Golder Associates Inc.

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June 4, 2001

Our ref: 013-1432.300

WSDOT
Field Operations Support Service Center
Materials Laboratory, MS, 47365
1655 S 2nd Ave, Tumwater, WA 98512

ATTENTION: Tony Allen, P.E.

RE: DESCHUTES PARKWAY GEOPHYSICAL SURVEY DATA APPENDIX

Dear Mr. Allen:

On May 1, 2001, Golder Associates Inc. submitted a report to J. W. Morressitte and Associates on the findings of the geophysical survey conducted at Deschutes Parkway in Olympia, Washington. Enclosed with this letter are the original side scan sonar and ground penetrating radar data collected during the survey.

The following is a description of data sets, their annotations and notes to assist with their interpretation.

SIDE SCAN SONAR DATA

The side scan sonar data for Capital Lake are plotted on nine sonargram images. The sonar image depicts the lake floor on the left and right side of the towfish. The blank area in the middle of the data is the water column. The event numbers generated by the navigation computer are written along the edge of the sonargram.

Figure A1 is the trackline map for the side scan sonar data. The numbers plotted on the tracklines correspond with the event numbers noted on the side scan sonar records.

Figure A2 shows an example of the swath width or coverage of a side scan sonargram image. The example shows where the side scan sonar data was collected, 50 meters (~164 feet) to the right and left of the trackline. All sonar data were collected using the same swath width.

GROUND PENETRATING RADAR DATA

The ground penetrating radar was used on the Lake as well as on shore. In the lake, GPR navigation was used to determine the location of the data. The ground penetrating radar profiles that were collected on Deschutes Parkway are each labeled with the corresponding station that the radar line crossed. Some specific information or comments that may aid in the interpretation of the lake and on-shore GPR data are presented in the following.

CAPITAL LAKE GPR DATA

- The radar records were annotated with event numbers in the same manner as was used for the sidescan sonar data. Figures A3 and A4 show the trackline locations for the ground penetrating radar data collected in the lake.
- The maximum time window for the radar data collected in the lakes was 350 nanoseconds. The depth on the radargrams profiles in feet is based on the travel time of the radar waves through the water and subsurface material. In fresh water, the radar waves travel slower than they do in the saturated sediment of the lakebed, therefor two depth scales should be used interpret these records. For the water column, radar waves travel 18 nanoseconds per foot of water or about 20 feet full scale on the radargrams. For saturated unconsolidated sediment, the radar waves travel approximately 10 nanoseconds per foot of material or 35 feet full scale on the radargram.
- Multiple reflections are seen on some of the radargrams collected in the lake. Multiple reflections are echoes of the radar signal that has bounced between the lake surface and the lakebed. The multiple reflections will be at twice the water depth of the lakebed.
- In the deeper areas of the lake, the lakebed reflector seems to disappear. This is caused by the presence of fine-grained sediment, such as clay, that is electrically conductive. These materials absorb the radar wave energy rather then reflecting it.

ON SHORE GPR DATA

- The depths plotted on the right side of the records are estimated using a radar wave travel time of 5 nanoseconds per foot of material. This velocity value was determined by direct measurement of the depth of a utility exposed near station 87+25.
- The distances marked along the top edge of the record are in feet.
- Lateral changes in the surface materials affect the subsurface reflection data on the radar record. The most common surface variation occurred at the transition from the roadway to the shoulder. Other transitions included variations in the asphalt, the presence of water, dirt and metal. Metal and shallow water produce dark 'ringing' patterns on the record.
- The location of specific features such as cracks or bumps that may be from the earthquake are noted along the top edge of most of the records. In a few cases, the

highly numerous cracks are noted as cracks, plural, rather then marking each individual crack.

- Utilities and some buried objects appear as hyperbolic shaped anomalies. The location of the object creating the hyperbola is at the vertex of the hyperbola. The utilities were not marked on the records; however, they can be identified by their consistent location on parallel GPR transects.

- Potential slip planes are indicated by reflectors that cut across sub-surface features such as fill layer boundaries. Sometimes these reflectors are associated with surface cracks, bumps or voids. The hyperbolas produced by utilities can be confused with potential slip planes, however the hyperbolas always dip downwards when imaged across a flat surface.

- Voids are indicated by a subsurface disturbance that produces a strong initial reflection(s) that is dark on the radargrams and has little or no signal returns below the feature (Figure A6).

- The diameter of voids is not easy to determine. Voids are often created by piping (such as the example in Figure A6), however, voids below the roadbed near the south end of the site are suspected to be caused by larger land slide features that are leaving the road-way unsupported. An estimate of the height of those voids may be made based on the amount of ground drop along the shoulder beside the road. At the time of the survey, the shoulder had dropped up to 8 inches in places.

It is hoped that with the data and these interpretation notes in hand, you may be able to determine the extent of any road repairs that may be needed along Deschutes Parkway prior to its reopening. If you have questions about subsurface features or notes on the data that do not seem to fit any of the above descriptions, please feel free to call us and ask for the undersigned at (425) 883-0777.

Sincerely,

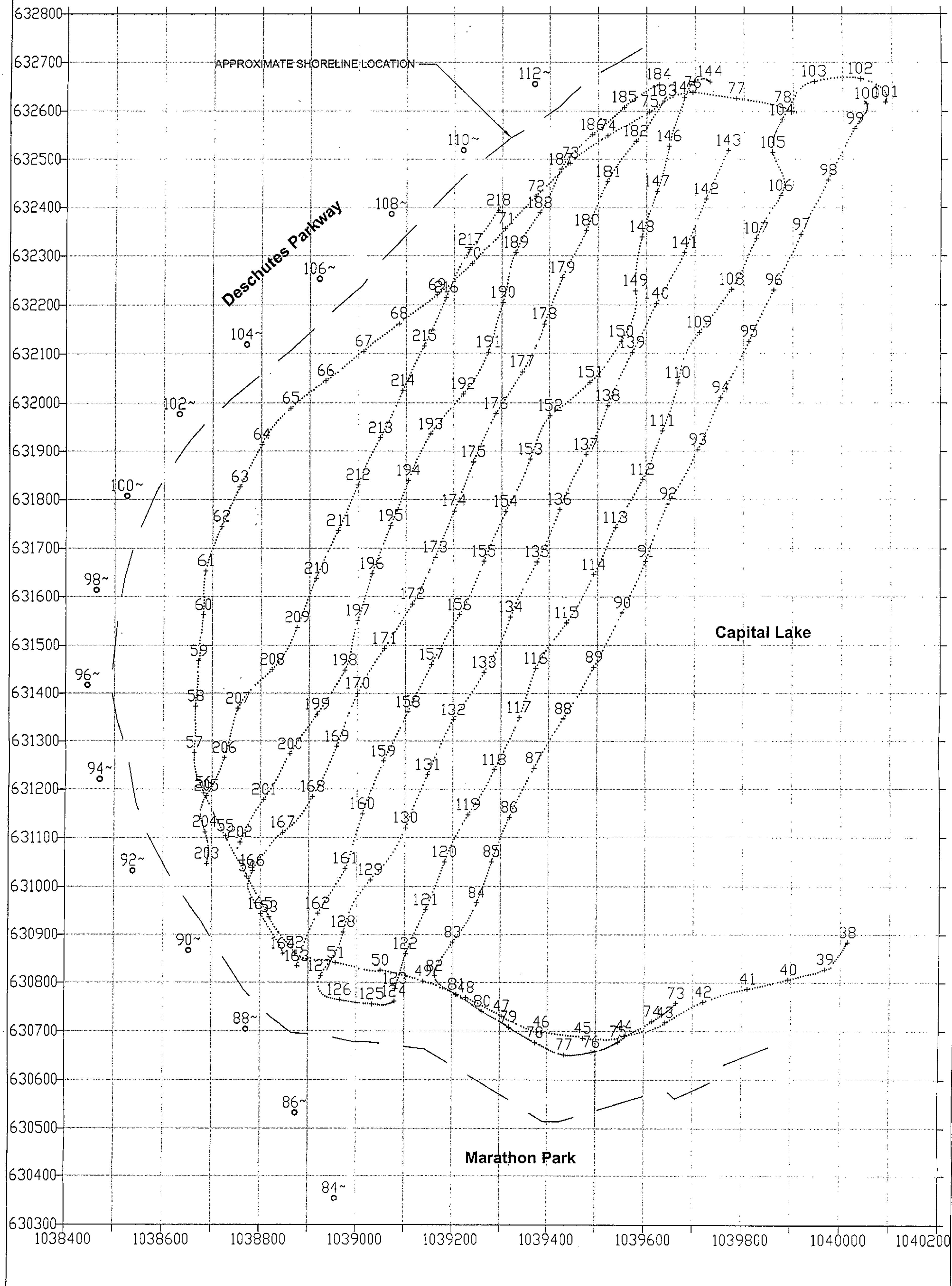
GOLDER ASSOCIATES INC.

David Hrutfiord
Staff Geophysicist

Dick Sylwester
Associate

DEH/RES/slg
0604deh1.doc

FIGURES



LEGEND:

89~ CENTERLINE OF DESCHUTES PARKWAY STATION MARK (89+00)

74 + SIDE SCAN SONAR TRACKLINE EVENT MARK, SEE SIDE SCAN DATA

TRACKLINE

DATUM; NAD 1983 HPGN (WASHINGTON / OREGON)
ZONE; WASHINGTON SOUTH 4602
SYSTEM; US STATE PLANE 1983 HPGN
UNITS; FEET

FIGURE **A1**

SIDE SCAN SONAR TRACKLINE MAP

JWM & A/CAPITAL LAKE GEOPHYSICS/WA

Golder Associates

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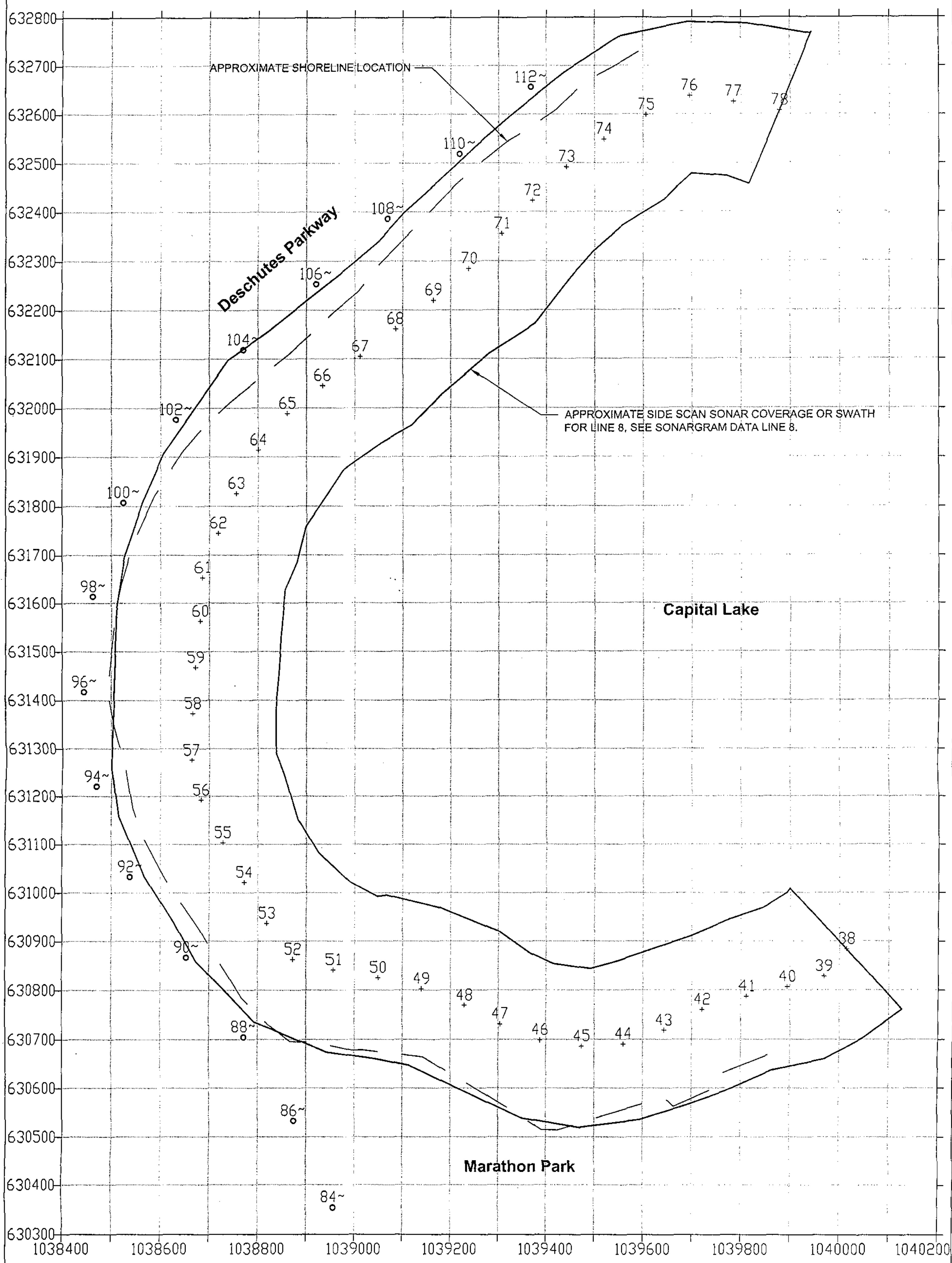

LEGEND:

89~ CENTERLINE OF DESCHUTES PARKWAY STATION MARK (89+00)

74 SIDE SCAN SONAR TRACKLINE EVENT MARK, SEE SIDE SCAN DATA

DATUM; NAD 1983 HPGN (WASHINGTON / OREGON)
ZONE; WASHINGTON SOUTH 4602
SYSTEM; US STATE PLANE 1983 HPGN
UNITS; FEET

FIGURE **A2**

LOCATION OF REPRESENTATIVE SIDE SCAN SONAR DATA

JWM & A/CAPITAL LAKE GEOPHYSICS/WA

Golder Associates

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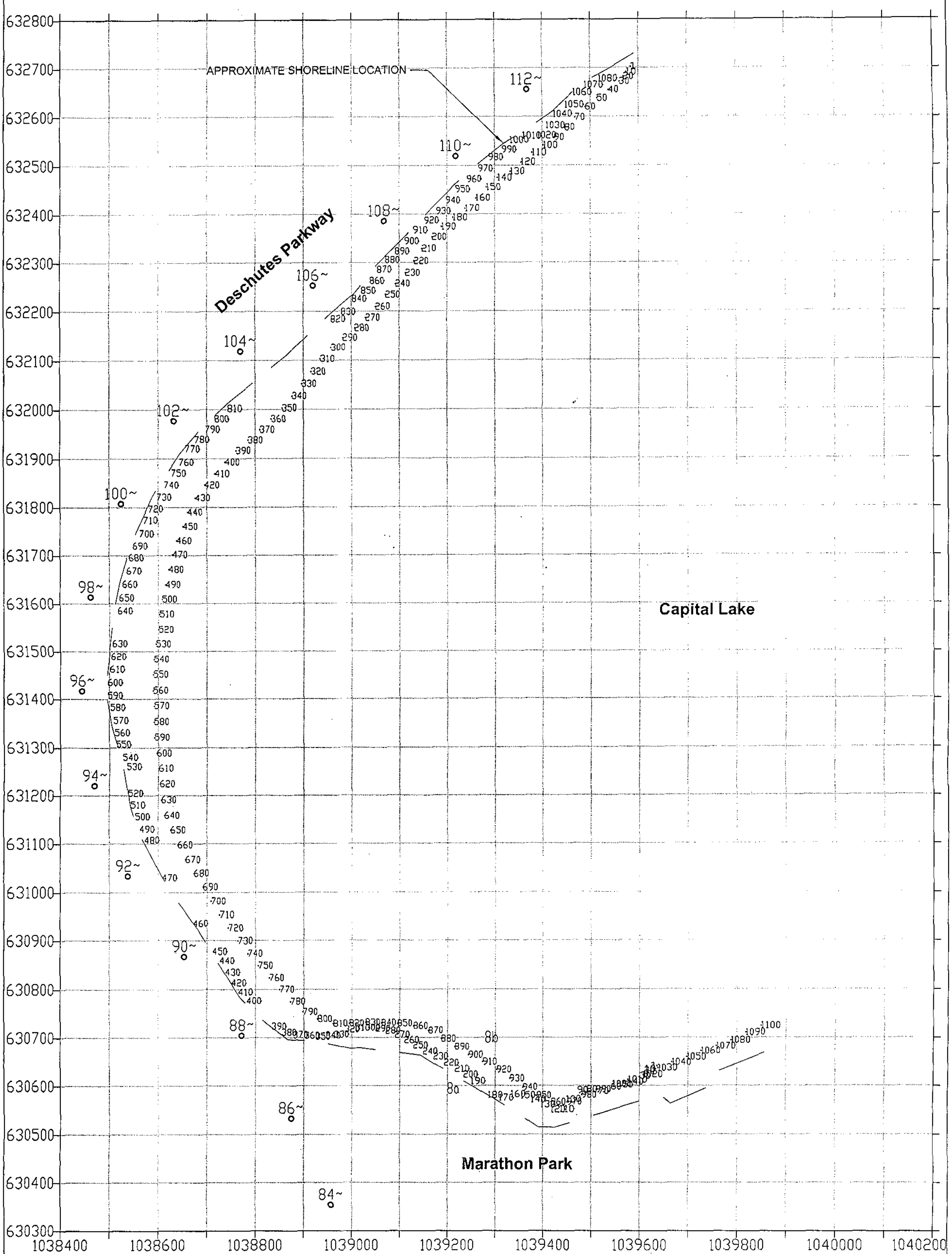


LEGEND:

89~ CENTERLINE OF DESCHUTES PARKWAY STATION MARK (89+00)

8a GROUND PENETRATING RADAR TRACKLINE REFERENCE FOR RADARGRAM DATA

10 20 30 GPR TRACKLINE AND EVENT NUMBERS

DATUM; NAD 1983 HPGN (WASHINGTON / OREGON)
ZONE; WASHINGTON SOUTH 4602
SYSTEM; US STATE PLANE 1983 HPGN
UNITS; FEET

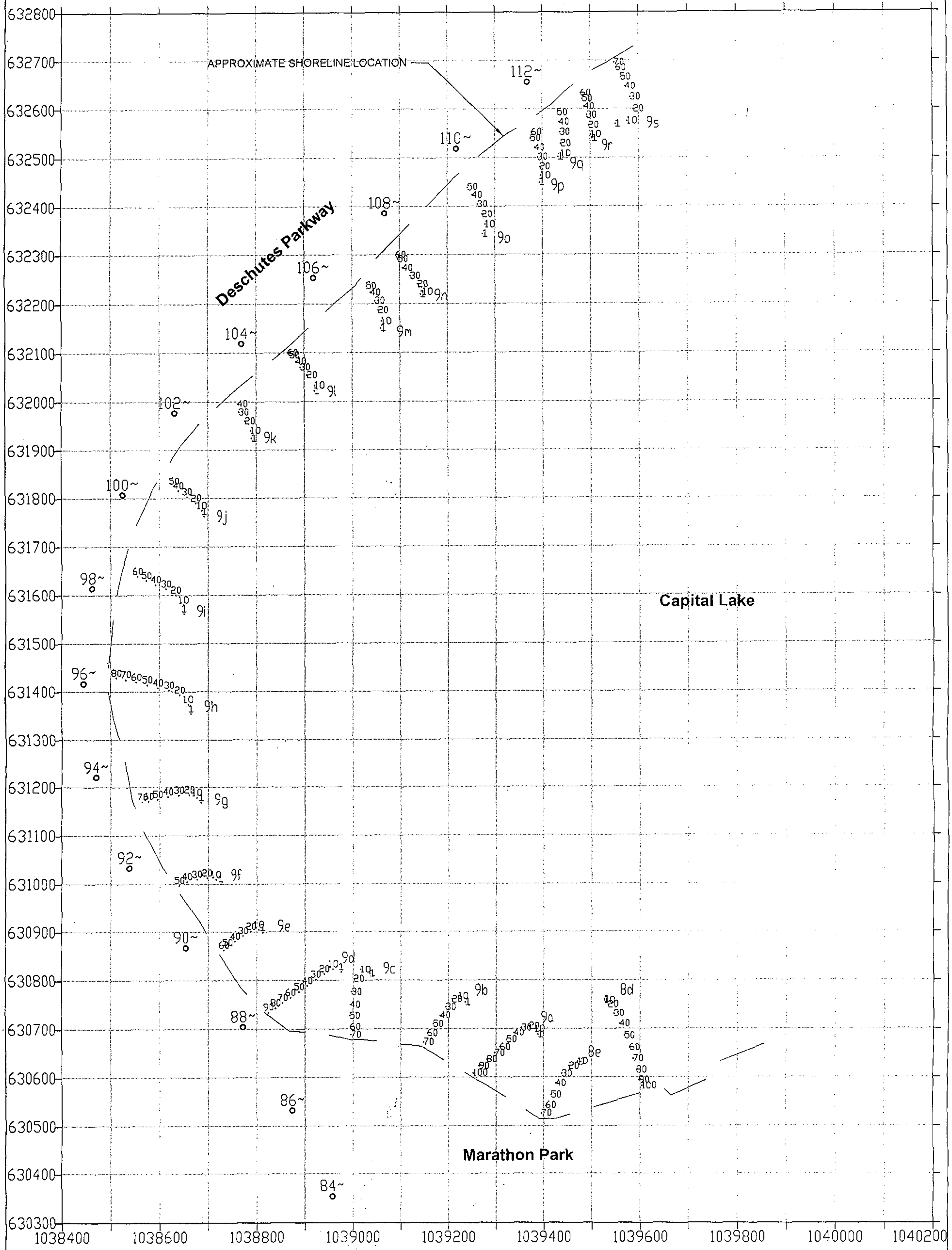
FIGURE **A3**

GROUND PENETRATING RADAR TRACKLINE MAP

JWM & A/CAPITAL LAKE GEOPHYSICS/WA

bclark|K:\Projects\2001\0131432\300\95808.dwg|5-30-1 14:55|x:-|i:-

Golder Associates



LEGEND:

89~ CENTERLINE OF DESCHUTES PARKWAY STATION MARK (89+00)

9d GROUND PENETRATING RADAR TRACKLINE REFERENCE FOR RADARGRAM DATA

10 20 30 GPR TRACKLINE AND EVENT NUMBERS

DATUM; NAD 1983 HPGN (WASHINGTON / OREGON)
ZONE; WASHINGTON SOUTH 4602
SYSTEM; US STATE PLANE 1983 HPGN
UNITS; FEET

FIGURE **A4**

GROUND PENETRATING RADAR TRACKLINE MAP

JWM & A/CAPITAL LAKE GEOPHYSICS/WA

bclark|K:\Projects\2001\0131432\300\95809.dwg|5-30-1 14:55|x:-|i:-

Golder Associates

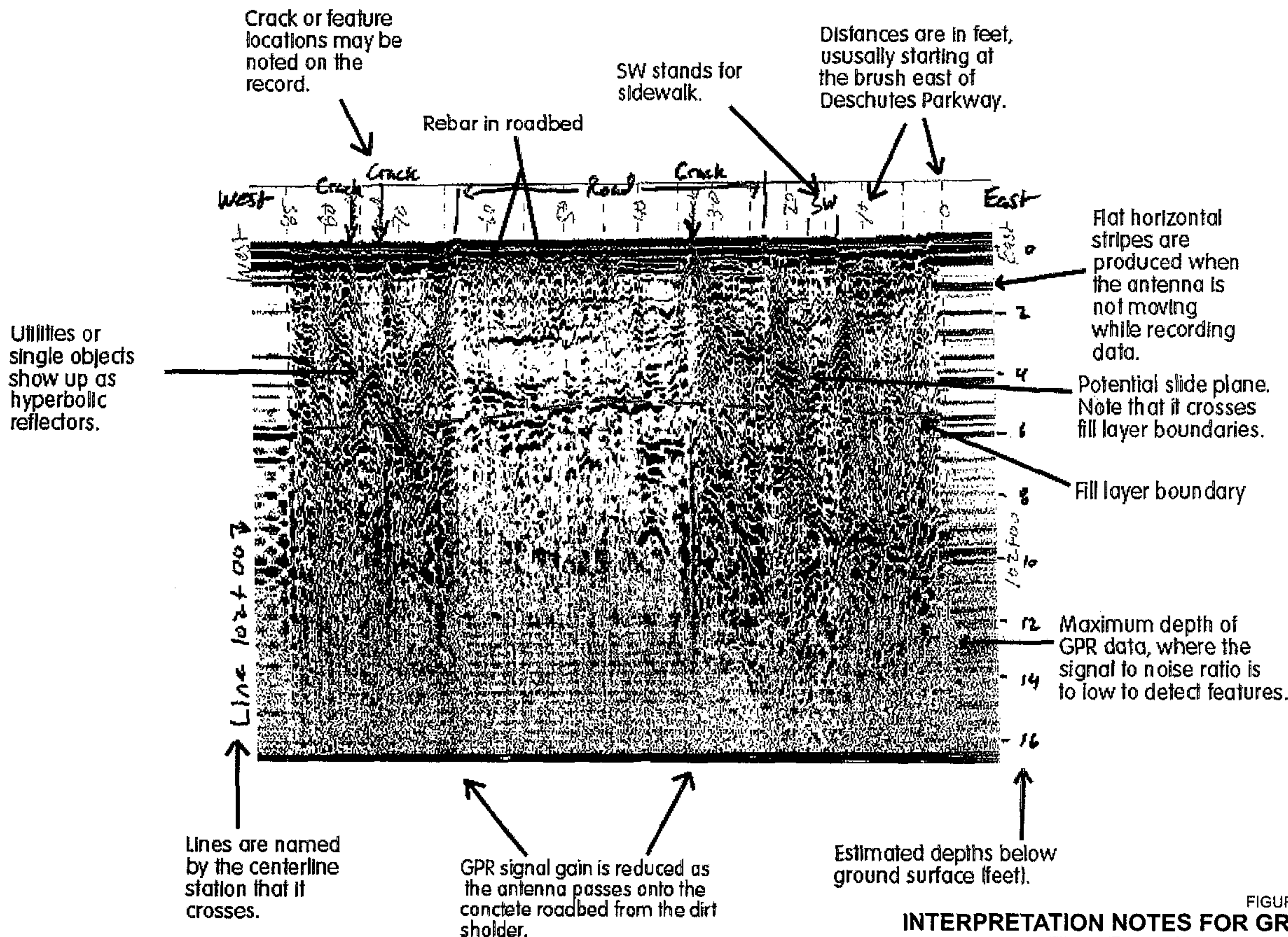


FIGURE **A5**

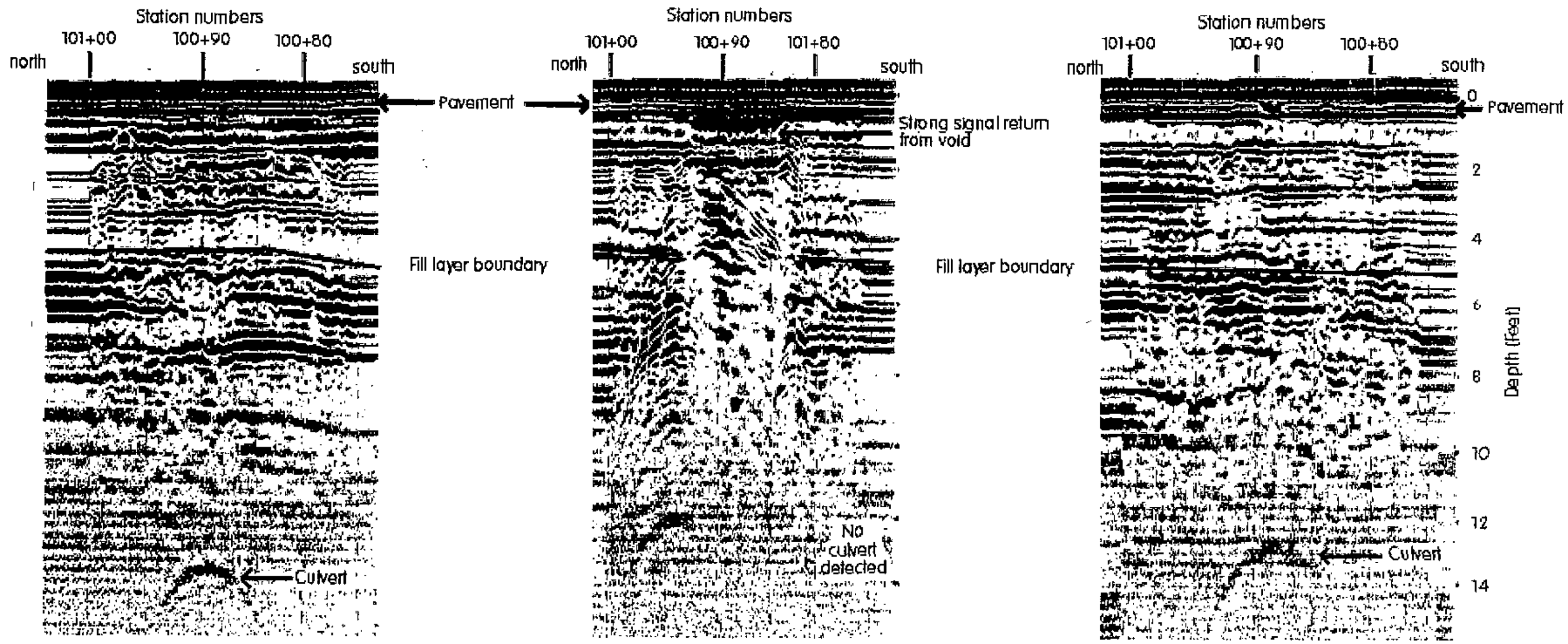
INTERPRETATION NOTES FOR GROUND PENETRATING RADAR DATA

J.W. MORRISSETTE/CAPITAL LAKE/WA

PROJECT NO. 013 1432.300 DRAWING NO. 92404 DATE 05/30/01 DRAWN BY EL

Golder Associates

Void detection by ground penetrating radar (GPR)



a. Profile from west parking lane   b. Profile from west driving lane   c. Profile from east driving lane

Each ground penetrating profile was collected parallel to each other approximately 9 feet apart.
Pipeing of sediments by a brake in the culvert has created a void below the road in profile b. The viod is indicated by the strong radar returns directly below the pavement and and the lack data beneath.
The fill layer boundary and culvert are not detected below the void.

FIGURE **A6**
INTERPRETATION OF A VOID FROM GROUND PENETRATING RADAR DATA
J.W. MORRISSETTE/CAPITAL LAKE/WA