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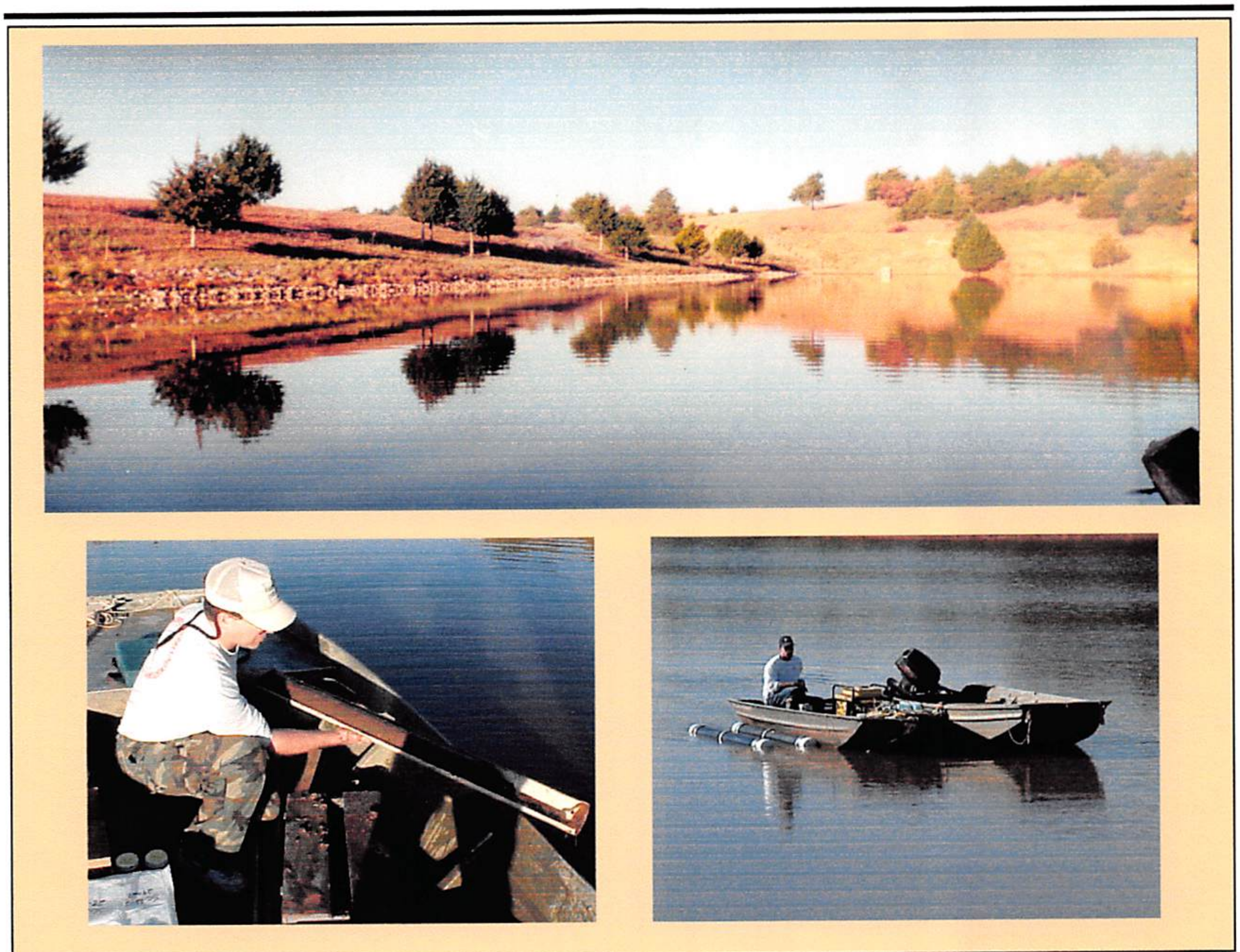
Research
Service

National Sedimentation Laboratory
Oxford, Mississippi 38655

Assessing Sedimentation Issues within Aging Flood Control Dams, Oklahoma



By Sean J. Bennett and Charles M. Cooper

Research Report No. 15

April 2000

A preliminary report prepared for the USDA-NRCS, Stillwater, OK

Executive Summary

Since 1948, the USDA-NRCS has constructed over 10,000 upstream flood-control dams in 2000 watersheds in 47 states, over two-thirds of these dams have a design life of 50 years. Because of population growth, land-use changes, and time, sediment pools are filling, some structural components have deteriorated, safety regulations are stricter, and the hazard classification has changed for some dams. Before any rehabilitation strategy can be designed and implemented, the sediment impounded by these dams must be assessed in terms of the structure's efficiency to regulate floodwaters and the potential hazard the sediment may pose if reintroduced into the environment. To this end, a demonstration project was designed to evaluate technologies, methodologies, and protocols for the cost-effective characterization of sediment. This report represents the completion of Phase I of the project and comprises seismic surveying at all locations and sediment quality analysis of select samples.

Three field sites were chosen for this project. Sugar Creek #12 and Sugar Creek #14 are located near Hinton, OK, and historic land use of cultivated fields of cotton and peanuts at Sugar Creek #12 suggests that agrochemicals may be present in the lake sediments. Sergeant Major #4 is located near Cheyenne, OK, and it has become the sole water supply for the town of Cheyenne. Thus, preserving water quality is a major concern.

In November 1999, seismic surveys of each lake were successfully completed. Seismic profiles at Sugar Creek #12 and Sugar Creek #14 show the presence of soft sediment near the bed surface, approximately 0.1 to 0.2 m thick, and this sediment is ubiquitous across each lake. In both reservoirs, a very strong seismic reflector of unknown origin is observed at a depth of 0.2 m. Very few deep reflectors are observed due to the presence of the unwanted noise in the seismic signal. The seismic profiles obtained at Sergeant Major #4 show numerous reflectors 0.1 to 0.5 m thick are observed in the seismic records to depths of up to 1.5 m, and several reflectors can be traced up to 80 m across the lake.

In October 1999, sediment samples were obtained and analyzed for select pesticides and PCBs, oil field contaminants, and Cesium. General analysis of oil and grease shows the presence of only small proportions of this contaminant. Of the pesticides and PCBs tested, there are no concentrations of major concern. Detectable levels of DDE are observed at Sugar Creek #12 and Sugar Creek #14, yet DDE, a metabolite of DDT, poses no health issue. Breakdown products of DDT are common in some reservoirs that trap sediments from land farmed in the 1950's and 1960's. Preliminary results of analysis for Cesium indicate that at Sugar Creek #12 sedimentation rate approaches or exceeds 2.5 cm/yr. Sedimentation rates in Sugar Creek #14 and Sergeant Major #4 are less than 1 cm/yr.

Phase II of the project will concentrate on (1) obtaining deep sediment cores using a vibracoring system and (2) examining the quality of the sediment in detail. Many of the results presented herein, especially the seismic data, will be reanalyzed in light of the new information gained through coring.

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Acknowledgments

This project would not have been possible without the direction and cooperation of Larry Caldwell and Glen Miller, USDA-NCRS, Stillwater, OK. Brad Elder, USDA-NRCS, Hinton, OK provided logistical assistance at the Sugar Creek sites. Greg Allen and Jerry Smartwood, USDA-NRCS, provided logistical assistance at Sergeant Major #4 and provided land-use, conservation practice, and herbicide/pesticide data for the watershed. We thank S. Testa and T. Welch for collecting and processing the sediment samples, and R. Wells, D. Wren, and G. Nabors for assisting in the seismic surveys. We acknowledge the rewarding participation of P. Simpkin, IKB-Technologies, LTD., who conducted the seismic surveys and the expertise and assistance of T. McGee and C. Lutkin, Mississippi Mineral Resource Institute, University of Mississippi, who processed the seismic data.

1. Introduction

1.1 Background

In response to devastating floods of the 1930's and 1940's, Congress enacted legislation for the construction of flood-control dams on small tributary streams. Local sponsors were to provide leadership in the program and secure land rights and easements for construction. The U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) was to provide technical assistance and cost-sharing for the construction of these dams.

Since 1948, the USDA-NRCS has constructed over 10,000 upstream flood-control dams in 2000 watersheds in 47 states, over two-thirds of these dams have a design life of 50 years. The watershed projects, which represent a $14 billion infrastructure, have provided flood control, municipal water supply, recreation, and wildlife habitat enhancement. Because of population growth and land-use changes through time, sediment pools are filling, some structural components have deteriorated, safety regulations are stricter, and the hazard classification has changed for some dams. In a recent survey, it was estimated that over 2000 dams need immediate rehabilitation at a cost of $540 million.

Before any rehabilitation strategy can be designed and implemented, the sediment impounded by these dams must be assessed in terms of the structure's efficiency to regulate floodwaters and the potential hazard the sediment may pose if reintroduced into the environment.

In response to a verbal requests by Larry Caldwell, State Conservation Engineer, USDA-NRCS, OK, and Glen Miller, Geologist, USDA-NRCS, the USDA-ARS National Sedimentation Laboratory and its partners at the University of Mississippi established a task force in September 1998 to address the immediate research needs of the USDA-NRCS. Members of this task force met with USDA-NRCS representatives in November 1998 and visited two reservoirs: Sugar Creek #12 near Hinton, OK, and Sergeant Major #4 near Cheyenne, OK. These two sites are of interest to the NRCS because (1) excessive sedimentation has occurred at Sugar Creek #12 and historic land use of cultivated fields of cotton and peanuts suggests that agrochemicals may be present in the lake sediments, and (2) the reservoir at Sergeant Major #4 has become the sole municipal source of water for neighboring communities, and water quality is a major concern.

1.2 Problem Statement

For a given lake within an embankment flood-control structure, the USDA-NRCS needs to determine (1) the volume of sediment deposited, (2) the rates of sedimentation, (3) the quality of sediment with respect to agrochemicals (related to agricultural practices) and petrochemicals (related to hydrocarbon extraction, drilling, and well development), and (4) the spatial distribution of the sediment quality.

To this end, a demonstration project was designed to evaluate technologies, methodologies, and protocols for the cost-effective characterization of sediment.

1.3 Statement of Work

Three field sites were selected for this demonstration project. These are Sugar Creek #12, Sugar Creek #14 (also located near Hinton, OK), and Sergeant Major #4. The work as described below represents the recommendations of the task force and subsequent discussions with the USDA-NRCS, and the project is to be completed in two phases. Phase I entails seismic surveying and sediment quality analysis of select samples at all three locations. Phase II entails vibracoring and detailed sediment analysis based on results from Phase I. This report represents the completion of Phase I.

Below is a description of the techniques to be used in the demonstration project, and the products to be delivered.

1. Seismic Surveying: High-resolution seismic technology relies on the detection of reflected seismic waves from subsurface horizons. A horizon might include any sediment deposit that displays variations in composition (such as mineralogy), texture (such as sediment grain size or porosity), or structure (such as bedding planes). These variations can occur both with depth and spatially. All geophysical equipment will be mounted to a boat, and seismic profiles will be recorded along selected lines at boat speeds of several knots in water as shallow as 0.6 m deep. Upon completion of these soundings, the digitally recorded seismic lines will be post-processed, and reflected horizons identified and verified.

2. Vibracoring of Sediment: Undisturbed sediment cores will be extracted in water depths from 0.6 to 15 m using a vibracorer. An aluminum irrigation pipe, either 3 or 4 inches in diameter, will be connected to a high frequency vibration unit via a core driver and flange. The corer will be suspended from a tripod on a pontoon boat, and stabilizing buoys will ensure the core remains in a vertical position as it descends into the water. A check-valve within the core tube flange creates the suction necessary to retain the sediment during extraction. Once extracted, each core will be cut open, photographed, and logged, and samples of the sediment will be secured.

3. Sediment Analysis: First, the sediment in the cores will be subsampled at 5-cm intervals and at the bounds of distinct horizons. Depending on the physical characteristics of the cores, these samples will be further analyzed for color, grain size distribution, and magnetic susceptibility. Magnetic susceptibility provides a stratigraphic signature that is related to the type and amount of iron-bearing minerals present and can be used for stratigraphic correlation. Second, based on the information provided by the USDA-NRCS on land-use within each watershed, the following suites of chemical analyses are recommended, and these are grouped in Table 1-1. Each sample is depth-integrated except for Group 6. The sediment quality analyses recommended for Phase I and Phase II of the project are listed in Table 1-2.

The number of samples and the types of compounds to be analyzed in Phase II will depend heavily on the results of Phase I as well as the distribution, stratigraphy, and thickness of sediment, and the results of a land-use inventory for the watershed (to be provided to the USDA-ARS by the USDA-NRCS).

Table 1-1. List of chemical groupings.

Group	Title	Elements/Compounds
(1)	U.S. Environmental Protection Agency Priority Pollutant Pesticide/PCB of potentially dangerous compounds	Pesticides: Aldrin, BHC-alpha, BHC-beta, BHC-delta, BHC-gamma, Chlordane, Toxaphene, DDD 4,4', DDE 4,4', DDT 4,4', Dieldrin, Endrin, Endrin aldehyde, Endosulfan I, Endosulfan II, Endosulfan sulfate, Heptachlor, Heptachlor epoxide PCBs: Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, and Aroclor 1260
(2)	U.S. Environmental Protection Agency Oil Field Contaminants	pH, Electrical Conductivity, Sodium Absorption Ratio, Cation Exchange Capacity, Exchangeable Sodium Percentage, Sodium, Potassium, Calcium, Magnesium, Oil & Grease, Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, Silver, Zinc
(3)	Herbicides and Insecticides	Command and Cotoran, Methyl Parathion, Lasso, Danitol and Thimet, Prowl, Dual, Karate, Lorsban
(4)	Rangeland	Nitrates, DDT, and metabolites (breakdown products from compounds such as DDT)
(5)	Sedimentation Rates	Cesium at 10 cm sampling; analyzing for Cesium may date specific horizons, hence sedimentation rates, based on known occurrences of nuclear testing (U.S., Russia, and China) and nuclear accidents (Chernobyl)

Table 1-2. Recommended sediment quality analysis for each field site for Phase I and Phase II of the demonstration project.

Site	Treatment	Phase	Groups
Sugar Creek #12	Cotton and peanuts	I	1 & 2
		II	3 & 5
Sugar Creek #14	Cotton and peanuts (minor amount)	I	1 & 2
Sergeant Major #4	Rangeland (with no herbicide application) and oil production	I	1 & 2
		II	4 & 5

1.4 Global Positioning Systems

In order to construct maps depicting all activities, two global positioning systems (GPS) were employed. A commercially-available, hand-held global positioning receiver was used to demarcate the outline of the reservoir, the location of the embankment, the dam marker, the principal spillway drain, and any other pertinent geographic indicators. Data were collected by (1) setting the receiver to record positions at one-second intervals, (2) walking the desired geographic feature, and (3) logging the data to a file. Once completed, the operator would cease recording data. Files for each geographic feature were temporarily stored in the receiver and later downloaded to a personal computer. All positioning data were differentially corrected (DGPS) using base station data from Vici, OK and Purcell, OK using commercially-available software. These base stations are part of the National Continuously Operating Reference Station network operated by the National Geodetic Survey, a division of the National Oceanic and Atmospheric Administration, and the corrections can be accessed through the following web-site: www.ngs.noaa.gov/Cors. Under optimum conditions, sub-meter accuracy of DGPS is possible.

A second hand-held global positioning receiver was used to demarcate the location of the seismic lines on the lake. These data were collected with a military-grade receiver that was placed on the vessel and exported time, latitude, and longitude to a dedicated laptop computer and to the DAT tape recorder used in the seismic surveys (see below). These data required no differential corrections, were accurate to less than 4 meters, and were converted into Universal Transverse Mercator (UTM) coordinates for consistency with the commercial receiver.

2. Field Sites

2.1 Sugar Creek #12

Sugar Creek #12 is located near Hinton, OK, and it is a relatively small lake with a silt bottom and fairly shallow water depths (0.6 to 2 m; Figures 2-1, 2-2, and 2-3). Dam construction was completed on April 6, 1964. This structure has an upstream drainage area of 2,016 acres. The main stream supplying the lake is considered unstable due to the presence of actively migrating knickpoints, and excessive sedimentation rates have significantly decreased storage capacity. Historic land use of cultivated fields of cotton and peanuts suggests that agrochemicals may be present in the lake sediments. No boat ramp is available, and access for small vessels is difficult but tolerable.

2.2 Sugar Creek #14

Sugar Creek #14 is also located near Hinton, OK, and it is a relatively small lake with a silt bottom and fairly shallow water depths (about 1 to 3 m; Figures 2-4, 2-5, and 2-6). Dam construction was completed in 1962. This structure has an upstream drainage area of 1,252 acres. Historic land use does include cultivation of cotton and peanuts, but this is small component of the watershed. Preliminary surveys indicate that sedimentation rates were not as high here as they were at Sugar Creek #12. A simple boat ramp enabled easy access to the site.

2.3 Sergeant Major #4

Sergeant Major #4 is located near Cheyenne, OK and was constructed in 1955. It is a moderately sized structure, covering an area of about 35 acres (Figures 2-7, 2-8, and 2-9), and has an upstream drainage area of 3,735 acres. This site was chosen for investigation because it has become the sole municipal source of water for the town of Cheyenne and preserving water quality is a major concern. At least three surface water sources as well as some underground springs feed the lake. Water depth ranges from 2 to 10 m, and near-vertical banks of terrigenous siliclastic rocks characterize the lake boundary. Some exposed salt deposits (primarily gypsum) also occur within the watershed. Access to the site for small vessels is good.

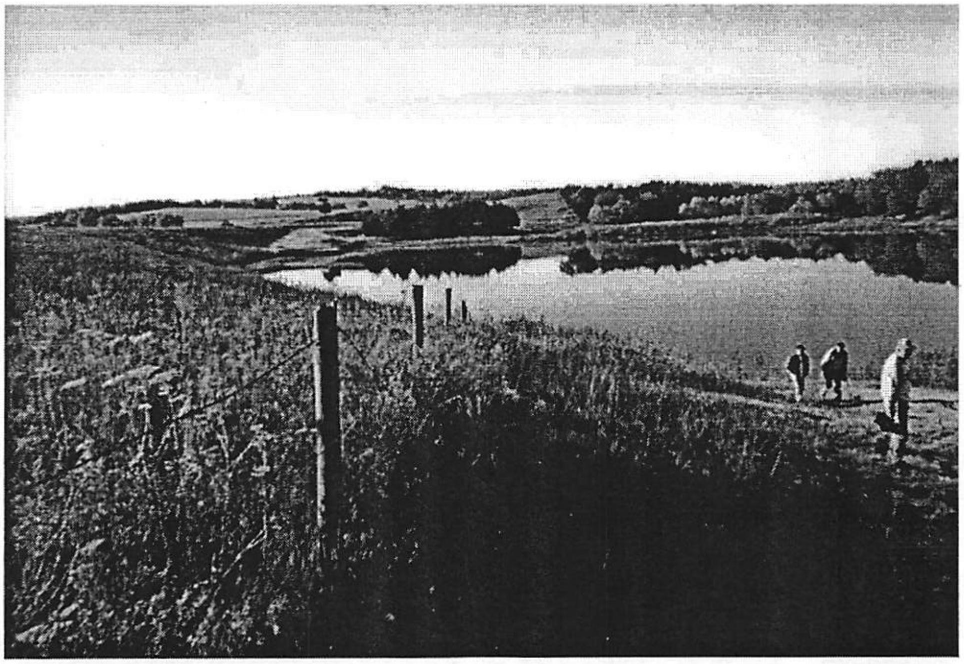


Figure 2-1. Photograph of Sugar Creek #12 looking directly south showing earthen embankment on left, spillway channel in far distance, and reservoir (November 1999).

Figure 2-2. Photograph of Sugar Creek #12 looking toward the southwest showing the reservoir and the main tributary on right.

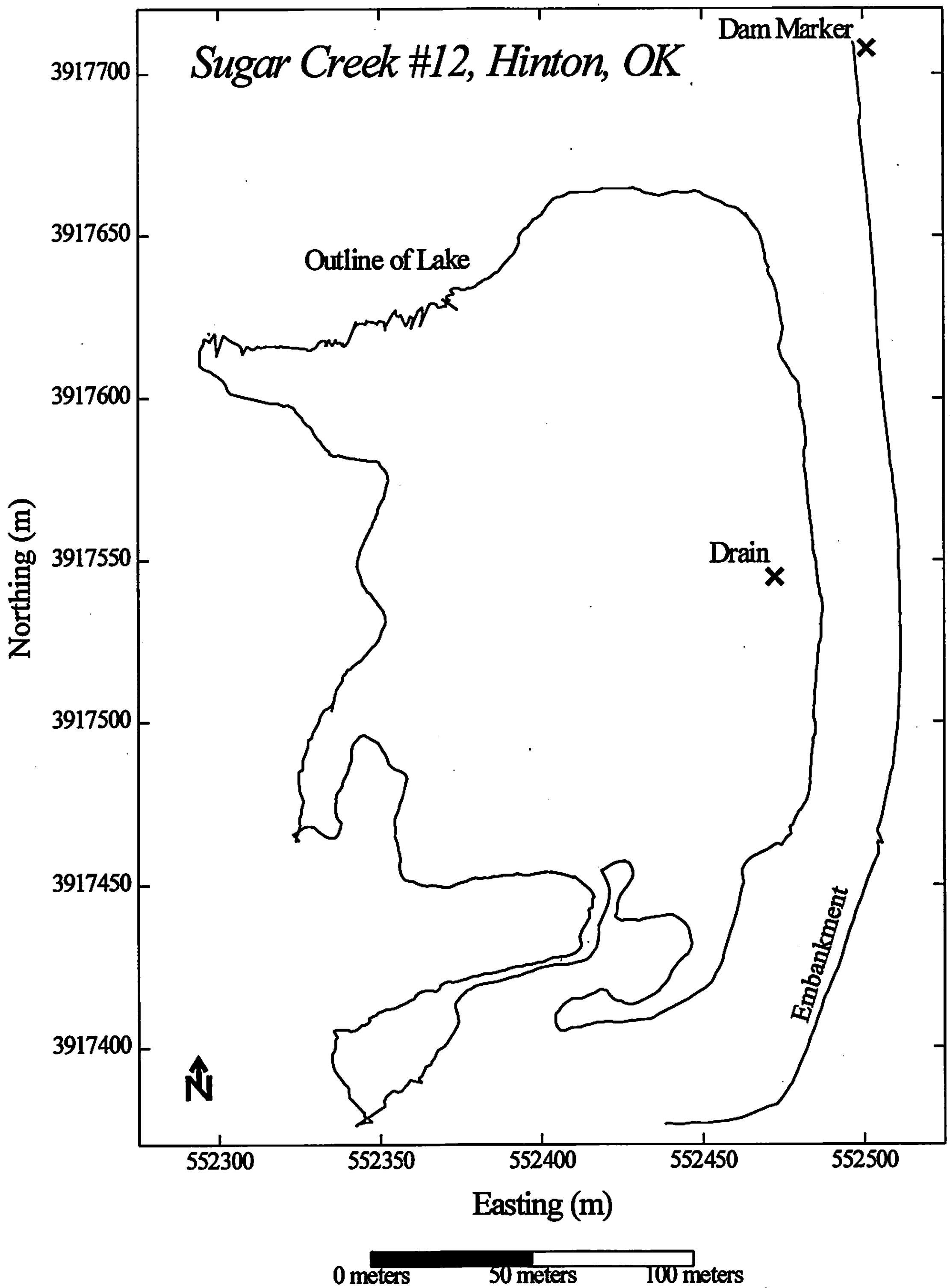


Figure 2-3. Base map of Sugar Creek #12 constructed from a hand-held global positioning system receiver with differential corrections applied. Shown are the outline of the lake, the centerline of the earthen embankment, the primary spillway drain, and the cement dam marker. All positions are in UTM coordinates.

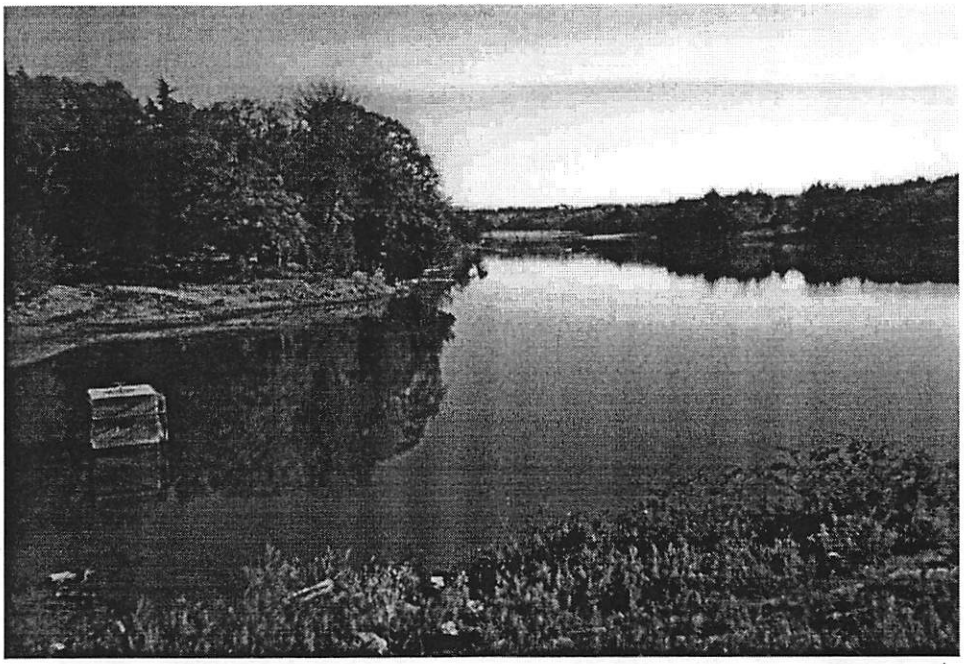


Figure 2-4. Photograph of Sugar Creek #14 looking northeast from the embankment showing reservoir, primary spillway drain on left, and main tributary source in far distance (November 1999).

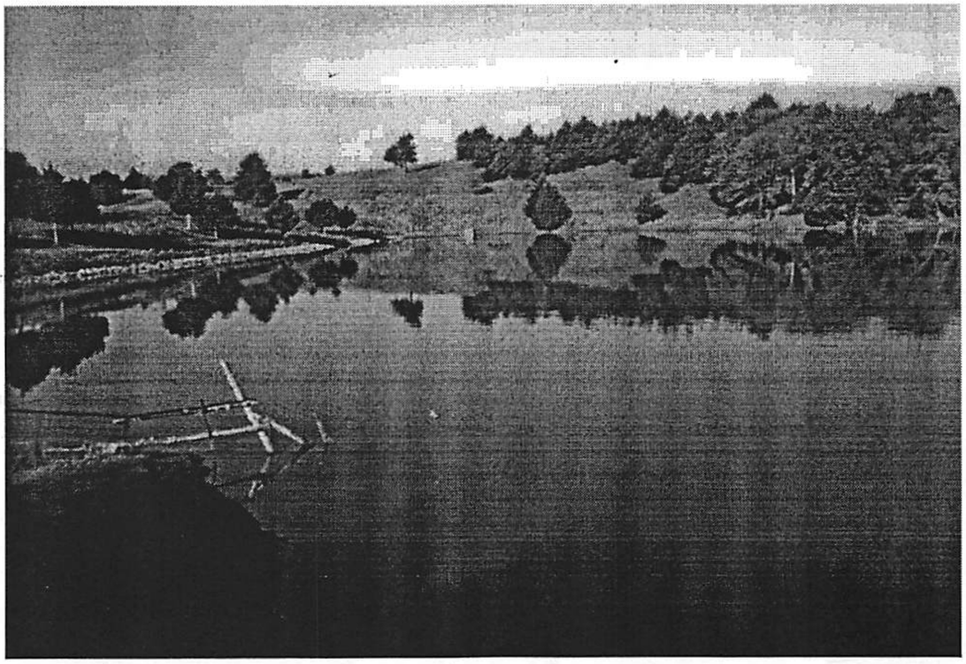


Figure 2-5. Photograph of Sugar Creek #14 looking directly west showing reservoir, earthen embankment of left, and primary spillway drain in far distance (November 1999).

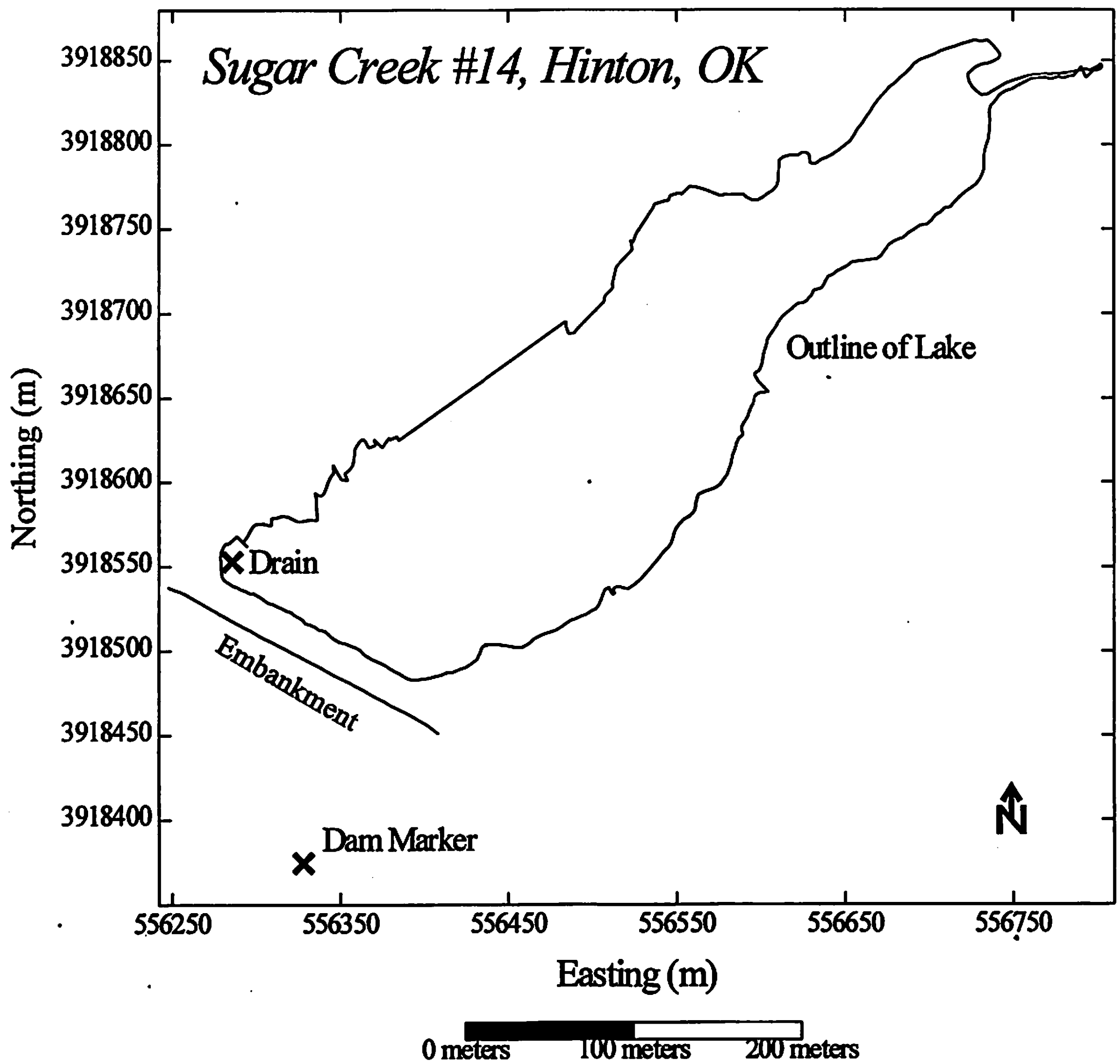


Figure 2-6. Base map of Sugar Creek #14 constructed from a hand-held global positioning system receiver with differential corrections applied. Shown are the outline of the lake, the centerline of the earthen embankment, the primary spillway drain, and the cement dam marker. All positions are in UTM coordinates.

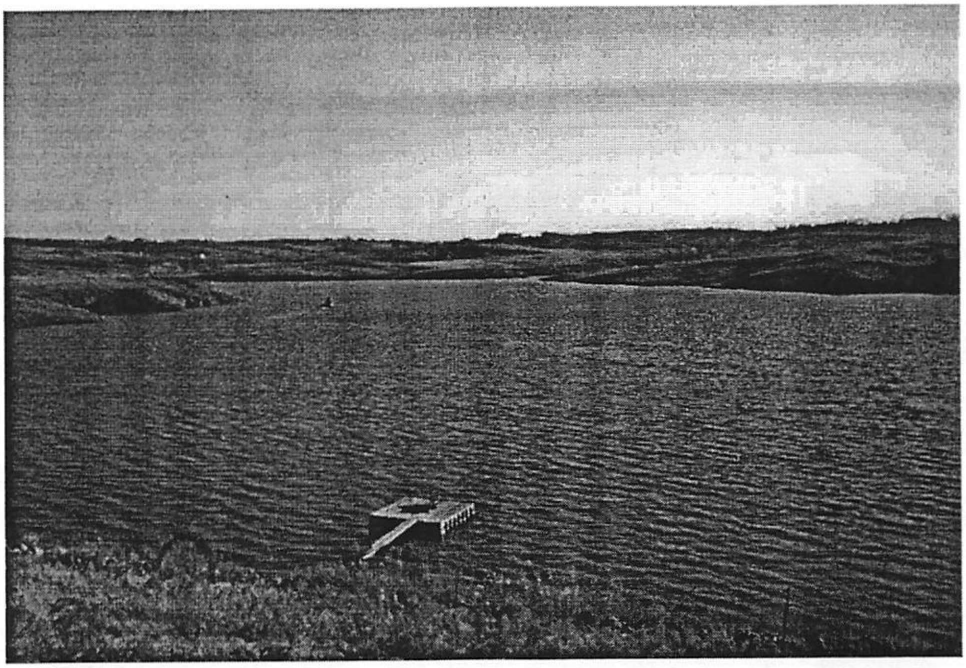


Figure 2-7. Photograph of Sergeant Major #4 looking almost directly south from the embankment showing reservoir, primary spillway drain in foreground, and the vessel used during seismic surveying in the distance (November 1999).

Figure 2-8. Photograph of Sergeant Major #4 looking southeast from access road showing the reservoir and the vessel used during seismic surveying in the distance (November 1999).

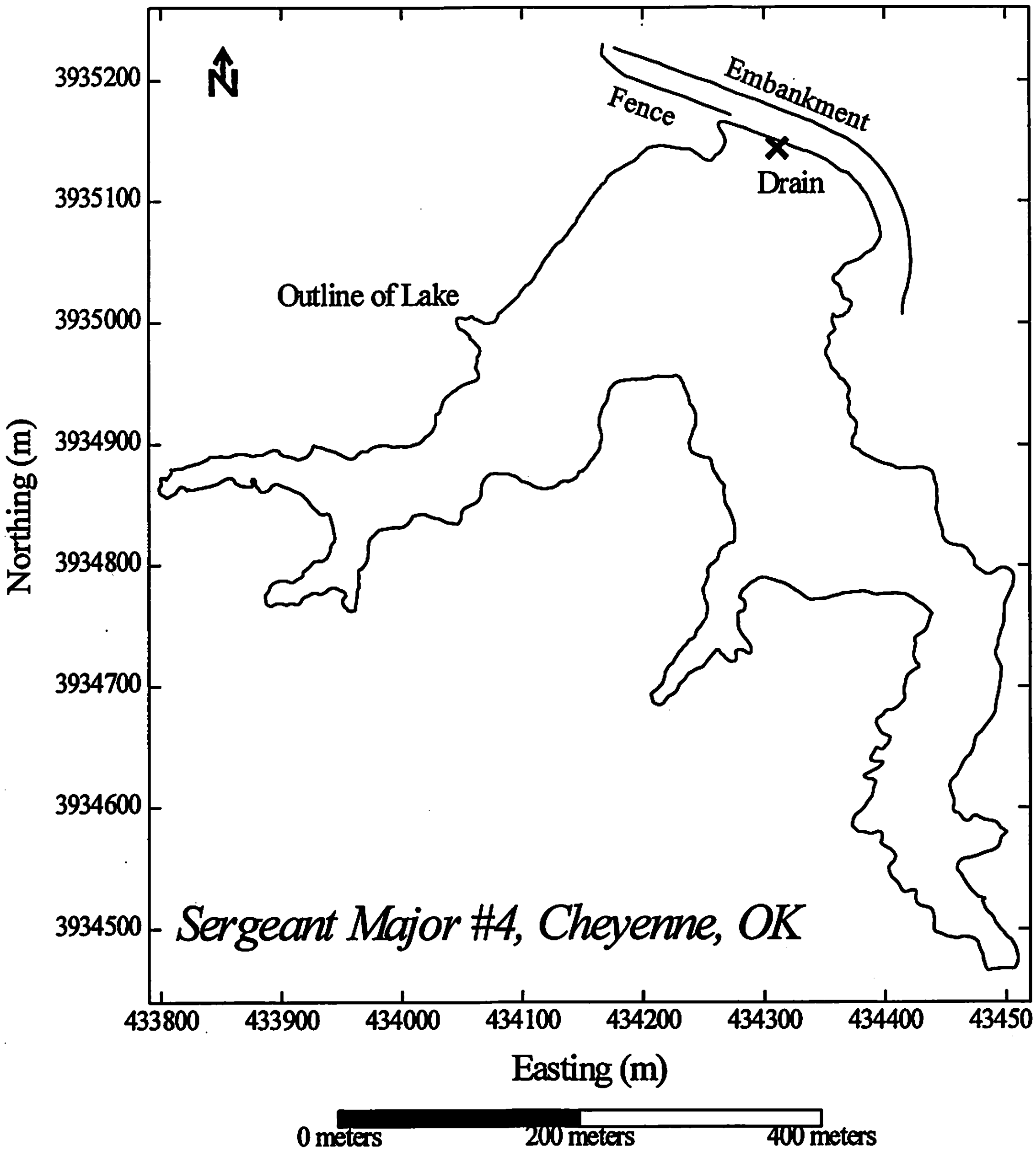


Figure 2-9. Base map of Sugar Creek #4 constructed from a hand-held global positioning system receiver with differential corrections applied. Shown are the outline of the lake, the centerline of the earthen embankment, the primary spillway drain, and the fence line near the embankment. All positions are in UTM coordinates.

Gregory Allen, District Conservationist, Cheyenne Field Office, USDA-NRCS, provided the following information on land use within the area. In 1940, there were approximately 1,426 acres of cropland, primarily cotton and rows crops with rotation of small grains, and 2,309 acres of grassland. In 1960, there were 1,029 acres of cropland and 2,686 acres of grassland. At this time, conservation measures were being employed and cotton fields were being reduced. At present, there are 705 acres of cropland consisting entirely of small grains and some sorghum and 3,030 acres of grassland.

The USDA-NRCS, Stillwater, OK provided the following information on the water quality of Sergeant Major #4. The town of Cheyenne monitors the levels of alkalinity, pH, hardness, and turbidity in the raw water. According to the water treatment plant operator, alkalinity is high, usually between 260 to 340 mg/l, pH generally ranges from 7.7 to 8.2, hardness usually ranges from 153 to 205 mg/l, and turbidity ranges from 2.0 to 20.0 NTU after a hard rain. Water samples obtained on October 7, 1998 showed key organic and inorganic indictors were in compliance with the Oklahoma Water Quality Standards for all classes of livestock and poultry and the water was deemed suitable for irrigation. The total dissolved solids measured (409 mg/l) were below the recommended limit for drinking water (500 mg/l).

3. Seismic Surveying

During the period from November 4 to November 6, 1999, each lake was surveyed using high-resolution geophysical equipment. The details of the equipment used, seismic lines run, and examples of the processed data are described below.

3.1 Seismic Equipment Used

The physical characteristics of the lakes and sediments necessitated the use of geophysical techniques that could be employed in shallow water (as little as 0.6 m) with small sediment thickness (no greater than 5 m). Most geophysical equipment commonly used cannot be applied in shallow water environments. IKB Technologies, LTD., Bedford, Nova Scotia, Canada, owned and operated by Dr. Peter Simpkin, has developed a seismic profiler for use in such environments.

The IKB-SEISTEC™ profiling system comprises a catamaran, boomer, source receiver, and signal processor. A 2.5-m long catamaran is towed by a vessel and supports the boomer source and receiver in a streamlined faring (Figures 3-1 and 3-2). The catamaran can be operated at 0 to 4 knots, and cable distance from the vessel to the catamaran was approximately 7 m.

The seismic source incorporated into the catamaran is a reliable, wide-band electrodynamic boomer that produces a single positive pressure pulse with very high repeatability. For the present application, the frequency of the boomer's pulse was set at four pulses per second.

The seismic receiver (hydrophone) is based on the line-in-cone concept with a circular array and a near-field distance of less than 1 m. It is fully enclosed and placed as close as physically possible to the source (about 0.7 m).

An SPA-3 analog signal conditioner and processor were used, which are suitable for a wide range of single channel seismic profiling systems. This processor provides input signal level matching, separate high and low pass filters, and raw and conditioned signal outputs. During operation, the processor was connected to (1) an oscilloscope to monitor and optimize the incoming seismic signal, (2) a gray-scale recorder for real-time display of the seismic profile, and (3) a DAT tape recorder for data storage (Figure 3-3).

All equipment was placed onto a 16-ft aluminum boat (Figure 3-4). This included signal processor, oscilloscope, gray scale recorder, DAT tape recorder, and boomer power unit. In addition, a laptop computer was used to log positioning data from a military-grade GPS receiver. A 5.8 kW generator supplied 220 V power to the boomer, and a 2.8 kW generator supplied a clean power source to all other electronic equipment. Three people typically were on the vessel: one to operate the boat and to monitor the position of the catamaran, one to operate the positioning system, and one to operate the seismic equipment.

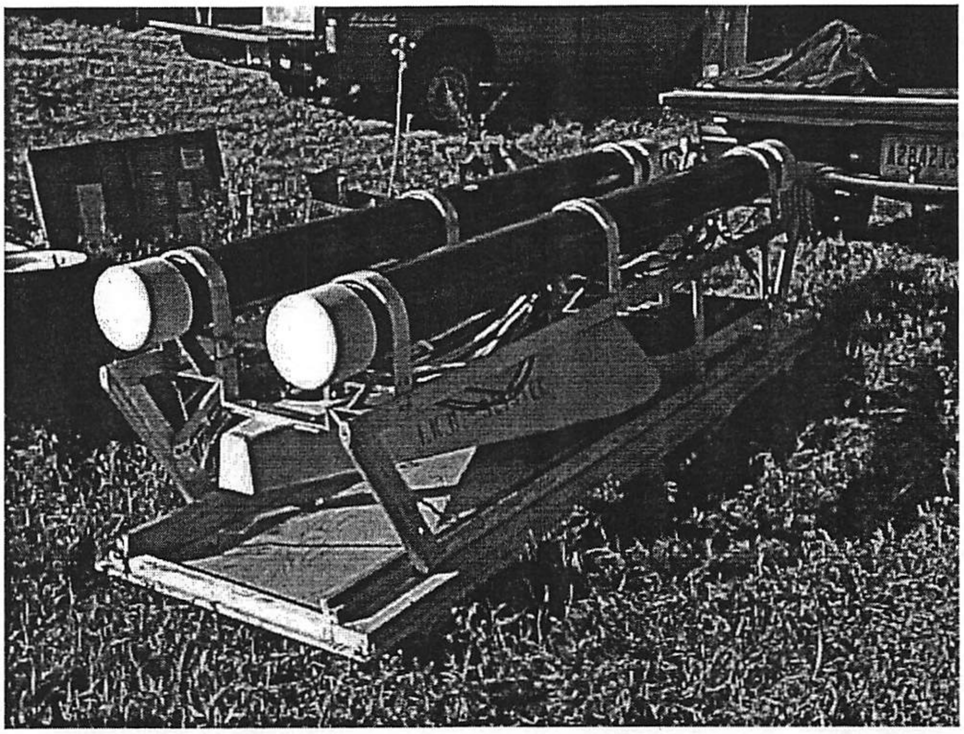


Figure 3-1. Photograph of the catamaran. The black PVC pipes provided floatation, the aluminum frame is resting on the wooden box the catamaran was shipped in, and the front of the catamaran is on the right (November 1999).

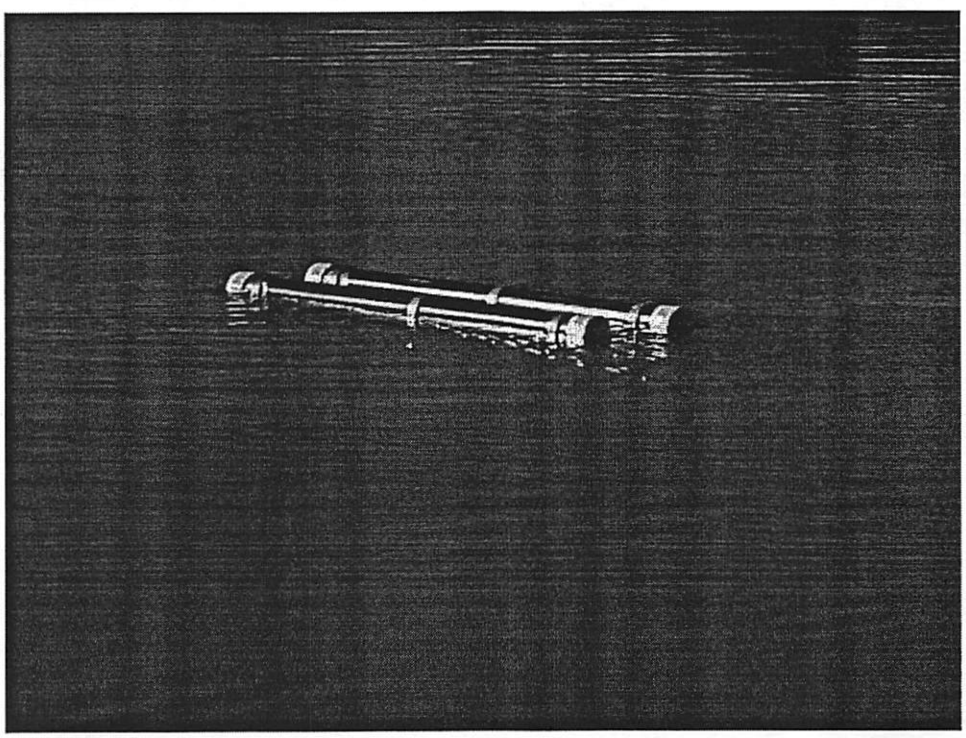


Figure 3-2. Photograph of the catamaran being towed by the vessel. The catamaran is about 7 meters from the vessel, and it is moving toward the left (taken at Sugar Creek #12, November 1999).

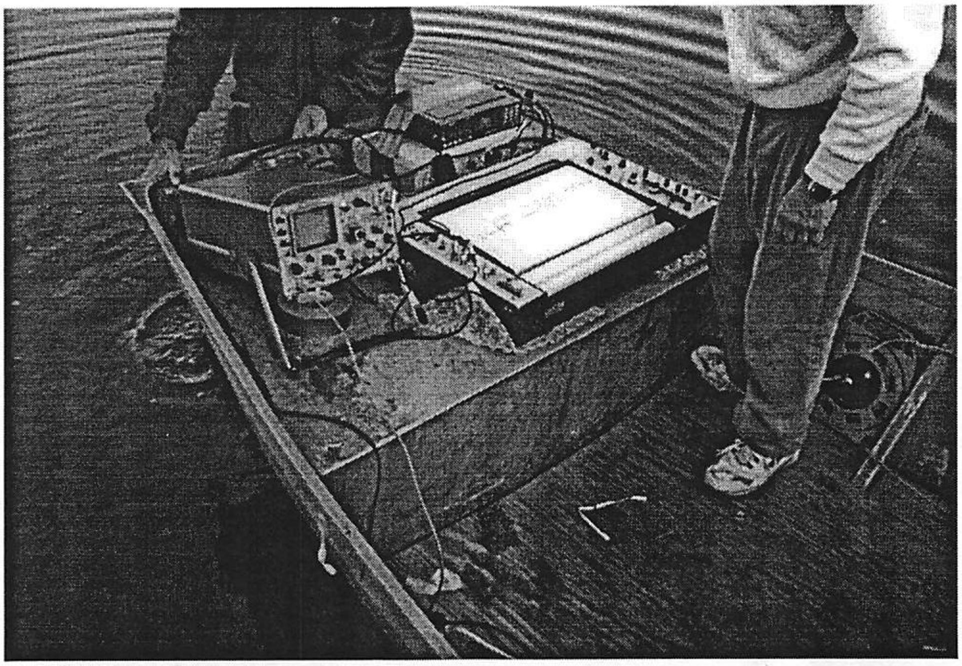


Figure 3-3. Photograph of the oscilloscope and gray-scale printer (foreground), and DAT tape recorder and signal processor (background; the tape recorder in sitting on top of and is taped to the signal processor).

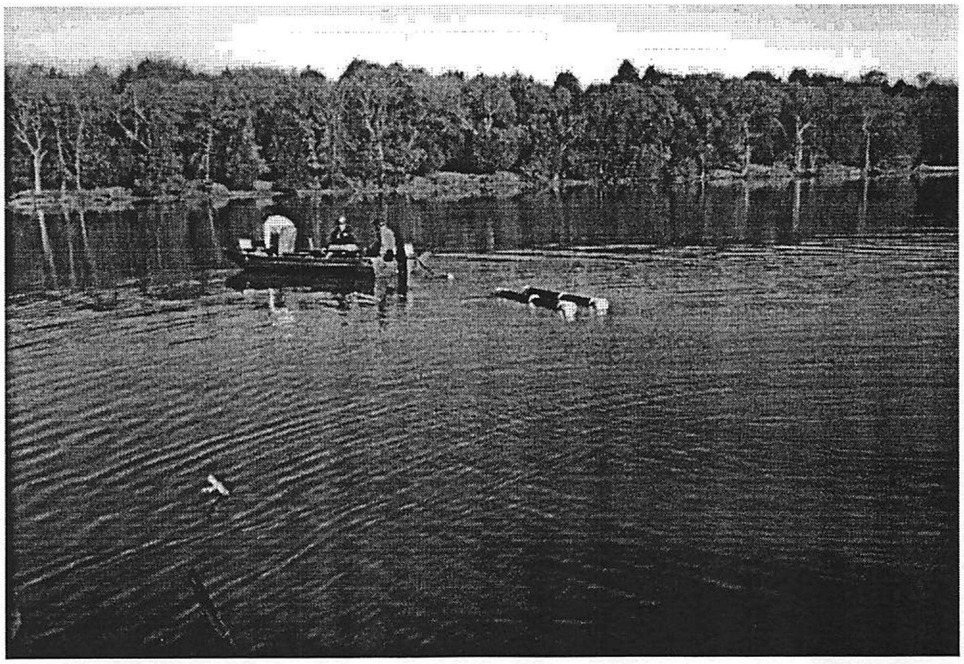


Figure 3-4. Photograph of general operating procedure for the seismic surveying and the number of personnel required (taken at Sugar Creek #14, November 1999).

3.2 Post-processing of Seismic Data

Geophysicists from the Mississippi Mineral Resources Institute, located at the University of Mississippi, conducted the post-processing of the seismic data. All data recorded to tape were played back in real-time and digitally recorded to a personal computer. During digitization, individual seismic lines were correlated to the GPS data so that all seismic data could be resolved in both time and space.

Once all data were digitized, specific segments of the seismic lines were identified for further processing in order to be included in this preliminary report. Post-processing entailed three steps. First, all data were digitally filtered in order to remove any low frequency oscillation in the seismic signal, and this process is called detrending. Second, all data were digitally processed in order to enhance the low-amplitude (low-magnitude) seismic data at depth, and this numerical technique is called spherical divergence. Third, all data were digitally filtered in order to reduce the number of reverberations (echos or multiples) or distortions in the seismic signal, and this process is called predictive deconvolution. These three steps employed both user-defined and commercially-available software packages.

After each seismic segment was detrended and both spherical divergence and predictive deconvolution were applied, the seismic lines were printed. The operator still can alter the magnitude or the gain of the seismic signal, thereby enhancing or suppressing reflectors prior to printing. In general, two copies of each line were generated, at low and high gain, and this enabled the identification of specific seismic reflectors. For clarity, only the low-gain seismograms are presented herein.

In addition, all seismograms were printed as a function of time. For the vertical scale, time in milliseconds can be converted to distance by assuming a velocity for the propagation of seismic waves through the water and the saturated, unconsolidated sediments and then back to the receiver. Herein this velocity is assumed to be 1500 m/s. Please note that this value depends greatly on water salinity and temperature, and the material's grain size, composition, degree of consolidation or lithification, and the presence of gas. For the horizontal scale, the GPS data were used to calculate the total distance of each line, assuming that the boat was moving at a constant velocity between these points.

3.3 Results

3.3.1 Seismograms for Sugar Creek #12

Figure 3-5 shows the seismic lines obtained for Sugar Creek #12 and the location of the three segments chosen for presentation here. Figures 3-6, 3-7, and 3-8.show the seismograms for sections A-A', B-B', and C-C', respectively.

At the time these seismic data were collected, water depth was quite low, no greater than 1 m. This caused the seismic source (boomer) and receiver to be in very close proximity to the sediment bottom. In fact, the catamaran frequently ran aground. Thus the areal coverage within the lake was restricted to water depths of at least 0.6 m. Moreover, this close proximity caused a great deal of reverberation and distortion of the seismic signal and many multiple reflectors from the same source were recorded. The numerical algorithms presented above were unable to filter the seismic signals completely.

In general, the following observations can be made. The sediment near the water-sediment interface is quite soft, and it is represented by weak or low-amplitude reflectors (Figure 3-6, 3-7, and 3-8). The thickness of this reflector is about 0.15 to 0.2 m and it does not vary in thickness across the basin. However, this reflector does appear to thicken towards the southern part of the lake (towards B'; see Figure 3-7). At a depth of approximately 0.4 m, a very strong seismic reflector is observed, and this reflector is ubiquitous in all the seismic records. This strong seismic reflector caused most of the seismic reverberations due to its strong seismic properties and its close proximity to the water surface and seismic receiver. Again, this seismic reflector is observed basin wide, and may represent a change in sediment composition such as a sand or gravel layer, a change in sediment density such as variation in mineralogy or relative compaction, have a biological origin, or represent some kind of hard-pan. Because this reflector has such strong seismic characteristics, it is difficult to observe any deep horizons, although some were delineated (see Figures 3-6 and 3-7). These deeper horizons occur at a depth of approximately 0.9 to 1.1 m, respectively, and it is approximately 0.1 m thick. At present, the reason for this deep reflector is unknown.

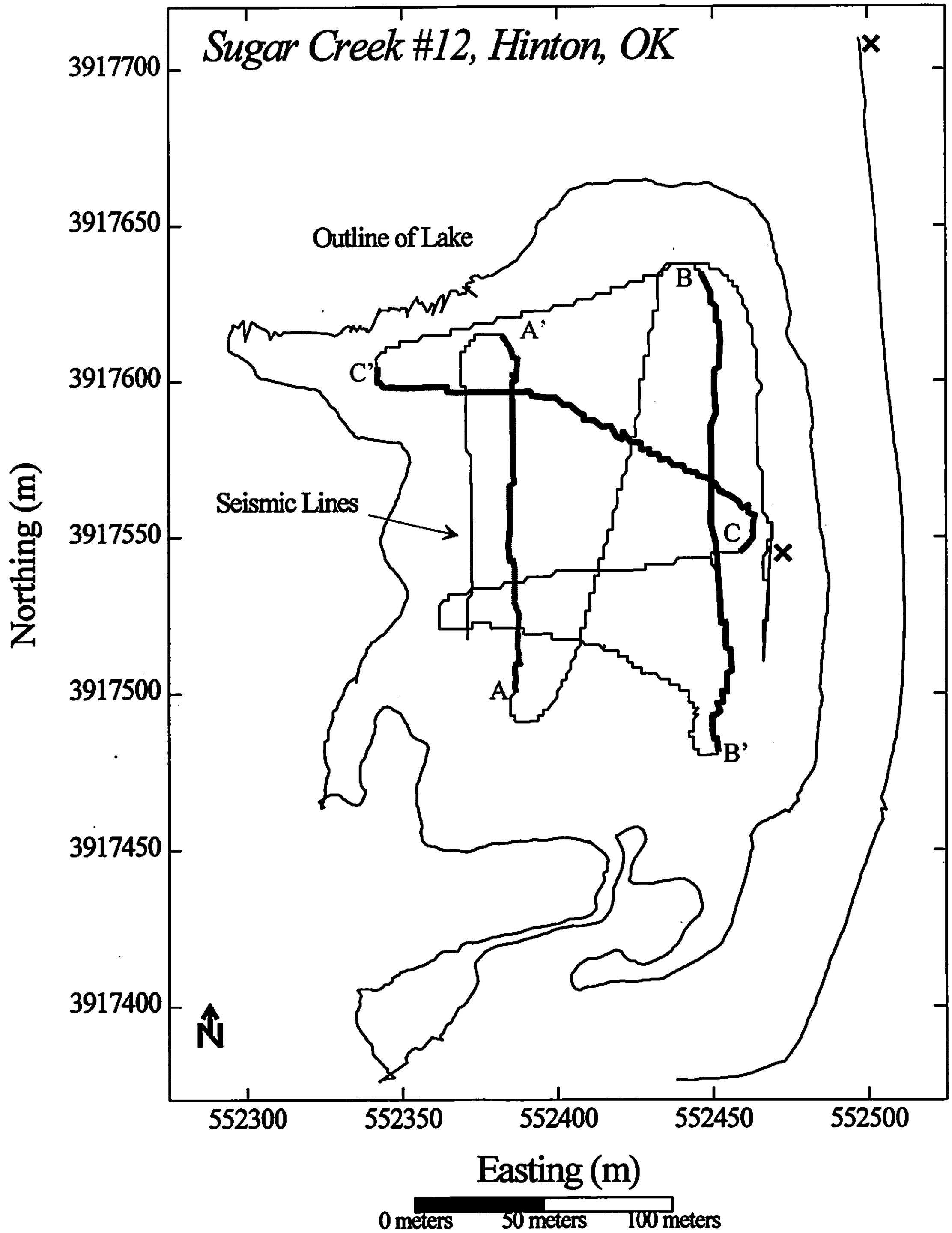
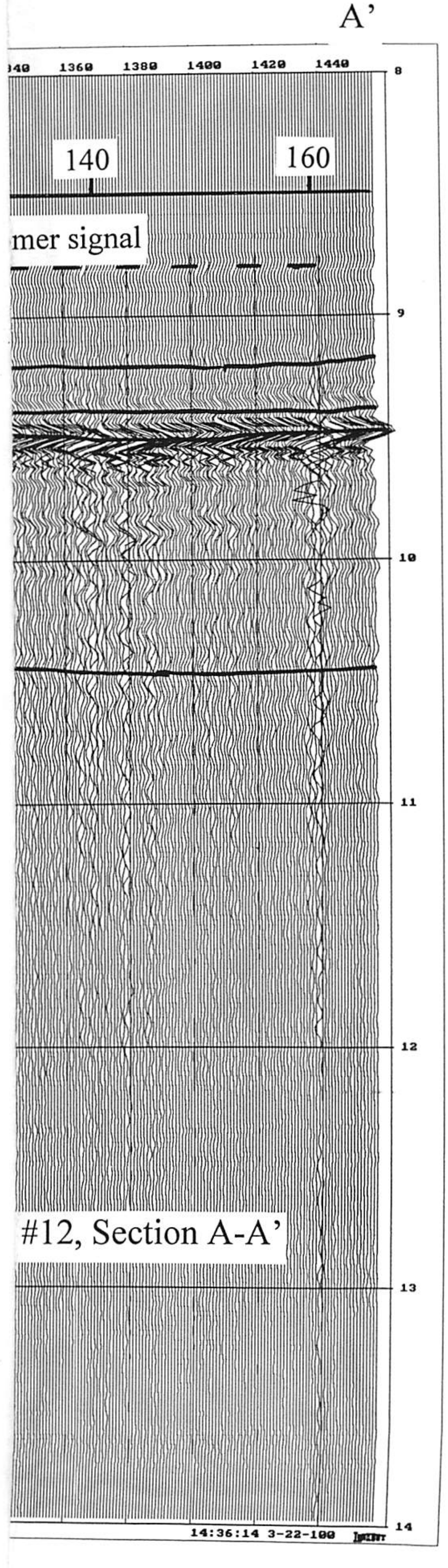


Figure 3-5. Base map of Sugar Creek #12 showing traces for all seismic lines. Three segments, labeled A-A', B-B', and C-C', are discussed in text. All positions are in UTM coordinates.

Figure 3-6. Seismogram of section A-A' from Sugar Creek #12 (next page; refer to Figure 3-5). Dashed line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 162 m.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13
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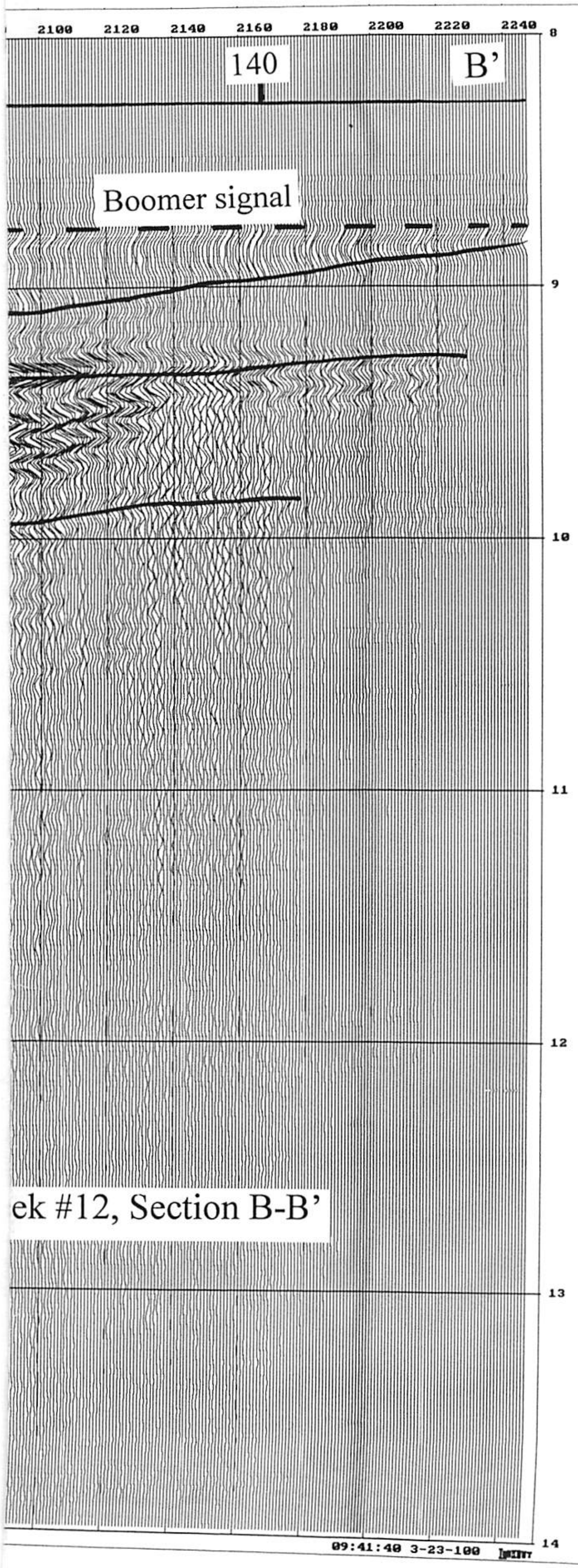
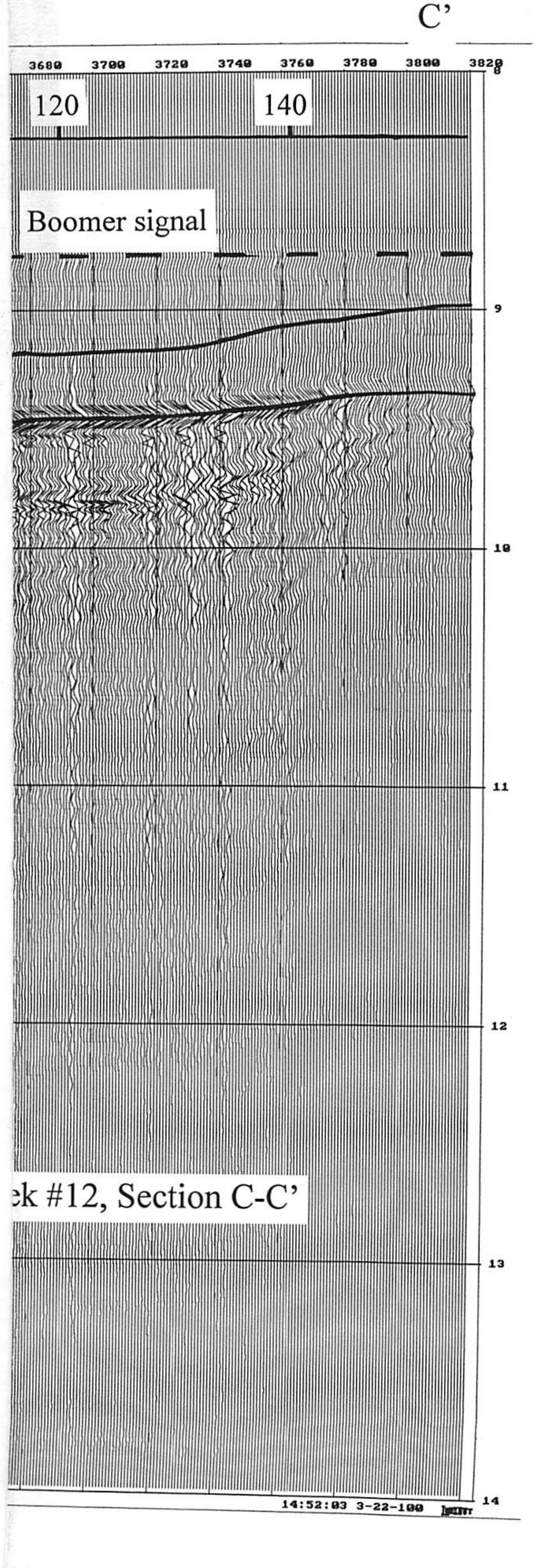
Figure 3-7. Seismogram of section B-B' from Sugar Creek #12 (next page; refer to Figure 3-5). Dashed line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 158 m.



2100 2120 2140 2160 2180 2200 2220 2240
140
B'
Boomer signal
8
9
10
11
12
13
14
ek #12, Section B-B'
09:41:40 3-23-100

Figure 3-8. Seismogram of section C-C' from Sugar Creek #12 (next page; refer to Figure 3-5). Dashed line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 156 m.


C'
3680
3700
3720
3740
3760
3780
3800
3820
120
140
Boomer signal
8
9
10
11
12
13
14
ek #12, Section C-C'
14:52:03 3-22-100

3.3.2 Seismograms for Sugar Creek #14

Figure 3-9 shows the seismic lines obtained for Sugar Creek #14 and the location of the three segments chosen for presentation here. Figures 3-10, 3-11, and 3-12 show the seismograms for sections A-A', B-B', and C-C', respectively. At the time these seismic data were collected, water depth was on the order of 1 to 3 m. As such, the post-processing algorithms were more successful in removing multiples here than at Sugar Creek #12.

In general, the following observations can be made. The sediment near the water-sediment interface is quite soft, and it is represented by weak or low-amplitude reflectors, similar to Sugar Creek #12 (Figures 3-10, 3-11, and 3-12). This near-surface reflector is about 0.2 m thick, and it displays little variation in thickness across the basin. Some thinning of this unit occurs towards the principal spillway (towards A'; Figure 3-10). At a depth of approximately 0.2 m, a very strong seismic reflector is observed, and this reflector is ubiquitous in all the seismic records. This strong seismic reflector is similar in depth and character to the reflector observed at Sugar Creek #12, and the reason for its presence is still unknown. Few deep seismic reflectors were observed. But in Figure 3-10 and Figure 3-12, a reflector is observed at depths of 0.6 and 0.5 m, respectively, and the thickness of this reflector is about 0.3 m. At present, the reason for this deep reflector is unknown.

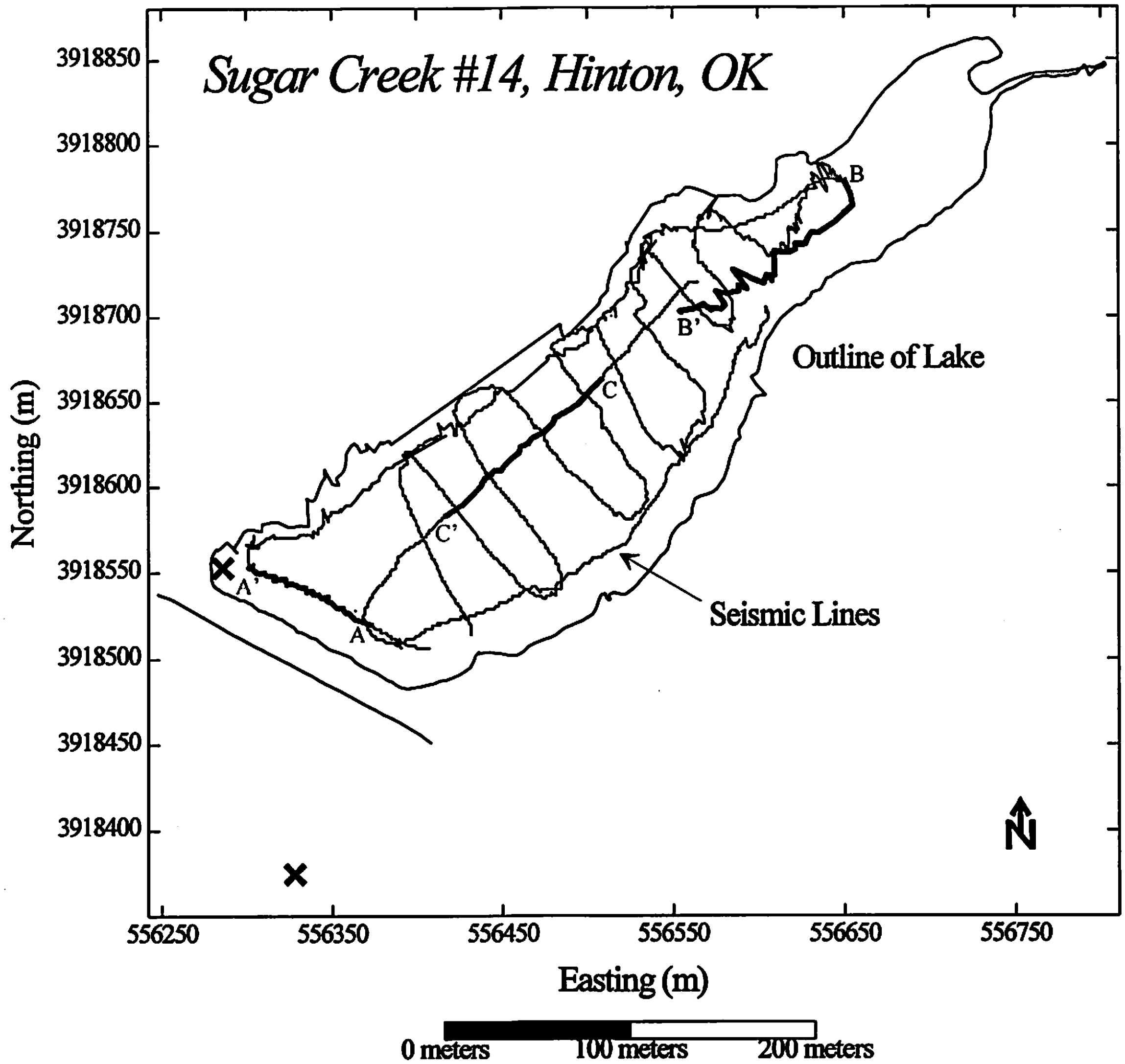
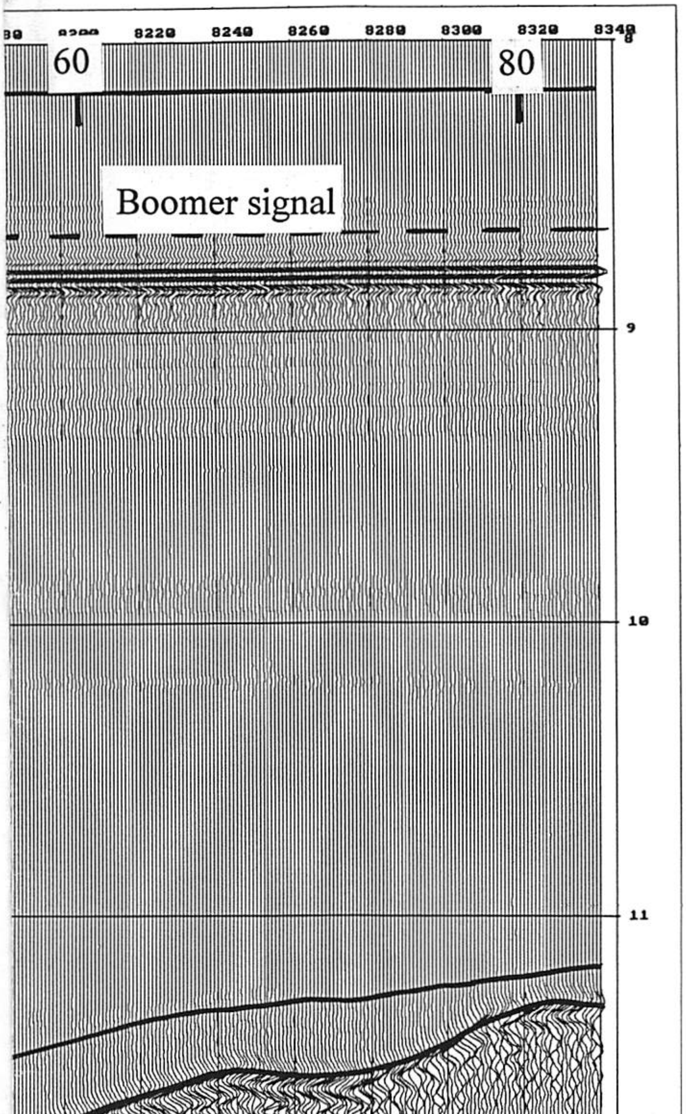


Figure 3-9. Base map of Sugar Creek #14 showing traces for all seismic lines. Three segments, labeled A-A', B-B', and C-C', are discussed in text. All positions are in UTM coordinates.

Figure 3-10. Seismogram of section A-A' from Sugar Creek #14 (next page; refer to Figure 3-9). Dashed line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 84 m.

A'



8220
8240
8260
8280
8300
8320
8340
60
80
Boomer signal
9
10
11
12
13
14
Creek #14, Section A-A'
16:59:45 3-21-100

Figure 3-11. Seismogram of section B-B' from Sugar Creek #14 (next page; refer to Figure 3-9). Dashed line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 134 m.

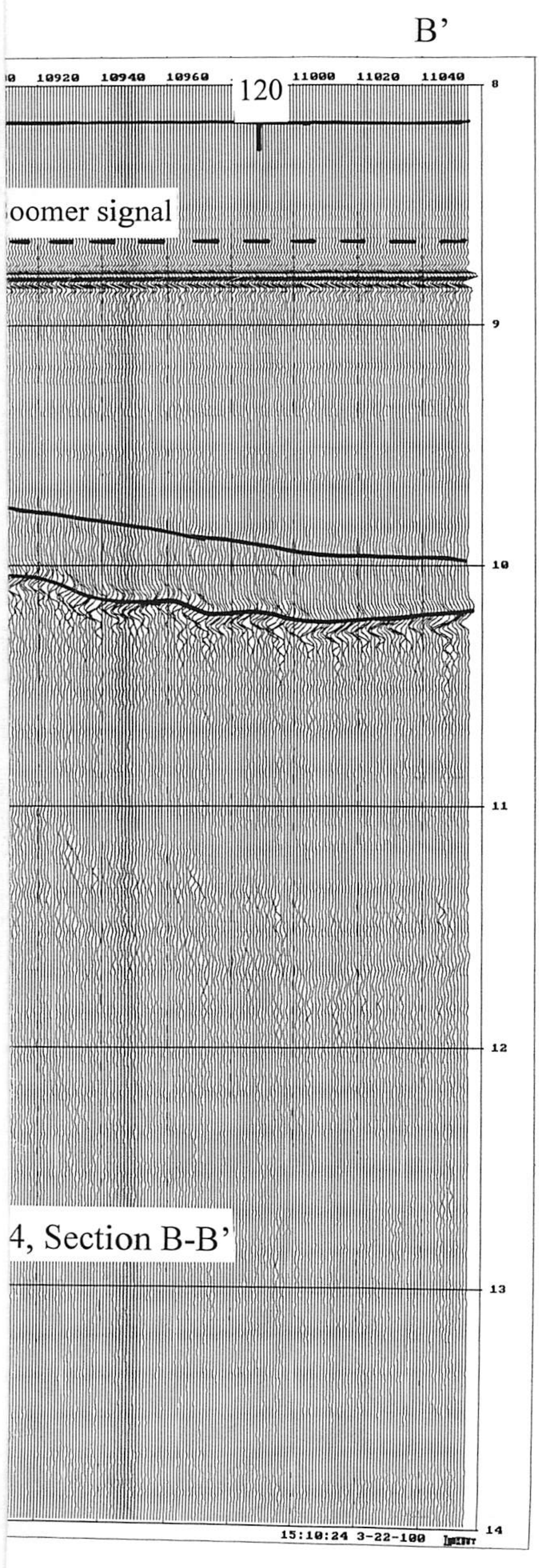
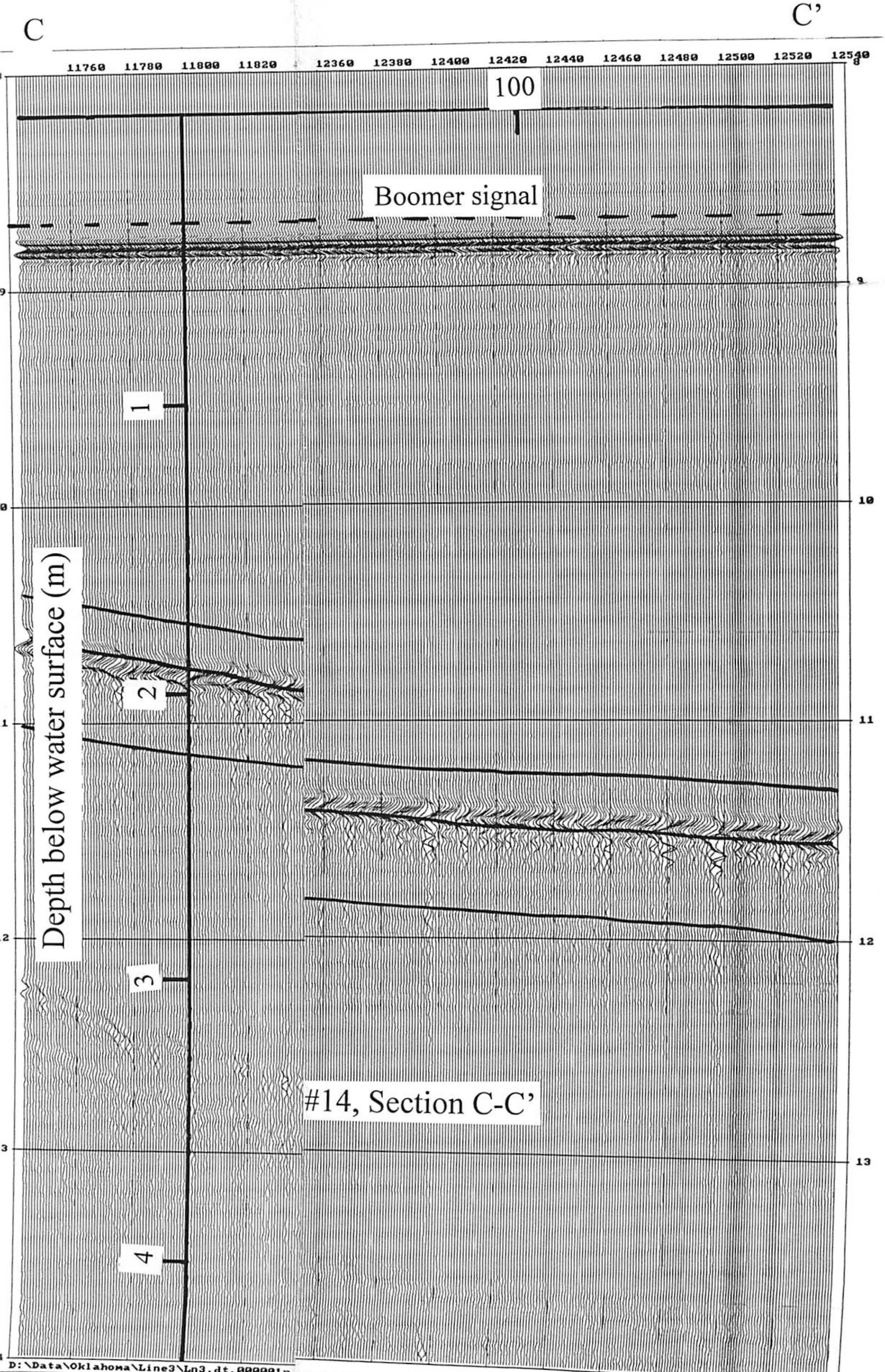

B’
10920 10940 10960 11000 11020 11040
120
oomer signal
8
9
10
11
12
13
14
4, Section B-B’
15:10:24 3-22-100

Figure 3-12. Seismogram of section C-C' from Sugar Creek #14 (next page; refer to Figure 3-9). Dashed line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 116 m.


C
C'
11760 11780 11800 11820
12360 12380 12400 12420 12440 12460 12480 12500 12520 12540
100
Boomer signal
1
2
3
4
9
10
11
12
13
14
Depth below water surface (m)
#14, Section C-C'
D:\Data\Oklahoma\Line3\Ln3.dt.000001p.
15:12:50 3-22-100

3.3.3 Seismograms for Sergeant Major #4

Figure 3-13 shows the seismic lines obtained for Sergeant Major #4 and the location of the three segments chosen for presentation here. Figures 3-14, 3-15, 3-16, 3-17, and 3-18 show the seismograms for sections A-A', B-B', C-C', D-D', and E-E', respectively. At the time these seismic data were collected, water depth ranged from about 1 m in the tributary arms to about 10 m near the center of the lake. Post-processing algorithms successfully removed the majority of multiples and distortions of the seismic signal.

In general, the following observations can be made. The seismic profiles show a number of reflectors in the subsurface. Along the northwestern tributary arm, (section A-A'; Figure 3-14), reflectors range in thickness from 0.1 to 0.5 m, they occur at depths up to 1 m, they have variable inclinations, and they are observed to thin towards the deeper part of the reservoir. In this deeper region, the reflectors become horizontal and much thinner, less than 0.2 m thick. The deeper region also displays greater seismic reflectivity, suggesting a change in substrate grain size and composition.

Similar reflectors are observed along the central tributary arm (section B-B'; Figure 3-15). But these reflectors are quite thin, about 0.2 m, they are restricted in depth to about 0.3 m, and they display little variation in thickness towards the deeper basin. Reflectors in the topographically low regions assume horizontal attitudes.

Along the southern tributary arm, (section C-C'; Figure 3-16), reflectors are more numerous in the topographically low regions, they range in thickness from 0.1 to 0.3 m, and they are restricted in depth to about 0.3 to 0.7 m. Many of these reflectors pinch-out towards the sides of the topographic depressions.

The seismic line parallel to the embankment (section D-D'; Figure 3-17) shows several reflectors that parallel the subsurface topography. These reflectors range in thickness from 0.1 to 0.2 m, and are observed to depths of about 1.5 m. Several of these reflectors are continuous for up to 80 m across the basin, while others show very short lateral extents.

The seismic line through the central part of the reservoir (section E-E'; Figure 3-18) also displays numerous reflectors ranging in thickness from 0.1 to 0.5 m. These reflectors drape the existing reservoir bathymetry and are restricted in depth to about 1 m. The reflectors appear to thicken towards the southeast (towards E'), away from the center of the basin.

The reservoir bathymetry is relatively rugged as compared to the Sugar Creek sites with several topographic highs and lows. The deepest part of the reservoir occurs near the center of the lake, and maximum bathymetric relief is about 4 m. The presumable cause of this topography is the rock outcrops observable above the water line.

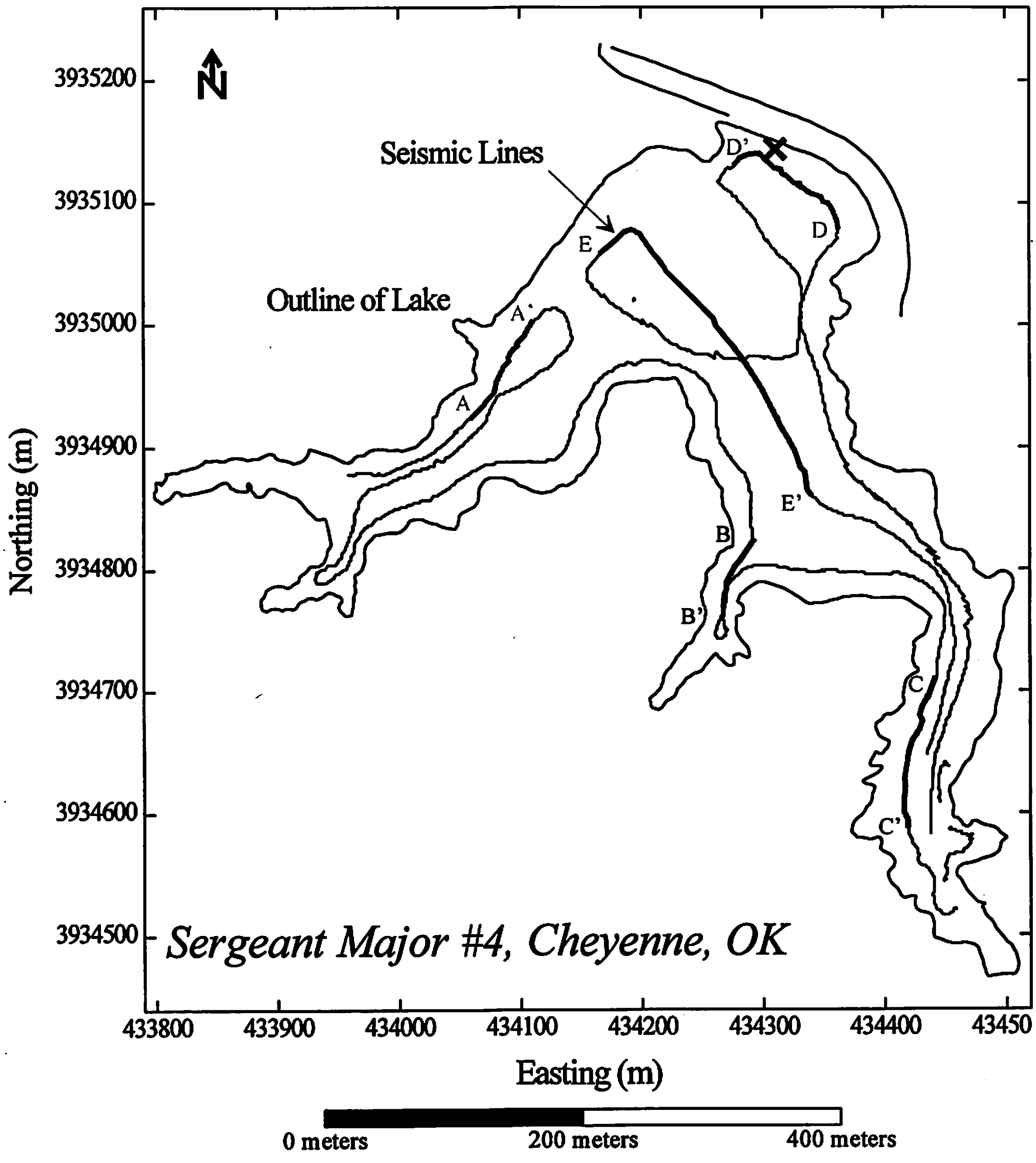


Figure 3-13. Base map of Sergeant Major #4 showing traces for all seismic lines. Five segments, labeled A-A', B-B', C-C', D-D', and E-E' are discussed in text. All positions are in UTM coordinates.

Figure 3-14. Seismogram of section A-A' from Sergeant Major #4 (next page; refer to Figure 3-13). Thick solid line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 105 m.

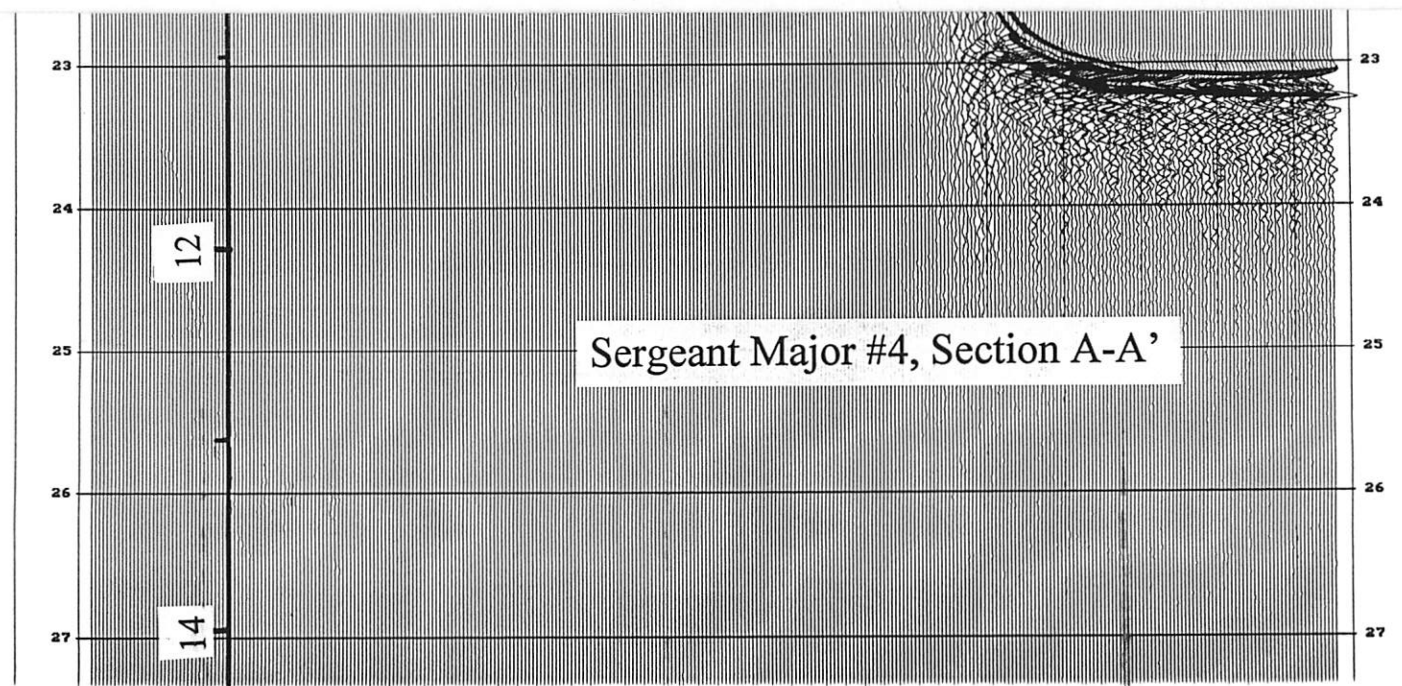

Sergeant Major #4, Section A-A'
12
14
23
24
25
26
27

Figure 3-15. Seismogram of section B-B' from Sergeant Major #4 (next page; refer to Figure 3-13). Thick solid line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 66 m.

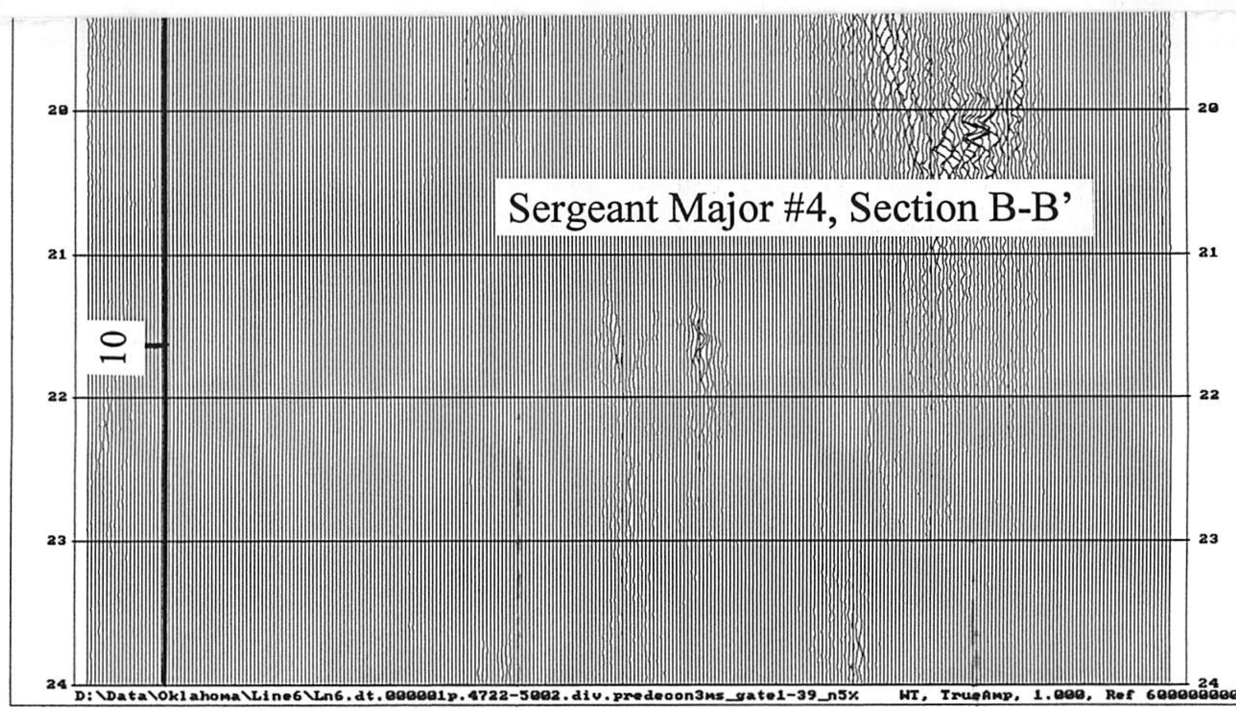

Sergeant Major #4, Section B-B'
10
20
21
22
23
24
D:\Data\Oklahoma\Line6\Ln6.dt.000001p.4722-5002.div.predecon3ms_gate1-39_n5%
WT, TrueAmp, 1.000, Ref 600000000.00

Figure 3-16. Seismogram of section C-C' from Sergeant Major #4 (next page; refer to Figure 3-13). Thick solid line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 120 m.

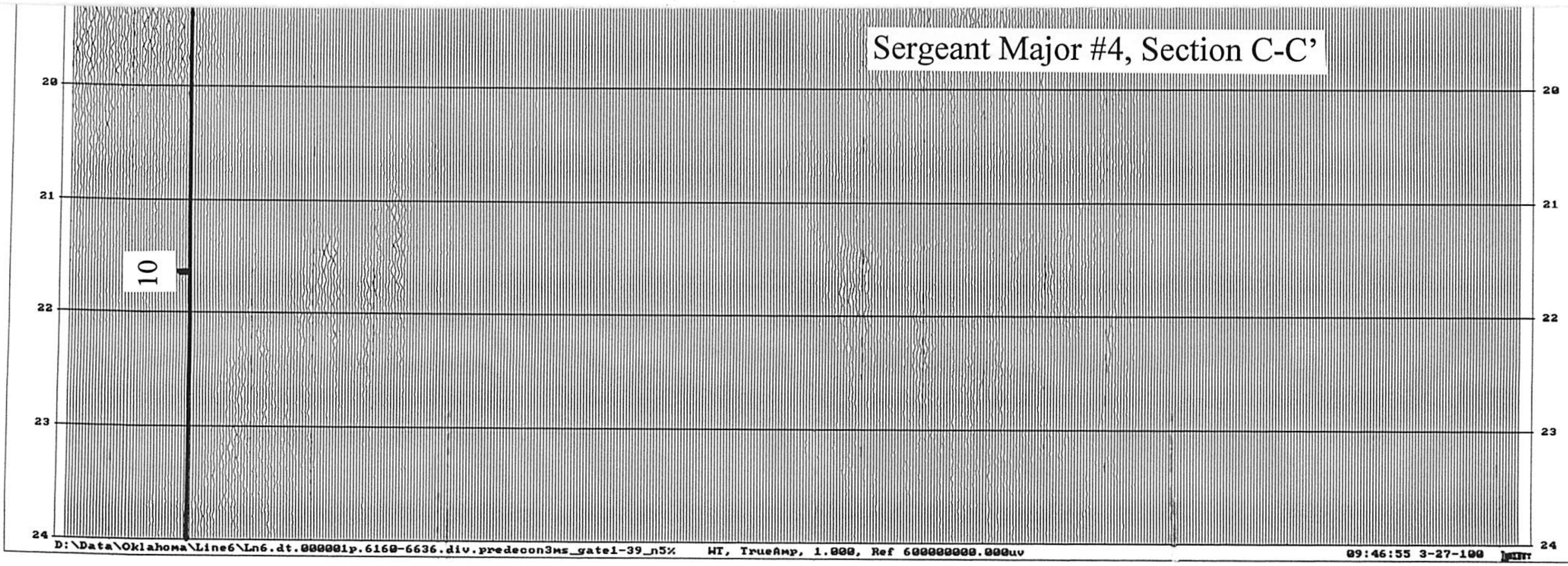

Sergeant Major #4, Section C-C'
10
20
21
22
23
24
D:\Data\Oklahoma\Line6\Ln6.dt.000001p.6160-6636.div.predecon3ms_gate1-39_n5%
WT, TrueAmp, 1.000, Ref 600000000.000uv
09:46:55 3-27-100

Figure 3-17. Seismogram of section D-D' from Sergeant Major #4 (next page; refer to Figure 3-13). Thick solid line is location of boomer (approximately 0.5 m below the water surface), and solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 127 m.

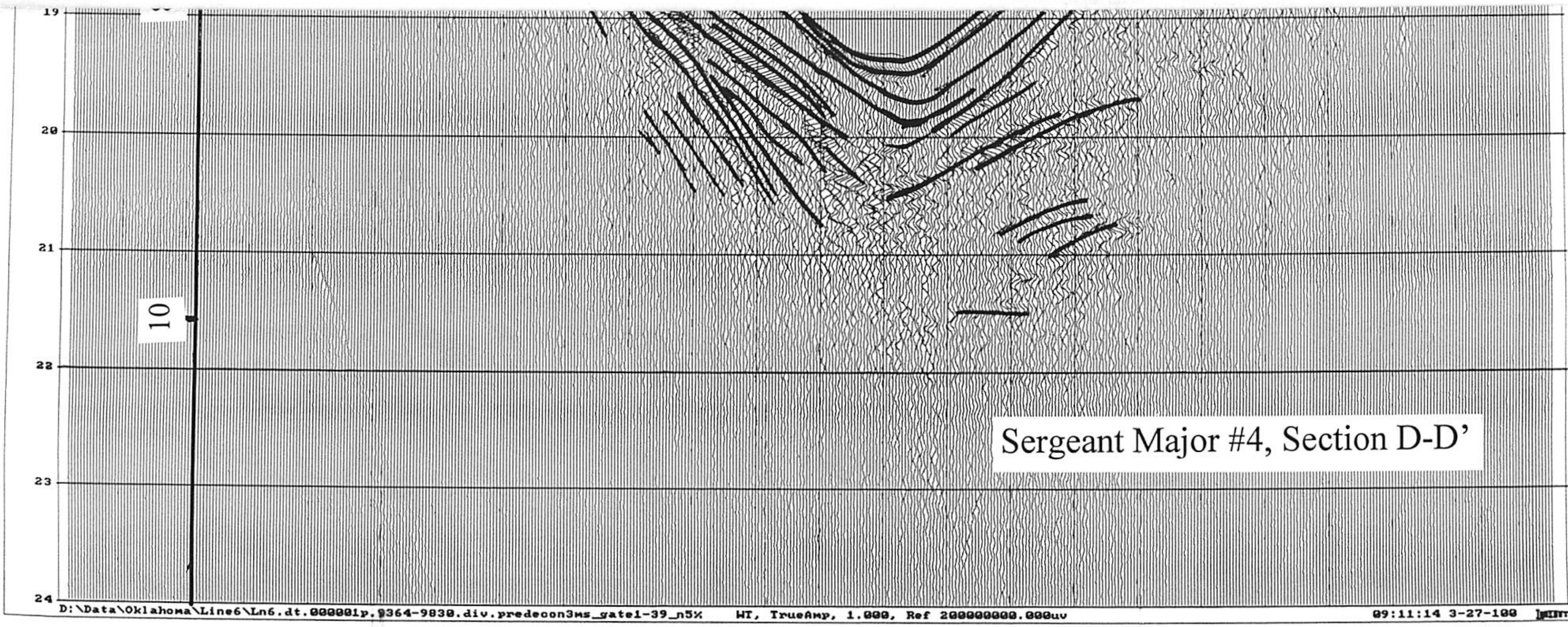
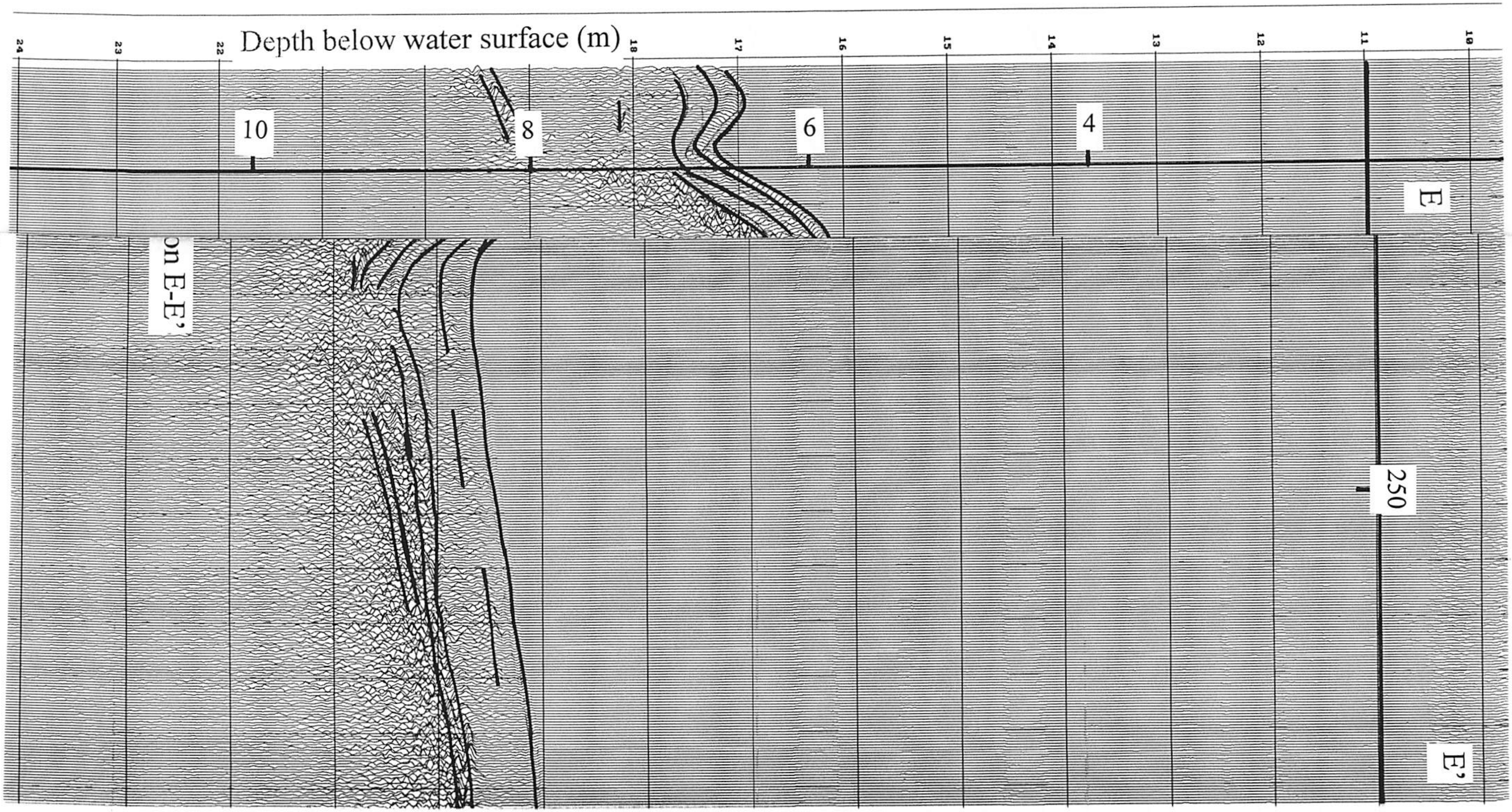

19
20
21
22
23
24
10
Sergeant Major #4, Section D-D'
D:\Data\Oklahoma\Line6\Ln6.dt.000001p.9364-9830.div.predecon3ms_gate1-39_n5%   WT, TrueAmp, 1.000, Ref 200000000.000uv
09:11:14 3-27-100

Figure 3-18. Seismogram of section E-E' from Sergeant Major #4 (next page; refer to Figure 3-13). Solid lines are seismic reflectors identified. Depth and length scales are shown, and total length of seismic record is 293 m. Due to space limitations, the location of the boomer was omitted.


Depth below water surface (m)
24
23
22
18
17
16
15
14
13
12
11
10
10
8
6
4
E
on E-E'
250
E'

3.4 Discussion

Seismic profiles were successfully obtained in each of the three reservoirs in Oklahoma. However, the very shallow water depths at Sugar Creek #12 and Sugar Creek #14 caused unwanted noise in the seismic signal, and the processed data are difficult to interpret. The seismic profiles obtained at Sergeant Major #4 required less processing, and hence these show optimum performance of the seismic system. Individual seismic reflectors of less than 0.1 m in thickness were recognizable at distances of 10 m below the water surface and at depths of up to 1.5 m below the sediment bed.

The seismic profiles obtained at Sugar Creek #12 and #14 show that very soft sediment occurs near the sediment-water interface, and this sediment is approximately 0.1 to 0.2 m thick. This horizon can be traced across each reservoir, but its thickness does not vary appreciably. In both lakes, a very strong seismic reflector is observed at a subsurface depth of approximately 0.2 m. This reflector caused a significant amount of unwanted noise in the seismic signal, thus requiring a great deal of meticulous numerical processing. Very few deep reflectors are observed in these seismic profiles due to this unwanted noise. The cause for this reflector and its characteristics are still unknown. It is interesting to note that this reflector is present in both lakes, and it may represent a deposit of sand or gravel due to a recent high discharge event.

The seismic profiles at Sergeant Major #4 show a number of distinct reflectors in the subsurface. These reflectors range in thickness form 0.1 to 0.5 m and occur at depths of up to 1.5 m below the sediment bed. Several reflectors can be traced up to 80 m across the lake, while others appear to be restricted to the topographically low regions. Reflector thickness appears to be greatest along the northwestern tributary arm, while the thinnest reflectors occur along the small central tributary arm. Nonetheless, reflectors were ubiquitous in all regions of the lake.

Seismic data alone is not enough to characterize the subsurface stratigraphy within these reservoirs. The acquisition of deep sediment cores at key locations will provide invaluable information because such data will constrain the location and physical characteristics of the observed seismic horizons. More importantly, the core data will provide the opportunity to reanalyze the seismic profiles with *a priori* knowledge of the subsurface stratigraphy. Hence the coring activities in Phase II of the project will greatly facilitate the processing and further analysis of the seismic data from Phase I.

4. Chemical Analysis

4.1 Sediment Sampling Methods

Phase I sediment sampling was completed during the period of October 26 to October 28, 1999. Sampling sites within each lake were selected to provide representative sediments from areas of deposition in major lake inlets and within the main pool area adjacent to the embankment. At each sampling site, sediment cores were taken to greatest depth possible with manual coring equipment and procedures from an anchored boat. Multiple attempts at sampling adjacent to an initially selected site were occasionally necessary when coring was hindered or impossible due to water depths exceeding manual coring equipment capabilities, lack of accumulated sediment, excessive large stony material in sediments, or dense clam or mussel populations.

A sufficient number of four-inch diameter sediment cores were driven at each site, lifted into a clean semi-tubular ruled trough, and separated as necessary for needed analyses. For Cesium analysis, 10 cm sections by depth from sediment surface were separated and stored until a minimum of 1 kg of sediment from each interval was acquired. At each site, depth-integrated sediment samples (proportionally representative of entire depth of core) were collected into appropriately prepared containers for pesticide and contaminant analyses for Group 1 (Priority Pollutant Pesticide/PCB, see Table 1-1) and Group 2 (Oil Field Contaminants, see Table 1-1) contaminants. Thus, at each site, sediment samples were taken for measurement of 45 physical properties and possible contaminants.

4.2 Sediment Sampling Locations

Proximate locations of sampling sites for each lake are illustrated on Figures 4-5, 4-6, and 4-7. At total of seven sites were sampled and each is described in Table 4-1. GPS data were collected at each sample location, but due to problems with the base station data these positions could not be differentially corrected.

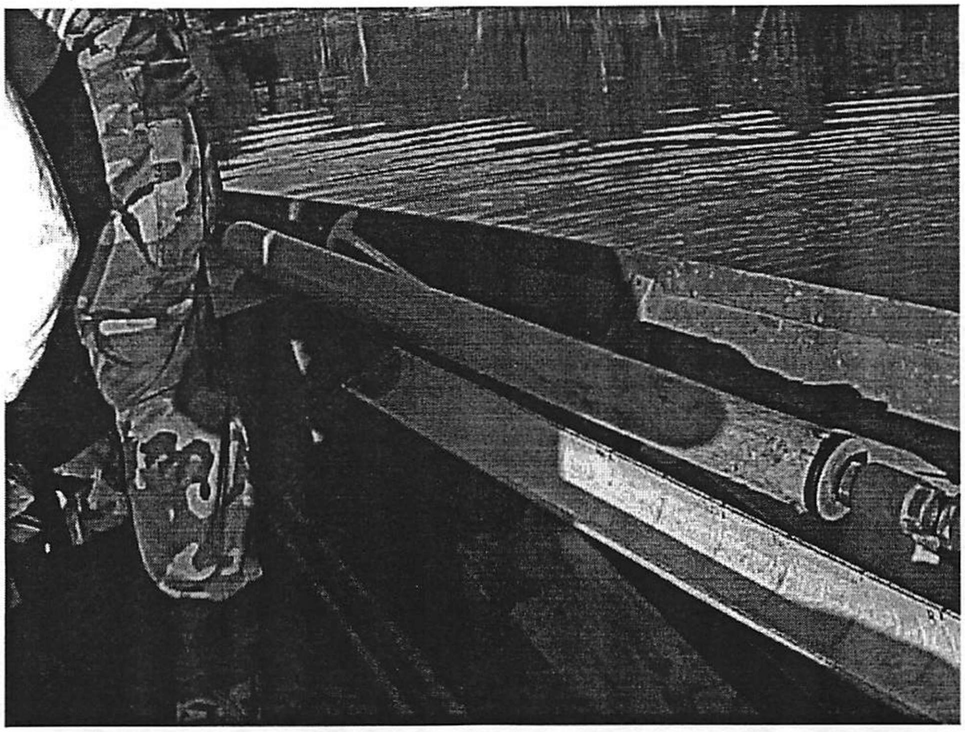


Figure 4-1. Photograph of the sediment coring tube used to obtain sediment samples (taken at Sugar Creek #12, October 1999).

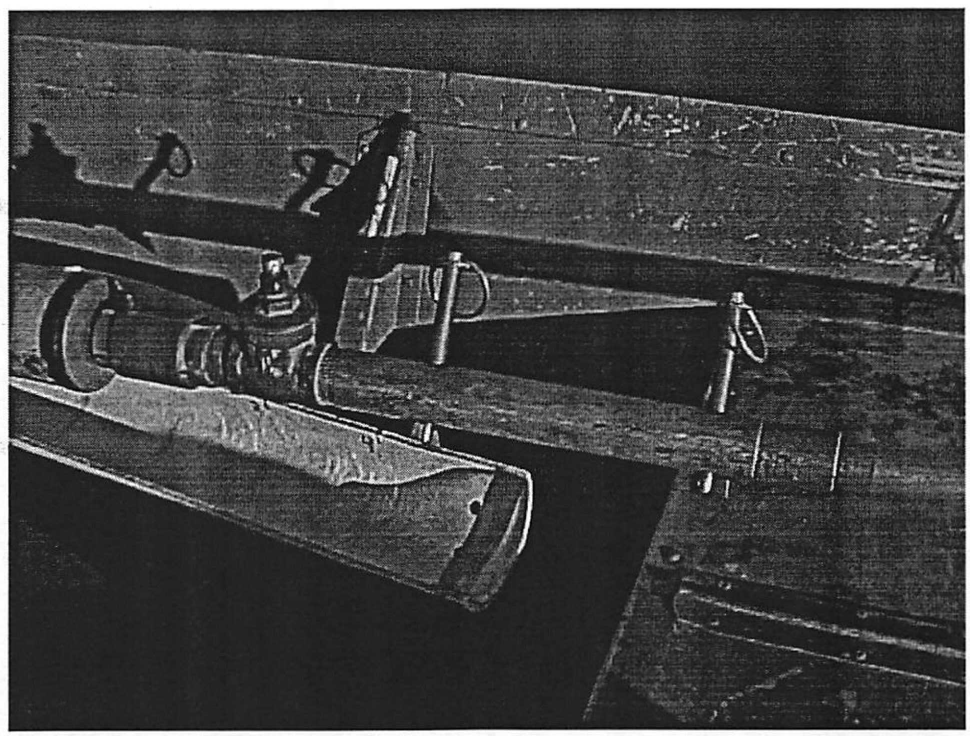


Figure 4-2. Photograph of the sediment coring tube used to obtain sediment samples and the ruled sediment core catcher (taken at Sugar Creek #12, October 1999). Also shown is the aluminum extension necessary to obtain deep-water samples.

Figure 4-3. Photograph of the sediment core being extruded into core catcher (taken at Sugar Creek #12, October 1999). Core is extruded by tipping core and shaking out contents.

Figure 4-4. Photograph of the sediment from core being placed into sample bottles for later analysis (taken at Sugar Creek #12, October 1999).

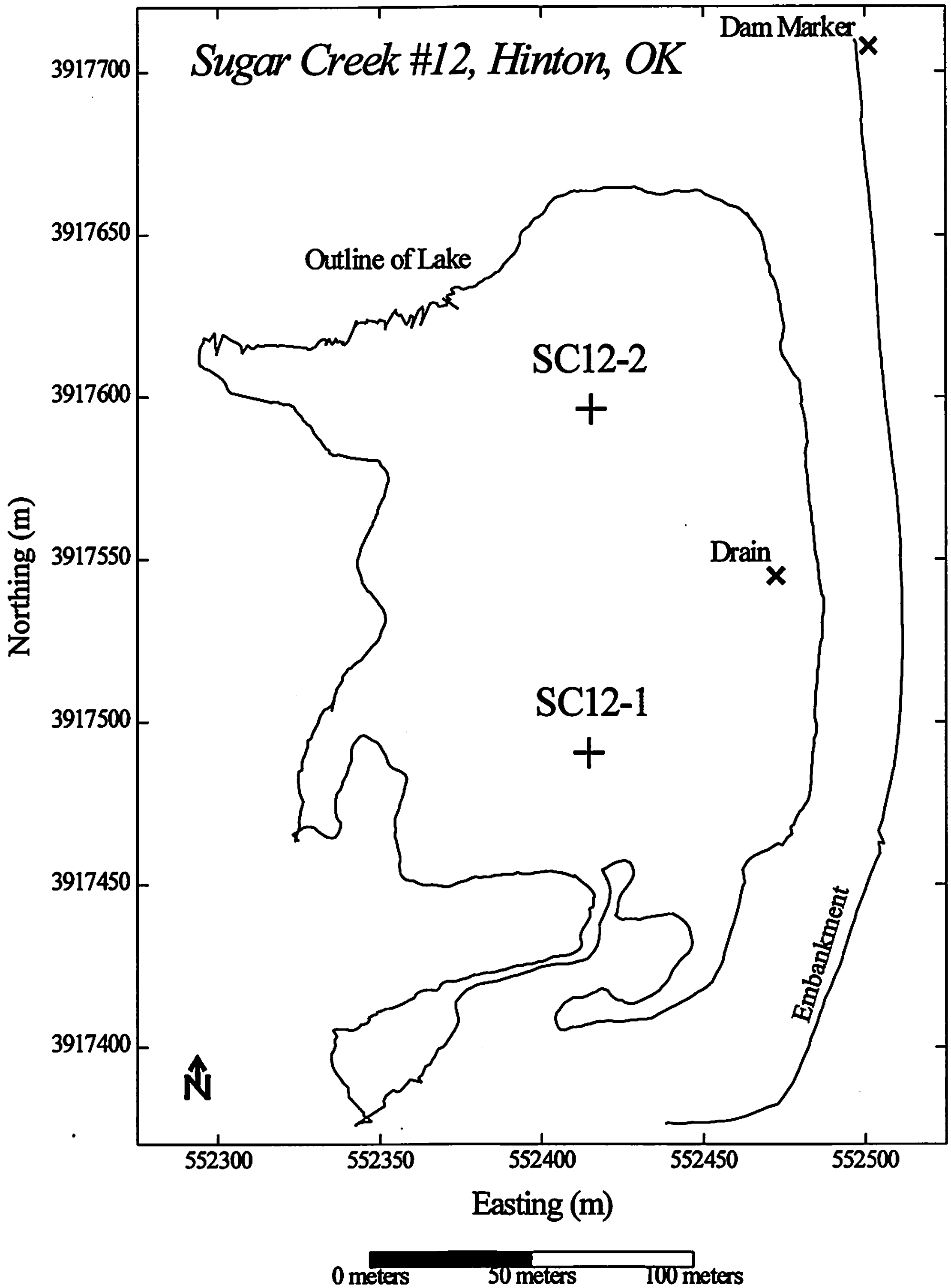


Figure 4-5. Map of Sugar Creek #12 showing sediment sample locations.

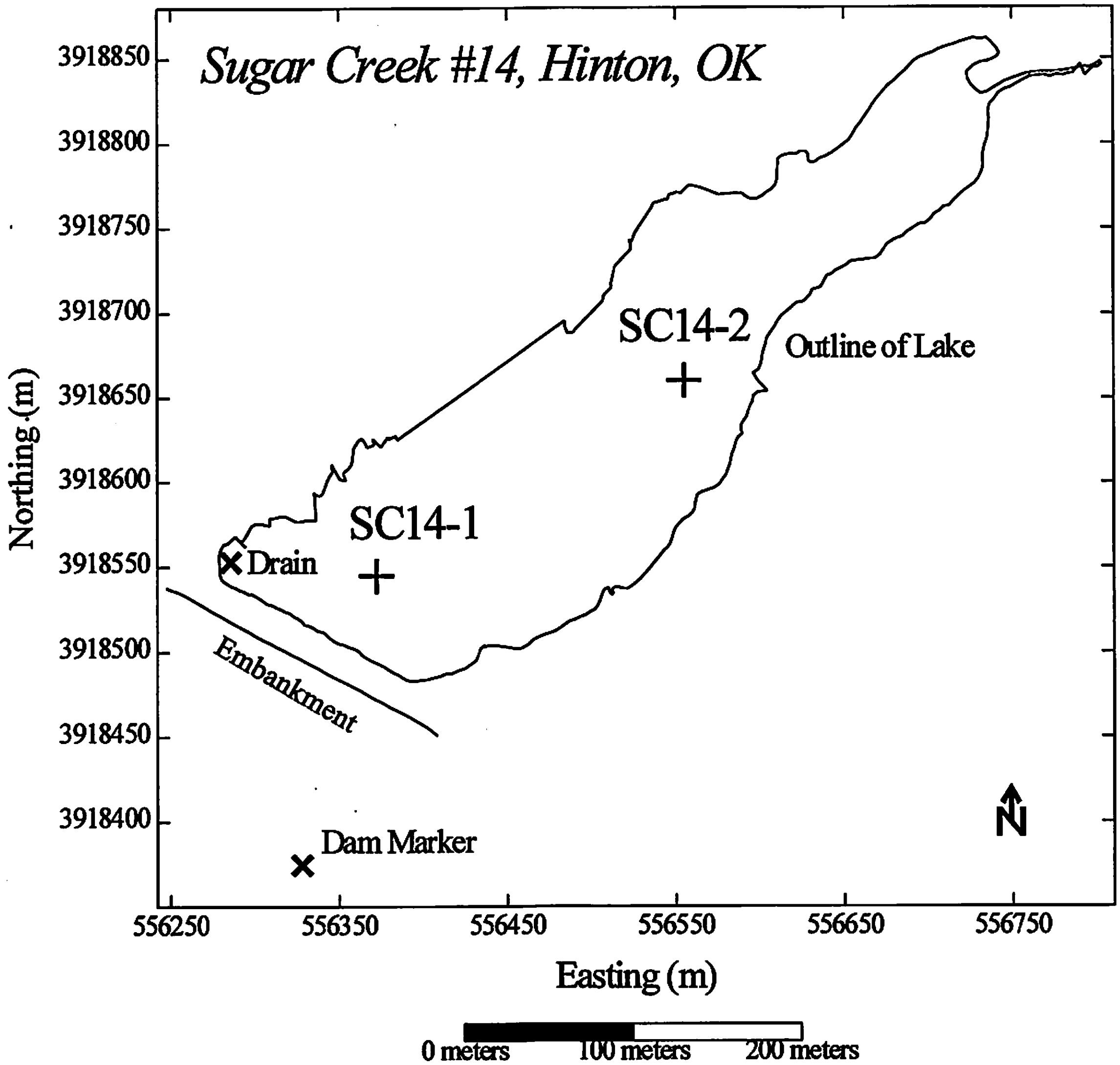


Figure 4-6. Map of Sugar Creek #14 showing sediment sample locations.

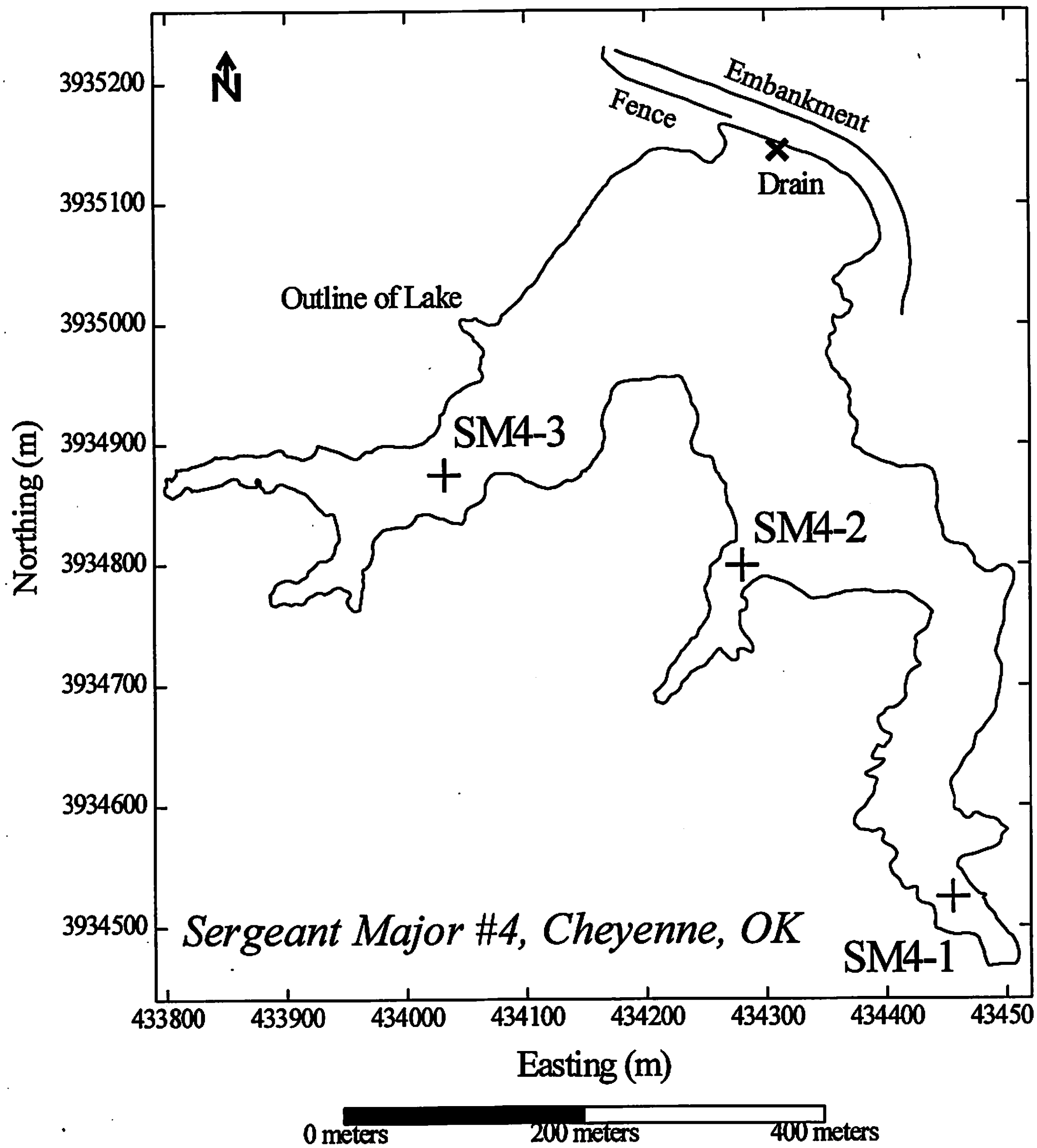


Figure 4-7. Map of Sergeant Major #4 showing sediment sample locations.

Table 4-1. Characteristics of sediment samples obtained by the USDA-ARS at Sugar Creek #12, Sugar Creek #14, and Sergeant Major #4, October 1999.

Sample Number	Location	Water Depth (m)	Thickness of Sediment Core Sampled (m)	Samples Secured
			Sugar Creek #12	
SC12-1	Mouth of major inflow	~0.6	0 to 0.8	8 sections for Cesium dating plus depth integrated sample
SC12-2	Mid-lake	~0.9	0 to 1.0	10 sections for Cesium dating plus depth integrated sample
			Sugar Creek #14	
SC14-1	Mid-lake	~1.2	0 to 0.2	2 sections for Cesium dating plus depth integrated sample
SC14-2	Main pool adjacent to levee	~2.4	0 to 0.3	3 sections for Cesium dating plus integrated sample
			Sergeant Major #4	
SM4-1	Southeastern arm of lake	~2.4	0 to 0.4	4 sections for Cesium dating plus depth integrated sample
SM4-2	Smaller central inlet arm of lake	~3.7	0 to 0.4	4 sections for Cesium dating plus depth integrated sample
SM4-3	Northwestern arm of lake	~5.5	0 to 0.4	4 sections for Cesium dating plus depth integrated sample

Observations made during Phase I sampling indicate that Sugar Creek #12 has received very high amounts of sediment and has very little storage capacity left. Due to its small size, sediment was sampled at only two sites in this reservoir during Phase I. Sample SC12-2 was taken at mid-lake to represent main pool sediments.

Sugar Creek #14 does not appear to have suffered from excessive sedimentation, as coring attempts encountered resistant substrates under shallow sediments throughout the lake. Numerous sampling attempts closer to the inlet area of this lake were unsuccessful due to encounters with a hardened substrate layer under very shallow layers of sediment.

Sergeant Major #4 did not show excessive sediment accumulation, but large stony substrate particles and high-density clam populations were frequently encountered while attempting to sample shoreward sections of inlet arms of this lake. Mouths of inlets near the main body of the lake exceeded the depth capacity of manual coring equipment used (water column depth greater than 25 ft). The main pool was not sampled within Sergeant Major #4 due to unsafe boating conditions caused by excessive wind velocities at the time of the site visit.

4.3 Results for Chemical Analysis

4.3.1 Cesium Analysis

Measurements of radioactive Cesium validated observations by USDA-NRCS and USDA-ARS personnel on site. Only Sugar Creek #12 appears to have excessive sedimentation rates. Results are preliminary and based on a number of assumptions that will be tested more fully, if necessary, during Phase II. The preliminary testing could not reveal if cores reached parent material. For purposes of this report, we note that even if cores in Sergeant Major #4 and Sugar Creek #14 only reached the 1964 horizon of radioactive material produced by Russian atmospheric bomb testing, sediment has accumulated at less that 1 cm/yr in the reservoirs. If manual cores reached parent material (which is likely), accumulation rates would be even less. Some sediment in shallow areas has evidently been mixed by wave action and little can be inferred from the core analysis except that sediment accumulation is not a major problem. To the contrary, sediment core analysis in Sugar Creek #12 reveals that sediment cores of one meter did not reach parent material. Thus, sediment accumulation approaches or exceeds 2.5 cm/yr since the reservoir was commissioned in 1964. This deposited sediment has greatly reduced the capacity of the reservoir. Cesium concentrations in the cores from Sugar Creek #12 can be interpreted to indicate that sheet erosion in the watershed has decreased proportional to gully erosion in the watershed.

4.3.2 Pesticides and PCB Analysis

All planned Phase I sediment chemical analyses have been completed. Table 1-1 lists all Pesticides and PCBs examined within sediment samples. Detectable Group I contaminants are listed in Table 4-2, and this table indicates that traces of one DDT breakdown product were detectable in the Sugar Creek watershed at both Sugar Creek #12 and Sugar Creek #14 reservoirs, but no other investigated pesticide or PCB compounds were detected. These were only 4 out of 175 possible detections for contaminant compounds in this group.

Table 4-2: List of all Pesticides/PCB (Group I) detected in Phase I samples. Note that DDE 4,4' was not detected in samples SM4-1, SM4-2, and SM4-3.

Sample	Compound	Concentration (ppb)
SC12-1	DDE 4,4'	58.7
SC12-2	DDE 4,4'	62.3
SC14-1	DDE 4,4'	9.8
SC14-2	DDE 4,4'	9.2

ppb = parts per billion
Laboratory: Northeast Louisiana University, Monroe, Louisiana

4.3.3 Oil Field Contaminants, Sediment Parameters, Major Element, and Heavy Metal Analysis

A variety of other sediment properties and possible contaminants often monitored in association with oil fields (Group II) was measured (Table 4-3). As expected, sediment pH was generally neutral in the more eastern Sugar Creek reservoirs, but was somewhat alkaline in Sergeant Major reservoir in western Oklahoma. Sodium, Potassium, Calcium and Magnesium concentrations were found within expected ranges of concentration values for sediments. Sediment electrical conductivity (EC), Sodium Absorption Ratio (SAR), Cation Exchange Capacity (CEC) and Exchangeable Sodium Percentage (ESP) were within expected limits at all sites. Observed values for those properties imply a natural balance of sediment elemental ion concentrations. General analysis for Oil & Grease showed presence of only very small proportions of this contaminant in tested sediments from all lakes. Metals concentrations were roughly similar between all sample sites, and fell within expected concentration ranges.

Table 4-3: List of elements, compounds, and other sediment properties comprising Group II (U.S. Environmental Protection Agency Oil Field Contaminants) and their measured values.

Material	Units	Sample						
		SC12-1	SC12-2	SC14-1	SC14-2	SM4-1	SM4-2	SM4-3
pH		6.9	6.8	6.8	6.8	7.9	8	8.1
EC	mmhos/cm	1.9	3.1	2.6	3.2	1.9	2.1	2.1
SAR		0.4	0.4	0.5	0.4	0.5	0.4	0.6
CEC		26.4	31	34.6	45.8	44.4	71.7	57.7
ESP	%	1.7	1.7	1.8	1.4	1.7	1.2	1.8
Sodium	ppm	101	125	141	142	176	193	237
Potassium	ppm	222	288	389	427	76	104	130
Calcium	ppm	3983	4646	4879	6972	7723	12720	9629
Magnesium	ppm	669	798	1049	1137	599	872	1013
Oil & Grease	%	0.06	0.01	0.07	0.07	0.08	0.08	0.21
Moisture		5.4	6.1	6.43	7.51	3.11	2.78	3.65
Arsenic	ppm	3.9	4.8	3.9	4.3	2.6	4.5	4.1
Barium	ppm	151.2	219.3	188.1	210.6	162.2	180.2	184
Cadmium	ppm	3.7	5.2	5.1	6	2.4	2.9	3.03
Chromium	ppm	17.8	28.3	30.5	31.5	12.2	14.5	14.6
Lead	ppm	10.3	15.2	15.6	17.11	6.65	8.63	9.85
Mercury	ppm	0.16	0.08	0.1	0.07	0.04	0.08	0.08
Selenium	ppm	0.55	0.34	0.13	0.47	0.54	0.54	nd
Silver	ppm	nd	0.37	1.34	1.56	1.5	1.59	2.35
Zinc	ppm	34.3	51.4	80.9	59.7	24.9	29.88	30.1

ppm—parts per million; EC—Electroconductivity; SAR—Sodium Absorption Ratio; CEC—Cation Exchange Capacity; ESP—Exchangeable Sodium Percentage
<u>Laboratory</u>: Northeast Louisiana University, Monroe, Louisiana

4.3.4 Previous Sediment Quality Analysis

In November 1998, USDA-NRCS personnel obtained three sediment samples from Sugar Creek #12, and Table 4-4 presents the results of their chemical analysis. The results show that the contaminants and total petroleum hydrocarbons examined were not detected in the sediment samples. The observed concentration of Arsenic in the sediments (Table 4-4) are quite comparable to those obtained by USDA-ARS sampling and analysis (Table 4-3).

Table 4-4. Sediment quality analysis of sediment samples taken by the USDA-NRCS at Sugar Creek #12, November 1998.

Material	Units	Sample 1-1	Sample 1-2	Sample 1-3	Laboratory	Method
2,3,5-T	ppm	nd	nd	nd	L1	M1
2,4,5-TP (Silvex)	ppm	nd	nd	nd	L1	M1
2,4-D	ppm	nd	nd	nd	L1	M1
2,4-DB	ppm	nd	nd	nd	L1	M1
Dalpon	ppm	nd	nd	nd	L1	M1
Dicamba	ppm	nd	nd	nd	L1	M1
Dichloroprop	ppm	nd	nd	nd	L1	M1
Dinoseb	ppm	nd[1]	nd[1]	nd[1]	L1	M1
MCPA	ppm	nd	nd	nd	L1	M1
MCPP	ppm	nd	nd	nd	L1	M1
Total Petroleum Hydrocarbons (C6-C24)	ppm	u	u	u	L2	M2
Arsenic	ppm	7.2	8.2	6.4	L2	M3

ppm—parts per million, nd—not detected, u—below detection limit of 3 mg/kg
Laboratories L1: Continental Analytical Services, Salina, Kansas; L2: Department of the Army, Corps of Engineers, Omaha, Nebraska
Analytical Methods: M1—EPA SW846 8151A non-aqueous; M2—EPA 8015 (modified); M3—EPA 6010B
[1]This analysis did not meet quality control criteria

4.4 Discussion

Results from testing sediments from all three reservoirs showed very good overall sediment quality. On contaminant analysis, there were no concentrations of major concern noted. The presence of DDE in sediment, a metabolite of DDT, poses no health issue. Breakdown products of DDT are common in some reservoirs that trap sediments from land farmed in the 1950's and 1960's. Metabolites degrade quite slowly in anaerobic sediments for decades. The greater concentration observed in Sugar Creek #12 reflects historical use and erosion rates.

Physical and elemental properties that were measured fell within expected ranges of values for naturally occurring sediments at all three lakes and do not indicate any potential adverse effects on water quality in the reservoirs. Concentrations of metals in reservoir sediments were below known toxic levels, and cation concentrations were balanced.

Projected Phase II sediment sampling will be greatly facilitated by information resulting from the seismic surveys made during the Phase I preliminary data gathering visits to the sites. Accurate knowledge of sediment layer depths will help yield selection of better representative sediment coring locations within each lake during Phase II. Also, the use of a mechanical vibracoring device during Phase II should allow deeper sampling into sediments and native surfaces, and will also allow sampling of a larger number of sites in each lake. With better representative sampling during Phase II, much more detailed analyses for sediment characterization and contamination will be carried out. Increased spatial coverage will be obtained within lakes and additional compounds of concern will be measured, yielding a sound assessment of the current conditions and possible consequences of future actions within these reservoirs.

5. Conclusions

Since 1944, the USDA-NRCS has constructed over 10,000 upstream flood-control dams in 2000 watersheds in 46 states, each with a design life of 50 years. The watershed projects, which represent a $14 billion infrastructure, have provided flood control, municipal water supply, recreation, and wildlife habitat enhancement. Because of population growth and land-use changes through time, sediment pools are filling, some structural components have deteriorated, safety regulations are stricter, and the hazard classification has changed for some dams.

Before any rehabilitation strategy can be designed and implemented, the sediment impounded by these dams must be assessed in terms of the structure's efficiency to regulate floodwaters and the potential hazard the sediment may pose if reintroduced into the environment. To this end, a demonstration project was designed to evaluate technologies, methodologies, and protocols for the cost-effective characterization of sediment.

For a given lake within an embankment flood-control structure, the USDA-NRCS needs to determine (1) the thickness of sediment deposited, (2) the rates of sedimentation, (3) the quality of sediment with respect to agrochemicals (related to agricultural practices) and petrochemicals (related to hydrocarbon extraction, drilling, and well development), and (4) the spatial distribution of the sediment quality. Based on visits to the reservoirs in Oklahoma and discussions with the USDA-NRCS, the USDA-ARS National Sedimentation Laboratory and its academic colleagues recommended the use of seismic surveying, vibracoring, and detailed chemical analysis to characterize the quality and quantity of sediment within these reservoirs.

The work was split into two phases. Phase I entails seismic surveying and sediment quality analysis of select samples at all three locations. Phase II entails vibracoring and detailed sediment analysis based on results from Phase I. This report represents the completion of Phase I.

Three field sites were chosen for this demonstration project. Sugar Creek #12 is located near Hinton, OK, and it is a relatively small lake with a silt bottom and fairly shallow water depths. The main stream supplying the lake is considered unstable due to the presence of actively migrating knickpoints, and excessive sedimentation rates have significantly decreased storage capacity. Moreover, historic land use of cultivated fields of cotton and peanuts suggests that agrochemicals may be present in the lake sediments. Sugar Creek #14 is also located near Hinton, OK, and it is a relatively small lake with a silt bottom and fairly shallow water depths. Historic land use includes a small amount of cultivated fields of cotton and peanuts, but preliminary surveys indicate that sedimentation rates were not as high here as they were at Sugar Creek #12. Sergeant Major #4 is located near Cheyenne, OK and is a moderately sized structure, covering an area of about 35 acres. This site was chosen because it has become the sole municipal source of water for the town of Cheyenne, and preserving water quality is a major concern.

In November 1999, seismic surveys of each lake were conducted in cooperation with IKB Technologies, LTD., using their IKB-SEISTEC system. An electrodynamic boomer and seismic receiver were mounted to a catamaran and towed behind a 16-ft boat that carried all peripheral equipment. All seismic data were processed and specific seismic reflectors were identified in the subsurface.

Very shallow water depths at Sugar Creek #12 and #14 caused unwanted noise in the seismic signal, and the processed data are difficult to interpret. Seismic profiles show the presence of soft sediment near the surface, approximately 0.1 to 0.2 m thick, and this sediment is ubiquitous across the lake. In both reservoirs, a very strong seismic reflector of unknown origin is observed at a depth of 0.2 m. Very few deep reflectors are observed due to the presence of the unwanted noise in the seismic signal. The shallow water depths at the Sugar Creek sites are typical of many flood-control reservoirs, and the seismic system as used herein may pose significant technical limitations

The seismic profiles obtained at Sergeant Major #4 required less processing, and hence these show optimum performance of the seismic system. Numerous reflectors 0.1 to 0.5 m thick are observed in the seismic records to subsurface depths of up to 1.5 m, and several can be traced up to 80 m across the lake.

Sediment samples were obtained at representative locations in each lake to assess the presence of environmentally harmful elements and compounds and to determine the relative rates of sedimentation. Sediment cores up to 1 m long were secured using manual coring equipment, and the extracted sediment was sampled for chemical analysis. All sediment samples were analyzed for Priority Pollutant Pesticide/PCB of potentially dangerous compounds and for oil field contaminants as prescribed by the U.S. Environmental Protection Agency.

General analysis of oil and grease shows the presence of only small proportions of this contaminant. Of the pesticides and PCBs tested, there are no concentrations of major concern. Detectable levels of DDE are observed at Sugar Creek #12 and Sugar Creek #14. However, DDE, a metabolite of DDT, poses no health issue. Breakdown products of DDT are common in some reservoirs that trap sediments from land farmed in the 1950's and 1960's.

Preliminary results of analysis of Cesium indicate that at Sugar Creek #12 sedimentation rate approaches or exceeds 2.5 cm/yr. Sedimentation rates in Sugar Creek #14 and Sergeant Major #4 are less than 1 cm/yr.

<u>Phase II</u> of the project will concentrate on (1) obtaining deep sediment cores using a vibracoring system and (2) examining the quality of the sediment in detail. Many of the results presented herein will be reanalyzed in light of the new information gained through coring.