EVALUATION OF PHYSICAL / CHEMICAL CHARACTERISTICS OF SOFT SEDIMENTS IN LAKE JESUP

---Technical Report---

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1. INTRODUCTION

This Technical Report provides a summary of work efforts conducted by Environmental Research & Design, Inc. (ERD) for the St. Johns River Water Management District (District) to evaluate the physical and chemical characteristics of unconsolidated flocculent sediments in Lake Jesup. The primary objective of this project is to measure the current depth and physical/ chemical characteristics of the unconsolidated floc layer in Lake Jesup using sample sites from a similar study conducted during 1996 by Cable, et al. (1997). The results of the current study will be compared by the District to data collected during the 1996 study to evaluate rates of sediment accumulation and general movement of sediment within the lake. In addition, isotope analyses were also conducted on supplemental sediment core samples collected at each of the monitoring sites to assess potential sources of soft floc within the lake.

2. FIELD SAMPLING

Evaluation of sediment characteristics was conducted in Lake Jesup at 49 locations used during the 1996 study. Sediment core samples were collected at each of the 49 sites and evaluated for moisture content, organic content, bulk density, total nitrogen, total organic matter, total phosphorus, non-apatite inorganic phosphorus (NAIP), sediment phosphorus speciation, and stable isotopes. A summary of field and laboratory methods used by ERD to accomplish these objectives is summarized in the following sections.

2.1 Sediment Monitoring Sites

Collection of sediment core samples in Lake Jesup was conducted on three consecutive days from August 4-6, 2014, with 14 sediment core samples collected on August 4th, 22 sediment core samples collected on August 5th, and 13 sediment core samples collected on August 6th. Locations of sediment monitoring sites in Lake Jesup used by ERD are illustrated on Figure 2-1. The monitoring sites illustrated on Figure 2-1 are intended to replicate the monitoring sites used during the 1996 study. A tabular comparison of the 1996 and 2014 sediment site coordinates is given on Table 2-1. As requested by the District, the horizontal datum is UTM 1 NAD 83 (90). The relative difference between the 1996 and 2014 sediment monitoring locations is provided in the final column of Table 2-1. Relative differences between the 1996 and 2014 sediment monitoring sites ranged from 1.4-60.2 m, with an overall mean relative difference of 21.2 m (69.5 ft).

2.2 Collection Methods

2.2.1 Soft Sediment Depth

Water depth at each of the 49 sediment monitoring sites was determined by lowering a 20-cm diameter Secchi disk attached to a graduated line until resistance from the sediment layer was encountered. The depth on the graduated line corresponding to the water surface was recorded in the field and is defined as the water depth at each site. After measurement of the water depth at each site, a 1.5-inch diameter graduated aluminum pole was then lowered into the water column and forced into the sediments to the point of refusal. The depth corresponding to the water surface is defined as the depth to the firm lake bottom. The difference between the depth to the firm lake bottom and the water depth at each site is defined as the depth of unconsolidated sediments.

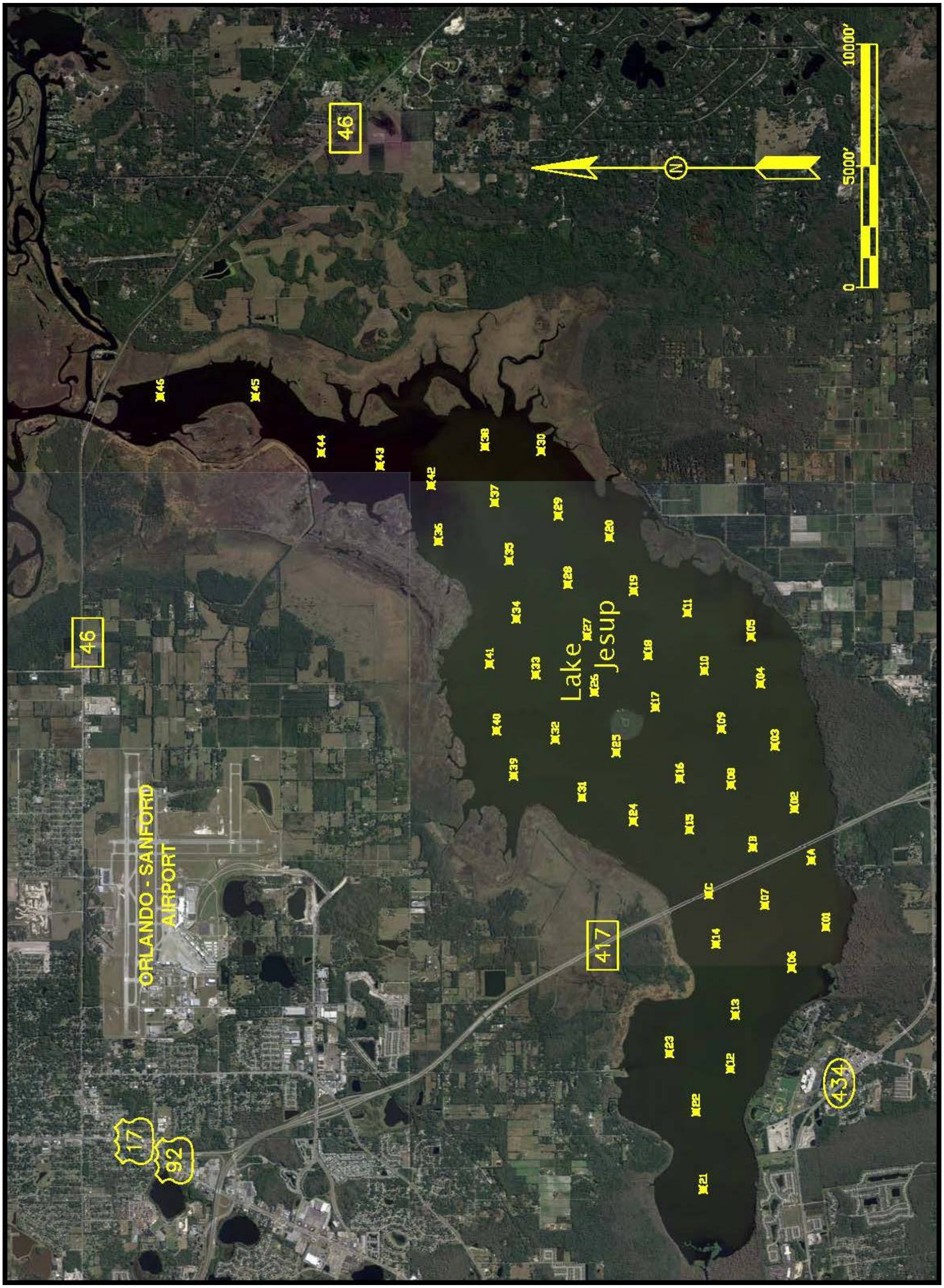


Figure 2-1. Sediment Monitoring Sites in Lake Jesup Used by ERD.

TABLE 2-1

COMPARISON OF 1996 AND 2014 SEDIMENT SITE COORDINATES

SITE	1996 STUDY		2014 STUDY		RELATIVE DIFFERENCE (m)
	Northing	Easting	Northing	Easting	
LJ-1	3175020	476015	3175012	476045	31.1
LJ-2	3175417	477508	3175431	477486	26.1
LJ-3	3175662	478295	3175669	478308	14.8
LJ-4	3175845	479082	3175850	479082	5.0
LJ-5	3175967	479679	3175992	479680	25.0
LJ-6	3175452	475500	3175464	475559	60.2
LJ-7	3175789	476288	3175834	476300	46.6
LJ-8	3176216	477808	3176200	477818	18.9
LJ-9	3176338	478513	3176340	478518	5.4
LJ-10	3176552	479246	3176577	479241	25.5
LJ-11	3176766	479979	3176744	479990	24.6
LJ-12	3176224	474227	3176270	474237	47.1
LJ-13	3176161	474905	3176170	474951	46.9
LJ-14	3176405	475800	3176424	475803	19.2
LJ-15	3176741	477239	3176746	477258	19.7
LJ-16	3176863	477890	3176857	477922	32.6
LJ-17	3177169	478786	3177167	478786	2.0
LJ-18	3177260	479437	3177251	479443	10.8
LJ-19	3177443	480251	3177479	480255	36.2
LJ-20	3177750	480930	3177761	480929	11.1
LJ-21	3176566	472708	3176585	472716	20.6
LJ-22	3176656	473685	3176698	473746	74.1
LJ-23	3176993	474418	3177020	474425	27.9
LJ-24	3177448	477349	3177470	477377	35.6
LJ-25	3177662	478217	3177660	478228	11.2
LJ-26	3177938	478977	3177930	478984	10.6
LJ-27	3178029	479683	3178039	479680	10.4
LJ-28	3178274	480334	3178272	480340	6.3
LJ-29	3178395	481202	3178395	481204	2.0
LJ-30	3178610	482017	3178611	482018	1.4
LJ-31	3178094	477649	3178110	477639	18.9
LJ-32	3178431	478382	3178433	478401	19.1
LJ-33	3178676	479196	3178662	479217	25.2
LJ-34	3178921	479901	3178915	479912	12.5
LJ-35	3179012	480634	3179020	480628	10.0
LJ-36	3179904	480879	3179902	480883	4.5
LJ-37	3179195	481367	3179199	481359	8.9
LJ-38	3179317	482072	3179325	482082	12.8
LJ-39	3178955	477921	3178930	477925	25.3
LJ-40	3179170	478491	3179159	478490	11.1
LJ-41	3179260	479332	3179269	479329	9.5
LJ-42	3179995	481585	3179985	481593	12.8
LJ-43	3180641	481830	3180654	481848	22.2
LJ-44	3181379	481994	3181395	481989	16.8
LJ-45	3182209	482700	3182221	482700	21.2
LJ-46	3183409	482702	3183424	482721	12.0
LJ-A	3175203	476856	3175174	476866	24.2
LJ-B	3175941	477020	3175935	477053	30.7
LJ-C	3176496	476425	3176496	476432	33.5
Mean Relative Difference (m):					**21.2**

2.2.2 Sediment Sampling Techniques

Sediment samples were collected at each of the 49 monitoring sites using a stainless steel split-spoon core device, which was penetrated into the sediments to the point of refusal. After retrieval of the sediment sample, any overlying water was carefully decanted before the split-spoon device was opened to expose the collected sample. Visual characteristics of each sediment core sample were recorded, the exposed core was photographed, and the 0-10 cm layer was carefully sectioned off and placed into a polyethylene container for transport to the ERD laboratory. Duplicate core samples were collected at each site, and the 0-10 cm layers were combined together to form a single composite sample for each of the sites. The polyethylene containers used for storage of the collected samples were filled completely to eliminate air space in the storage container above the composite sediment sample. Each of the collected samples was stored in ice and returned to the ERD laboratory for physical and chemical characterization.

A supplemental sediment core sample was also collected at each of the 49 monitoring sites for analysis of stable isotopes. These samples were collected using the same methodology outlined above with the exception that the entire muck layer was removed rather than just the 0-10 cm layer. The entire soft muck layer was placed into a stainless steel mixing bowl and thoroughly mixed using a stainless steel spoon. A sub-sample of the mixed sediment layer was placed into a polyethylene container for transport to the ERD Laboratory. The polyethylene containers were filled completely to eliminate air space in the storage container above the composite sediment sample. Each of the samples was stored in ice and returned to the ERD Laboratory.

2.2.3 Meteorological Data

Meteorological characteristics of air temperature and wind speed were measured at each of the 49 monitoring sites using a SpeedTech WindMate Model 350 wind/weather meter. Wind direction was determined using a compass.

3. LABORATORY METHODS

3.1 Sediment Characterization Methods

A summary of methods and analytical procedures for general parameters and nutrients conducted on the Lake Jesup sediment samples is given in Table 3-1. Analyses for moisture content, bulk density, organic content, total nitrogen, total organic carbon, total phosphorus, and NAIP were conducted on the 0-10 cm layer, with analyses conducted by ERD for all parameters except total nitrogen and TOC. The stable nitrogen isotope analyses were conducted by the Colorado Plateau Isotope Laboratory using the composite layer of the soft sediment material. Instructions on preparation and shipping of the sediment samples were provided to ERD by the Isotope Laboratory.

TABLE 3-1

LIST OF GENERAL PARAMETERS AND NUTRIENTS

PARAMETER	METHOD/ PREPARATION	ANALYTICAL PROCEDURE	REFERENCE	SEDIMENT LAYER (cm)	ANALYSIS CONDUCTED BY
Water Content	Dry sub-sample of sediment to a constant weight	70^{o}C for 72 hours	--	0-10	ERD
Bulk Density	Wet weight of sediment divided by volume of wet sediment	--	--	0-10	ERD
Organic Content	Loss on ignition	550^{o}C for 2 hours in muffle furnace	Hâkanson & Jansson (1983)	0-10	ERD
Total N and Total Organic C	Combust fine, dried and sieved sediment	Carlo Erba CNS elemental analyzer	--	0-10	Colorado Plateau Isotope Laboratory
Total P	Combust sample in muffle furnace for 2 hours at 550^{o}C and dissolve ash in 6 *M* HCl	Analyze for TP using EPA Method 365.1	--	0-10	ERD
Non-Apatite Inorganic P (NAIP)	Extract sediment with 0.1 *M* NaOH for 17 hours at 25^{o}C	Analyze for SRP using EPA Method 365.1	Williams, et al. (1976)	0-10	ERD
Stable Isotope Analysis of N	Dry at 550^{o}, crush and grind, sieve using #20 sieve	--	--	Composite of soft sediment layer	Colorado Plateau Isotope Laboratory

3.2 Sediment Speciation Techniques

In addition to general sediment characterization, a fractionation procedure for inorganic soil phosphorus was conducted on each of the 49 collected sediment samples. A modified version of the Chang and Jackson Procedure, as proposed by Peterson and Corey (1966), was used for phosphorus fractionation. The Chang and Jackson Procedure allows the speciation of sediment phosphorus into saloid-bound phosphorus (defined as the sum of soluble plus easily exchangeable sediment phosphorus), iron-bound phosphorus, and aluminum-bound phosphorus. Although not used in this project, subsequent extractions of the Chang and Jackson procedure also provide calcium-bound and residual fractions.

The Chang and Jackson procedure was originally developed at the University of Wisconsin to evaluate phosphorus bonding in dried agricultural soils. However, drying of wet sediments will significantly impact the phosphorus speciation, particularly the soluble and iron-bound associations. Therefore, the basic Chang and Jackson method was adapted and modified by ERD for wet sediments by adjusting solution concentrations and extraction timing to account for the liquid volume in the wet sediments and the reduced solids mass. This modified method has been used as the basis for all lake sediment inactivation projects which have been conducted in the State of Florida.

Saloid-bound phosphorus is considered to be available under all conditions at all times. Iron-bound phosphorus is relatively stable under aerobic environments, generally characterized by redox potentials greater than 200 mv (E_h), while unstable under anoxic conditions, characterized by redox potential less than 200 mv. Aluminum-bound phosphorus is considered to be stable under all conditions of redox potential and natural pH conditions. A schematic of the Chang and Jackson Speciation Procedure for evaluating soil phosphorus bounding is given in Figure 3-1.

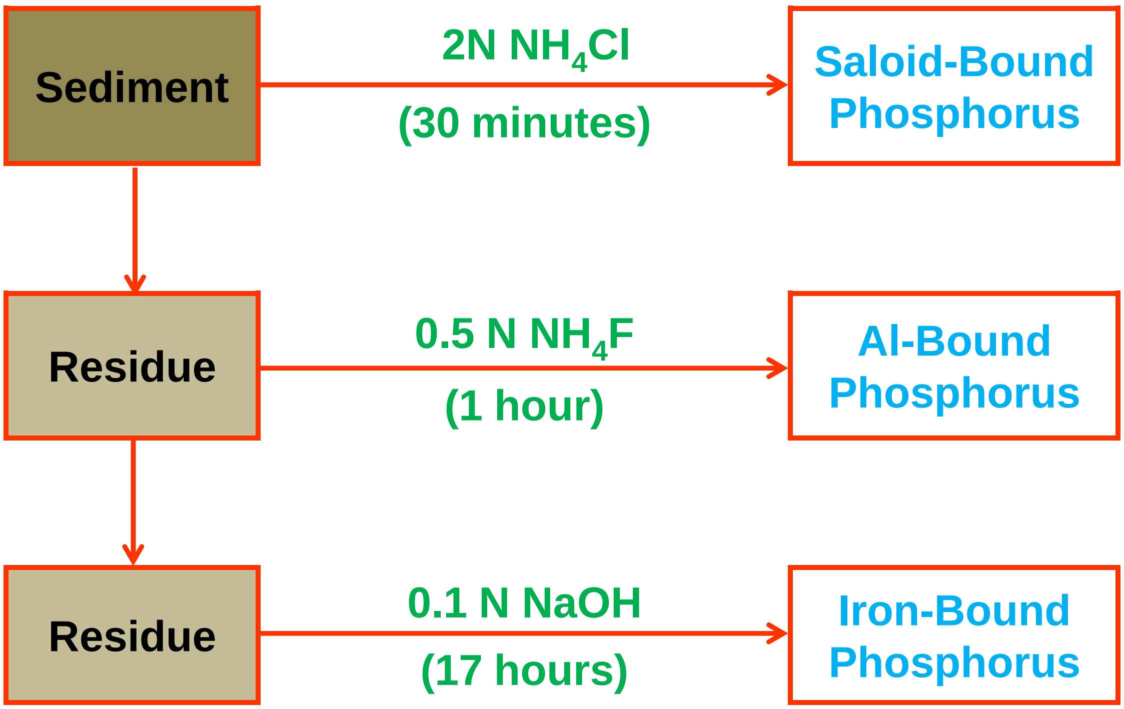


Figure 3-1. Schematic of Chang and Jackson Speciation Procedure for Evaluating Soil Phosphorus Bonding.

For purposes of evaluating release potential, ERD typically assumes that potentially available inorganic phosphorus in soils/sediments, particularly those which exhibit a significant potential to develop reduced conditions below the sediment-water interface, is represented by the sum of the soluble inorganic phosphorus and easily exchangeable phosphorus fractions (collectively termed saloid-bound phosphorus), plus iron-bound phosphorus which can become solubilized under reduced conditions. Aluminum-bound phosphorus is generally considered to be unavailable in the pH range of approximately 5.5-7.5 under a wide range of redox conditions.

4. RESULTS

4.1 Meteorological Conditions

A summary of meteorological conditions during the Lake Jesup sediment monitoring program is given on Table 4-1. Sediment collection was conducted on three consecutive days from August 4-6, 2014. Air temperatures ranged from the low 80s to the low 90s, with low to moderate wind speeds ranging from calm to 7.4 mph. Wind direction was primarily from the west.

4.2 Visual Sediment Characteristics

Visual characteristics of sediment core samples were recorded for each of the 49 sediment samples collected in Lake Jesup. In general, a surficial layer of unconsolidated organic muck was observed at 42 of the 49 monitoring sites, with measured depths ranging from 0-7 cm. This unconsolidated surficial layer is comprised primarily of fresh organic material, such as dead algal cells, and detritus which has recently accumulated onto the bottom of the lake, and this layer is relatively easily disturbed by wind action or boating activities. Beneath the unconsolidated surficial layer, the organic muck becomes more consolidated with a consistency similar to pudding. These layers reflect older organic deposits which are resistant to further degradation and do not resuspend into the water column except during vigorous wind activity on the lake. Several of the monitoring locations were characterized by brown fine sand with no visual muck accumulations. Photographs of sediment characteristics at each of the 49 sites in Lake Jesup are given in Appendix A.

4.3 Soft Sediment Accumulation

A tabular summary of soft sediment measurements conducted in Lake Jesup by ERD is given on Table 4-2. Estimates of the soft sediment depth are obtained by subtracting the measured water depth from the depth to firm bottom at each monitoring site. Calculated soft sediment depths in Lake Jesup ranged from 0-7.68 ft, with an overall geometric mean of 1.96 ft.

A summary of changes in soft sediment depth from 1996-2014 is given in Table 4-3. During the period from 1996-2014, soft sediment depth in Lake Jesup changed from a loss of 1.09 ft to a gain of 3.81 ft, depending upon location within the lake. Overall, soft sediment depth increased by approximately 1.16 ft within the lake from 1996-2014.

4.4 Physical Sediment Characteristics

Each of the 49 collected sediment core samples was evaluated for moisture content, organic content, and bulk density. In addition, ERD also evaluated sediment pH to support the evaluation of feasibility for an alum treatment to the lake sediments. A tabular summary of physical characteristics of Lake Jesup sediments is given in Table 4-4. Sediment pH values ranged from slightly acidic to slightly alkaline, with an overall geometric mean value of 6.96.

TABLE 4-1

METEOROLOGICAL CONDITIONS DURING LAKE JESUP SEDIMENT MONITORING

SITE	DATE	TIME	AIR TEMPERATURE (°F)	WIND	
				Speed (mph)	Direction
LJ-1	8/4/14	11:08	87.0	1.4	W
LJ-2	8/4/14	13:32	87.5	4.0	W
LJ-3	8/4/14	13:38	87.3	5.0	W
LJ-4	8/5/14	10:20	84.0	6.0	W
LJ-5	8/5/14	10:40	84.4	7.6	W
LJ-6	8/4/14	10:49	86.0	2.5	W
LJ-7	8/4/14	11:27	85.2	4.0	W
LJ-8	8/5/14	9:47	82.8	5.3	W
LJ-9	8/5/14	10:02	81.5	7.4	W
LJ-10	8/5/14	10:59	83.0	1.5	W
LJ-11	8/5/14	11:47	84.6	6.4	W
LJ-12	8/4/14	9:56	86.8	1.6	W
LJ-13	8/4/14	10:33	86.8	1.4	W
LJ-14	8/4/14	11:48	85.1	5.2	W
LJ-15	8/5/14	9:16	82.3	4.4	W
LJ-16	8/5/14	9:32	82.8	5.4	W
LJ-17	8/5/14	11:19	84.4	5.0	W
LJ-18	8/5/14	11:33	85.6	5.3	W
LJ-19	8/5/14	12:04	85.0	6.0	W
LJ-20	8/5/14	12:20	86.3	5.5	W
LJ-21	8/4/14	9:15	83.5	2.0	W
LJ-22	8/4/14	9:38	83.6	3.7	W
LJ-23	8/4/14	10:15	84.1	4.4	W
LJ-24	8/6/14	9:11	84.5	1.8	W
LJ-25	8/6/14	9:26	84.1	3.3	W
LJ-26	8/6/14	9:39	85.0	2.1	W
LJ-27	8/6/14	9:54	85.7	1.1	W
LJ-28	8/6/14	10:07	84.1	1.0	W
LJ-29	8/5/14	12:56	89.0	6.3	W
LJ-30	8/5/14	13:09	86.1	5.8	W
LJ-31	8/6/14	12:32	87.8	1.3	NW
LJ-32	8/6/14	12:15	88.1	1.7	W
LJ-33	8/6/14	12:02	91.0	0.6	W
LJ-34	8/6/14	11:01	88.6	2.3	W
LJ-35	8/6/14	10:28	90.9	4.4	W
LJ-36	8/5/14	15:16	87.4	5.5	SW
LJ-37	8/5/14	13:24	86.8	3.1	W
LJ-38	8/5/14	13:38	86.9	6.5	W
LJ-39	8/6/14	11:45	94.5	Calm	-
LJ-40	8/6/14	11:35	92.1	1.5	W
LJ-41	8/6/14	11:22	87.1	2.3	W
LJ-42	8/5/14	15:03	87.9	3.3	W
LJ-43	8/5/14	13:55	88.0	3.4	W
LJ-44	8/5/14	14:09	91.9	2.1	W
LJ-45	8/5/14	14:27	90.0	4.7	W
LJ-46	8/5/14	14:42	87.5	5.8	W
LJ-A	8/4/14	12:41	86.4	2.7	W
LJ-B	8/4/14	12:24	90.1	3.6	W
LJ-C	8/4/14	12:04	87.7	3.2	W

TABLE 4-2

LAKE JESUP SOFT SEDIMENT MEASUREMENTS

SITE	DATE	WATER DEPTH		DEPTH TO FIRM BOTTOM		SOFT SEDIMENT DEPTH	
		ft	m	ft	m	ft	m
LJ-1	8/4/14	6.40	1.95	10.3	3.14	3.90	1.19
LJ-2	8/4/14	6.89	2.10	10.9	3.32	4.01	1.22
LJ-3	8/4/14	7.22	2.20	10.0	3.05	2.78	0.85
LJ-4	8/5/14	6.89	2.10	11.8	3.60	4.91	1.50
LJ-5	8/5/14	6.23	1.90	10.8	3.29	4.57	1.39
LJ-6	8/4/14	6.89	2.10	13.5	4.12	6.61	2.02
LJ-7	8/4/14	7.22	2.20	14.9	4.54	7.68	2.34
LJ-8	8/5/14	7.54	2.30	12.7	3.87	5.16	1.57
LJ-9	8/5/14	9.51	2.90	10.0	3.05	0.49	0.15
LJ-10	8/5/14	8.86	2.70	11.0	3.35	2.14	0.65
LJ-11	8/5/14	6.89	2.10	10.5	3.20	3.61	1.10
LJ-12	8/4/14	7.90	2.41	13.1	3.99	5.20	1.58
LJ-13	8/4/14	7.94	2.42	9.7	2.96	1.76	0.54
LJ-14	8/4/14	7.90	2.41	9.8	2.99	1.90	0.58
LJ-15	8/5/14	7.38	2.25	12.5	3.81	5.12	1.56
LJ-16	8/5/14	7.54	2.30	13.2	4.02	5.66	1.72
LJ-17	8/5/14	5.48	1.67	5.5	1.68	0.02	0.01
LJ-18	8/5/14	8.53	2.60	9.3	2.84	0.77	0.24
LJ-19	8/5/14	6.23	1.90	10.6	3.23	4.37	1.33
LJ-20	8/5/14	6.23	1.90	9.8	2.99	3.57	1.09
LJ-21	8/4/14	6.56	2.00	11.4	3.48	4.84	1.48
LJ-22	8/4/14	8.04	2.45	10.3	3.14	2.26	0.69
LJ-23	8/4/14	7.05	2.15	8.5	2.59	1.45	0.44
LJ-24	8/6/14	6.89	2.10	11.1	3.38	4.21	1.28
LJ-25	8/6/14	6.89	2.10	7.2	2.20	0.31	0.10
LJ-26	8/6/14	8.69	2.65	9.5	2.90	0.81	0.25
LJ-27	8/6/14	7.54	2.30	9.9	3.02	2.36	0.72
LJ-28	8/6/14	9.18	2.80	10.2	3.11	1.02	0.31
LJ-29	8/5/14	6.89	2.10	10.2	3.11	3.31	1.01
LJ-30	8/5/14	5.90	1.80	10.0	3.05	4.10	1.25
LJ-31	8/6/14	6.89	2.10	8.0	2.44	1.11	0.34
LJ-32	8/6/14	6.43	1.96	8.5	2.59	2.07	0.63
LJ-33	8/6/14	7.05	2.15	9.7	2.96	2.65	0.81
LJ-34	8/6/14	7.87	2.40	8.0	2.44	0.13	0.04
LJ-35	8/6/14	6.56	2.00	9.7	2.96	3.14	0.96
LJ-36	8/5/14	5.90	1.80	9.1	2.77	3.20	0.97
LJ-37	8/5/14	7.54	2.30	9.3	2.84	1.76	0.54
LJ-38	8/5/14	6.23	1.90	9.8	2.99	3.57	1.09
LJ-39	8/6/14	5.90	1.80	9.1	2.77	3.20	0.97
LJ-40	8/6/14	6.49	1.98	9.1	2.77	2.61	0.79
LJ-41	8/6/14	6.00	1.83	6.0	1.83	0.00	0.00
LJ-42	8/5/14	7.22	2.20	9.7	2.96	2.48	0.76
LJ-43	8/5/14	6.23	1.90	8.8	2.68	2.57	0.78
LJ-44	8/5/14	5.90	1.80	8.5	2.59	2.60	0.79
LJ-45	8/5/14	5.90	1.80	8.9	2.71	3.00	0.91
LJ-46	8/5/14	4.59	1.40	9.7	2.96	5.11	1.56
LJ-A	8/4/14	7.54	2.30	9.9	3.02	2.36	0.72
LJ-B	8/4/14	7.22	2.20	11.8	3.60	4.58	1.40
LJ-C	8/4/14	6.89	2.10	9.3	2.84	2.41	0.74
Minimum Value:		**4.59**	**1.40**	**5.50**	**1.68**	**0.00**	**0.00**
Maximum Value:		**9.51**	**2.90**	**14.90**	**4.54**	**7.68**	**2.34**
Geometric Mean:		**6.95**	**2.12**	**9.87**	**3.01**	**1.96**	**0.61**

TABLE 4-3

CHANGES IN SOFT SEDIMENT DEPTH FROM 1996 TO 2014

SITE	1996 SOFT SEDIMENT (ft)	2014 SOFT SEDIMENT (ft)	CHANGE IN SOFT SEDIMENT (ft)
LJ-1	3.10	3.90	0.80
LJ-2	2.75	4.01	1.26
LJ-3	1.00	2.78	1.78
LJ-4	1.90	4.91	3.01
LJ-5	2.95	4.57	1.62
LJ-6	4.00	6.61	2.61
LJ-7	4.20	7.68	3.48
LJ-8	3.70	5.16	1.46
LJ-9	1.30	0.49	-0.81
LJ-10	0.85	2.14	1.29
LJ-11	2.60	3.61	1.01
LJ-12	4.10	5.20	1.10
LJ-13	0.64	1.76	1.12
LJ-14	1.60	1.90	0.30
LJ-15	2.35	5.12	2.77
LJ-16	1.85	5.66	3.81
LJ-17	0.20	0.02	-0.18
LJ-18	0.80	0.77	-0.03
LJ-19	2.50	4.37	1.87
LJ-20	3.00	3.57	0.57
LJ-21	2.12	4.84	2.72
LJ-22	2.25	2.26	0.01
LJ-23	0.70	1.45	0.75
LJ-24	1.38	4.21	2.83
LJ-25	0.48	0.31	-0.17
LJ-26	1.10	0.81	-0.29
LJ-27	0.80	2.36	1.56
LJ-28	0.97	1.02	0.05
LJ-29	2.32	3.31	0.99
LJ-30	2.38	4.10	1.72
LJ-31	0.51	1.11	0.60
LJ-32	0.70	2.07	1.37
LJ-33	1.30	2.65	1.35
LJ-34	0.45	0.13	-0.32
LJ-35	1.40	3.14	1.74
LJ-36	1.70	3.20	1.50
LJ-37	1.25	1.76	0.51
LJ-38	2.00	3.57	1.57
LJ-39	1.40	3.20	1.80
LJ-40	1.85	2.61	0.76
LJ-41	0.60	0.00	-0.60
LJ-42	2.00	2.48	0.48
LJ-43	1.65	2.57	0.92
LJ-44	1.30	2.60	1.30
LJ-45	0.65	3.00	2.35
LJ-46	2.67	5.11	2.44
LJ-A	3.45	2.36	-1.09
LJ-B	3.40	4.58	1.18
LJ-C	2.40	2.41	0.01
		Minimum Value:	**-1.09**
		Maximum Value:	**3.81**
		Geometric Mean:	**1.16**

TABLE 4-4

PHYSICAL CHARACTERISTICS OF LAKE JESUP SEDIMENTS

SITE	SEDIMENT LAYER (cm)	pH (s.u.)	MOISTURE CONTENT (%)	PERCENT SOLIDS (%)	ORGANIC CONTENT (%)	WET DENSITY (g/cm^3)	TOC (% dry wt.)	RATIO TOC/ ORGANIC
LJ-1	0-10	6.95	91.1	8.9	31.7	1.09	12.11	0.38
LJ-2	0-10	6.90	92.9	7.1	35.1	1.07	16.30	0.46
LJ-3	0-10	6.74	91.3	8.7	31.7	1.09	14.15	0.45
LJ-4	0-10	6.61	91.2	8.8	28.7	1.09	10.31	0.36
LJ-5	0-10	6.79	91.9	8.1	33.3	1.08	16.04	0.48
LJ-6	0-10	6.89	91.6	8.4	33.3	1.08	13.70	0.41
LJ-7	0-10	6.81	93.2	6.8	34.3	1.07	15.18	0.44
LJ-8	0-10	6.95	90.1	9.9	25.7	1.11	8.86	0.35
LJ-9	0-10	7.13	57.2	42.8	9.0	1.58	6.95	0.77
LJ-10	0-10	7.00	48.1	51.9	7.6	1.72	4.89	0.64
LJ-11	0-10	6.82	92.9	7.1	37.4	1.07	5.28	0.14
LJ-12	0-10	7.01	90.8	9.2	28.2	1.10	13.24	0.47
LJ-13	0-10	6.96	89.8	10.2	26.2	1.11	11.32	0.43
LJ-14	0-10	7.01	91.2	8.8	27.9	1.10	4.78	0.17
LJ-15	0-10	6.99	92.5	7.5	31.9	1.08	13.94	0.44
LJ-16	0-10	6.94	90.1	9.9	26.7	1.11	13.78	0.52
LJ-17	0-10	7.32	24.7	75.3	0.9	2.12	0.47	0.51
LJ-18	0-10	6.54	44.5	55.5	5.1	1.79	3.96	0.78
LJ-19	0-10	6.85	92.2	7.8	33.2	1.08	6.51	0.20
LJ-20	0-10	6.89	90.2	9.8	30.2	1.10	11.88	0.39
LJ-21	0-10	6.86	93.0	7.0	34.2	1.07	15.51	0.45
LJ-22	0-10	6.91	90.2	9.8	22.7	1.11	10.07	0.44
LJ-23	0-10	6.94	90.8	9.2	27.4	1.10	10.81	0.39
LJ-24	0-10	6.99	88.6	11.4	20.8	1.13	13.96	0.67
LJ-25	0-10	7.49	22.8	77.2	0.8	2.15	0.63	0.79
LJ-26	0-10	6.91	46.2	53.8	6.6	1.75	5.90	0.90
LJ-27	0-10	6.90	86.0	14.0	15.9	1.18	9.79	0.62
LJ-28	0-10	6.98	60.4	39.6	12.3	1.54	10.48	0.85
LJ-29	0-10	6.87	92.8	7.2	37.4	1.07	12.55	0.34
LJ-30	0-10	6.81	92.2	7.8	34.9	1.08	14.04	0.40
LJ-31	0-10	7.00	87.9	12.1	22.8	1.14	8.84	0.39
LJ-32	0-10	6.90	90.6	9.4	27.6	1.10	5.27	0.19
LJ-33	0-10	6.93	91.4	8.6	28.4	1.09	5.70	0.20
LJ-34	0-10	8.22	30.3	69.7	3.1	2.01	0.85	0.28
LJ-35	0-10	6.90	88.8	11.2	23.0	1.13	11.43	0.50
LJ-36	0-10	6.83	87.1	12.9	17.7	1.16	7.49	0.42
LJ-37	0-10	6.90	92.0	8.0	31.5	1.08	9.84	0.31
LJ-38	0-10	6.86	94.1	5.9	38.5	1.05	13.28	0.34
LJ-39	0-10	6.89	89.2	10.8	20.7	1.13	7.35	0.36
LJ-40	0-10	7.02	89.4	10.6	22.3	1.12	8.00	0.36
LJ-41	0-10	8.45	26.0	74.0	1.1	2.10	0.37	0.33
LJ-42	0-10	6.91	86.0	14.0	16.5	1.18	11.32	0.68
LJ-43	0-10	6.87	85.9	14.1	19.9	1.17	6.43	0.32
LJ-44	0-10	7.02	90.2	9.8	26.3	1.11	11.05	0.42
LJ-45	0-10	6.80	84.4	15.6	17.4	1.19	13.07	0.75
LJ-46	0-10	6.83	91.4	8.6	30.7	1.09	10.90	0.36
LJ-A	0-10	6.58	90.2	9.8	28.3	1.10	16.92	0.60
LJ-B	0-10	6.85	91.9	8.1	31.0	1.08	15.68	0.51
LJ-C	0-10	6.63	93.9	6.1	38.3	1.06	12.25	0.32
Minimum Value:		**6.54**	**22.8**	**5.9**	**0.8**	**1.05**	**0.37**	**0.14**
Maximum Value:		**8.45**	**94.1**	**77.2**	**38.5**	**2.15**	**16.92**	**0.90**
Geometric Mean:		**6.96**	**77.0**	**12.9**	**18.8**	**1.21**	**7.90**	**0.42**

Measurements of sediment moisture content in Lake Jesup sediments were found to be highly variable throughout the lake. The majority of the sediment core samples are characterized by elevated values of moisture content, suggesting that the sediments consist primarily of organic muck. Twenty-nine (29) of the 49 sediment samples are characterized by moisture contents of 90% or greater, with 40 of the 49 samples exhibiting moisture contents of 85% or greater. Only 7 of the 49 sediment sites are characterized by moisture contents less than 50% which suggests mixtures of sand and organic muck. Sediment moisture contents less than 25%, reflecting primarily sand-type sediments, were observed at 3 of the 49 sites. The overall geometric mean moisture content within the lake is 77%.

Measured sediment organic contents (loss on ignition) in Lake Jesup sediments were also highly variable, ranging from 0.8-38.5%. Thirty-five (35) of the 49 sediment samples are characterized by organic contents of approximately 20% or greater which is primarily associated with organic muck.

Sediment density values in Lake Jesup were also highly variable, ranging from 1.05-2.15 g/cm^3. Sediment wet densities of approximately 1.2 g/cm^3 or less primarily reflect organic muck-type sediments, with densities of approximately 2 g/cm^3 or greater reflecting primarily sand.

Measurements of total organic carbon (TOC) in the Lake Jesup sediments were conducted by the Colorado Plateau Laboratory. TOC concentrations in the sediment samples ranged from 0.37-16.92%, with an overall geometric mean of 7.9%. Calculated ratios of TOC/ organic content were relatively consistent among the sediment monitoring sites, with the vast majority of measured values ranging from approximately 0.3-0.5. The overall geometric mean ratio of TOC/organic content is 0.42.

4.5 <u>Nutrients and Organic Carbon</u>

A summary of sediment nutrient concentrations in Lake Jesup is given in Table 4-5. Sediment phosphorus concentrations are provided for ashed sediments based upon the analytical technique requested by the District and for comparison with the previous 1996 analyses which also used ashed sediments. However, phosphorus concentrations measured on ashed sediments have limited value in highly organic liquid sediments similar to those which exist in Lake Jesup, and phosphorus concentrations measured on a wet weight or volumetric basis provide a much better method of comparison. Therefore, calculations are also provided for total phosphorus concentrations on a wet sediment basis as well as concentrations per cm^3 of sediment which is perhaps the most useful method of expressing phosphorus concentrations for these type sediments. Total phosphorus concentrations in terms of μg/cm^3 of wet sediment ranged from 55-347 μg/cm^3, with an overall geometric mean of 126 μg/cm^3.

Sediment nitrogen concentrations were measured as a percentage of dry sediment weight to be consistent with the 1996 measurements and the analytical technique used for nitrogen determination. Overall, the sediments in Lake Jesup are approximately 0.58% nitrogen on a dry weight basis. Similar to the comments provided previously for phosphorus, nitrogen concentrations expressed on a dry weight basis have limited value in highly organic liquid sediments similar to those which exist in Lake Jesup due to the relatively small amount of solid matter in the surficial sediments. A more useful method of expressing nitrogen concentrations is on a wet weight or volumetric basis similar to that used for phosphorus. Total nitrogen concentrations in terms of μg/cm^3 of wet sediment in Lake Jesup ranged from 232-2,618 μg/cm^3, with an overall geometric mean of 904 μg/cm^3.

TABLE 4-5

MEASURED SEDIMENT NUTRIENT CONCENTRATIONS IN LAKE JESUP

SITE	SEDIMENT LAYER (cm)	DATE COLLECTED	SEDIMENT PHOSPHORUS CONCENTRATION				SEDIMENT NITROGEN CONCENTRATION			
			μg/g ash wt.	μg/g dry wt.	μg/g wet wt.	μg/cm³ wet	% dry wt.	mg/g dry	μg/g wet	μg/cm³ wet
LJ-1	0-10	8/4/14	1,795	1,226	109	119	0.64	6.4	567	618
LJ-2	0-10	8/4/14	2,193	1,424	101	108	1.32	13.2	932	996
LJ-3	0-10	8/4/14	2,053	1,403	122	133	1.10	11.0	957	1,043
LJ-4	0-10	8/5/14	1,537	1,095	96	105	0.82	8.2	720	787
LJ-5	0-10	8/5/14	1,438	959	78	84	1.09	10.9	886	958
LJ-6	0-10	8/4/14	1,211	808	68	73	1.11	11.1	931	1,009
LJ-7	0-10	8/4/14	2,377	1,561	106	113	1.21	12.1	822	878
LJ-8	0-10	8/5/14	1,192	886	88	97	0.69	6.9	687	763
LJ-9	0-10	8/5/14	393	358	153	242	0.36	3.6	1,546	2,448
LJ-10	0-10	8/5/14	157	145	75	129	0.29	2.9	1,523	2,618
LJ-11	0-10	8/5/14	2,186	1,369	97	103	0.43	4.3	304	324
LJ-12	0-10	8/4/14	1,263	907	84	92	1.13	11.3	1,040	1,143
LJ-13	0-10	8/4/14	2,583	1,906	194	216	0.93	9.3	945	1,051
LJ-14	0-10	8/4/14	1,299	937	83	90	0.37	3.7	322	353
LJ-15	0-10	8/5/14	1,144	779	58	63	1.22	12.2	907	976
LJ-16	0-10	8/5/14	1,020	748	74	82	1.14	11.4	1,132	1,256
LJ-17	0-10	8/5/14	197	195	147	311	0.04	0.4	335	711
LJ-18	0-10	8/5/14	324	308	171	306	0.23	2.3	1,280	2,293
LJ-19	0-10	8/5/14	1,707	1,141	90	97	0.50	5.0	392	423
LJ-20	0-10	8/5/14	2,072	1,445	141	156	0.96	9.6	937	1,033
LJ-21	0-10	8/4/14	1,868	1,230	86	92	0.96	9.6	676	723
LJ-22	0-10	8/4/14	2,213	1,711	168	187	0.64	6.4	628	700
LJ-23	0-10	8/4/14	1,837	1,334	122	135	0.89	8.9	815	896
LJ-24	0-10	8/6/14	800	633	72	82	1.19	11.9	1,355	1,538
LJ-25	0-10	8/6/14	211	209	161	347	0.03	0.3	212	457
LJ-26	0-10	8/6/14	93	87	47	82	0.21	2.1	1,122	1,967
LJ-27	0-10	8/6/14	974	819	115	135	0.94	9.4	1,315	1,547
LJ-28	0-10	8/6/14	591	519	205	317	0.34	3.4	1,332	2,057
LJ-29	0-10	8/5/14	1,541	964	69	74	1.03	10.3	739	789
LJ-30	0-10	8/5/14	2,493	1,622	127	136	1.03	10.3	806	867
LJ-31	0-10	8/6/14	1,384	1,068	129	147	0.68	6.8	816	930
LJ-32	0-10	8/6/14	1,527	1,106	103	114	0.23	2.3	211	232
LJ-33	0-10	8/6/14	1,543	1,104	95	103	0.46	4.6	397	433
LJ-34	0-10	8/6/14	205	199	138	279	0.07	0.7	478	961
LJ-35	0-10	8/6/14	1,071	825	92	104	1.05	10.5	1,179	1,331
LJ-36	0-10	8/5/14	673	553	72	83	0.68	6.8	876	1,016
LJ-37	0-10	8/5/14	1,589	1,088	87	94	0.71	7.1	569	615
LJ-38	0-10	8/5/14	1,591	978	58	61	0.89	8.9	527	555
LJ-39	0-10	8/6/14	918	729	79	89	0.59	5.9	644	727
LJ-40	0-10	8/6/14	1,587	1,232	131	147	0.66	6.6	704	791
LJ-41	0-10	8/6/14	145	144	106	223	0.03	0.3	248	521
LJ-42	0-10	8/5/14	1,908	1,592	223	263	0.84	8.4	1,180	1,388
LJ-43	0-10	8/5/14	1,159	928	130	152	0.41	4.1	578	676
LJ-44	0-10	8/5/14	1,268	935	92	101	0.80	8.0	786	871
LJ-45	0-10	8/5/14	1,628	1,346	210	250	1.10	11.0	1,713	2,044
LJ-46	0-10	8/5/14	1,742	1,207	104	113	0.88	8.8	759	827
LJ-A	0-10	8/4/14	1,975	1,415	138	153	1.41	14.1	1,374	1,518
LJ-B	0-10	8/4/14	911	629	51	55	1.32	13.2	1,075	1,165
LJ-C	0-10	8/4/14	2,884	1,780	108	114	1.05	10.5	636	672
Minimum Value:			**93**	**87**	**47**	**55**	**0.03**	**0.3**	**211**	**232**
Maximum Value:			**2,884**	**1,906**	**223**	**347**	**1.41**	**14.1**	**1,713**	**2,618**
Geometric Mean:			**1,069**	**805**	**104**	**126**	**0.58**	**5.8**	**745**	**904**

A tabular summary of sediment characteristics measured by ERD in 25 Central Florida lakes, ranging from oligotrophic to hypereutrophic, is given in Table 4-6 for comparison purposes. Summary statistics are provided at the bottom of Table 4-6, with an overall geometric mean value listed for eutrophic and hypereutrophic lakes. The overall geometric mean phosphorus concentration in Lake Jesup sediments of 126 $\mu g/cm^3$ is approximately half of the total phosphorus concentration of 260 $\mu g/cm^3$ measured by ERD in other eutrophic and hypereutrophic Central Florida lakes. The lower phosphorus concentrations in Lake Jesup may suggest that phosphorus in upper portions of the sediment layer may be continuously stripped and recycled from the sediments into the overlying water column, perhaps aided by wind activity, resulting in a relatively low sediment accumulation rate for phosphorus. In addition, the sediments are highly anoxic, as evidenced by the strong hydrogen sulfide smell even in surficial sediment layers, which creates conditions unsuitable for long-term phosphorus retention. The overall total nitrogen concentration in Lake Jesup sediments of 904 $\mu g/cm^3$ is also slightly lower than the mean value of 1,109 $\mu g/cm^3$ measured by ERD in other Florida lakes. The slightly lower nitrogen concentration in Lake Jesup sediments may also be related to the anoxic conditions which, combined with the abundance of organic matter, likely supports a significant population of denitrifying bacteria.

4.6 Sediment Phosphorus Speciation

As discussed in Section 3.2, each of the 49 collected sediment samples was fractionated to identify phosphorus bonding mechanisms within the sediments. A summary of sediment phosphorus speciation in Lake Jesup sediments is given in Table 4-7. Saloid-bound phosphorus, reflecting soluble plus easily exchangeable associations, was highly variable in Lake Jesup sediments, ranging from 2.4-43.2 $\mu g/cm^3$ with an overall geometric mean of 15.2 $\mu g/cm^3$. This value is somewhat greater than commonly observed by ERD in other Central Florida lake sediments.

Concentrations of iron-bound phosphorus in the sediments of Lake Jesup were also highly variable, ranging from 2.7-24.4 $\mu g/cm^3$ with an overall geometric mean of 12.7 $\mu g/cm^3$. This value is substantially lower than iron-bound phosphorus concentrations commonly observed in other lakes and is likely related to the continuous anoxic conditions within the sediments which limits the ability for iron-phosphorus bonds to form. Overall, the sediments in Lake Jesup contain an average of 29.8 $\mu g/cm^3$ of available sediment phosphorus.

Measured concentrations of aluminum-bound phosphorus in Lake Jesup sediments range from 4.9-62.3 $\mu g/cm^3$ with an overall geometric mean of 23.4 $\mu g/cm^3$. Based on an average total phosphorus concentration of 126 $\mu g/cm^3$, approximately 20% of the sediment phosphorus is bound with aluminum in an unavailable form.

Measured concentrations of NAIP are provided in the final column of Table 4-7 for comparison purposes. NAIP concentrations are highly variable, ranging from 1.8-84.3 $\mu g/cm^3$, with an overall geometric mean of 39.6 $\mu g/cm^3$. The NAIP fraction appears to over-estimate the total available phosphorus measurement by approximately 33% since it combines multiple bonding mechanisms together.

TABLE 4-6

SEDIMENT CHARACTERISTICS OF CENTRAL FLORIDA LAKES MONITORED BY ERD

LAKE	DATE COLLECTED	PARAMETER										TROPHIC STATUS
		pH (s.u.)	Moisture Content (%)	Organic Content (%)	Wet Density (g/cm^3)	Total N ($\mu g/cm^3$)	Total P ($\mu g/cm^3$)	Saloid-Bound P ($\mu g/cm^3$)	Iron-Bound P ($\mu g/cm^3$)	Total Available P ($\mu g/cm^3$)	Percent of Sediment P Available (%)	
Asher	9/15/10	5.67	93.6	66.8	1.03	2,874	140	1.2	11	12	9	Hypereutrophic
Cub	11/9/10	6.13	47.7	3.2	1.69	2,022	70	0.1	12	13	19	Mesotrophic
Little Bear	11/9/10	6.21	40.6	1.8	1.85	2,568	66	0.2	9	10	15	Mesotrophic
Bear	12/17/10	6.59	34.7	2.2	1.87	871	115	0.2	10	11	10	Oligotrophic
Booker	7/21/05	6.48	77	25	1.26	527	400	10	59	69	17	Eutrophic
Belair	12/15/11	5.81	47.3	4.2	1.68	668	90	0.2	39	39	43	Eutrophic
Deforest	12/15/11	5.99	70.4	15.8	1.32	329	63	0.7	18	19	30	Mesotrophic
East Crystal	12/15/11	5.97	42.5	3.9	1.77	681	104	0.7	38	39	38	Eutrophic
Amory	12/15/11	5.90	46.3	6.9	1.64	763	86	1.1	36	38	44	Eutrophic
Jesup	7/11/12	6.10	41.9	2.8	1.76	5,043	1,871	0.8	47	51	3	Mesotrophic
Jessamine	12/10/11	6.41	51.2	33.8	1.57	1,653	125	0.4	45	46	37	Mesotrophic
Anderson	1/20/11	6.17	48.8	5.2	1.57	5,390	3,477	3	172	178	8	Eutrophic
Holden	10/8/03	6.59	36.3	2.1	1.81	755	335	9.6	155	167	50	Eutrophic
Killarney	3/24/11	6.39	40.5	3.1	1.74	4,470	923	4	64	72	8	Mesotrophic
Lawne	8/22/11	6.50	44.7	5.0	1.63	5,228	1,365	6	47	56	7	Eutrophic
Pineloch	3/29/06	6.98	92.1	50.4	2.41	5,692	1,198	45	201	216	34	Mesotrophic
Howell	10/16/08	6.7	48.3	10.7	1.75	596	273	14.3	15	29	15	Eutrophic
Bear Gully	10/16/08	6.42	61.5	16.8	1.54	1,320	119	1.1	11	12	11	Eut./Hyp.
Middle Triplet	2/27/13	6.21	68.9	24.1	1.27	1,400	170	2.3	52	56	33	Eutrophic
North Triplet	2/27/13	6.26	55.6	10.4	1.44	904	121	2.6	54	57	48	Mesotrophic
South Triplet	3/3/12	6.10	84.8	52.6	1.16	1,304	132	4.4	38	42	31	Eut./Hyp.
Queens Mirror	3/3/12	5.88	87.8	57.5	1.12	1,126	123	4.0	42	46	37	Eut./Hyp.
Silver	3/28/12	6.49	48.3	6.8	1.58	463	1,164	1.4	50	52	5	Eut./Hyp.
Thonotosassa	4/2/07	7.03	34.2	1.4	1.80	565	226	-	-	-	-	Hypereutrophic
Virginia	2/8/08	6.62	47.4	4.0	1.64	944	220	0.8	13	15	7	Mesotrophic
Minimum Value:		**5.67**	**34.2**	**1.4**	**1.03**	**329**	**63**	**0.1**	**9**	**10**	**3**	
Maximum Value:		**7.03**	**93.6**	**66.8**	**2.41**	**5,692**	**3,477**	**45**	**201**	**216**	**50**	
Geometric Mean (Eut./Hyp.):		**6.25**	**55.2**	**10.2**	**1.48**	**1109**	**260**	**2.4**	**40**	**45**	**19**	

TABLE 4-7

SPECIATION OF SEDIMENT PHOSPHORUS BONDING IN LAKE JESUP SEDIMENTS

SITE	DATE COLLECTED	SEDIMENT P CONC. (μg/cm³ wet)			Al-Bound P (μg/cm³ wet)	Total P (μg/cm³ wet)	Percent Sediment P Available (%)	NAIP (μg/cm³ wet)
		Saloid-Bound P	Fe-Bound P	Total Available P				
LJ-1	8/4/14	10.3	10.5	20.8	19.1	119	17.4	39.8
LJ-2	8/4/14	26.2	13.4	39.6	25.9	108	36.8	53.3
LJ-3	8/4/14	25.6	12.5	38.1	30.4	133	28.6	47.5
LJ-4	8/5/14	28.2	11.9	40.0	16.4	105	38.1	38.2
LJ-5	8/5/14	29.6	12.9	42.4	25.1	84	50.2	42.3
LJ-6	8/4/14	11.3	9.4	20.7	19.8	73	28.3	61.9
LJ-7	8/4/14	15.8	10.1	26.0	20.1	113	22.9	47.0
LJ-8	8/5/14	8.9	14.1	22.9	31.2	97	23.6	50.2
LJ-9	8/5/14	7.4	20.6	28.0	57.8	242	11.6	84.3
LJ-10	8/5/14	5.4	11.5	16.9	30.4	129	13.1	35.9
LJ-11	8/5/14	15.5	17.1	32.6	25.7	103	31.6	40.4
LJ-12	8/4/14	7.9	12.5	20.4	20.4	92	22.2	50.9
LJ-13	8/4/14	25.4	14.8	40.2	36.7	216	18.6	69.3
LJ-14	8/4/14	7.8	10.5	18.3	17.1	90	20.3	12.3
LJ-15	8/5/14	16.0	12.7	28.7	22.3	63	45.8	38.3
LJ-16	8/5/14	9.8	13.6	23.4	24.8	82	28.4	53.1
LJ-17	8/5/14	2.8	10.0	12.8	4.9	311	4.1	13.8
LJ-18	8/5/14	7.8	17.5	25.3	47.9	306	8.3	51.1
LJ-19	8/5/14	24.7	14.9	39.6	30.6	97	41.0	49.1
LJ-20	8/5/14	29.6	14.6	44.2	62.3	156	28.3	48.3
LJ-21	8/4/14	17.0	11.3	28.3	14.6	92	30.7	53.9
LJ-22	8/4/14	15.1	12.1	27.2	25.5	187	14.5	27.8
LJ-23	8/4/14	26.6	13.0	39.6	32.4	135	29.4	51.4
LJ-24	8/6/14	25.2	2.7	28.0	25.2	82	34.2	57.1
LJ-25	8/6/14	5.4	11.8	17.2	6.4	347	5.0	28.3
LJ-26	8/6/14	8.2	24.4	32.6	33.3	82	39.7	46.2
LJ-27	8/6/14	14.1	6.4	20.5	28.2	135	15.2	40.6
LJ-28	8/6/14	13.4	17.4	30.9	17.1	317	9.7	31.0
LJ-29	8/5/14	17.2	11.9	29.1	24.8	74	39.3	40.9
LJ-30	8/5/14	24.0	11.2	35.2	23.5	136	25.9	40.1
LJ-31	8/6/14	28.1	16.8	44.9	39.5	147	30.5	42.7
LJ-32	8/6/14	17.7	16.3	34.0	45.6	114	29.9	50.7
LJ-33	8/6/14	22.5	13.9	36.4	25.3	103	35.2	46.6
LJ-34	8/6/14	2.4	7.3	9.7	6.1	279	3.5	1.8
LJ-35	8/6/14	28.1	16.1	44.2	25.3	104	42.3	41.8
LJ-36	8/5/14	22.2	11.6	33.8	25.2	83	40.7	55.6
LJ-37	8/5/14	29.3	11.5	40.8	28.1	94	43.3	51.1
LJ-38	8/5/14	17.3	9.2	26.5	16.5	61	43.3	51.7
LJ-39	8/6/14	19.3	12.7	32.0	23.8	89	35.9	47.9
LJ-40	8/6/14	26.7	16.7	43.4	25.1	147	29.6	44.1
LJ-41	8/6/14	2.6	21.3	23.9	6.3	223	10.7	5.8
LJ-42	8/5/14	26.6	15.0	41.7	25.7	263	15.9	53.1
LJ-43	8/5/14	21.3	22.7	44.0	60.0	152	28.8	27.8
LJ-44	8/5/14	24.3	12.7	37.0	19.2	101	36.5	50.2
LJ-45	8/5/14	25.0	14.9	39.9	24.9	250	16.0	49.7
LJ-46	8/5/14	20.6	14.6	35.2	22.7	113	31.1	65.1
LJ-A	8/4/14	43.2	13.9	57.1	30.8	153	37.4	49.8
LJ-B	8/4/14	19.0	9.1	28.1	18.5	55	50.8	44.9
LJ-C	8/4/14	10.1	10.4	20.6	19.5	114	18.1	53.2
Minimum Value:		**2.4**	**2.7**	**9.7**	**4.9**	**55.3**	**3.5**	**1.8**
Maximum Value:		**43.2**	**24.4**	**57.1**	**62.3**	**347**	**50.8**	**84.3**
Geometric Mean:		**15.2**	**12.7**	**29.8**	**23.4**	**126**	**23.6**	**39.6**

4.7 Isotope Analyses

A tabular summary of isotope analyses conducted on Lake Jesup sediments is given on Table 4-8. The results of the isotope analyses will be discussed in a separate report prepared by the Colorado Isotope Laboratory.

5. SEDIMENT INACTIVATION COST ANALYSIS

A supplemental analysis was conducted to prepare a cost estimate for sediment inactivation in Lake Jesup to provide information for comparison of potential lake restoration projects. This analysis is based upon the speciation of phosphorus bonding in Lake Jesup sediments, summarized in Table 4-7. Since seepage flux also migrates through the sediments, the analysis includes both phosphorus loadings from sediments and from groundwater seepage entering Lake Jesup.

5.1 Introduction

Sediment phosphorus inactivation is a lake restoration technique which is designed to reduce sediment phosphorus release by combining available phosphorus in the sediments with a metal salt to form an insoluble inert precipitate, rendering the sediment phosphorus unavailable for release into the overlying water column. Although salts of aluminum, calcium, and iron have been used for sediment inactivation in previous projects, aluminum salts are the clear compounds of choice for this application. Inactivation of sediment phosphorus using aluminum is often a substantially less expensive option for reducing sediment phosphorus release since removal of the existing sediments is not required.

Sediment phosphorus inactivation is most often performed using aluminum sulfate, commonly called alum, which is applied at the surface in a liquid form using a boat or barge. Upon entering the water column, the alum forms an insoluble precipitate of aluminum hydroxide which attracts phosphorus, bacteria, algae, and suspended solids within the water column, settling these constituents into the bottom sediments. Upon reaching the bottom sediments, the residual aluminum binds tightly with phosphorus within the sediments, forming an inert precipitate which will not be re-released under any conceivable condition of pH or redox potential which could occur in a natural lake system. These sediment treatments have been shown to be effective from 5-20 years, depending upon the sediment accumulation rate within the lake from the remaining phosphorus sources.

5.2 Chemical Requirements

Sediment inactivation in Lake Jesup would involve addition of liquid aluminum sulfate at the water surface using an application boat. Upon entering the sediments, the alum will combine with existing phosphorus within the sediments, primarily saloid- and iron-bound associations, forming insoluble inert precipitates which will bind the phosphorus, making it unavailable for release into the overlying water column. It is generally recognized that the top 10 cm layer of the sediments is the most active in terms of release of phosphorus under both aerobic and anoxic conditions. Therefore, the objective of a sediment inactivation project is to provide sufficient alum to bind the saloid- and iron-bound phosphorus associations in the top 10 cm of the sediments.

TABLE 4-8

RESULTS OF SEDIMENT ISOTOPE ANALYSES CONDUCTED ON LAKE JESUP SEDIMENTS

SAMPLE I.D.	SITE	DATE ANALYZED	POSITION	MASS (mg)	CO_2 Ampl (volts)	N_2 Ampl (volts)	CO_2 Area (V/s)	N_2 Area (V/s)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)
S14-273	LJ-1	25-Aug-14	95	19.884	5.69	3.63	142.42	53.94	-17.86	2.08
S14-274	LJ-2	25-Aug-14	6	9.999	4.34	3.67	96.51	56.16	-22.68	1.06
S14-265	LJ-3	25-Aug-14	96	10.391	3.92	3.09	87.01	48.61	-22.46	1.97
S14-305	LJ-4	25-Aug-14	28	20.080	5.19	4.70	122.45	70.26	-21.95	2.08
S14-306	LJ-5	25-Aug-14	12	9.996	4.29	3.03	94.90	46.33	-21.46	1.38
S14-266	LJ-6	25-Aug-14	10	10.091	3.80	3.09	81.83	47.82	-23.04	0.61
S14-270	LJ-7	25-Aug-14	5	9.986	4.08	3.37	89.70	51.50	-21.74	1.34
S14-303	LJ-8	25-Aug-14	11	10.047	2.55	1.84	52.60	29.74	-22.92	1.12
S14-304	LJ-9	25-Aug-14	27	19.955	3.77	1.97	81.79	30.85	-17.84	3.15
S14-307	LJ-10	25-Aug-14	29	19.972	2.75	1.58	57.44	25.10	-23.28	3.56
S14-310	LJ-11	25-Aug-14	30	20.047	2.95	2.32	62.29	36.86	-18.11	2.70
S14-275	LJ-12	25-Aug-14	7	10.051	3.67	3.13	78.72	48.38	-23.14	0.13
S14-267	LJ-13	25-Aug-14	98	10.515	3.30	2.60	70.37	41.58	-22.87	1.58
S14-271	LJ-14	25-Aug-14	21	20.025	2.70	1.98	56.32	31.25	-22.78	1.43
S14-301	LJ-15	25-Aug-14	99	9.989	3.78	3.31	82.40	51.75	-22.61	1.16
S14-302	LJ-16	25-Aug-14	103	9.952	3.73	3.08	81.16	48.42	-22.12	1.82
S14-308	LJ-17	25-Aug-14	53	69.824	0.83	0.77	17.81	13.79	-21.25	1.57
S14-309	LJ-18	25-Aug-14	41	29.977	3.28	1.88	69.78	29.57	-26.58	1.55
S14-311	LJ-19	25-Aug-14	31	20.059	3.58	2.75	76.98	42.77	-19.76	1.89
S14-312	LJ-20	25-Aug-14	110	10.619	3.48	2.73	74.61	43.35	-20.12	1.88
S14-278	LJ-21	25-Aug-14	9	10.119	4.22	2.71	92.87	41.49	-24.12	1.44
S14-276	LJ-22	25-Aug-14	8	10.044	2.86	1.71	59.82	27.40	-24.42	0.68
S14-269	LJ-23	25-Aug-14	104	10.570	3.19	2.50	67.57	40.02	-21.98	2.01
S14-336	LJ-24	25-Aug-14	101	10.108	3.81	3.28	83.51	51.37	-22.06	1.75
S14-337	LJ-25	25-Aug-14	54	69.982	1.16	0.48	24.55	8.62	-12.11	1.38
S14-338	LJ-26	25-Aug-14	48	30.089	4.62	1.72	104.73	26.94	-16.42	2.56
S14-339	LJ-27	25-Aug-14	16	9.957	2.78	2.50	57.64	39.90	-21.27	0.40
S14-340	LJ-28	25-Aug-14	94	10.377	2.98	0.91	64.30	14.91	-7.81	4.37
S14-313	LJ-29	25-Aug-14	14	10.315	3.60	2.90	76.56	45.10	-21.13	1.19
S14-314	LJ-30	25-Aug-14	106	10.409	3.94	2.95	86.46	45.80	-18.41	1.75
S14-348	LJ-31	25-Aug-14	18	9.998	2.52	1.78	52.23	28.78	-20.72	1.93
S14-347	LJ-32	25-Aug-14	58	70.012	7.59	4.70	217.45	67.49	-11.73	2.50
S14-346	LJ-33	25-Aug-14	39	19.983	3.16	2.52	67.18	39.49	-21.59	2.45
S14-342	LJ-34	25-Aug-14	56	70.009	1.64	1.23	33.85	20.98	-19.78	1.59
S14-341	LJ-35	25-Aug-14	100	10.445	3.31	2.94	70.60	46.78	-20.35	1.58
S14-322	LJ-36	25-Aug-14	34	19.953	4.01	3.75	88.18	57.68	-22.04	2.02
S14-315	LJ-37	25-Aug-14	109	10.599	2.94	1.99	61.64	32.11	-18.95	2.15
S14-316	LJ-38	25-Aug-14	108	9.993	3.64	2.40	78.55	37.88	-19.16	2.25
S14-345	LJ-39	25-Aug-14	38	19.922	3.95	3.28	86.44	50.49	-21.45	2.32
S14-344	LJ-40	25-Aug-14	17	9.954	2.29	1.74	47.05	28.20	-21.53	1.28
S14-343	LJ-41	25-Aug-14	57	69.968	0.68	0.58	13.68	10.31	-22.85	2.62
S14-321	LJ-42	25-Aug-14	33	20.025	5.54	4.81	134.01	71.81	-20.34	2.33
S14-317	LJ-43	25-Aug-14	46	30.054	4.94	3.49	113.94	52.82	-18.37	1.70
S14-318	LJ-44	25-Aug-14	107	9.972	3.09	2.13	65.17	34.12	-18.54	1.94
S14-319	LJ-45	25-Aug-14	15	10.044	3.63	3.02	77.64	47.12	-21.32	1.73
S14-320	LJ-46	25-Aug-14	32	19.967	5.38	5.02	128.69	75.12	-20.26	2.35
S14-277	LJ-A	25-Aug-14	102	10.471	4.58	4.12	104.89	62.76	-22.55	1.92
S14-272	LJ-B	25-Aug-14	97	9.849	4.09	3.58	91.43	55.57	-22.29	1.39
S14-268	LJ-C	25-Aug-14	4	10.080	3.43	2.91	73.04	45.11	-23.32	0.26
				Minimum Value:	**0.68**	**0.48**	**13.68**	**8.62**	**-26.58**	**0.13**
				Maximum Value:	**7.59**	**5.02**	**217.45**	**75.12**	**-7.81**	**4.37**

Isopleths of saloid-bound phosphorus concentrations in the top 10 cm of Lake Jesup sediments were generated using the measured sediment speciation data summarized in Table 4-7. An isopleth map of saloid-bound phosphorus concentrations in Lake Jesup sediments is given on Figure 5-1. In general, areas of highest saloid-bound phosphorus concentrations appear to correspond roughly with areas of the largest muck accumulations. In general, saloid-bound phosphorus concentrations in Lake Jesup are approximately 10 times greater than saloid-bound phosphorus typically measured by ERD in urban lakes.

An isopleth map of iron-bound concentrations in the top 10 cm of Lake Jesup sediments is given in Figure 5-2. Areas of iron-bound phosphorus also correspond roughly with areas of highest sediment accumulations within the lake. In contrast to the substantially elevated concentrations of saloid-bound phosphorus, iron-bound phosphorus concentrations in Lake Jesup sediments are substantially lower in value than commonly observed by ERD in urban lakes.

Total available phosphorus is defined as the sum of saloid-bound and iron-bound phosphorus associations in lake sediments. Isopleths of total available phosphorus in the top 10 cm of Lake Jesup sediments are illustrated on Figure 5-3. Total available phosphorus isopleths range from approximately 20-55 $\mu g/cm^3$ throughout the lake. The top 0-10 cm layer of the sediments is considered to be the most active layer with respect to exchange of phosphorus between the sediments and the overlying water column. Inactivation of phosphorus within the 0-10 cm layer is typically sufficient to substantially eliminate sediment release of phosphorus within a lake. Prior research involving sediment inactivation has indicated that an excess of aluminum is required within the sediments to cause phosphorus to preferentially bind with aluminum rather than other available competing agents. Previous sediment inactivation projects performed by ERD have been conducted at molar Al:P ratios of 2, 3, 5, and 10, with most recent sediment inactivation projects performed using a 10:1 ratio which has been demonstrated to reduce available sediment phosphorus by 80-90%.

A summary of estimated total available phosphorus in the sediments of Lake Jesup is given in Table 5-1. On a mass basis, the sediments of Lake Jesup contain approximately 106,126 kg of available phosphorus in the top 10 cm. On a molar basis, this equates to approximately 3,423,415 moles of available phosphorus to be inactivated. A summary of alum requirements for sediment inactivation is also provided in Table 5-1. Using an Al:P ratio of 10:1, sediment inactivation in the Lake Jesup would require approximately 4,168,616 gallons of alum, equivalent to approximately 926 tankers. The equivalent aerial aluminum dose for this application would be 28.3 g Al/m^2 based on an assumed lake area of 8,068 acres.

Previous alum surface applications performed for inactivation of sediment phosphorus release by ERD have indicated that the greatest degree of improvement in surface water characteristics and the highest degree of inactivation of sediment phosphorus release are achieved when the total recommended alum addition occurs through multiple applications of aluminum to the waterbody spaced at intervals of approximately 3-6 months. Using multiple applications also reduces the applied water column alum dose and can eliminate the need for additional chemicals (such as sodium aluminate) to buffer the water column which can substantially enhance the treatment cost. Each subsequent application results in additional improvements in water column quality and additional aluminum floc added to the sediments for long-term inactivation of sediment phosphorus release.

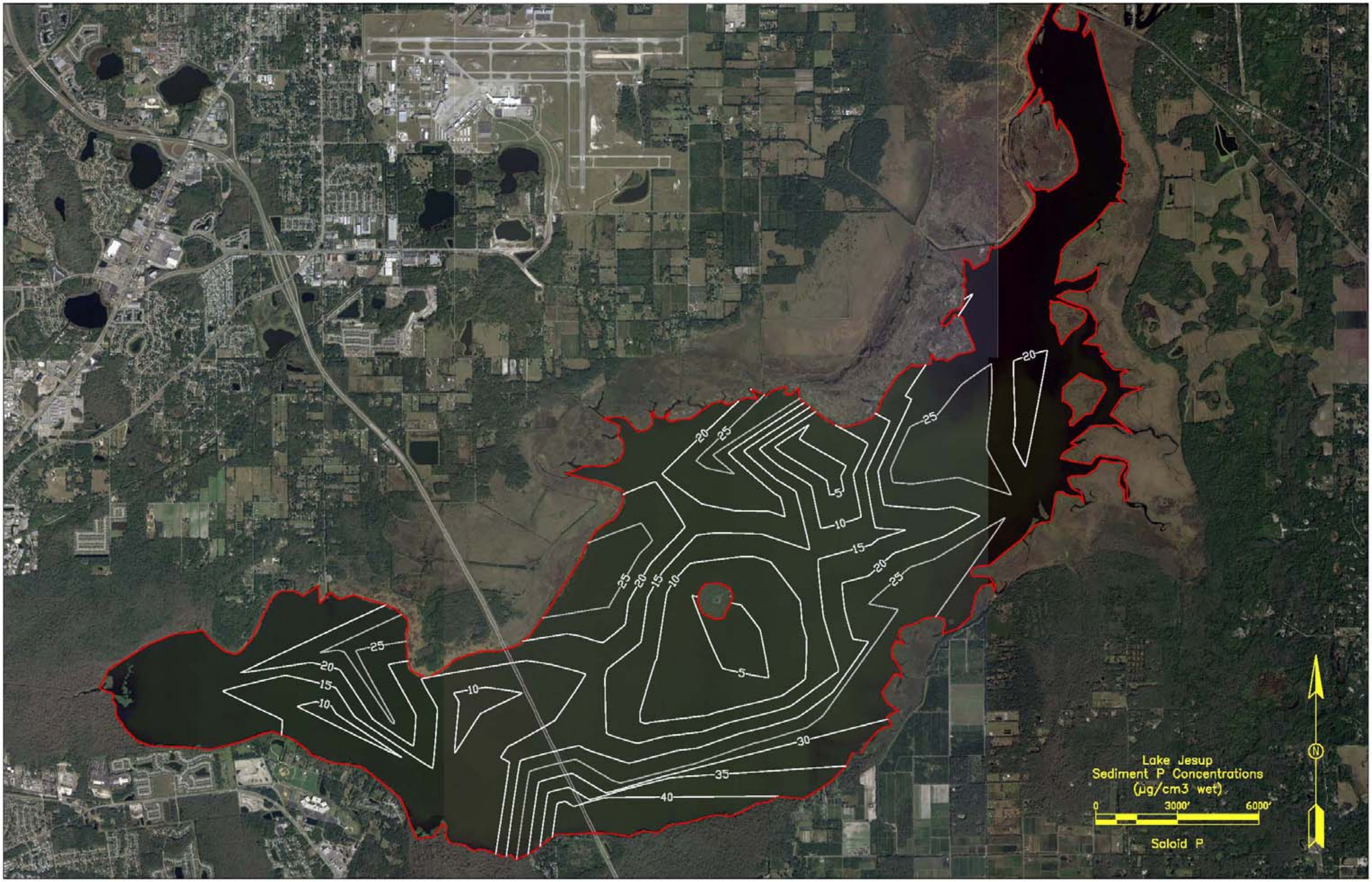


Figure 5-1. Isopleths of Saloid-Bound Phosphorus in the Top 10 cm of Lake Jesup Sediments.

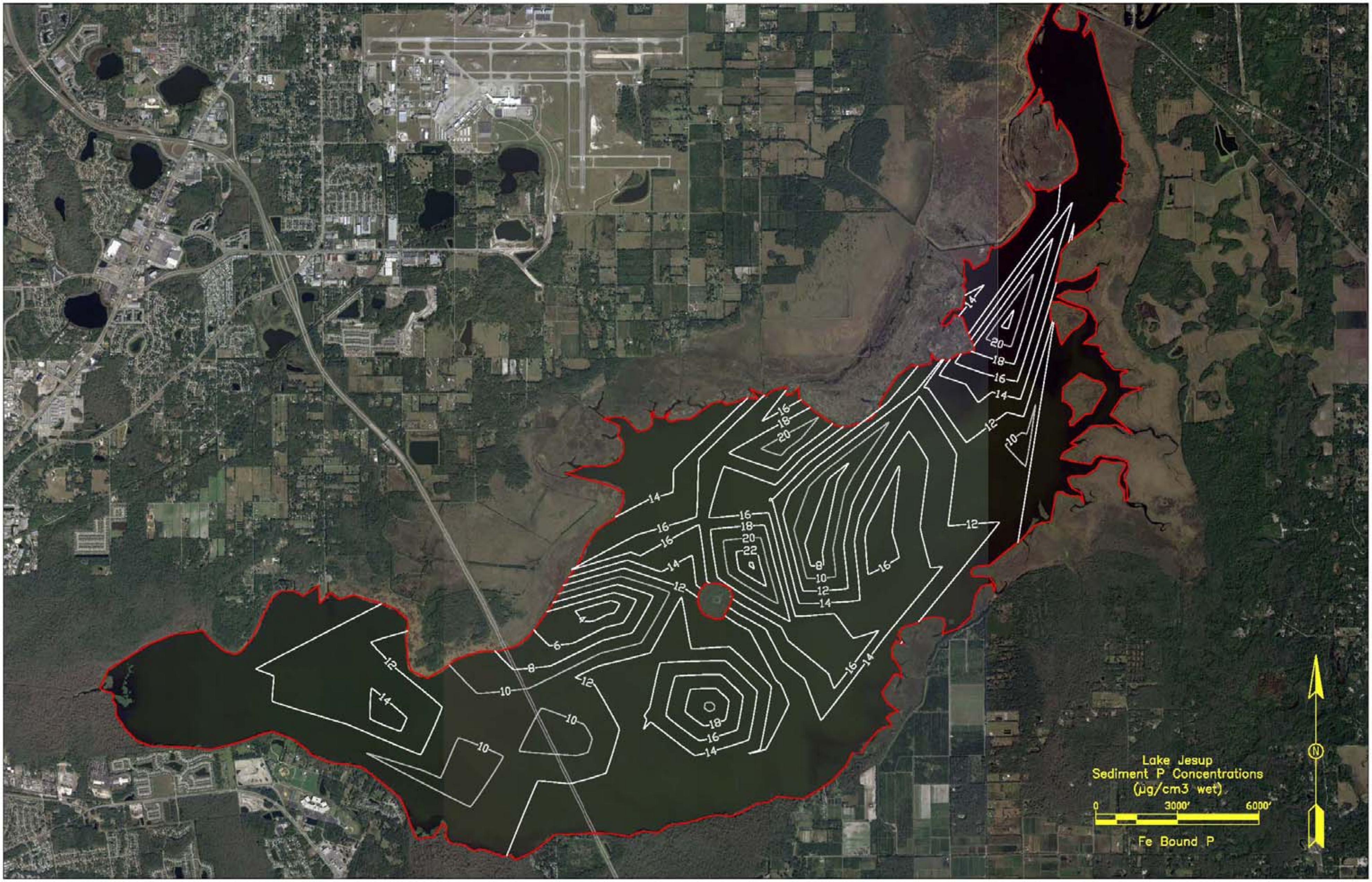


Figure 5-2. Isopleths of Iron-Bound Phosphorus in the Top 10 cm of Lake Jesup Sediments.

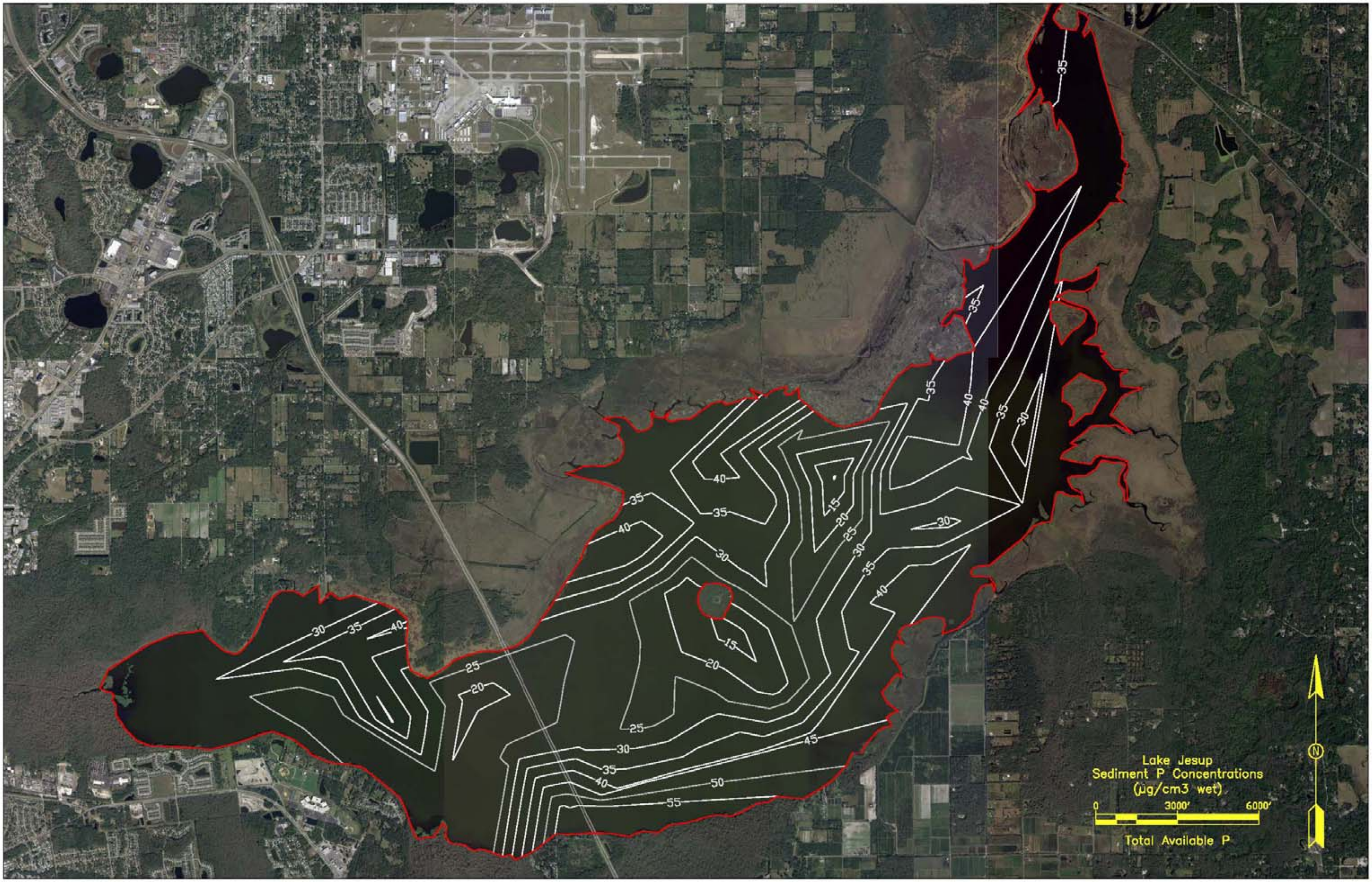


Figure 5-3. Isopleths of Total Available Phosphorus in the Top 10 cm of Lake Jesup Sediments.

TABLE 5-1

SUMMARY OF SEDIMENT AVAILABLE PHOSPHORUS AND INACTIVATION REQUIREMENTS FOR LAKE JESUP

AVAILABLE P CONTOUR INTERVAL (μg/cm³)	CONTOUR INTERVAL MID-POINT (μg/cm³)	CONTOUR AREA (acres)	AVAILABLE PHOSPHORUS		ALUM REQUIREMENTS (Al:P Ratio = 10:1)	
			kg	moles	moles Al	gallons alum
< 10	7.5	0.10	0	10	102	12
10-15	12.5	55.8	282	9,112	91,116	11,095
15-20	17.5	317	2,247	72,472	724,719	88,247
20-25	22.5	1,267	11,540	372,273	3,722,733	453,309
25-30	27.5	1,707	19,005	613,074	6,130,740	746,526
30-35	32.5	1,410	18,548	598,320	5,983,200	728,561
35-40	37.5	2,098	31,860	1,027,755	10,277,549	1,251,474
40-45	42.5	704	12,107	390,547	3,905,471	475,560
45-50	47.5	181	3,480	112,245	1,122,449	136,678
50-55	52.5	180	3,834	123,679	1,236,787	150,601
> 55	57.5	138	3,222	103,929	1,039,286	126,552
Overall Totals:		**8,058**	**106,126**	**3,423,415**	**34,234,153**	**4,168,616**

Additional aluminum can also be added to the sediments to create an active absorption mechanism for phosphorus inputs into the water column as a result of groundwater seepage. An evaluation of hydrologic and nutrient loadings from groundwater seepage to Lake Jesup was conducted by ERD from 2009-2010. Groundwater seepage meters were installed at 40 locations within Lake Jesup, and 9 separate monitoring events were conducted over a 14-month field monitoring program. Groundwater seepage entering Lake Jesup was characterized by elevated levels of total phosphorus, with an estimated annual phosphorus influx of 9,484 kg/yr from groundwater seepage. A carefully planned application of alum can provide an abundance of aluminum which can intercept groundwater inputs of phosphorus over a period of many years. As a result, alum applications can be used to eliminate phosphorus from the combined inputs resulting from internal recycling as well as groundwater seepage.

A summary of calculations of alum requirements for control of phosphorus loading from groundwater seepage is given in Table 5-2. This analysis is based upon the measured phosphorus seepage loadings to Lake Jesup of 9,484 kg/yr and assumes a control period of 10 years. Over the 10-year control period, approximately 94,840 kg of phosphorus will enter Lake Jesup through groundwater seepage. This is equivalent to approximately 3,059,355 moles of phosphorus to be inactivated.

TABLE 5-2

ALUM REQUIREMENTS FOR SEEPAGE CONTROL IN LAKE JESUP

PARAMETER		UNITS	VALUE
Estimated Phosphorus Mass to be Controlled	Seepage Phosphorus Loading	g/m^2-yr	0.234
	Annual Phosphorus Loading from Seepage	kg/yr	9,484
	Desired Length of Control	years	10
	Total Phosphorus Mass to be Inactivated	kg	94,840
	Moles of Phosphorus to be Inactivated	moles	3,059,355
Alum Requirements	Inactivation Al:P Ratio	--	10:1
	Moles of Aluminum Required	moles	30,593,548
	Alum Required	gallons	3,725,307
	Number of Tankers @ 4,500 gallons	--	828
	Mean Water Column Dose	mg Al/liter	20.8

Assuming an inactivation Al:P ratio of 10:1, inactivation of 3,059,355 moles of phosphorus will require 30,593,548 moles of aluminum which is equivalent to approximately 3,725,307 gallons of alum. This volume of alum is equivalent to approximately 828 tankers containing 4,500 gallons each, with an overall mean water column dose of 20.8 mg Al/liter.

In addition to the estimated alum requirements for sediment inactivation and seepage control, additional alum will also be consumed for removal of total phosphorus within the water column of the lake during each proposed alum application. However, the amount of alum required for removal of water column phosphorus is typically minimal in comparison with the volume of alum added for sediment inactivation and seepage control. A summary of alum requirements for removal of water column phosphorus concentrations in Lake Jesup is given in Table 5-3. This analysis assumes a mean water column volume of approximately 32,231 ac-ft and a mean water column total phosphorus concentration of 100 μg/l. The corresponding water column total phosphorus mass is 3,975 kg or 128,224 moles of total phosphorus. For removal of water column phosphorus, an Al:P ratio of 1:1 is assumed. The required alum for removal of water column total phosphorus is approximately 15,613 gallons per application. This value is insignificant in comparison with the alum requirements for sediment inactivation and seepage control. It is assumed that this volume of alum would be required for water column phosphorus removal during each of the proposed applications, even though water column concentrations will likely be reduced from the assumed value of 100 μg/l as the application process progresses.

TABLE 5-3

ALUM REQUIREMENTS FOR WATER COLUMN TOTAL PHOSPHORUS REMOVAL

PARAMETER		UNITS	VALUE
Estimated Phosphorus Mass in Water Column	Water Column Volume	ac-ft	32,231
	Mean Total Phosphorus Concentration	μg/l	100
	Water Column Total Phosphorus Mass	kg moles	3,975 128,224
Alum Requirements	Applied Al:P Ratio	--	1:1
	Moles of Aluminum Required	moles	128,224
	Alum Required	gallons	15,613
	Number of Tankers @ 4,500 gallons	--	3.5

A summary of chemical requirements for sediment inactivation and seepage control in Lake Jesup is given in Table 5-4. The combined quantity of alum required to inactivate sediment phosphorus release and intercept seepage phosphorus loadings is 7,893,923 gallons of alum, equivalent to 1,754 tankers. The water column dose, if the entire alum volume were to be applied during a single application, would be 44 mg Al/liter, equivalent to an areal dose of 53.7 g Al/m^2.

TABLE 5-4

CHEMICAL REQUIREMENTS FOR SEDIMENT INACTIVATION AND SEEPAGE CONTROL IN LAKE JESUP

PARAMETER		UNITS	VALUE
Alum Quantity	Inactivation + Seepage	gallons	7,893,923
	Number of Tankers	--	1,754
	Water Column Dose	mg Al/liter	44.0
	Areal Dose	g Al/m^2	53.7
Chemical Requirements per Treatment	Number of Treatments	--	6
	Alum Required per Treatment[1]	gallons	1,331,267
	Dose per Treatment	mg Al/liter	7.3
	Number of Tankers @ 4,500 gallons	--	296

1. Includes an additional 15,613 gallons for removal of water column total phosphorus

The calculated whole water column dose of 44.0 mg Al/liter far exceeds the buffering capacity within Lake Jesup, and multiple applications will be required to avoid undesirable pH impacts or the use of supplemental buffering compounds. A minimum of six separate applications is recommended for Lake Jesup, with one-sixth of the total aluminum mass added during each treatment. If the overall recommended application were to be divided into six individual applications, the overall mean water column dose would be approximately 7.3 mg Al/liter which could likely be tolerated without significant pH impact. The alum volume added during each application would be 1,315,654 gallons, equivalent to 292 tankers. Each application would cover the entire lake area, with the alum volume of 1,315,654 gallons applied on a weighted basis according to the available phosphorus isopleth map given on Figure 5-3.

5.3 Cost Analysis

A summary of estimated costs for sediment inactivation and seepage control in Lake Jesup is given in Table 5-5, based upon the information and assumptions provided in Table 5-4. Application costs are calculated assuming that six separate applications will be conducted, with approximately 1,331,267 gallons added during each application. Planning and mobilization costs are assumed at $25,000 per application, and alum costs are based upon a unit contract price of $0.55/gallon. Costs are also included for field monitoring and laboratory analyses.

TABLE 5-5

ESTIMATED COSTS FOR SEDIMENT INACTIVATION AND SEEPAGE CONTROL IN LAKE JESUP

PARAMETER		QUANTITY/ TREATMENT	UNITS	UNIT COST ($)	COST/ TREATMENT	TOTAL COST ($)
Chemical Costs	Alum	1,331,267	gallons	0.55	732,197	4,393,182
Labor Costs	Planning and Mobilization	1	each	25,000	25,000	150,000
	Chemical Application	296	tankers	1,000	296,000	1,776,000
Monitoring and Lab Testing	Field Monitoring	1	each	500	500	3,000
	Lab Analyses (Pre-/Post-)	16	samples	200	3,200	19,200
				TOTAL:	**$ 1,056,897**	**$ 6,341,382**

The overall estimated cost for each of the six applications is $1,056,897 or $6,341,382 for the total project cost. However, since the applications would be spaced approximately six months apart, the overall project cost would be spread out over multiple fiscal years. A summary of calculated phosphorus removal costs for sediment inactivation and seepage control in Lake Jesup is given in Table 5-6 based upon a 10-year cost cycle. The alum addition is expected to reduce loadings from internal recycling and seepage inflow by approximately 80% each, resulting in an overall phosphorus load reduction of approximately 160,772 kg over the 10-year period of analysis. Based upon the estimated overall project cost of $6,341,382, the calculated phosphorus removal costs are $39/kg or approximately $18/pound.

TABLE 5-6

PHOSPHORUS REMOVAL COSTS FOR SEDIMENT INACTIVATION AND SEEPAGE CONTROL IN LAKE JESUP

PARAMETER		UNITS	VALUE
Existing Total Phosphorus Loadings	Internal Recycling	kg	106,126
	Seepage Inflow	kg	94,840
	Total:	**kg/yr**	**200,966**
Removal by Alum Treatment	Internal Recycling	% kg	80 84,900
	Seepage Inflow	% kg	80 75,872
	Total:	**kg**	**160,772**
Alum Treatment Cost	Internal Recycling + Seepage	$	6,340,405
Total Phosphorus Removal Cost		$/kg lb/kg	39 18

5.4 Longevity of Treatment

After initial application, the alum precipitate will form a visible floc layer on the surface of the sediments within the lake. This floc layer will continue to consolidate for approximately 30-90 days, reaching maximum consolidation during that time. Due to the unconsolidated nature of the sediments in much of the lake, it is anticipated that a large portion of the floc will rapidly migrate into the existing sediments rather than accumulate on the surface as a distinct layer. This process is beneficial since it allows the floc to sorb soluble phosphorus during migration through the surficial sediments. Any floc remaining on the surface will provide a chemical barrier for adsorption of phosphorus which may be released from the sediments.

More than 30 sediment inactivation projects have been conducted in the State of Florida on a wide variety of waterbody sizes, depths, and water quality characteristics. Each of these treatments has resulted in substantial improvements in water quality characteristics. The observed improvements in water quality have lasted from a minimum of 10 years to more than 20 years.

The evaluated alum application to Lake Jesup would be an extremely large project. ERD is not aware of any previous projects which have been conducted on a lake of this size and shallow water depth. Although there are no conceivable reasons why the proposed sediment inactivation would not be effective, it may be prudent to conduct a pilot project on a portion of the lake, perhaps in areas west of the S.R. 417 bridge, to evaluate the success and impacts of an alum treatment prior to implementation of a whole-lake treatment.

APPENDIX A

PHOTOGRAPHS OF SEDIMENT CORE SAMPLES COLLECTED IN LAKE JESUP

Lake Jesup – Site LJ - 1

Lake Jesup – Site LJ - 2

Lake Jesup – Site LJ - 3

Lake Jesup – Site LJ - 4

Lake Jesup – Site LJ - 5

Lake Jesup – Site LJ - 6

Lake Jesup – Site LJ - 7

Lake Jesup – Site LJ - 8

Lake Jesup – Site LJ - 9

Lake Jesup – Site LJ - 10

Lake Jesup – Site LJ – 11

Lake Jesup – Site LJ – 12

Lake Jesup – Site LJ - 13

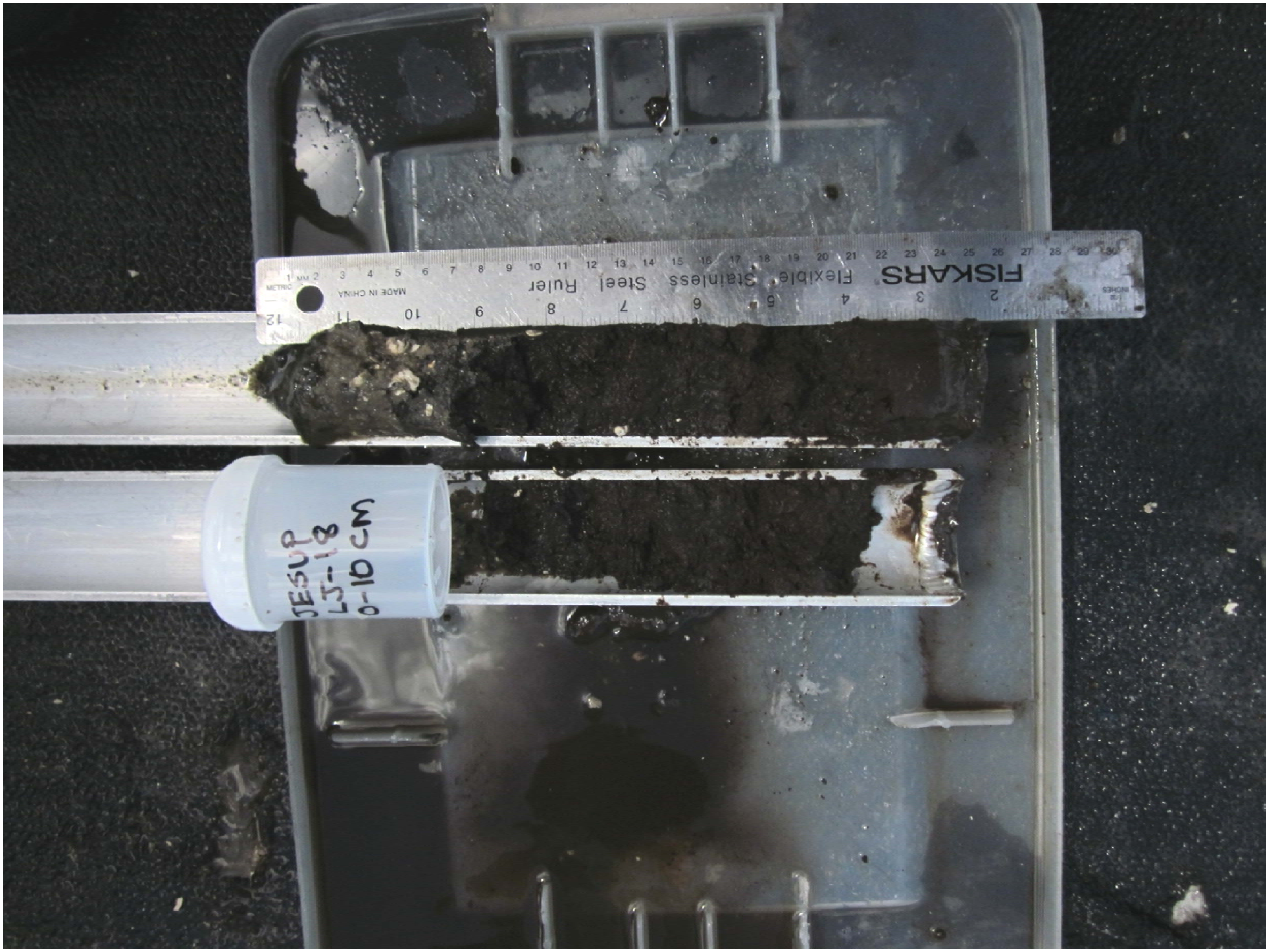
Lake Jesup – Site LJ - 14

Lake Jesup – Site LJ - 15

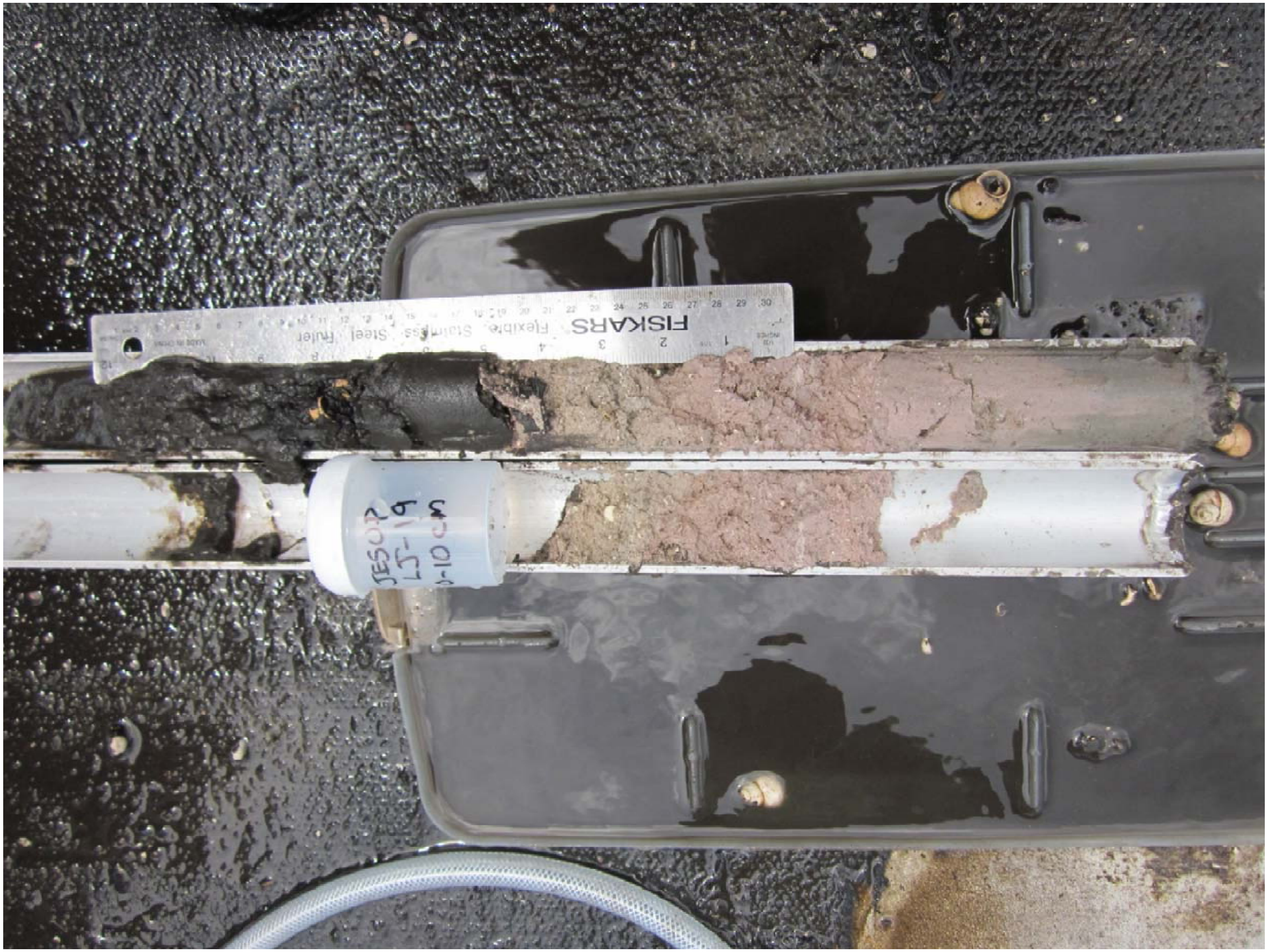
Lake Jesup – Site LJ - 16

Lake Jesup – Site LJ - 17

Lake Jesup – Site LJ - 18



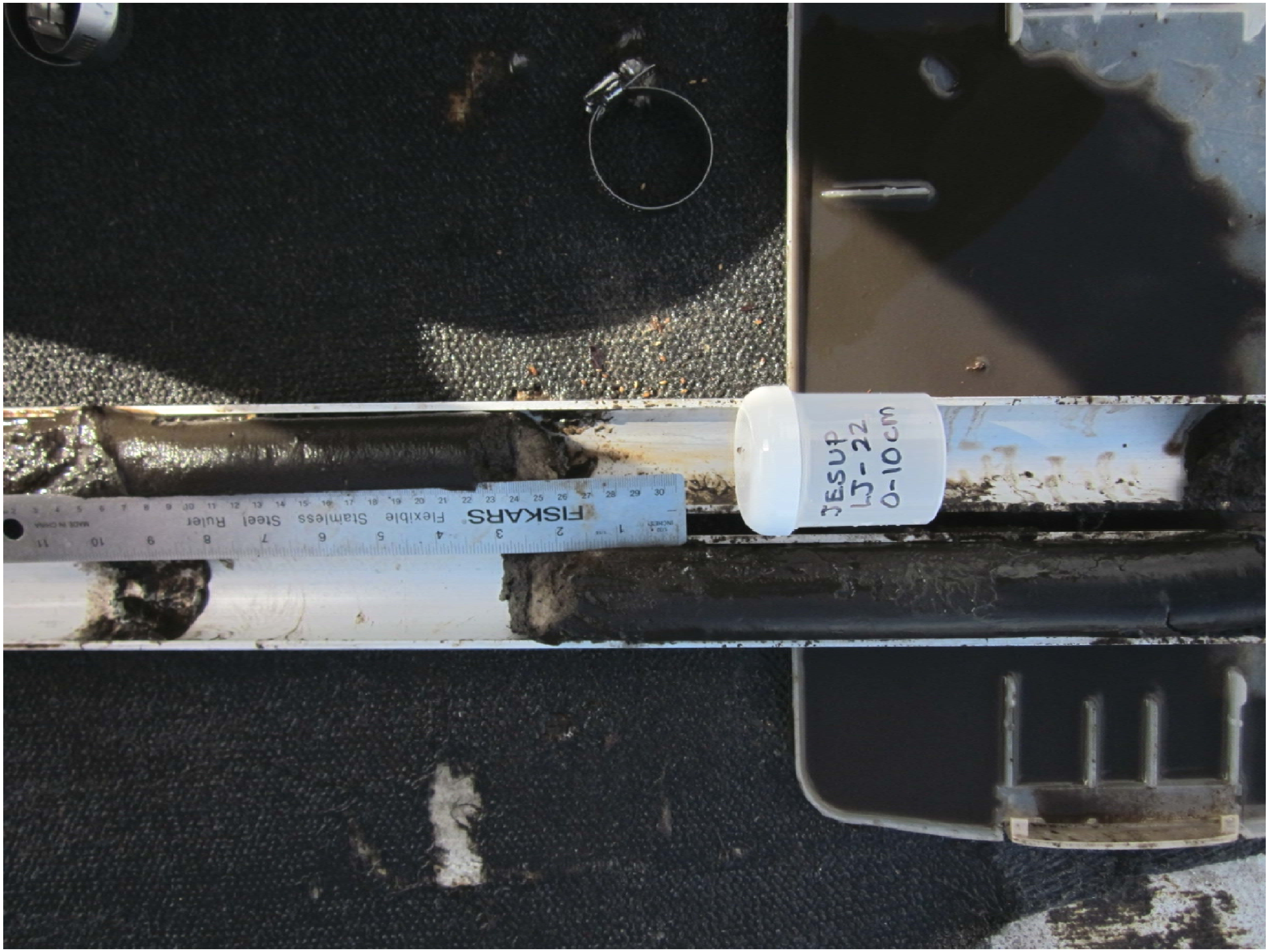
Lake Jesup – Site LJ - 19



Lake Jesup – Site LJ - 20

Lake Jesup – Site LJ – 21

Lake Jesup – Site LJ – 22



Lake Jesup – Site LJ - 23

Lake Jesup – Site LJ - 24

Lake Jesup – Site LJ - 25

Lake Jesup – Site LJ – 26

(Bottle labeled incorrectly – changed during lab log-in)

Lake Jesup – Site LJ - 27

Lake Jesup – Site LJ - 28

Lake Jesup – Site LJ - 29

Lake Jesup – Site LJ - 30

Lake Jesup – Site LJ - 31

Lake Jesup – Site LJ - 32

Lake Jesup – Site LJ - 33

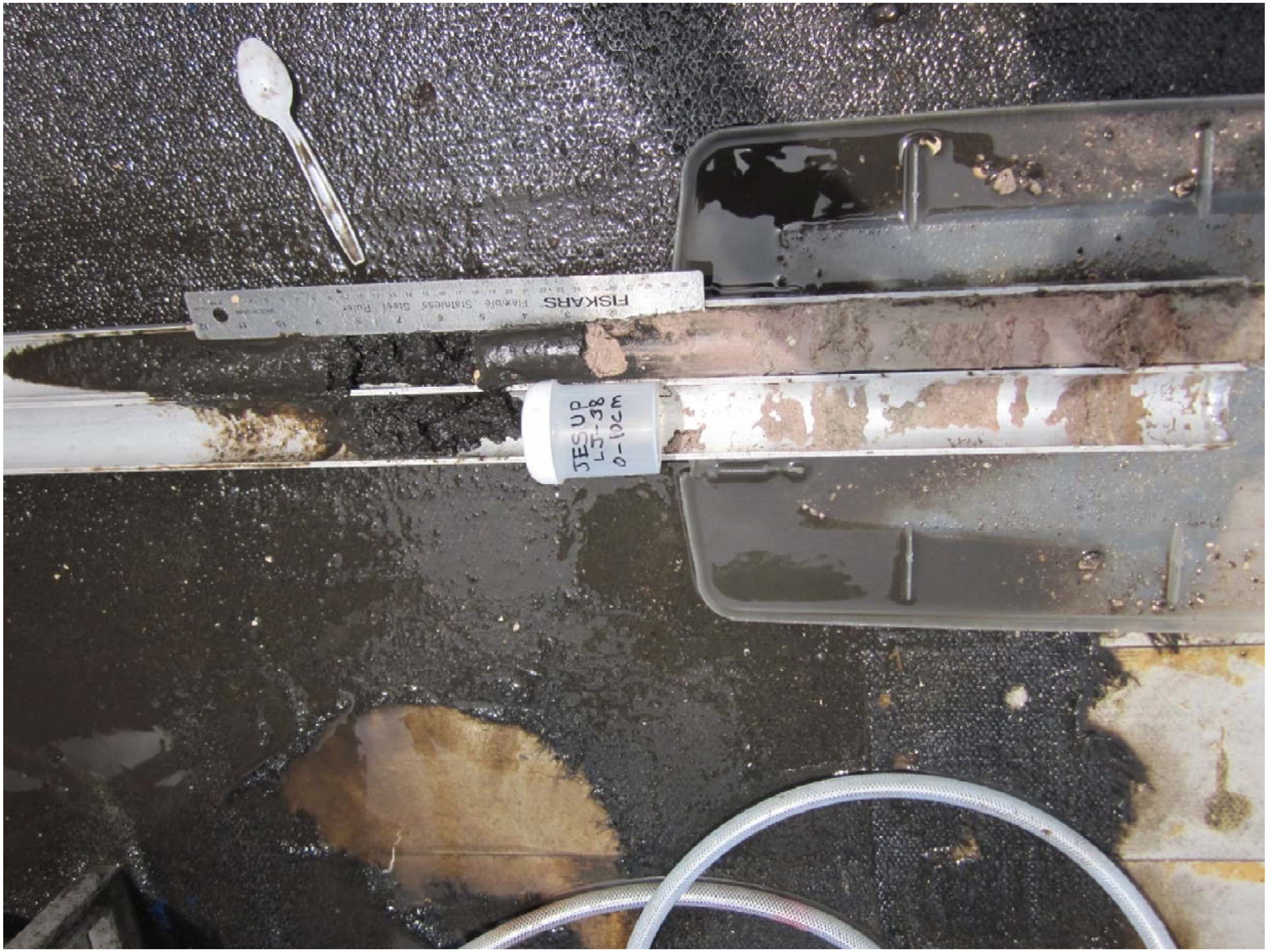
Lake Jesup – Site LJ - 34

Lake Jesup – Site LJ - 35

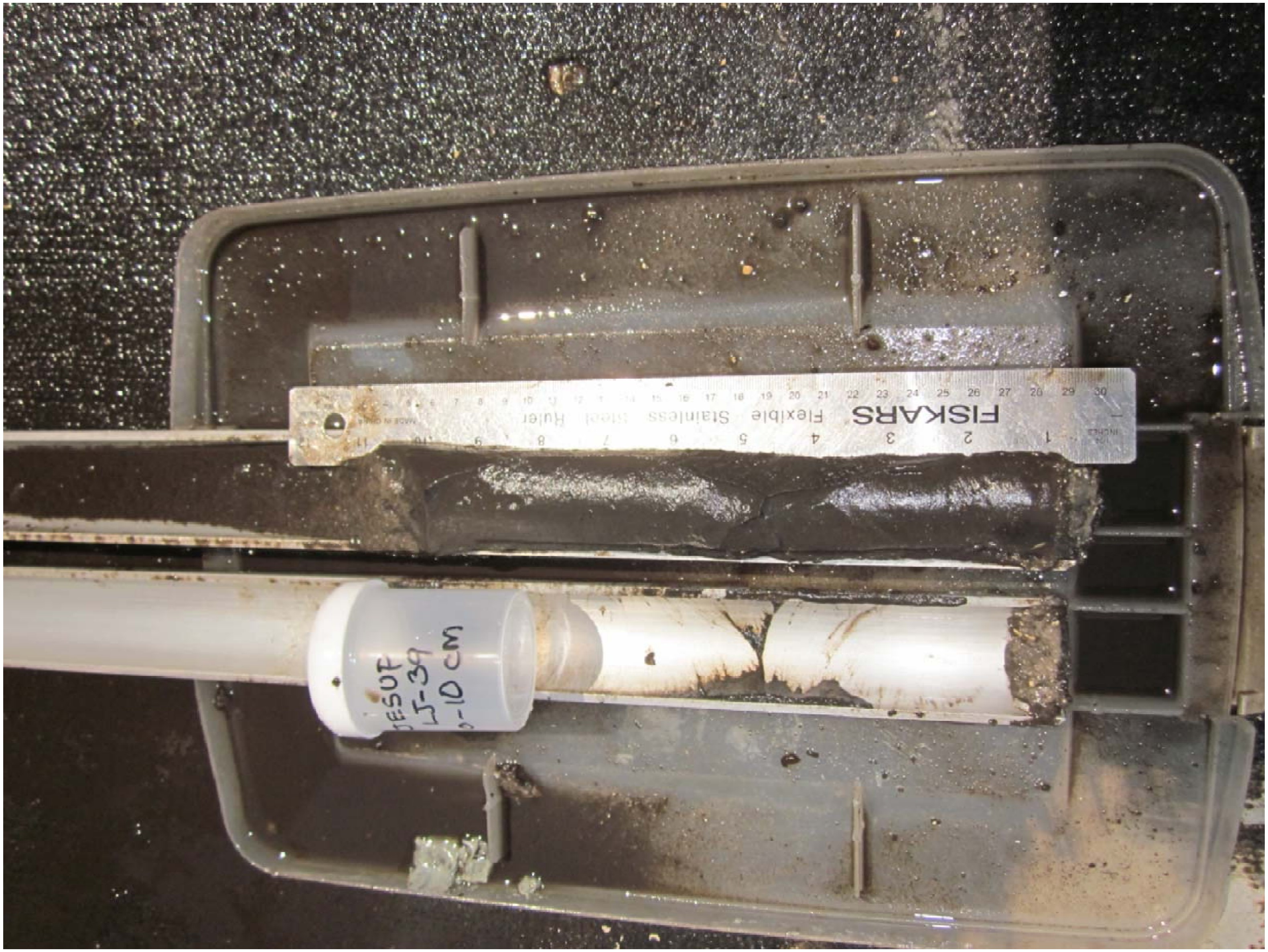
Lake Jesup – Site LJ - 36

Lake Jesup – Site LJ - 37

Lake Jesup – Site LJ - 38



Lake Jesup – Site LJ - 39



Lake Jesup – Site LJ - 40

Lake Jesup – Site LJ - 41

Lake Jesup – Site LJ - 42

Lake Jesup – Site LJ - 43

Lake Jesup – Site LJ - 44

Lake Jesup – Site LJ - 45

Lake Jesup – Site LJ - 46

Lake Jesup – Site LJ - A

Lake Jesup – Site LJ - B

Lake Jesup – Site LJ - C