 1997 and 2019.

In-Situ Water Quality Measurements Recently Documented for Existing Borrow Pits Along the LMR																
New Date	**Location**	**WQ Depth S**	**WQ Max Depth (ft)**	**S Water Temp**	**M Water Temp**	**B Water Temp**	**S Cond**	**M Cond**	**B Cond**	**S DO**	**M DO**	B DO	S pH	**M pH**	**B pH**	**S Turb**
7/10/1981	Borrow_Pit_13	0.65	0.75	34.5			315			8.65			8.4			8
7/21/1997	Borrow_Pit_13		11.4	35.3	32.8	27.86	269	272	303	7.27	4.5	0.33	8	7.64	7	7.2
8/21/2019	Borrow_Pit_13	0.12	11.1	33.9	30.1	29.7	440.2	443.4	450.8	12.2	18.2	4.1	8.93	9.17	8.92	8.3
8/21/2019	Borrow_Pit_13	0.18	11.5	30.3	30.3	29.4	443.3	444.3	453.1	3.41	3.44	0.15	7.59	7.98	8.2	9.4
7/13/1981	Borrow_Pit_15	0.45	0.6	33.25			355			6.2			7.7			11
7/28/1997	Borrow_Pit_15			37.89		36.11	228		235	8.14		6.46	8.4		8.01	33.4
7/29/1997	Borrow_Pit_15			33.24		33.16	234		234	3.2		2.4	7.45		7.52	68.9
8/19/2019	Borrow_Pit_15	0.15	2.3	31.6	30.9	29.9	455.3	438.8	438.7	7.19	6.97	6.35	9.3	9.29	9.33	8.6
8/19/2019	Borrow_Pit_15	0.21	2.7	28.3	28.4	28.3	403.5	409.1	401.4	3.4	3.45	3.33	7.97	8.05	8.03	8.3
7/20/1981	Borrow_Pit_17	0.75	0.85	33.25			235			9.65			8.05			16
8/5/1997	Borrow_Pit_17		2.5	24.15			205			3.62			7.49			26.6
9/11/2019	Borrow_Pit_17	0	2.6	29.7	29	28.6	369.8	367.5	367.2	7.24	6.82	6.31	10.5	10.46	10.4	25.2
9/11/2019	Borrow_Pit_17	0.007	2.4	27.7	27.7	27.7	367.4	367.4	367.3	3.51	3.51	3.63	9.02	9.43	9.55	11.8
8/4/1981	Borrow_Pit_25	0.95	1.05	32.5			335			5.35			7.85			10
8/18/1997	Borrow_Pit_25		4.5	32.6	31.1	31	279	283	283	7.4	2.5	2.15	7.5	7.3	7.5	
9/24/2019	Borrow_Pit_25	0.14	4	31.8	27.7	29	536	535	542	10.52	9.42	5.72	12	12.02	11.9	24
9/24/2019	Borrow_Pit_25	0.04		28.4	28.4	28.4	546	546	546	3.77	3.66	3.8	10.4	10.76	10.8	30.3
8/12/1997	Borrow_Pit_26		4	31.26	30.1	29.8	288	293	298	8.19	3.5	2.5	8.4	8.1	8	31.2
9/25/2019	Borrow_Pit_26	0	4	30.5	28.2	28.1	277	281.1	282.4	9.98	2.53	2.07	9.87	9.57	9.35	43.2
9/25/2019	Borrow_Pit_26	0	4	28.1	28.1	28.1	278.2	278.2	278.6	3.14	3.04	3	8.44	8.53	8.59	40.7
8/20/2019	MODOC	0.052	4.8	34.4	31.8	31	375.8	390.4	409.6	19.88	9.42	0.28	9.57	9.28	8.62	15.5
8/20/2019	MODOC	0.026	4.8	31.3	30.9	30.9	395.3	396.8	397.6	5.2	3.48	2.83	8.47	8.71	8.72	18.5

A12-5 Groundwater Water Quality

Studies conducted by the USGS in the LMR Valley have documented changes in groundwater quality of the Mississippi River Alluvial Aquifer (MRAA) (Kingsbury et al., 2014; Huff and Bonck, 1993; Borrok and Broussard, 2016; USGS, 2017). Over the last 40 years, there has been an increased demand for agricultural irrigation from the MRAA. This increased demand has contributed to conditions where upward migration of salt water found in lower geological formations is displacing fresh water (Huff and Bonck (1993). In some areas of northeast Louisiana and southeastern Arkansas, the salt concentration in water withdrawn from the MRAA for agricultural irrigation exceeds the upper limit of salt concentration for crop production. The upward migration of salt water into the MRAA may result in higher salt concentrations in discharges from relief wells. If this occurs, it may have an adverse effect on surface water quality. The U.S. Army Corps of Engineers (USACE) intends to study the potential impact of relief well discharges on surface water quality.

Water discharged from relief wells meets all water quality standards except for dissolved oxygen, which typically re-aerates close to the well. However, there is some concern that the water may increase the salinity in receiving waters. Surface waters landside of the levee are often comprised mainly of precipitation runoff and are very low in dissolved salts. Water coming out of the relief wells is from the Mississippi River, which has higher levels of dissolved salts than precipitation. Previous studies of this groundwater salinity suggest that the aerial extent of high salinity water is scattered in the Mississippi Alluvial Plain of northeastern Louisiana and southeastern Arkansas (Huff and Bonck, 1993; USGS, 2017). Prior to construction of the levee, these areas would have been connected to the Mississippi River, and would have had dissolved salt concentrations similar to the Mississippi River. Although the flow from these wells is very slow, the cumulative volume per month greatly exceeds precipitation. Some local landowners collect surface runoff for agricultural use. As the salt concentration from relief wells exceeds the concentration of rain water, the commixing of surface and groundwater in some BAs used for irrigation water may present a legitimate concern. One set of in situ water quality samples was collected on 5 February 2020 from four existing relief wells and one irrigation well in Concordia Parish, Louisiana. The discharge from each well did not exceed applicable standards for aquatic life for temperature, specific conductivity and pH. However, the dissolved oxygen was measured between 1.34 and 2.25 mg/L. These anoxic conditions are expected from groundwater until the water has adequate time to re-aerate. The observed in situ water quality can be found in Table A12-16.

Table A12-16. Water Quality Measurements collected from existing relief wells and an irrigation well in Concordia Parish, Louisiana

	Temperature	Specific Conductivity	Salinity (calculated)	pH	Dissolved Oxygen	Total Suspended Solids	Total Alkalinity
	˚C	µS/cm	mg/L	SU	mg/L	mg/L	mg/L
Irrigation Well 2	19.45	521	287	7.12	2.25	1.20	155
Relief well 2	19.01	785	432	6.76	1.57	46.0	351
Relief well 22	19.44	637	350	6.83	1.34	33.6	268
Relief well 51	19.90	717	394	6.77	1.39	44.8	308
Relief well 80	19.80	790	435	6.77	1.74	33.0	363

The suitability of water for irrigation of agricultural crops is dependent upon several factors, which includes salinity and the specific crop being grown. According to the Louisiana State University Department of Agriculture, the suitability of water for the irrigation of rice is determined by three parameters, which are total salinity, electrical conductivity (EC), and the sodium adsorption ratio (SAR). Samples collected from the discharge of each well were analyzed in a laboratory to determine the anion and cation concentrations. The results allowed for the SAR to be calculated. These values are useful for water used for irrigation, giving some sense of suitability for sensitive crops like rice. The SAR values from the groundwater wells adjacent to the Mississippi River ranged from 0.25 to 1.54, all of which were very conducive for agriculture. However, when coupled with elevated values for specific conductance, the suitability slightly diminishes (Huff and Bonck, 1993). Saichuk et al. (19??) with the Louisiana State University AgCenter determined that if irrigation water had salt concentrations (mg/L) less than 500 and an SAR value less than 4, then crop yields should not be adversely effected. These values match closely with the measurements collected from the relief well discharge and are thus not considered harmful for rice production. These values can be found in Table A12-17. To address these concerns, this matter deserves further study. The temporal nature of groundwater with elevated salt concentrations along the Mississippi River flowing from the MRAA requires a more extensive monitoring effort. A monitoring program will be implemented to document this trend in existing and future relief wells. Conductivity meters will be deployed to monitor concentrations of salinity in various reaches along the LMR. These efforts will help to isolate possible problem reaches and allow for better planning and design of future seepage mitigation strategies.

Table A12-17. Cation and Anion Concentrations from groundwater samples collected along the protected side of Mississippi River Levee in Concordia Parish, Louisiana.

	Chloride	Sulfate	Total Alkalinity	Magnesium	Potassium	Sodium	Calcium	SAR
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Irrigation Well 2	21.50	9.73	174.00	13.40	3.23	44.00	39.20	1.55
Relief well 2	6.59	7.11	351.00	24.80	3.05	11.20	108.00	0.25
Relief well 22	10.90	11.20	268.00	21.10	2.88	10.60	81.90	0.27
Relief well 51	8.03	10.40	308.00	22.00	2.64	12.20	102.00	0.29
Relief well 80	10.30	3.71	363.00	24.60	3.07	15.90	108.00	0.36

The median monthly SAR values for the Mississippi River at Thebes, Vicksburg, St. Francisville and New Orleans were graphed for the available POR and can be seen in Figure A12-13. The SAR values computed from the median anion and cation concentrations of the Mississippi River varied inversely with flow (i.e., are lower during high flow and higher during low flow). SAR values decreased from Thebes as flow moved downstream to Vicksburg and St. Francisville. The increased SAR value at St. Francisville over Vicksburg observed in the fall can likely be attributed to the increased flow coming into the Mississippi River from the Red River, which typically has higher salt concentrations. The SAR values increased at New Orleans likely as a result of the salt wedge commonly observed working upstream from the Gulf of Mexico during periods of low flow.

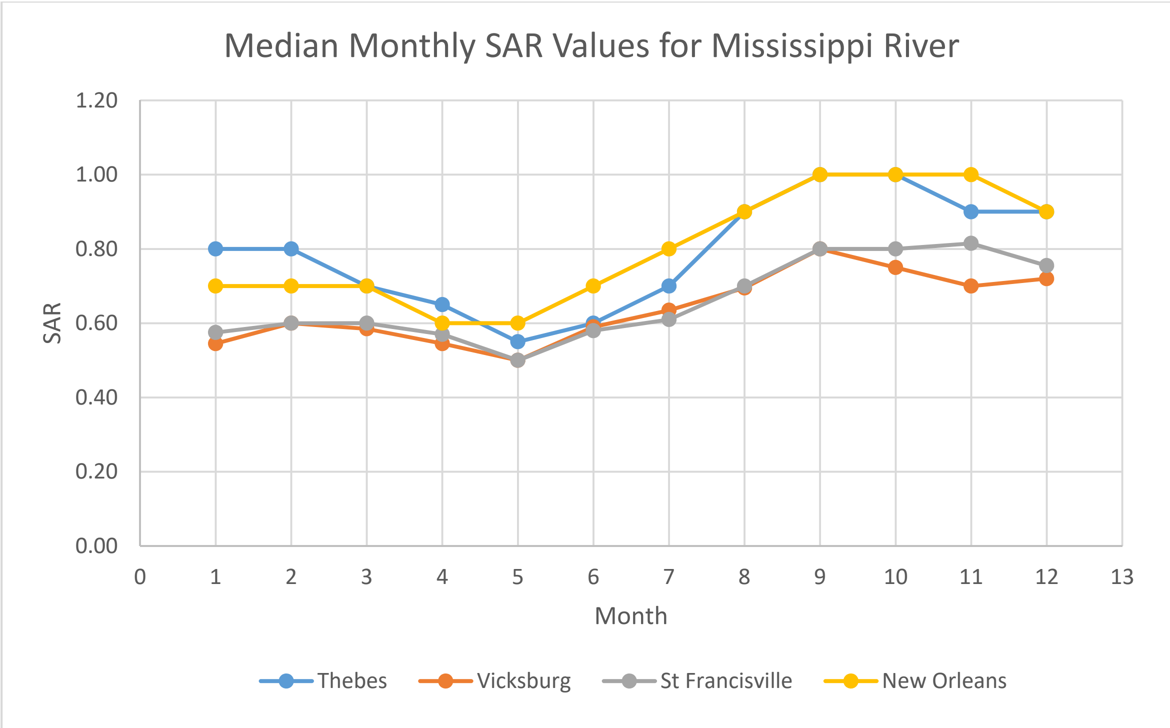

Figure A12-13. Average Median Monthly SAR values observed along the Mississippi River

A12-6 Borrow Area Construction

Three alternatives were considered for BA construction when material is needed for Work Items involving levee enlargement, seepage berm enlargement and/or creation. The alternatives included no action, traditional construction, and avoid and minimize.

Under the No Action Alternative, no new construction would be undertaken to address the known deficiencies for the proposed 143 items of work. The overall system, including the areas with the identified deficiencies, would continue to be operated and maintained at current standards. This would include mowing and brush management, maintaining the gravel road surface and access ramps, operation of pump stations, repair of minor levee slides or other damages (animal burrows, tire ruts, etc.) and routine inspections. When the river reached flood stage, USACE would initiate flood-fight activities, which include monitoring performance of features, surveying for new seepage, installing poly sheeting, and ringing sand boils. It could also include temporary levee and floodwall raises using mud-boxes, sandbags or other materials. These emergency measures are not as robust and reliable as relief wells, berms, permanent levee/floodwall raises and teams would have limited time to get them in place during a flood. The probability of a failure in this system would be highest at the areas identified here as deficient. It is not likely that all of the areas would fail during a flood, but a single failure will impact other areas.

The Traditional Construction Alternative would implement the proposed improvements and modifications using the most cost efficient means available. Earthen borrow material for construction would be acquired from the nearest site with suitable material. Most often, these BAs would be located along the riverside toe of the levee adjacent to the proposed construction locations. Impacts to wetlands or wildlife habitat would not be avoided or minimized under this alternative, as this plan would require no special configuration or location of BAs other than for engineering purposes. In the Memphis, Vicksburg, and New Orleans Districts, a total of 878 acres of batture land is needed for borrow. This would convert approximately 0.0552 percent of the overall terrestrial land present in the batture to open water. These borrow acreage estimates for Alternative 2 are further clarified in Table A12-18. No provisions would be made for drainage, reforestation, or other environmental enhancement features for the BAs. Mitigation to compensate for losses would be included as required by law and policy.

Table A12-18. Required Borrow Acreage for Implementation of Alternatives 2 – Traditional Construction.

Required Borrow Acreages for Alternative 2 - Traditional Construction by state		
State	**Landside**	**Riverside**
AR	0.0	74.5
IL	0.1	9.9
KY	0.3	0.0
LA	176.1	516.4
MS	0.0	172.6
MO	20.7	62.9
TN	328.3	41.4
TOTAL	525.6	877.7

Required Borrow Acreages for Alternative 2 - Traditional Construction by district				
District	**Batture**	**Landside**	**Riverside**	**% Reduction**
MVM	708,421	349.5	207.9	0.0293%
MVK	735,429	77.9	479.7	0.0652%
MVN	144,989	98.2	190.1	0.1311%
TOTAL	**1,588,839**	**525.6**	**877.7**	**0.0552%**

Lastly, the Avoid and Minimize Alternative would seek to avoid and minimize impacts to forested areas by placing BAs in less environmentally sensitive locations, when practicable. During scoping, location of borrow sites, loss of BLH forest and associated wetlands, and landowner input would be pertinent design guidelines. Additional environmental features (e.g., irregular shorelines, islands, variable depths, reforestation, etc.) that could be incorporated into BA designs to increase habitat value would be explored with willing landowners and non-Federal sponsors during project design. In the Memphis, Vicksburg, and New Orleans Districts, a total of 988 acres of batture land is needed for borrow. This would convert approximately 0.0622 percent of the overall terrestrial land present in the batture to open water. These borrow acreage estimates for Alternative 3 are further clarified in Table A12-19.

Table A12-19. Required Borrow Acreage for Implementation of Alternatives 3 – Avoid and Minimize.

Required Borrow Acreages for Alternative 3 - Avoid and Minimize by state		
State	**Landside**	**Riverside**
AR	0.0	93.5
IL	0.0	9.8
KY	0.3	0.0
LA	315.7	376.1
MS	55.2	98.5
MO	43.2	45.1
TN	0.0	364.7
TOTAL	414.4	987.7

Required Borrow Acreages for Alternative 3 - Avoid and Minimize by district				
District	**Batture**	**Landside**	**Riverside**	**% Reduction**
MVM	708,421	43.5	513.1	0.0724%
MVK	735,429	147.6	409.6	0.0557%
MVN	144,989	223.2	65.0	0.0449%
TOTAL	**1,588,839**	**414.4**	**987.7**	**0.0622%**

The No Action Alternative offers the least impact to water quality but at the expense of flood protection. While the vegetative buffer found in the batture area of the LMR provides multiple functions to enhance water quality in the Mississippi River, the impacts of the Traditional Construction or Avoid and Minimize Alternatives show relatively no change in the aerial extent of forested lands. The overall construction area of BAs for the 143 Work Items projected for the three districts is far less than the overall batture area in the LMR. The construction of BAs have a relatively short-term duration and localized impacts to water quality. The major impact will be localized increases in turbidity due to the disturbance of land. While the excavation of material from BAs is always done when the area is dry, seasonal flooding of the disturbed areas may contribute to localized increases in turbidity. Temporary stabilization measures shall be employed to help reduce the potential impacts to water quality. Furthermore, areas surrounding the borrow locations will be re-vegetated before the project is completed. The construction of BAs described in Alternatives 2 and 3 show similar overall changes in land area. With this consideration, the alternative to avoid and minimize strikes a balance between the public safety associated with flood risks and the value of existing vegetation found in batture land, which provides functional enhancement to water quality.

A12-7 Conclusion

The historical in situ data presented for the Mississippi River shows that overall water quality is good and that it meets all aquatic life standards. The Mississippi River does carry excess nutrients, but this nutrient load does not have an adverse effect on aquatic life in the Mississippi River. The proposed MRL Work Items are relatively short-term events and are not believed to have a lasting impact on the overall system. The overall loss of BLH acreage from batture area within each district is extremely low (less than 0.07 percent) and would not have a noticeable impact on water quality. Alternative 3, Avoid and Minimize, is the recommended alternative that will facilitate the completion of the Work Items needed to maintain the flood protection integrity of the MRL system. The water quality from relief well discharge falls within acceptable limits for the National recommended water quality criteria for fresh water published by the EPA, as long as minimal time for re-aeration is available. Some land owners have expressed concern for the mixing of discharge from relief wells and precipitation runoff in surface waters used for irrigation. This issue warrants further study so that better information is available to assist with future design of Work Items in the MRL system.

A12-8 References

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