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Strandline and Sediment Analysis of Stump Lake Area, Nelson County, North Dakota

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STRANDLINE AND SEDIMENT ANALYSIS OF STUMP LAKE AREA, NELSON COUNTY, NORTH DAKOTA

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INTRODUCTION

The purpose of this paper is to describe and interpret the late glacial and Recent history of Stump Lake, a closed basin lake, in Nelson County, North Dakota, T. 151 N., R. 60 W. (see fig.1). The work was started as a summer project under a National Science Foundation Undergraduate Research Participation Program and completed for credit in Geologic Problems 421.

The research began in July, 1967, after several weeks of familiarization with field techniques and problems associated with glacial terrain. The project included mapping, leveling, and analysis of strandlines and their sediments.

DEFINITIONS

The primary study in the Stump Lake area centered on the former strandlines. Much initial difficulty was encountered in defining both the limits and the parts of the strandlines. It was finally decided to map the strandlines on the basis of the following definitions (see fig. 2):

STRANDLINE:

Flint(1948, p.163, cited in Aronow,1955, p.68) defined the term "strandline" as:

> The line traces on shore rocks, either firm or unconsolidated, by erosional or depositional shore features, developed at mean sea level or at the level of a lake, whether or not the line is now at mean sea level or lake level.

SCARP or BEACH SCARP:

Knochenmus (Geological Survey Research, 1967, Chapter C, p.C 238) defined a beach scarp as:

... a miniature cliff cut into the lakeshore by wave action.

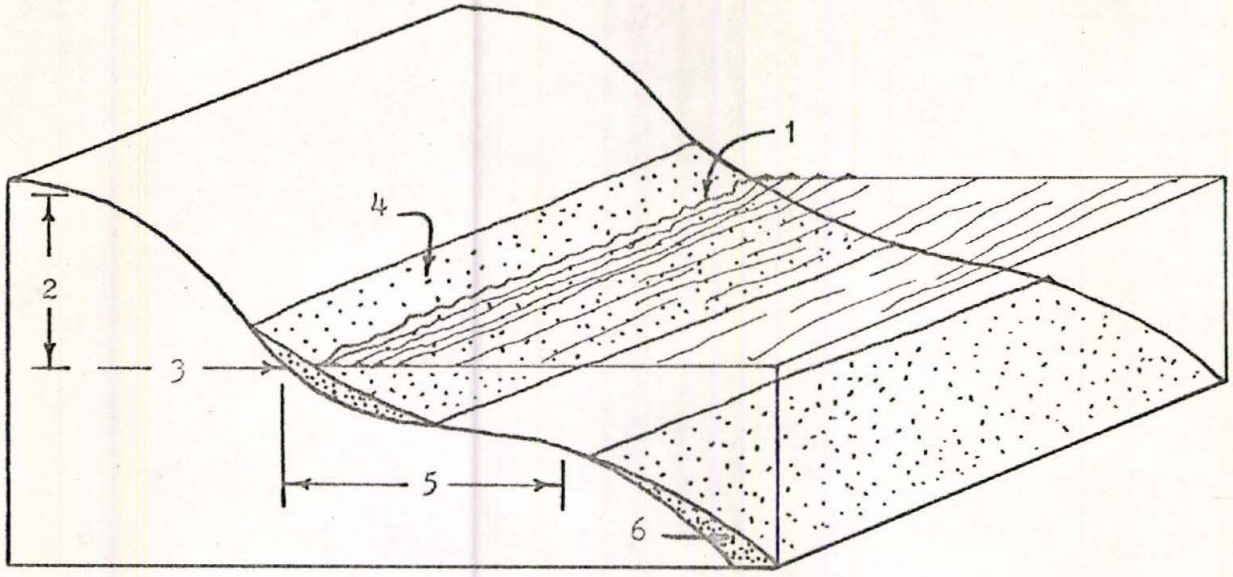


Fig. 2. Block diagram showing parts of a typical strandline.

1. Strandline.
2. Scarp.
3. Break in the slope of the scarp marking the strandline in the case of no beach sediments.
4. Beach sediments.
5. Wave-cut terrace.
6. Sediment in transit.

(modified after Longwell & Flint, 1955, p.245)

GEOGRAPHICAL SETTING

The East Bay of Stump Lake, in which this research project was confined, is located in the west half of Wamduska Township, T. 151 N., R. 60 W., approximately five miles north of Pekin, North Dakota. Stump Lake is a closed basin lake which was once a part of a drainage system of the Sheyenne River to the south.

The region is underlain by glacial drift of late Wisconsinan age which rests unconformably on the Pierre Shale of late Cretaceous age (Simpson, 1929, p.38).

East Bay (see fig. 3) is approximately four and one-half miles

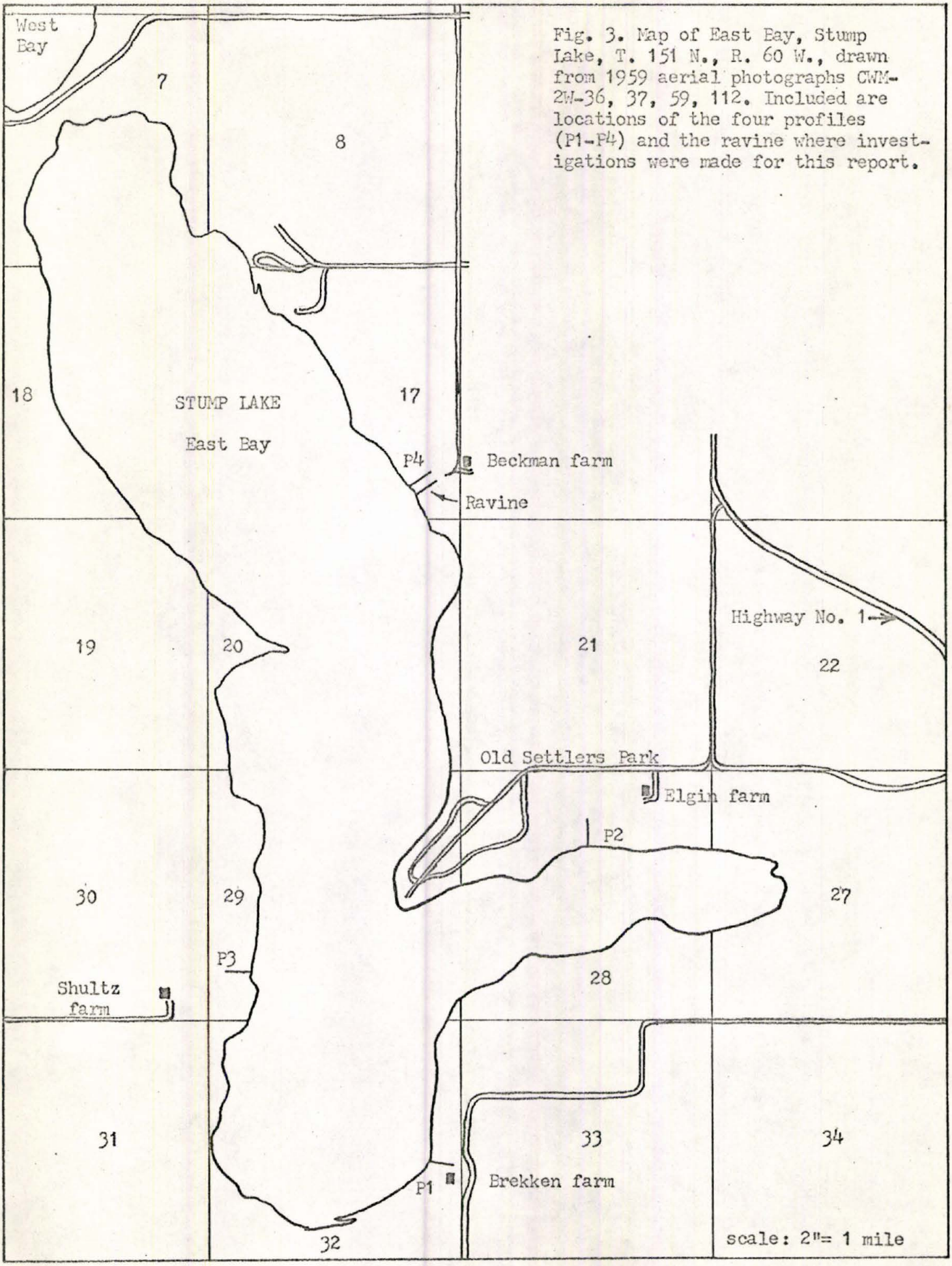


Fig. 3. Map of East Bay, Stump Lake, T. 151 N., R. 60 W., drawn from 1959 aerial photographs CWM-2W-36, 37, 59, 112. Included are locations of the four profiles (P1-P4) and the ravine where investigations were made for this report.

long (north-south), one mile wide (east-west), and according to local farmers, is less than ten feet deep. The long axis of the lake lies west of and parallel to Nelson County Highway #1.

PREVIOUS WORK

Upham (1896) and Simpson (1912) mapped strandlines around Devils Lake. Aronow, Dennis and Akin (1953) later mapped strandlines around West Bay of Devils Lake and Aronow (1955, p.68) subsequently mapped the strandlines around Devils and Stump Lake, but was not primarily concerned with the Stump Lake strandlines (p. 73). Other than these related studies, no mapping of Stump Lake has been published to my knowledge.

ACKNOWLEDGMENTS

My research was completed as a requirement for Geologic Problems 421, at the University of North Dakota. I want to thank Dr. John R. Reid for his suggestions, encouragement and supervision. Dr. Reid also read and offered constructional criticism of the content and style of this paper. Roger Reede, a Doctoral candidate, and Dennis Nielsen, and Howard Reith, graduate students, were extremely helpful with familiarization of field and laboratory techniques. Also, I want to thank Kermit Brekken, Alvin Elgin, Kenneth Shultz and George Beckman for access to their properties on the lake. My sincerest appreciation is extended to all these people.

METHODS OF INVESTIGATION

Strandlines

Strandline elevations given in this report are the elevations above sea level of the break in slope of the scarp. Fig. 4 shows some typical strandlines on the north-east shore of East Bay.

Fig. 4. Boulder-covered lower abandoned shoreline of north-east shore of Stump Lake looking northwest from the Beckman Farm (see fig. 3). The terrace of the 1441-foot strandline can be seen on the lower right corner of the photo.

Four areas were chosen for cross-section correllation profiles. In each case, the profile was chosen in an area of little or no farm traffic and where the area was sheltered from the prevailing westerly winds as best as possible to give the most complete data. Air photos aided in determining where the best sites were, but the most effective method was to walk the shoreline and select the areas.

The profiles were measured by the use of a hand level and a one-hundred foot tape measure. Each profile was surveyed three times to

minimize the error. The present lake level was determined by level survey with a theodolite from a 1963 Coast & Geodetic Survey Bench Marker # T-285 located in the west half of Sec. 26, T. 151 N., R. 60 W., on a culvert along Highway # 1. The lake level was found to be 1388 feet above sea level on October, 1967.

The selected sites for profiles were:

Profile 1- East half of Sec. 32, T. 151 N., R. 60 W.

Profile 2- North half of Sec. 28, T. 151 N., R. 60 W.

Profile 3- South-west quarter of Sec. 29, T. 151 N., R. 60 W.

Profile 4- South-east quarter of Sec. 17, T. 151 N., R. 60 W.

Elevation data for each profile are as follows:

Profile 1 (see figs. 5 & 6)

The highest and most clearly defined strandline along Profile 1 is at 1453 feet above sea level. The associated scarp is cut in till. Residual boulders mark the terrace. The top of the scarp levels off at 1460 feet above sea level. The next strandline, at 1435 feet above sea level, is also cut in till. The scarp rises ten and one-half feet at an angle of 40°. At the base of the scarp are residual boulders and over five feet of sand and small boulders underlying the terrace surface.

This profile is approximately 50 yards from the bay-mouth bar and flanking beach which Aronow (1955, p.101) described as having a high shale content. He was unable, however, to find an outcrop of shale in the area. On Profile 1, between the elevations of 1430 feet and 1415 feet, there is an outcrop of shale that may have been the source of the shale in the bar and beach.

Samples were collected at the two strandlines for later size

analysis.

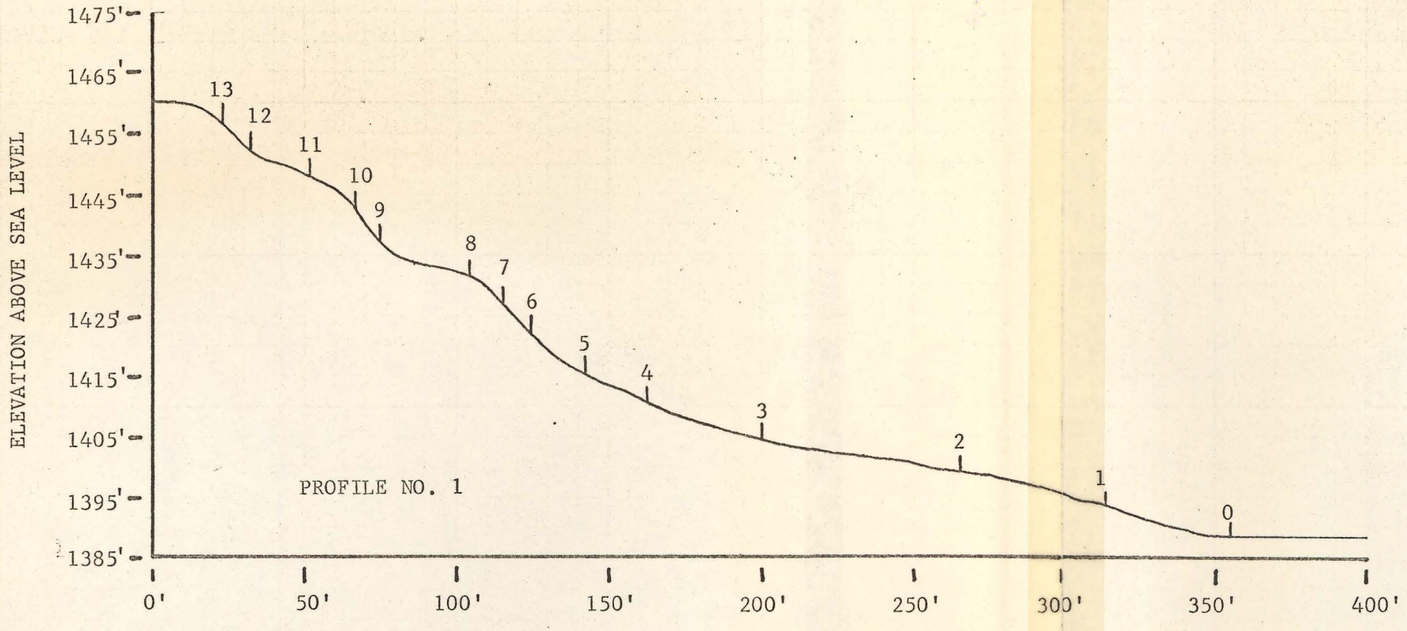
Fig. 5. Looking east at the boulder-covered terrace of the 1435-foot strandline at Profile 1 on the Brekken Farm (see fig. 3).

Profile 2 (see figs. 6 & 7)

The upper strandline, at 1453 feet above sea level, is also cut in till. The terrace is presently marked by a lag concentration of boulders. Underlying the terrace is till.

The next strandline is at 1441 feet above sea level. Between this and the 1453-foot strandline are several smaller strandlines. These suggest a fluctuating water level between 1453 feet and 1441 feet. Samples were collected at both the 1453-foot and 1441-foot strandlines for later size analysis.

This area, on the Elgin Farm (see fig. 3), is in an area of little farm traffic and, according to Mr. Elgin, has been used only for cattle grazing. The area is well protected by trees and is in the lee of the prevailing westerly winds. This may be the reason the area has such



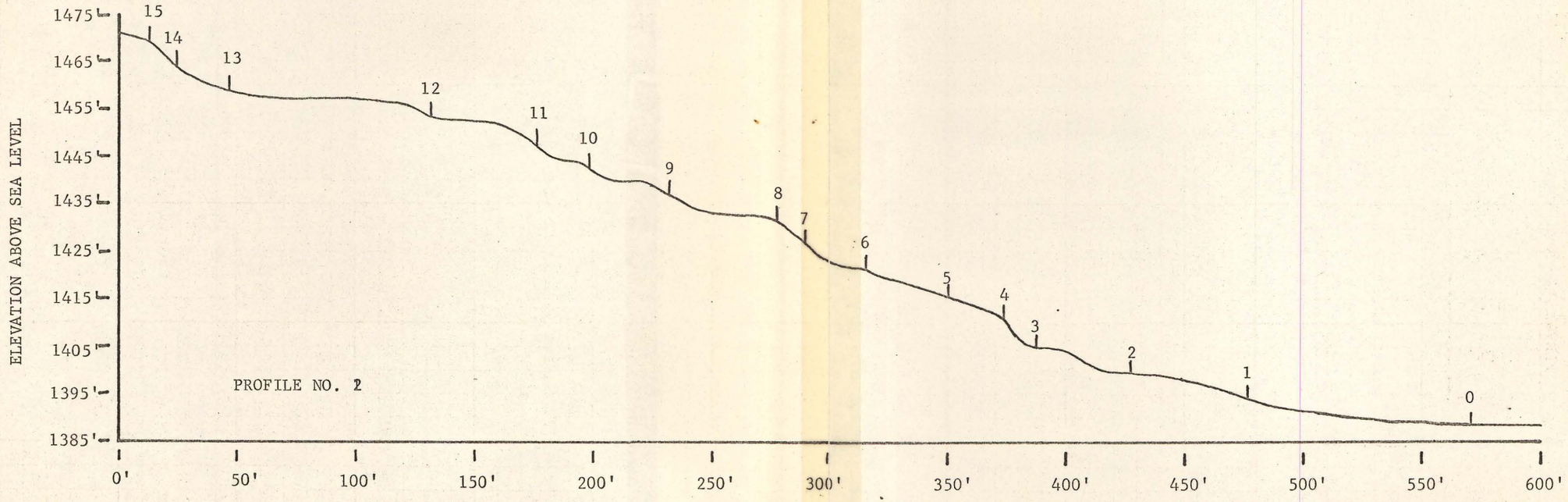


Fig. 6. Profiles #1 & #2, T. 151 N., R. 60 W., showing elevations of strandlines around East Bay of Stump Lake. The numbered stations on the profiles are hand-level stations representing intervals of five-foot four inches.

classic strandlines, and is the most well preserved of all the profiles.

Fig. 7. Looking west along the 1441-foot strandline (center) at Profile 2 on the Elgin Farm (see fig. 3). The next higher strandline on the upper right corner is the 1453-foot strandline.

Profile 3 (see figs. 8 & 10)

The upper strandline of Profile 3, at 1453 feet above sea level, is also cut in till. The terrace is very wide, and it is the grazing area for sheep on the Shultz Farm (see fig. 3).

The next strandline is at 1441 feet above sea level, and it, too, is underlain directly by till. An outcrop of shale extends from the lower terrace of the 1441-foot strandline, at 1435 feet, to 1420 feet. This site is directly opposite the Brekken Farm, and may also have contributed shale to the bar and beach at the south end of the bay.

Profile 4 (see figs. 9 & 10)

At Profile 4, the upper strandline is at 1463 feet above sea level, and is cut in till. A pit was dug on the terrace at 1461 feet to a

depth of four feet, and a hand auger extended the depth to seven feet. Samples were collected from various depths for later size analysis.

Fig. 8. Looking northwest along the 1441-foot strandline and terrace of Profile 3 on the Shultz Farm (see fig. 3). On the terrace is a typical lag concentration of boulders.

The next strandline is at 1441 feet above sea level. The terrace, at the base of the scarp, is paralleled by residual boulders.

This profile does not have a visible 1453-foot strandline as do the other profiles. The absence of this strandline may have been due to a storm, or storms, that destroyed it; or there may have been a rise in lake level above 1453 feet which could have buried the 1453-foot strandline beneath sediments. More detailed drilling is necessary to test this possibility.

Fig. 9. Looking southeast along the 1463-foot strandline and terrace of Profile 4 on the Beckman Farm (see fig.3). On the right of the photo is the scarp of the 1441-foot strandline.

Sediments

A ravine, cutting across all the strandlines below the 1463-foot level, was discovered about three-hundred feet south of Profile 4 (see fig. 12). Several strata were exposed on the walls of this ravine, including two organic layers (see fig. 12). The upper layer, at 1455 feet above sea level, has both upper and lower sharp contacts of stratified sand and silt (see fig. 11). The layer is relatively horizontal, as are the overlying and underlying sediments, and it terminates at the scarp of the 1441-foot strandline (see fig.12). The lower organic layer, at 1439 feet above sea level, has a sharp upper contact separating pebble shale and the organic layer. The bottom contact grades into the underlying till(see fig. 14). The lower layer is not horizontal, but conforms to the bedrock, as does the till which lies be-

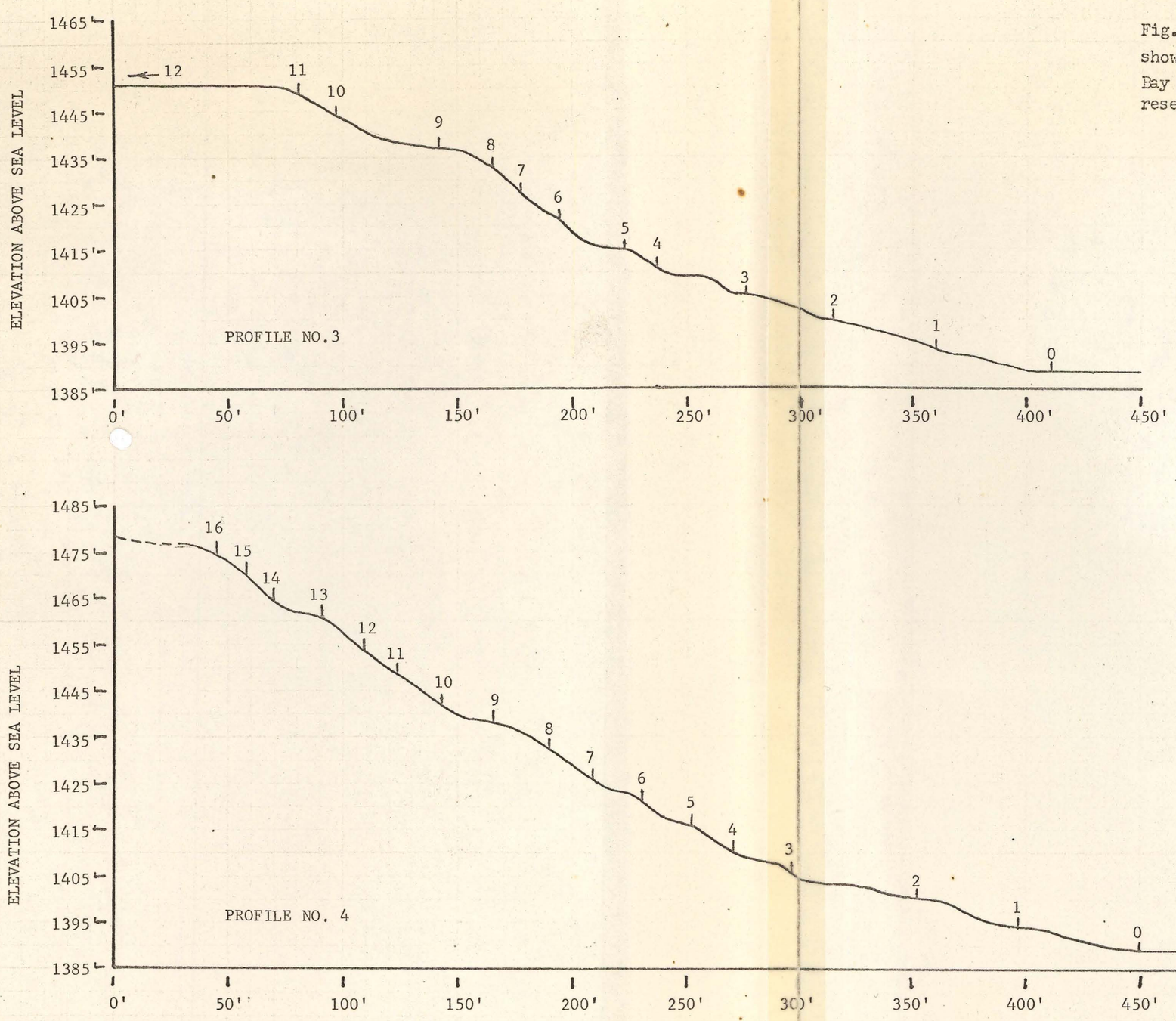


Fig. 10. Profiles #3 & #4, T. 151 N., R. 60 W., showing elevations of strandlines around East Bay of Stump Lake. The numbered stations represent intervals of five-foot four inches.

tween the lower organic layer and the shale bedrock. Each layer was highly organic and at first appeared to represent a soil zone.

Samples were collected from the upper and lower organic layers for later laboratory analysis. The samples of the lower layer were taken at one-foot vertical intervals at three stations three feet apart for subsequent size and x-ray analysis.

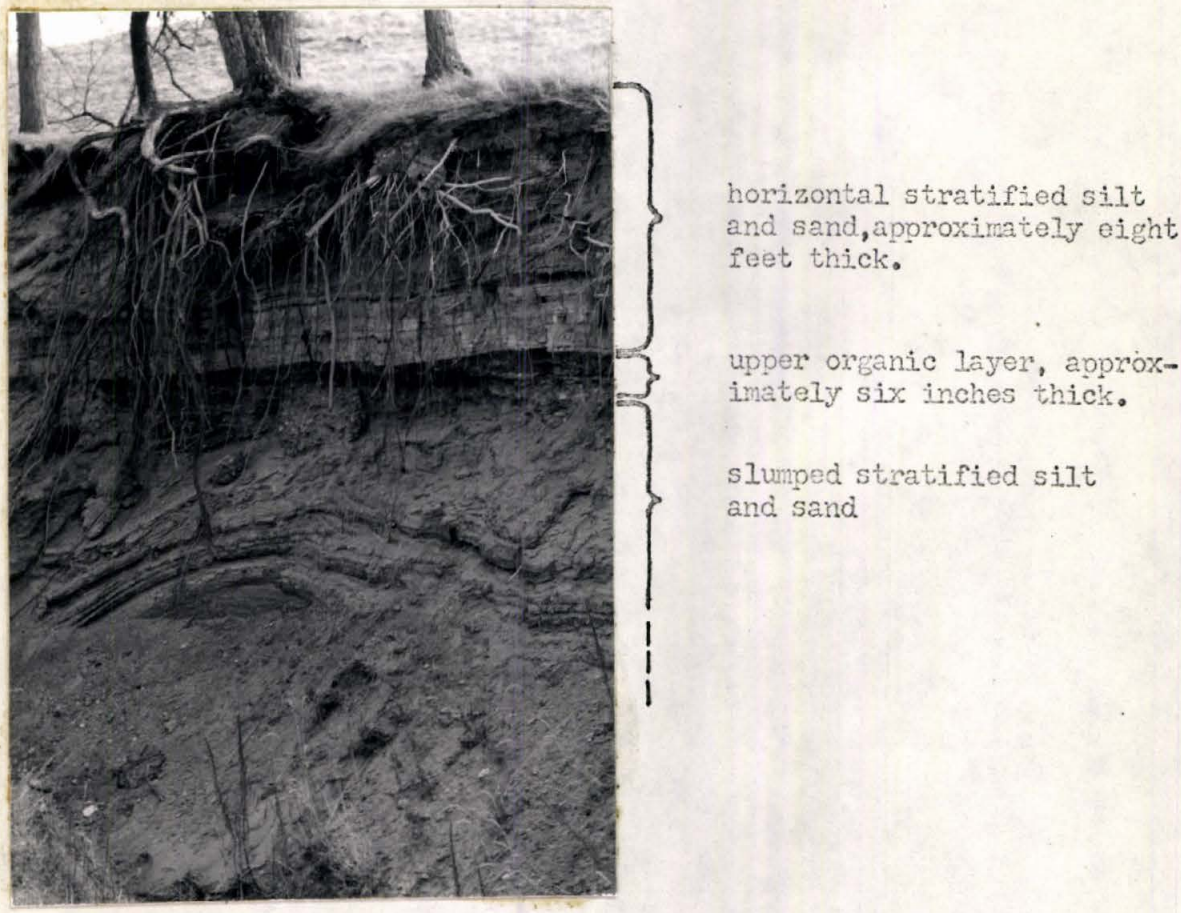


Fig. 11. Ravine south of Profile 4 (see fig. 3), looking southeast and showing the sequence of sediments, including the upper organic layer at 1455 feet above sea level.

Fig. 12. Exposed wall of the ravine at Profile 4 showing the upper zone (dark layer near base of roots at top of photo) and lower zone (at extreme bottom of photo). This view was taken farther to the right of Fig. 11.

FIELD AND LABORATORY RESULTS

Field Results

Profile 1

At the base of the 1453-foot strandline, at Profile 1, close to the scarp of the next strandline, till was exposed. The sand content of the till increased down the scarp, and at 1440 feet, the base of the scarp, a bouldery, gravely, shaly, silty sand lay beneath sparse grass cover. Large residual boulders made hand augering impossible and limited shoveling to a few feet.

On the lower terrace of the 1435-foot strandline, the sediment changed to shaly, gravely sand, much cleaner than nearer the scarp. The size and number of the buried boulders decreased farther down the terrace toward the next scarp. A core was taken here to a depth of five feet, the limit of the hand auger. The core revealed the following lithology:

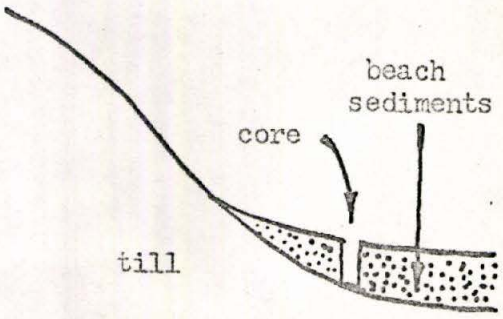
Six inches- sandy pebble gravel

Two feet- gravely sandy silt

Three feet- gravely silty clay

Four feet- slightly sandy clay

Five feet- sandy clay



On the next scarp, at 1432 feet, there is an outcrop of Pierre shale that extends almost to the present lake level.

Profile 2

The uppermost strandline, at 1453 feet, is in till. As in Profile 1, the sand content increases toward the base of the scarp. There are also residual boulders paralleling the base of the scarp. The upper terrace of the 1453-foot strandline is predominantly gravely sand,

while the lower terrace has a shaly, gravely sand composition. A core was taken in the lower terrace and revealed till beneath the sand. From this point to all lower elevations, there is little or no topsoil. This is in contrast to the topsoil at higher elevations, where depths up to one foot were found.

The strandline of this profile are well preserved, as the area has not been used for any farm traffic or operations except cattle grazing. The preservation is evidenced by small intermittent strandlines at 1453 feet and 1445 feet.

The next major strandline is at 1441 feet above sea level. The scarp from 1453 feet to 1445 feet and the scarp from 1445 feet to 1441 feet are both underlain by gravely sand. The terraces, however, are underlain by stratified sand with some gravel and shale.

The next strandline, at 1435 feet, has many residual boulders covering the terrace. Trees also parallel the strandline here. From 1432 feet to the water's edge, the lithology remains stratified sand and gravely sand. The last tree row ends at 1410 feet.

Profile 3

This profile is not as well preserved as the others. The upper strandline, at 1453 feet, is, as usual, cut in till. The terrace of this strandline is the present site of the Shultz Farm. The terrace is so wide it is a grazing field for sheep, and it includes almost all of the farm.

The next strandline is at 1441 feet. The scarp of this strandline is in till, and it slopes 35° onto the terrace. On the terrace are numerous dead trees, and the living ones are very young and deformed because of slumping . At 1435 feet, there is an outcrop of shale ex-

tending to 1420 feet.

Profile 4

The uppermost strandline at Profile 4 is at 1463 feet and is also cut in till. The scarp slopes 20° - 25° to the next evident strandline at 1441 feet. The 1453-foot strandline is absent. On the lower terrace of the 1463-foot strandline, a pit was dug four feet deep that terminated in stratified sand. Judging this to be beach sand, there may be a buried strandline here. Measurements were made to determine the elevation of the sand. The pit was at 1461 feet. A four-foot pit would place the elevation of the sand at 1457 feet. There is no further proof to confirm that this represents a buried strandline, though. Also, no evidence was found for the 1453-foot strandline. The sediment immediately beneath the sand is till.

The next visible strandline is at 1441 feet. At the base of the scarp are residual boulders.

Laboratory Results

Sediments

The upper organic layer in the ravine (see figs. 3 & 11) lacked pebbles that would be present in a soil that was formed in place and appears to have been washed into its present position. The layer is horizontal and has stratified sediments both above and beneath.

Nine samples were collected from this lower organic layer (see fig. 14) They were numbered as follows:

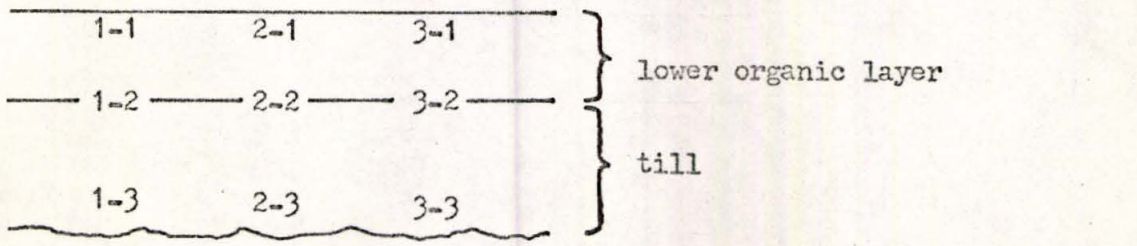


Fig. 13. Location of samples taken at one-foot vertical intervals at three stations three feet apart in the lower organic layer in the ravine (see fig. 14).

Equal amounts were taken from 1-1, 2-2, and 3-1 and analysed for gravel, sand, and silt-clay percentages. Also, equal amounts were taken from 1-2, 2-2, and 3-2, and from 1-3, 2-3, and 3-3 for the same tests.

Fig. 14. The lower organic layer in the ravine at the Beckman Farm (see fig. 3) showing the sharp upper contact with pebble shale and the lower gradational contact with till.

The analysis procedure used was the N. D. G. S. Standard Procedure A-65, November 1965. The results show that the gravel content increases half-way down the column, and then decreases again toward the bottom; the sand content decreases half-way down, and then increases toward the bottom; and the silt-clay content increases all the way to the bottom. The percentages are given below:

	% Gravel	% Sand	% Silt & Clay
1-1,2-1,3-1:	6.23	40.62	53.15
1-2,2-2,3-2:	14.17	30.20	55.63
1-3,2-3,3-3:	10.60	32.70	56.70

The clay percentage for each of the nine samples was calculated by pipette analysis. Procedure A-65 was used with one exception, the dispersing agent was omitted because such an agent would chemically alter the clay in the sample and give erroneous x-ray readings. Dispersal was enhanced by extended mixing time, but two of the samples still had to be analized a second time because of insufficient dispersal. The results of the pipette analysis are listed below:

	% Silt	% Clay		% Silt	% Clay		% Silt	% Clay
1-1	37.9	14.2	2-1	42.2	13.4	3-1	39.6	29.6
1-2	37.9	14.2	2-2	46.0	9.6	3-2	49.4	6.3
1-3	40.6	12.5	2-3	45.6	10.0	3-3	46.5	9.2

The clay obtained from each of the nine samples was prepared for subsequent x-ray studies.

STUMP LAKE: RELATIONSHIP TO DEVILS LAKE

Strandlines

Devils Lake and Stump Lake are each encircled by a 1453-foot strandline. This strandline was controlled by the threshold of the Big Stony spillway (see fig. 1) from the West Bay of Stump Lake to the Sheyenne River (Aronow, 1955, p. 16, 68, 73). This strandline was found, during the course of the investigation for this paper, at three of the four profiles around East Bay of Stump Lake.

The next lowest strandline encircling Devils Lake is 1445 feet above sea level (Aronow, 1955, p.73). But, this strandline was not found around Stump Lake. The threshold of the Jerusalem outlet that connected Devils Lake to Stump Lake is between 1445 feet and 1450 feet above sea level, probably around 1448 feet above sea level (Aronow, 1955, p.63). A lower strandline, at 1441 feet above sea level, was mapped around the East Bay of Stump Lake at three of the four profiles (see figs. 6 & 8). Therefore, only one strandline is common to both lakes.

Sediments

Aronow (1957, p.416) reported a sequence of buried soils in 30-foot thick deposits at elevations slightly higher than 1453 feet above sea level in the Devils Lake basin. During the course of this survey, no buried soils could be found at that elevation around East Bay of Stump Lake that would correlate with those of Devils Lake, but a buried organic rich layer was found at an elevation of 1439 feet above sea level. This layer may correlate with one of the many soils found by Aronow between 1429 feet and 1451 feet above sea level (Aronow, 1957, p.418).

CONCLUSIONS

Encircling the East Bay of Stump Lake, Nelson County, North Dakota, are well defined abandoned strandlines and accompanying shore features left as the result of previous high-water levels. Profiles around the and sediment analysis indicate two previous major high-water levels of 1453 feet and 1441 feet above sea level. These elevations were determined by instrument leveling from a 1963 Coast & Geodetic Survey benchmark to the present lake level of 1388 feet above sea level. From the present lake level, profiles were determined by hand-leveling of selected sites around the bay. Correlation of the strandlines among the profiles and shore sediments confirmed the existance of higher water levels.

A dark organic-rich layer, which appears to be a buried soil, was discovered in a ravine near one of the profiles. The "soil" appears to have been formed in place, with till as the parent material. All the overlying sediments are shore and lake deposits.

These data are sufficient proof of previous high-water levels around East Bay of Stump Lake.

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