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Sediment Thickness from Coring and Acoustic Profiling, Lake Buchanan, Llano and Burnet Counties, TX

Final Report

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SUMMARY

On August 26, 2006 we collected six vibracore samples in Lake Buchanan, Llano and Burnet Counties, Texas. We also collected short profiles through each core location using a multi-frequency sub-bottom acoustic profiling system from Specialty Devices Inc., of Wylie, Texas (SDI). The SDI profiler imaged the water bottom and sub-bottom at signal frequencies of 208, 50, and 25 kHz. These data were used to verify acoustically determined sediment thicknesses in a sediment survey conducted by the Texas Water Development Board (TWDB). Of the six cores, three contained only post-impoundment sediment and no pre-impoundment material, and three successfully penetrated the entire post-impoundment sediment layer and sampled underlying pre-impoundment material. Overall, the coring results indicate that the post-impoundment layer is thickest in the northern part of the reservoir, near the main tributary inlet. The layer varies from a thickness of about 2 m in the northern part of the reservoir to a few tens of centimeters, south of the middle of the reservoir. In the north, the base of the post-impoundment layer appears to coincide with base of returns of the 50 kHz signal, although this was not directly proven by coring. In the mid-lake region, the base of returns at all three frequencies track the base of the post-impoundment layer. South of the mid-lake region, where the sediment is only a few tens of centimeters thick, the base of sediment coincides with the base of returns of the 208 kHz signal.

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1. INTRODUCTION

On August 26, 2006 we collected six vibracore samples in Lake Buchanan, Llano and Burnet Counties, Texas. The goal of this study was to determine the thickness of sediments that have accumulated in the reservoir since its impoundment in 1937 to verify acoustically determined sediment thicknesses in a sediment survey conducted by the Texas Water Development Board (TWDB). This report describes the results of the coring operation.

2. PROCEDURES

2.1 Sediment Coring

A commercially available vibracoring system from Specialty Devices, Inc. of Wylie, Texas (SDI) was used to collect 3-in diameter sediment cores of varying length. The SDI vibracore uses a 1-HP, DC motor that drives a pair of eccentrically mounted weights, which vibrates an attached aluminum core tube into the bottom. The vibration liquefies the sediment adjacent to the tube wall, allowing the sediment core to slide into the tube with relatively little disturbance to the sample. Cores were collected by lowering the vibrator with core tube attached to the bottom by hand winch, switching on the vibrator, and allowing the tube to slowing vibrate into the bottom. When the core had reached the point of refusal, the vibrator was turned off and the core was winched out of the bottom. On deck, the retrieved cores were capped top and bottom with rubber end-caps and stored upright during transport. While still at anchor the geographic position of the core the locations were determined with the differential Global Positioning System (DGPS) built into the SDI profiler.

2.2 Core analysis:

The main objective of our core analysis was to determine the thickness of the post-impoundment sediment so that the base of sediment could be identified on co-located acoustic records. In this analysis, we relied on visual examination of the sampled material and measurements of the water content and sediment penetration resistance. The cores were brought back from the field, cut in half lengthwise and split open for examination for evidence of the pre-impoundment surface. Once the visual examination was complete, the sediment within each 5-cm interval was weighed, dried for 48 hours at 106º C, reweighed and stored for further analysis. The wet and dry weights of the samples were used to compute water content profiles along the cores. During the sub-sampling operation the penetration resistance of the sediment was determined using a penetrometer to measure the force required to drive a 2.5 cm diameter disk into the sediment. These tests were performed on each 5 cm sub-sample, while the sample was confined in the core tube.

2.3 Discriminating Between Pre- and Post-impoundment materials

We determined the depth to the pre-impoundment surface in cores where it was present based on the following evidence: (1) a visual examination of the core for in-place terrestrial materials, such as leaf litter, tree bark, twigs, intact roots, etc., concentrations of which tend to occur on or just below the pre-impoundment surface, (2) changes in texture from well sorted, relatively fine-grained sediment to poorly sorted mixtures of coarse and fine-grained materials, and (3) variations in the physical properties of the sediment, particularly sediment water content and penetration resistance with depth. Sediments deposited in reservoirs typically have water contents that range from 60 to 80% at the water bottom and decrease with burial to 30 to 40% at depths of several meters. Soils, in contrast, typically have water contents of 20 to 30% when saturated. The penetration resistance of reservoir sediments (as measured with penetration devices) typically ranges from near 0 to 2 kg/cm^2. The penetration resistance of saturated clay-rich soils typically ranges from 3 to over 10 kg/cm^2.

2.4 Acoustic Profiling

We used an acoustic sub-bottom profiling system to select coring locations and to record co-located acoustic records at the core sites. The acoustic profiling system we used is a high-resolution version of the SDI profiler used by the TWDB in its sediment surveys. Normally, the system images the bottom and sub-bottom sediments with acoustic transducers with frequencies of 208, 125, 50, 25, and 12 kHz. The high-resolution system samples the acoustic signals up to 1,000,000 times per second, compared to 100,000 samples per second in the conventional SDI profiler. For this study we used only the 208, 50, and 25 kHz, signals sampled 500,000 samples per second, so that the resulting data would approximate that collected with the TWDB system. We used this system to collect short profiles through each core location to compare with the coring results. During post-survey processing core diagrams that show the interpreted post-impoundment sediment thicknesses were posted on the acoustic data at the point of closest approach of the profiles to the core locations.

3. Results

Six cores were collected in Lake Buchanan at locations selected by the TWDB to span the range of apparent sediment thicknesses observed in their survey (Figure 3-1). A summary of core locations, core lengths, and the interpreted depth to the pre-impoundment surface is given in Table 3-1. Water content and penetration resistance versus depth in the cores are shown in Figure 3-2. Interpreted pre- and post-impoundment intervals are posted on co-located acoustic profiles in Figures 3-3 to 3-8. Tables recording the results of the physical analysis of the cores are given in Appendix A.

Of the six cores, three contained only lake sediments and pre-impoundment material, and three penetrated the complete post-impoundment layer and sampled the underlying pre-impoundment material. Cores 1 and 2, were the northern-most cores collected. The normal water depth at these core locations was the shallowest of the six core sites and the locations were the closest to the main tributary inlet. Cores 1 and 2 penetrated 152 and 109 cm of post-impoundment sediment, respectively, but did not reach the pre-impoundment surface. Physical analysis suggests that both cores penetrated a desiccation surface near their base (Figure 3-2 a and b). The desiccation surface is marked by an isolated zone of low water content and high penetration resistance and is indicative of a time in which the reservoir bottom was subaerially exposed, dried, and compacted. Both cores reach approximately 40 cm below the desiccation surface and end in relatively soft sediment. Friction on the core tube associated with the desiccation interval most likely prevented the cores from penetrating to the base of the post-impoundment layer. Acoustic profiles through the core sites indicate that the full sediment thickness at both locations is approximately 190 cm (Figures 3-3 and 3-4). This is indicated by the 50 and 25 kHz records, but not the 208 kHz records.

Cores 3 and 4 were collected near the middle of the reservoir, about halfway between the main tributary inlet and the dam. Core 3 penetrated 93 cm of post-impoundment mud and 32 cm of compacted sand containing preserved plant roots (Figure 3-2 c). The sharp contact between the mud and sand is interpreted as the pre-impoundment surface. The acoustic profile through the core location shows a close agreement between the thickness of the post-impoundment layer observed in the core and the acoustically determined thickness (Figure 3-5). The base of post-impoundment sediment corresponds to the base of acoustic returns at all three acoustic frequencies (208, 50, and 25 kHz). Core 4 penetrated 150 cm of post-impoundment mud and bottomed in relatively soft sediment, with no indication of pre-impoundment materials. The acoustic profile through the core site indicates that the base of post-impoundment layer is at or near the bottom of the core (Figure 3-6). As was the case at the site of Core 3, the base of Core 4 corresponds to the base of returns at all three signal frequencies. Hence, Cores 3 and 4 are similar in all respects, except that Core 4 did not penetrate the pre-impoundment surface. It is possible that Core 4 happened to be located at a site were the post-impoundment sediment was deposited directly over rock outcrop that cannot be penetrated with the vibracore.

Cores 5 and 6 were the southern-most cores collected. Both cores penetrated thin layers of post-impoundment sediment (15 and 23 cm) and then longer intervals of compacted granitic sand and gravel containing preserved plant roots (Figure 3-2 e and f). Acoustic profiles though the core sites suggest that the base of the post-impoundment layer in this part of the reservoir most closely corresponds to the base of the returns at the 208 kHz signal frequency. However, the correlation between the base of sediment and the base of the 208 kHz returns is not real close (Figures 3-7 and 3-8). It is likely that the discrepancy is caused by a combination of rapidly varying sediment thickness and error in the co-location of the cores and acoustic records. The returns at the 50 and 25 kHz signals penetrate into the underlying sand and gravel and end at the base of the core at both sites. Hence, it is possible that both cores bottomed on solid rock and that is what the 50 and 25 kHz signals track in this part of the reservoir.

Overall, the coring results indicate that the post-impoundment layer is thickest in the northern part of the reservoir, near the main tributary inlet and thins from a thickness of about 2 m in that region to a few tens of centimeters, south of the middle of the reservoir. In the north, the base of the post-impoundment layer appears to coincide with the base of returns of the 50 kHz signal, although this was not directly proven by coring. In the mid-lake region, the base of returns at all three frequencies tracks the base of the post-impoundment layer. South of the mid-lake region, where the sediment is only a few tens of centimeters thick, the base seems to follow the base of returns of the 208 kHz signal.

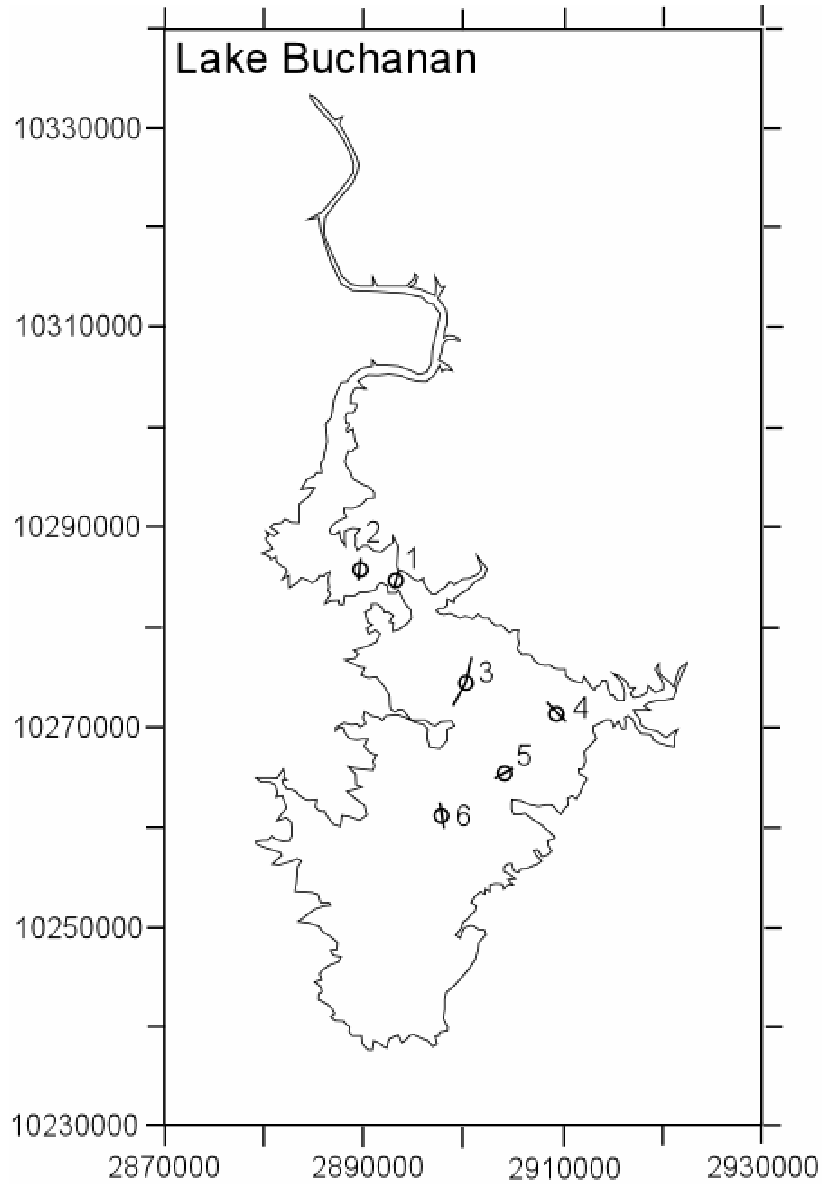
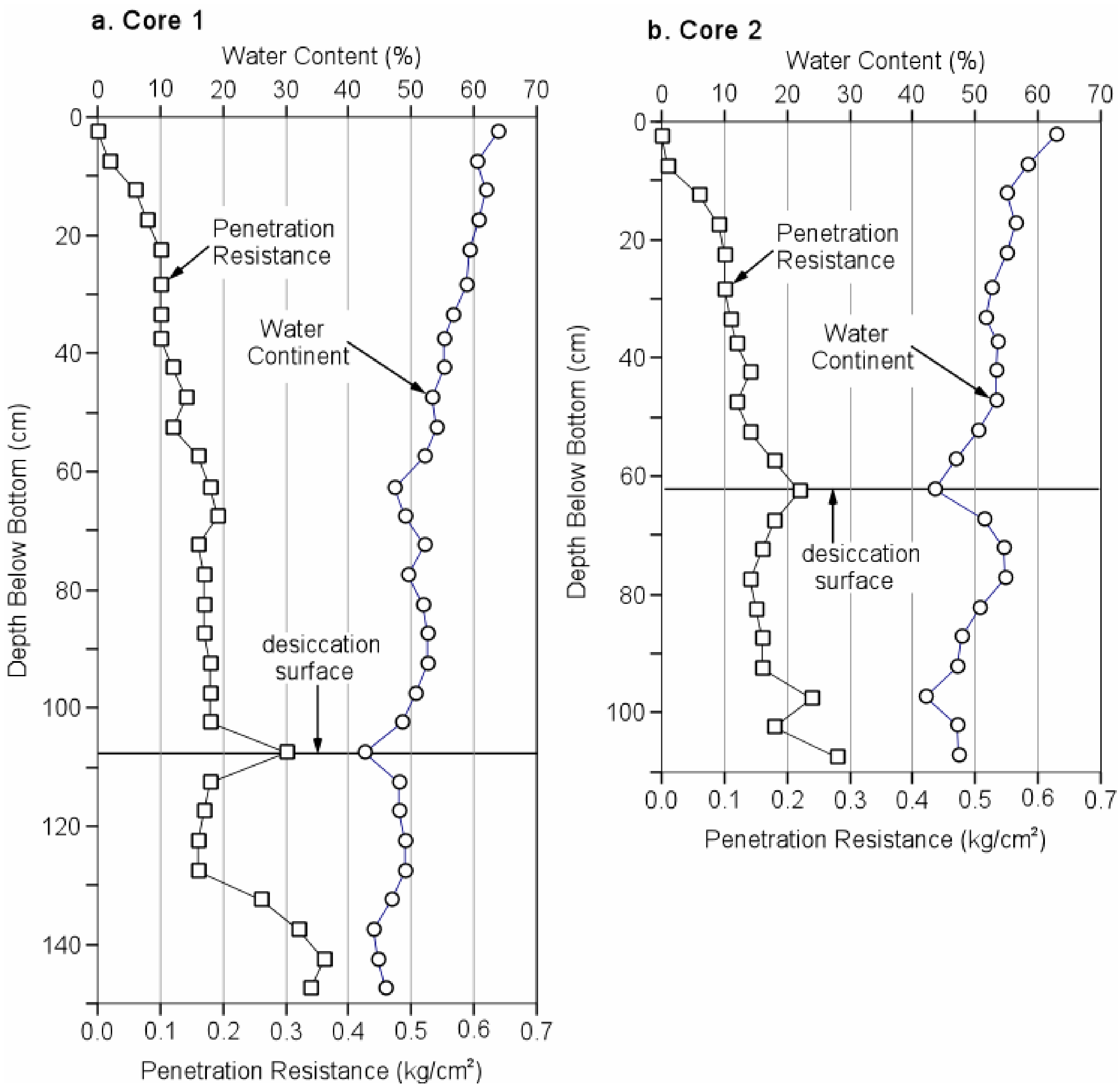
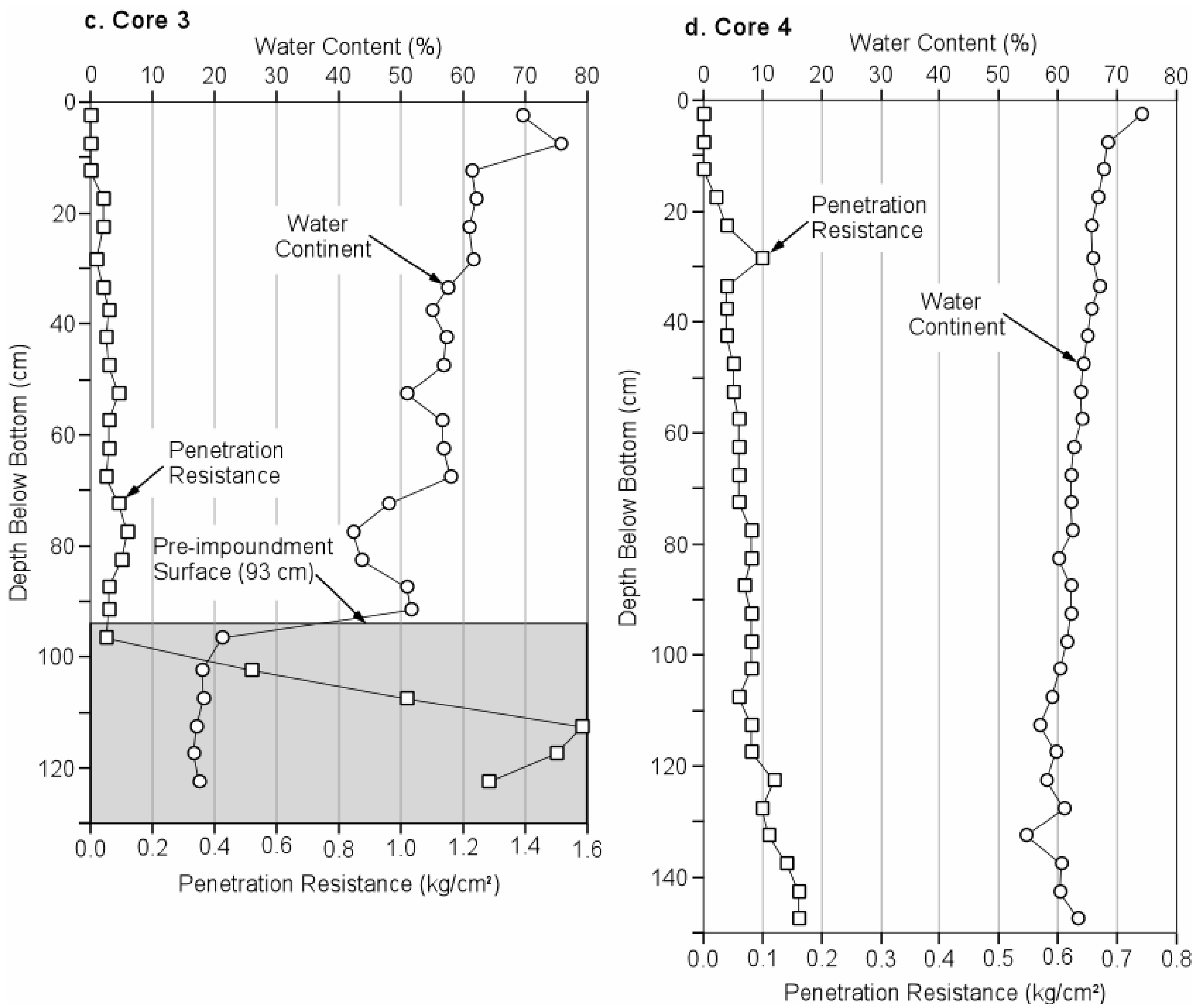


Figure 3-1. Map of core locations in Lake Buchanan (circles). Core numbers are shown adjacent to the corresponding core location. Short acoustic lines (black lines) were collected across each core location. Map coordinates are Texas State Plane, North Central Zone, NAD 83, feet.

Table 3-1. Summary of sediment cores collected in Lake Buchanan. Core locations are given in Texas State Plane, North Central, NAD 83, feet. The length of core and depth to the pre-impoundment surface are given. Estimates of the post impoundment sediment thickness based on acoustic data and not confirmed by direct sampling of the pre-impoundment material are qualified with question marks “?“. Survey line numbers refer to acoustic profiles collected during the coring operation.

Core ID	Easting (ft)	Northing (ft)	Length (cm)	Depth to pre-impoundment (cm)	Line No.
1	2893542.0	10284819.2	152	193?	1
2	2889792.5	10285809.1	109	194?	4
3	2900427.7	10274451.2	125	93	6
4	2909525.3	10271486.8	150	150?	8
5	2904231.1	10265503.5	72	15	12
6	2897996.6	10261132.3	42	23	11


a. Core 1
Water Content (%)
0 10 20 30 40 50 60 70
Penetration Resistance
Water Continent
desiccation surface
Depth Below Bottom (cm)
0 20 40 60 80 100 120 140
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
Penetration Resistance (kg/cm²)
b. Core 2
Water Content (%)
0 10 20 30 40 50 60 70
Penetration Resistance
Water Continent
desiccation surface
Depth Below Bottom (cm)
0 20 40 60 80 100
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
Penetration Resistance (kg/cm²)



c. Core 3
Water Content (%)
Depth Below Bottom (cm)
Water Continent
Penetration Resistance
Pre-impoundment Surface (93 cm)
Penetration Resistance (kg/cm²)
d. Core 4
Water Content (%)
Depth Below Bottom (cm)
Penetration Resistance
Water Continent
Penetration Resistance (kg/cm²)

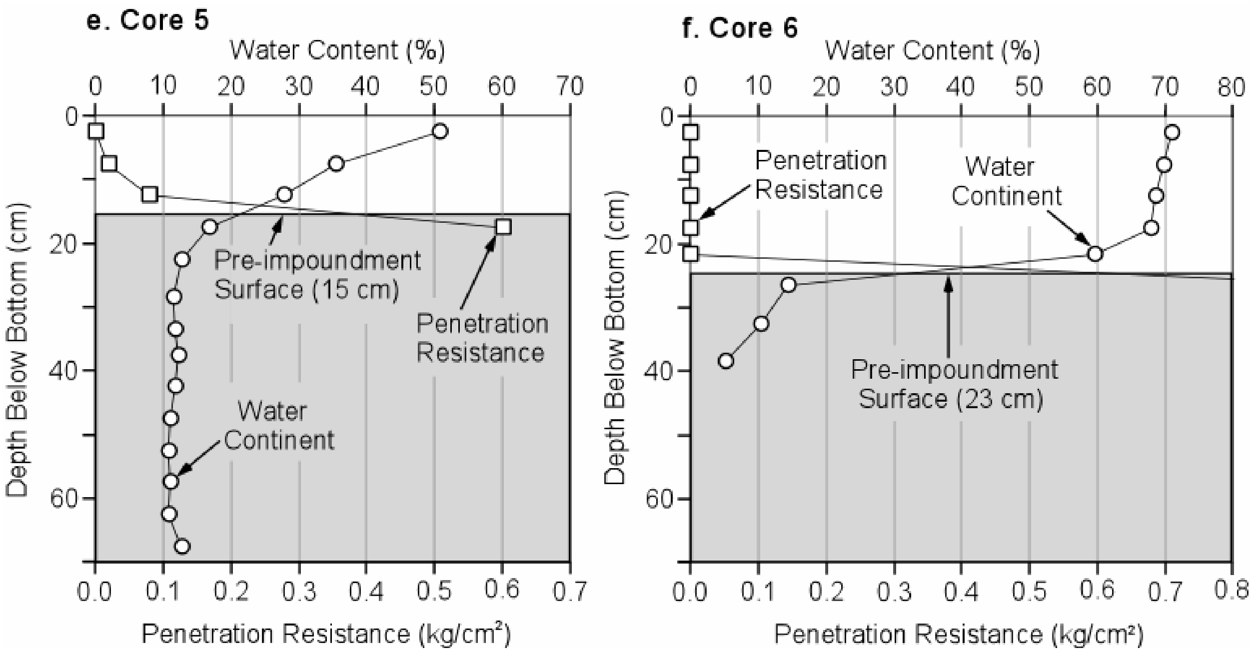


Figure 3-2. Physical analyses of cores collected in Lake Buchanan.

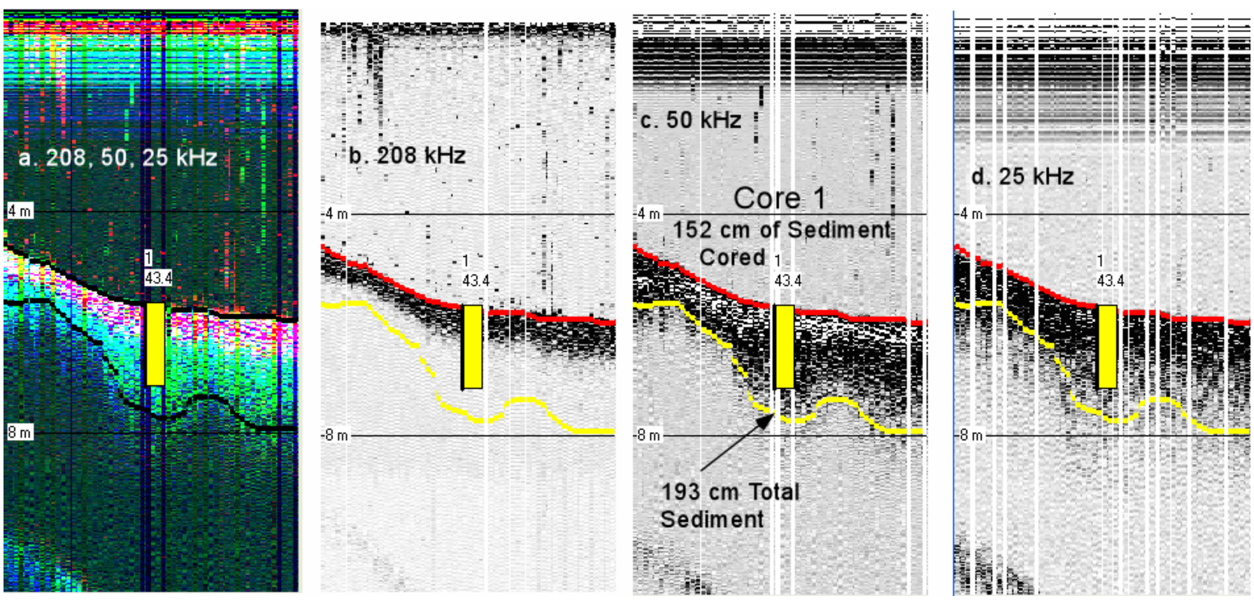


Figure 3-3. Correlation of Core 1 and co-located acoustic records along Line 1. The location of Core Site1 is shown in Figure 3-1. The acoustic record is converted from travel time to depth below the water bottom assuming a speed of sound in sediment of 1460 m/s. (a) Composite display of 208, 50, and 25 kHz. (b) 208 kHz. (c) 50 kHz. (d) 25 kHz. The core did not reach the pre-impoundment surface, which appears to occur at a depth of 193 cm below the bottom and 41 cm below the base of the core.

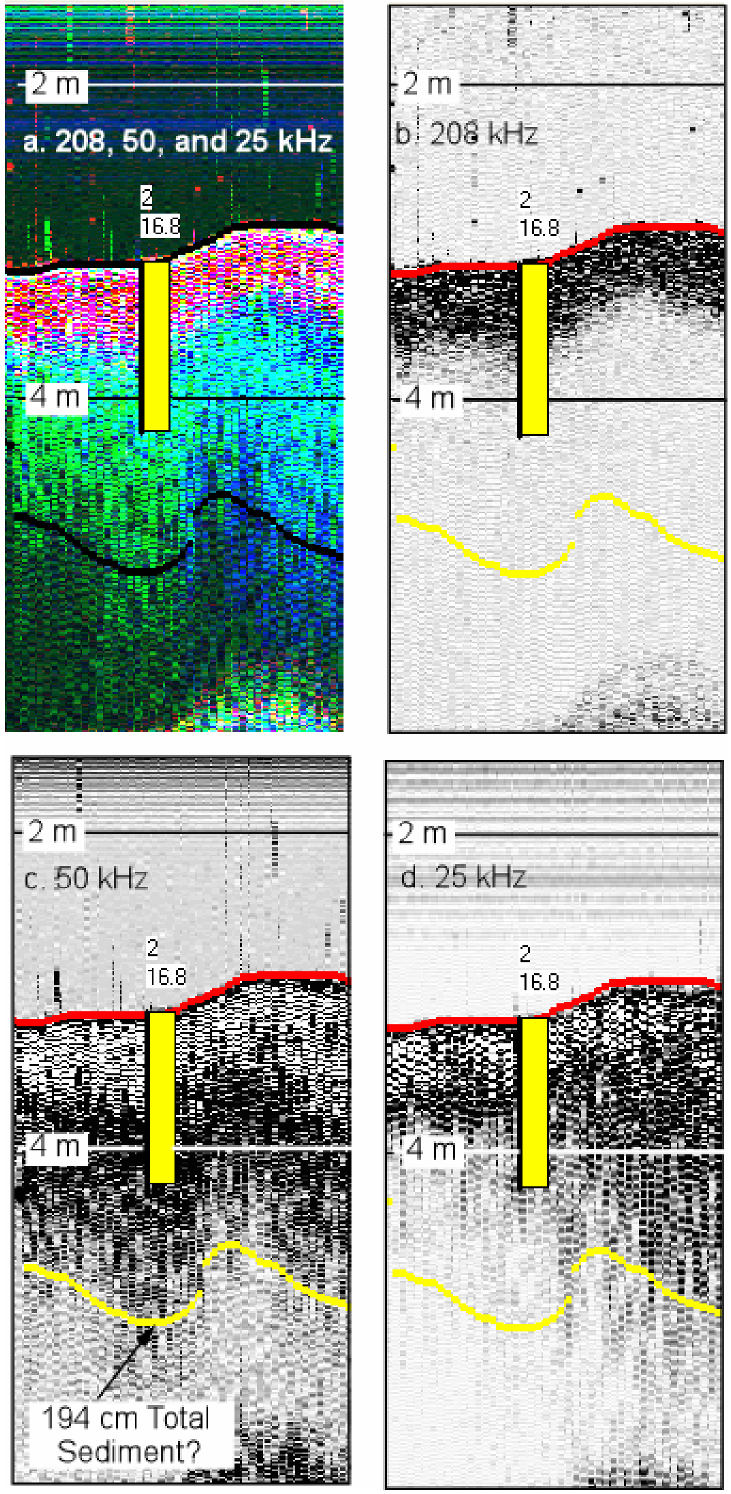


Figure 3-4. Correlation of Core 2 and co-located acoustic records and Line 4. (a) Composite display of 208, 50, and 25 kHz signals. (b) In this location the 208 kHz signal penetrates only 60 cm into the bottom, suggesting a layer of high water content sediment that might normally be interpreted as the post-impoundment layer. However, the core contains post-impoundment material throughout its length to a depth of 109 cm below the bottom. The base of the 208 kHz signal corresponds to an apparent desiccation surface in the core (Figure 3-2b).

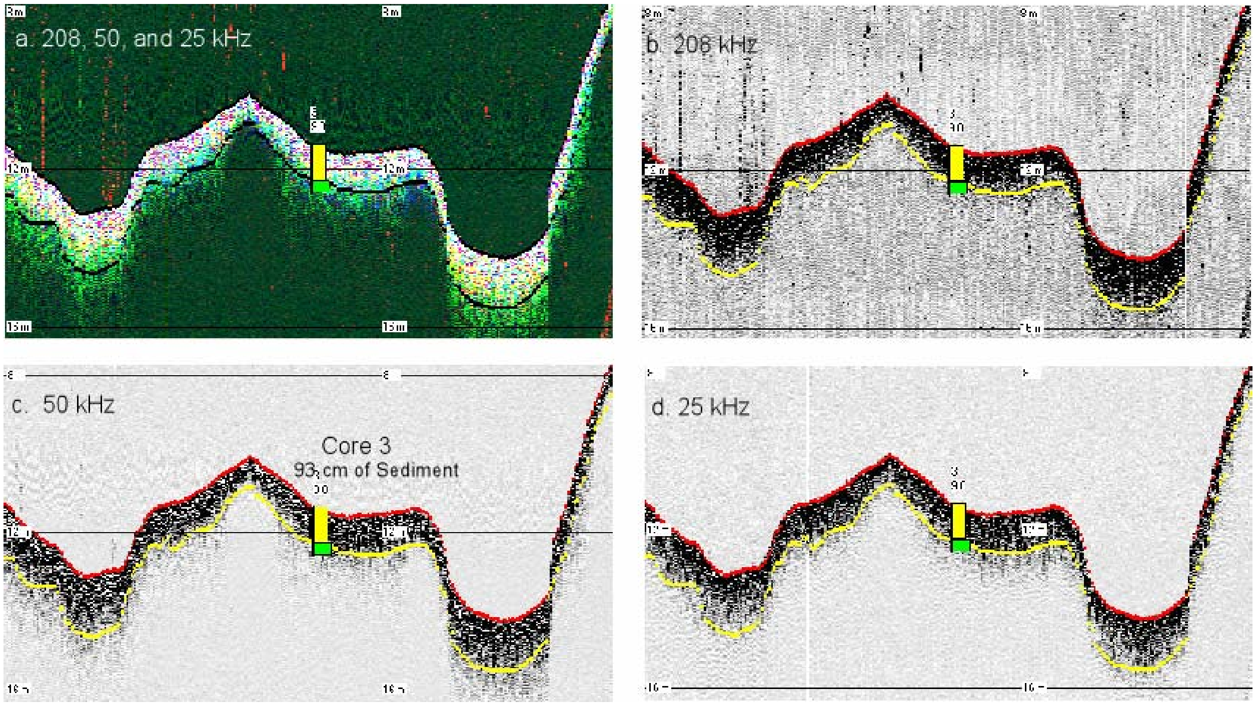


Figure 3-5. Correlation of Core 3 and co-located acoustic records and Line 6. (a) Composite display of 208, 50, and 25 kHz. (b) 208 kHz. (c) 50 kHz. (d) 25 kHz. Core 3 sampled a clear pre-impoundment surface at a depth of 93 cm below bottom. The pre-impoundment material at this location consists of compact, dark brown sand containing plant roots.

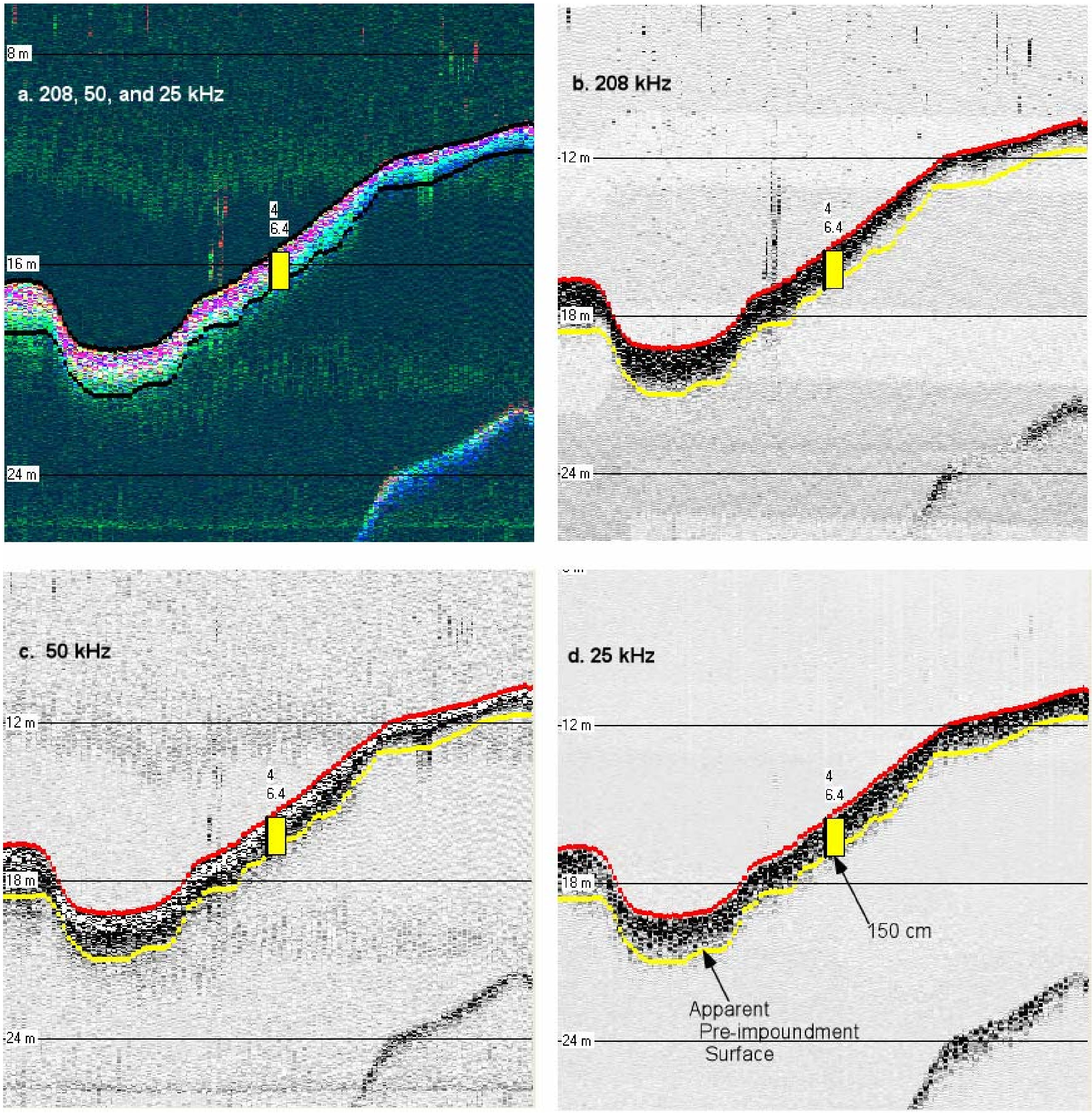


Figure 3-6. Correlation of Buchanan Core 4 and co-located acoustic records and Line 8. (a) Composite display of 208, 50, and 25 kHz. (b) 208 kHz. (c) 50 kHz. (d) 25 kHz. Core 4 did not sample pre-impoundment material. However, acoustically, the pre-impoundment surface appears to occur at or just below the bottom of the core at a depth of 150 cm.

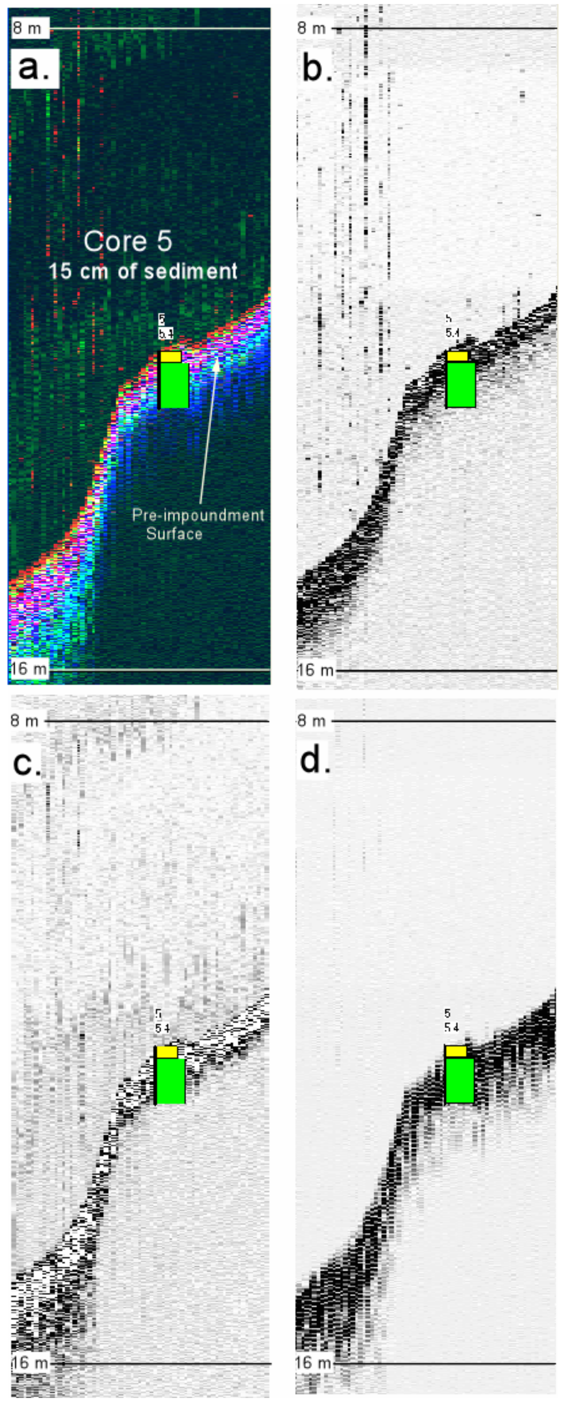


Figure 3-7. Correlation of Core 5 and co-located acoustic records and Line 12. (a) Composite display of 208, 50, and 25 kHz. (b) 208 kHz. (c) 50 kHz. (d) 25 kHz. Core 5 sampled pre-impoundment material at a depth of 15 cm below the bottom consisting of coarse sand and gravel up to ½ cm in diameter. The position of the core was projected 5.4 meters onto the closest point along Line 12. At the point of closest approach on Line 12 the apparent thickness of the post-impoundment sediment is 38 cm (shown in part a.). This discrepancy may be due to the projection distance. Note that the thickness of the post-impoundment layer appears to thin rapidly down slope.

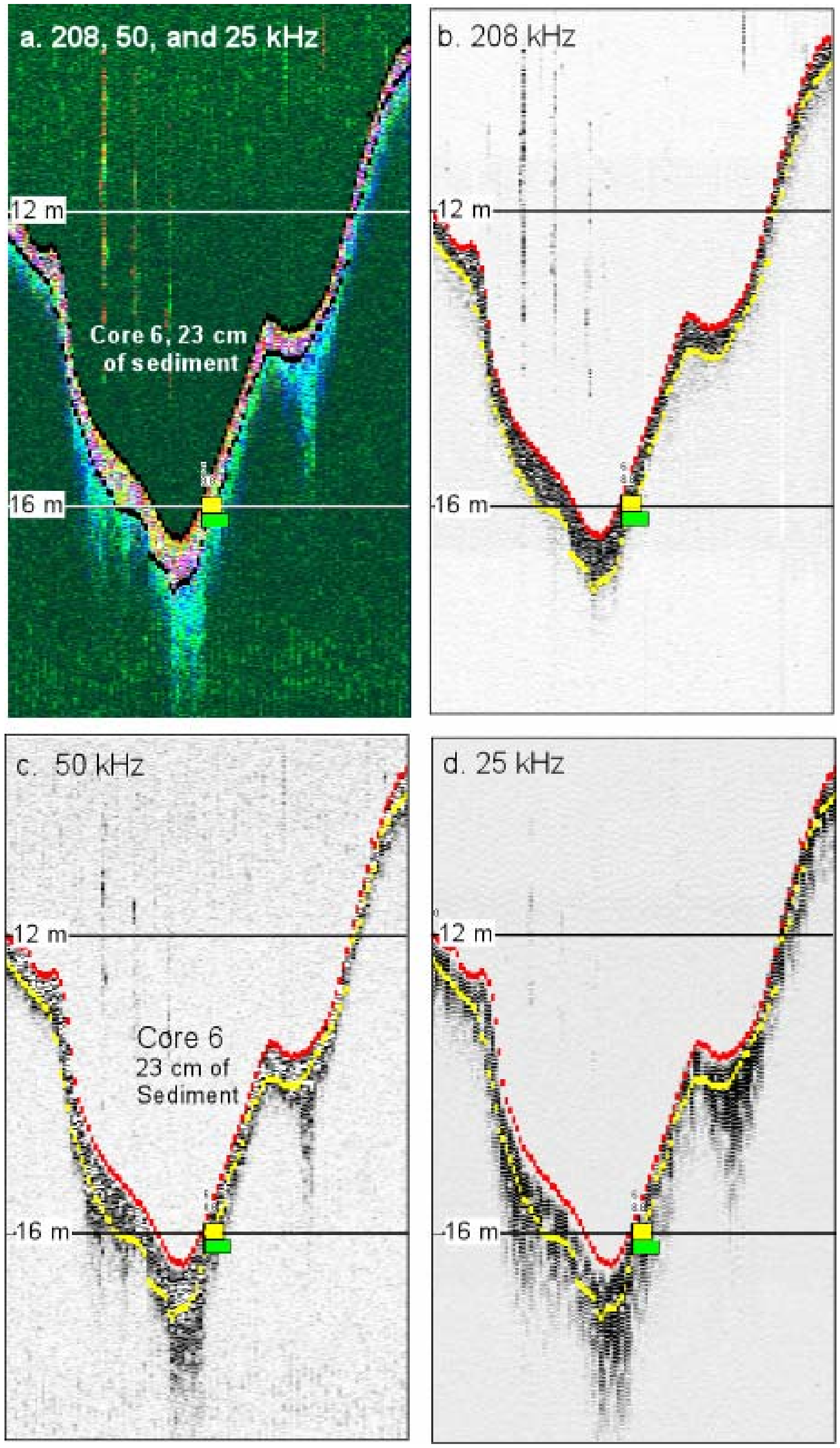


Figure 3-8. Correlation of Core 6 and co-located acoustic records and Line 11. Core 6 sampled pre-impoundment material at a depth of 23 cm below the bottom consisting of coarse sand and granite gravel containing plant roots.

4. Discussion

The goal of this study was to collect co-located core and acoustic data to verify the identification of the base of post-impoundment sediment on the acoustic records in the TWDB survey of the reservoir. In spite of the fact that only three of the six cores sampled the pre-impoundment material, the results still provide useful information. However, it would have been better to have had six cores that penetrated the complete post-impoundment layer and sampled at least the top few centimeters of the underlying pre-impoundment material. Part of the problem was likely associated with the large lake-level changes that have occurred over the life of Lake Buchanan and part was likely just the bad luck in selecting a core site underlain by rock outcrop.

To avoid such problems in the future, we suggest the following changes to the coring procedure. When a core is retrieved, we suggest examining the material lodged in the tip of the core. If it appears to be pre-impoundment material, based on the characteristics described in this report, the core can be capped and stored. If it appears to be post-impoundment sediment, a second core should be taken. If the top of the core tube reached the mud line and the pre-impoundment surface was not reached, a longer core tube should be used on the second try. If the top of the core tube did not reach the mud line and the sediment in the tip of core tube seems to be stiff and compacted, more weight should be added to the coring device and/or the vibration should be carried out for a longer period during the second try. If the sediment in the tip of the core is soft and the top of the core did not reach the mud line, it is possible that the pre-impoundment surface at this location is impenetrable. In this case, we suggest moving to a new location for the second try, in the hopes of finding a nearby area where the pre-impoundment material can be sampled.

5. CONCLUSIONS

This study was done to to serve as a guide for interpreting sedimentation survey data collected in Lake Buchanan. The main conclusions are listed below.

1. In the northern part of the lake, where the sediment appears to be near 2 m thick, the base of the 50 kHz returns seems to correspond to the base of sediment. Associating the base of 200 kHz returns with the base of sediment in this region would result in a significant underestimate of the amount of sediment present.

2. In the mid-lake region, where the base of returns is the same at all three acoustic frequencies, the base of all the acoustic returns track the base of post-impoundment surface.

3. In the southern part of the lake, where the base of 200 kHz returns is only a few tens of centimeters deep, the base of the 200 kHz signal tracks the base of post-impoundment sediment. Associating the base of 50 or 25 kHz returns with the base of sediment in this region would result in a significant over estimate of the amount of sediment present.

Appendix A: Physical Analysis of Cores

Core 1	x=2893542.0	y=10284819.2						
Sample	**Top**	**Bottom**	**cont wt**	**wet**	**dry**	**water cont**	**pen**	**Comments**
1	0	5.0	8.73	135.06	52.25	65.55	0	
2	5	10.0	8.62	111.59	53.17	56.73	0.1	
3	10	15.0	8.48	138.95	70.5	52.46	0.3	
4	15	20.0	8.69	168.19	92.37	47.54	0.4	
5	20	25.0	8.36	169.24	86.00	51.74	0.5	
6	25	32.0	8.62	135.73	67.09	54.00	0.5	
7	32	35.0	8.48	174.37	82.3	55.50	0.5	Organic-rich mud
8	35	40.0	8.48	162.9	73.84	57.67	0.5	Dark gray
9	40	45.0	8.55	177.42	82.44	56.24	0.6	
10	45	50.0	8.67	154.82	74.44	55.00	0.7	
11	50	55.0	8.63	154.95	74.42	55.04	0.6	
12	55	60.0	8.61	150.72	72.18	55.27	0.8	
13	60	65.0	8.64	173.46	80.09	56.65	0.9	
14	65	70.0	8.64	152.14	79.67	50.50	0.95	
15	70	75.0	8.47	175.0	94.05	48.61	0.8	
16	75	80.0	8.50	161.54	81.64	52.21	0.85	
17	80	85.0	8.68	145.95	70.64	54.86	0.85	
18	85	90.0	8.59	162.39	82.67	51.83	0.85	
19	90	95.0	8.57	174.95	86.22	53.33	0.9	
20	95	100.0	8.71	156.98	79.10	52.53	0.9	
21	100	105.0	8.57	150.57	77.43	51.51	0.9	Shift to brown color
22	105	110.0	8.26	145.31	79.68	47.89	1.5	
23	110	115.0	8.60	153.19	85.13	47.07	0.9	
24	115	120.0	8.54	122.28	68.85	46.98	0.85	
25	120	125.0	8.65	143.81	79.36	47.68	0.8	
26	125	130.0	8.65	136.5	72.66	49.93	0.8	
27	130	135.0	8.70	144.22	76.28	50.13	1.3	
28	135	140.0	8.55	165.68	91.44	47.25	1.6	
29	140	145.0	8.61	150.00	89.34	42.90	1.8	
30	145	150.0	8.64	236.06	156.91	34.80	1.7	No pre-impoundment

Core 2	x=2889792.5	y=10285809.1						
Sample	**Top**	**Bottom**	**cont wt**	**wet**	**dry**	**water cont**	**pen**	**Comments**
1	0	5.0	8.26	76.00	33.45	62.81	0.0	
2	5	10.0	8.29	105.10	48.73	58.23	0.1	
3	10	15.0	8.25	131.99	63.86	55.06	0.3	
4	15	20.0	8.17	117.47	55.76	56.46	0.5	
5	20	25.0	8.32	113.92	55.79	55.05	0.5	
6	25	32.0	8.34	146.38	73.84	52.55	0.5	
7	32	35.0	8.64	154.13	78.88	51.72	0.6	Organic-rich mud
8	35	40.0	8.23	144.47	71.57	53.51	0.6	Dark gray
9	40	45.0	8.62	143.53	71.80	53.17	0.7	
10	45	50.0	8.21	119.73	60.28	53.31	0.6	
11	50	55.0	8.47	152.89	80.26	50.29	0.7	
12	55	60.0	8.26	161.40	89.83	46.74	0.9	
13	60	65.0	8.23	155.12	91.20	43.52	1.1	
14	65	70.0	8.11	131.18	68.06	51.29	0.9	
15	70	75.0	8.20	142.62	69.46	54.43	0.8	
16	75	80.0	8.19	103.24	51.31	54.63	0.7	
17	80	85.0	8.13	124.72	65.68	50.64	0.8	
18	85	90.0	8.15	136.40	75.23	47.70	0.8	
19	90	95.0	8.13	132.07	73.88	46.95	0.8	
20	95	100.0	8.14	159.05	95.57	42.06	1.2	
21	100	105.0	8.15	65.95	38.68	47.18	0.9	
22	105	110.0	8.17	62.83	36.95	47.35	1.4	No pre-impoundment

Core 3	x=2900427.7			y=10274451.2				
Sample	**Top**	**Bottom**	**cont wt**	**wet**	**dry**	**water cont**	**pen**	**Comments**
1	0	5.0	8.13	69.61	26.88	69.50	0.0	
2	5	10.0	8.18	94.80	29.31	75.61	0.0	Dark gray - black
3	10	15.0	8.16	106.42	46.15	61.34	0.0	
4	15	20.0	8.11	111.64	47.46	61.99	0.2	
5	20	25.0	8.12	117.63	51.02	60.83	0.2	
6	25	32.0	8.54	114.92	49.36	61.63	0.1	
7	32	35.0	8.25	108.72	50.97	57.48	0.2	Brown
8	35	40.0	8.18	124.58	60.61	54.96	0.3	Clay-rich
9	40	45.0	8.37	96.35	46.03	57.19	0.3	
10	45	50.0	8.28	133.79	62.43	56.86	0.3	
11	50	55.0	8.22	139.78	72.66	51.02	0.5	
12	55	60.0	8.20	135.57	63.37	56.69	0.3	
13	60	65.0	8.12	78.59	38.52	56.86	0.3	
14	65	70.0	8.14	117.43	54.19	57.86	0.3	
15	70	75.0	8.19	147.60	80.76	47.94	0.5	
16	75	80.0	8.20	129.19	77.98	42.33	0.6	
17	80	85.0	8.10	144.57	85.07	43.60	0.5	
18	85	90.0	8.14	129.68	67.85	50.87	0.3	
19	90	93.0	8.19	90.67	48.13	51.58	0.3	
20	93	100.0	8.13	149.47	119.62	21.12	0.3	Pre-impoundment
21	100	105.0	8.16	199.49	165.11	17.97	2.6	surface
22	105	110.0	8.16	171.16	141.63	18.12	5.1	Dark brown
23	110	115.0	8.67	156.39	131.15	17.09	7.9	sand, with roots
24	115	120.0	8.19	164.17	138.16	16.68	7.5	
25	120	125.0	8.47	146.20	122.24	17.40	6.4	

Core 4	x=2909525.3			y=10271486.8				
Sample	**Top**	**Bottom**	**cont wt**	**wet**	**dry**	**water cont**	**pen**	**Comments**
1	0	5.0	8.18	109.14	34.31	74.12	0.00	
2	5	10.0	8.19	61.52	25.07	68.35	0.00	
3	10	15.0	8.19	84.71	32.92	67.68	0.00	
4	15	20.0	8.13	91.04	35.81	66.61	0.10	
5	20	25.0	8.15	95.96	38.48	65.46	0.20	
6	25	32.0	8.78	107.75	42.63	65.80	0.50	
7	32	35.0	8.30	101.31	39.05	66.94	0.20	Organic-rich mud
8	35	40.0	8.16	100.02	39.80	65.56	0.20	Dark gray-black
9	40	45.0	8.35	116.20	46.27	64.84	0.20	
10	45	50.0	8.30	109.36	44.62	64.06	0.25	
11	50	55.0	8.31	105.96	43.72	63.74	0.25	
12	55	60.0	8.30	108.70	44.45	63.99	0.30	
13	60	65.0	8.14	117.61	49.19	62.50	0.30	
14	65	70.0	8.16	108.82	46.42	61.99	0.30	Brown
15	70	75.0	8.25	126.60	53.13	62.08	0.30	
16	75	80.0	8.29	111.35	47.21	62.24	0.40	
17	80	85.0	8.36	117.17	51.81	60.07	0.40	
18	85	90.0	8.17	109.65	46.68	62.05	0.35	Brown
19	90	95.0	8.21	100.38	43.19	62.05	0.40	Gray
20	95	100.0	8.18	98.96	43.15	61.48	0.40	
21	100	105.0	8.17	94.58	42.50	60.27	0.40	
22	105	110.0	8.16	82.02	38.55	58.85	0.30	
23	110	115.0	8.64	82.44	40.53	56.79	0.40	
24	115	120.0	8.18	77.11	36.03	59.60	0.40	
25	120	125.0	8.43	97.83	46.11	57.85	0.60	
26	125	130.0	8.24	94.76	42.13	60.83	0.50	
27	130	135.0	8.22	89.60	45.27	54.47	0.55	
28	135	140.0	8.22	103.54	45.92	60.45	0.70	
29	140	145.0	8.23	89.07	40.47	60.12	0.80	
30	145	150.0	8.22	169.61	67.73	63.13	0.80	No pre-impoundment

Core 5	x=2904231.1			y=10265503.5				
Sample	**Top**	**Bottom**	**cont wt**	**wet**	**dry**	**water cont**	**pen**	**Comments**
1	0	5.0	8.51	74.31	41.05	50.55	0	0-8 cm, organic rich
2	5	10.0	8.36	119.41	80.22	35.29	0.2	8-15, light gray
3	10	15.0	8.26	144.91	107.10	27.67	0.8	
4	15	20.0	8.19	133.37	112.45	16.71	6	Pre-impoundment
5	20	25.0	8.22	133.88	117.85	12.76		Coarse sand to
6	25	30.0	8.62	169.23	150.63	11.58		gravel (1/2 cm max)
7	30	35.0	8.30	176.89	157.16	11.70		
8	35	40.0	8.21	173.03	152.94	12.19		
9	40	45.0	8.38	188.65	167.57	11.69		
10	45	50.0	8.30	136.42	122.36	10.97		
11	50	55.0	8.10	188.11	168.91	10.67		
12	55	60.0	8.36	147.72	132.56	10.88		
13	60	65.0	8.17	148.15	133.19	10.69		Gravel
14	65	70.0	8.18	183.66	161.37	12.70		

Core 6	x=2897996.6			y=10261132.3				
Sample	Top	Bottom	cont wt	wet	dry	water cont	pen	
1	0	5.0	8.57	64.44	24.72	71.09	0	0-8 cm, organic rich
2	5	10.0	8.69	112.05	39.98	69.73	0	8-15, light gray
3	10	15.0	8.69	99.30	37.04	68.71	0	
4	15	20.0	8.64	112.30	41.82	67.99	0	Pre-impoundment
5	20	23.0	8.54	103.24	46.75	59.65	0	Grus with plant
6	23	30.0	8.72	225.72	194.19	14.53	10	roots, poorly sortedl
7	30	35.0	8.46	225.32	202.79	10.39		sand and gravel
8	35	42.0	8.74	254.45	241.52	5.26		