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CONSULTING ENGINEERS

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September 18, 1986

Wharf Resources (USA) Inc.
P.O. Box 446
Deadwood, S.D. 57732
U.S.A.

Mr. R. Barnes

Ross Valley Hydrogeology Report

Dear Bob:

Please find enclosed two copies of our Ross Valley Hydrogeology Report for your use. Should you have any queries regarding our conclusions, please give me a call.

Yours very truly,

KLOHN LEONOFF INC.

J. ANDREW LEACH
Project Manager

JAL/sh

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REPORT

HYDROGEOLOGY OF ROSS VALLEY

FOR

WHARF RESOURCES (USA) INC.

PW 0066

SEPTEMBER 1986

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CONSULTING ENGINEERS

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REPORT

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for

WHARF RESOURCES (U.S.A.) INC.

PW 0066

September 1986

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1.0 STUDY SCOPE

In 1984 Klohn Leonoff conducted a preliminary hydrogeological investigation of the Annie Creek Mine area as part of a feasibility assessment of several possible sites for a valley fill heap leach pad. From the initial study, Wharf Resources (USA) Inc., (Wharf) chose to proceed to the design stage with the Ross Valley alternative for the heap leach site. A geotechnical program was initiated in the Ross Valley area to supply information necessary for final design of the heap leach. As part of the geotechnical program, detailed hydrogeological investigations were carried out to characterize the groundwater regime of the area. This report outlines the results of the hydrogeological program.

2.0 AREA SETTING

Annie Creek Mine is situated within the Black Hills on a ridge top plateau in the Spearfish Creek Drainage Basin. Elevations of the mining area range from 5900 to 6200 ft. with a gentle slope to the south towards Spearfish Creek. The Annie Creek ridge is dissected by the valleys of McKinley Gulch, Ross Springs and Annie Creek.

The Ross Valley proposed heap leach site is a relatively broad swale running from the Annie Creek haul road to Spearfish Canyon, 7 miles south. Elevation at the top of Ross Valley (on the haul road) is approximately 6000 ft.; elevation at Ross Springs, just downstream of the proposed dike, is 5850 ft.

Ross Valley is mainly a runoff course; however, discharge of 10-15 gpm from a spring at the top of the valley flows down the valley. This flow is increased by discharge of approximately 80-100 gpm from Ross Springs.

2.1 Surficial Deposits

The Black Hills region of South Dakota is unglaciated. Surficial deposits in the Annie Creek Mine area, therefore, are primarily of

colluvial origin. On the ridge tops and valley walls the colluvium is generally less than 10 feet thick and underlain by weathered bedrock (residual soils). In the bottom of Ross Valley the colluvium is highly variable in thickness but locally up to 45 feet deep. Weathering of the near surface bedrock is severe in the center of the valley with the depth of weathering relatively great in some places.

2.2 Bedrock Stratigraphy and Geology

The geology of the Annie Creek area has been described previously, most notably by J.P. Gries. The stratigraphy of the area from oldest to youngest consists of Precambrian schists (basement rocks), Deadwood Formation, Winnipeg Shale, Roughlock Siltstone, Whitewood Dolomite, Englewood Limestone and Madison (or Pahasapa) Formation. Any or all of the above geologic units may be intruded by Tertiary igneous intrusions, mostly sills of a porphyritic nature. The stratigraphic sequence and lithology are shown in Table 1.

The porphyry intrusions resulted in low grade gold mineralization and caused local thermal metamorphism. The intrustions also caused extensive structural deformation leading to faulting and folding of the sedimentary sequence.

3.0 HYDROGEOLOGICAL INVESTIGATIONS

The program conducted to characterize the hydrogeological regime of the Ross Valley site involved borehole drilling, piezometer installations and in situ permeability testing.

3.1 Drilling and Piezometer Installations

Seven boreholes were drilled in the Ross Valley area to obtain stratigraphic, structural and groundwater information. The holes were situated to form one section across the valley and a second section along the valley. Borehole locations are shown on Drawing D-0066.013 and drilling details are presented in Appendix I. Of the holes drilled in the profile along the valley, one hole (MW-7) is

situated up-gradient of the heap leach area; and one hole (MW-2) is located immediately downstream of Ross Springs. In addition, three holes (MW-8, -9, -10) were drilled in the McKinley Gulch area to provide hydrogeological data on a more regional scale. Borehole depths range from 147 to 304 ft. Standpipe piezometers have been installed in all the boreholes to permit permeability testing, water level monitoring and water sampling. Nests of two piezometers were installed in boreholes MW-1, -4, -7, -9 and -10. Single installations exist in MW-2, -5, -6 and -8. Borehole lithologs and piezometer completion details are included in Appendix I. Piezometer details and water level data are summarized in Table 2.

TABLE 1

STRATIGRAPHIC SEQUENCE - ANNIE CREEK MINING AREA

	Thickness (ft.)	Lithology
Madison Formation	200-400	Buff to grey dolomitic limestone and dolomites.
Englewood Formation	30	Pink to maroon argillaceous dolomitic limestone. Locally may have dense grey shale at base.
Whitewood Dolomite	30-40	Mottled tan and red-brown dolomite
Roughlock Siltstone	10-30	Dark grey dolomitic shaly siltstone.
Winnipeg Shale	35-45	Dark grey to green, dense plastic shale.
Deadwood Formation	400	Mottled brown to rust red sandstones, argillaceous sandstones, siltstones, shales and occasional limestones; locally metamorphosed.
Precambrian Schists	unknown	

TABLE 2

PIEZOMETER COMPLETION DETAILS

Piezometer No.	Collar Elevation (ft.)	Completion Interval (ft.)	Formation	Water Level June 1986 Depth (ft.)	Water Level June 1986 Elevation (ft.)
MW-1	5924	299-304	Deadwood	73.53	5850.47
MW-1A	5924	93-98	Madison	64.46	5859.54
MW-2	5843	291-296	Porphyry	65.12	5777.88
MW-3		Not Drilled			
MW-4	5957	291-296	Winnipeg	61.62	5895.38
MW-4A	5957	102-105	Madison	51.96	5905.04
MW-5	6061	240-245	Madison	185.61	5879.39
MW-6	6003	142-147	Madison	61.20	5941.80
MW-7	6220	340-345	Porphyry	160.72	6059.28
MW-7A	6220	91-96	Whitewood	81.96	6138.04
MW-8	6035	143-172	Madison	95.44	5939.56
MW-9	5983	260-265	Porphyry	181.44	5801.56
MW-9A	5983	235-240	Englewood	175.94	5807.06
MW-10	5889	153-158	Madison	118.50	5770.50
MW-10A	5889	128-133	Madison	116.61	5772.39
				$\bar{x}$ 105.7	

3.2 In Situ Permeability Testing

Falling head permeability tests were conducted in all the piezometers except MW-8 which has too long a completion interval for a valid test to be run. Hvorslev's (1951) method for piezometers in saturated isotropic strata of infinite depth was used. The permeability test results are summarized in Table 3.

TABLE 3

HYDRAULIC CONDUCTIVITIES

Piezometer	Completion Interval (ft)	Hydrogeologic Unit	Rock Type	Hydraulic Conductivity K gpd/ft^2	Hydraulic Conductivity K cm/s
MW-1	299-304	Deadwood	Quartzite	3.4	1.6×10^{-4}
MW-1A	93-98	Madison	Limestone	53.0	2.5×10^{-3}
MW-2	291-296	Porphyry	Qtz Monzonite	0.6	3.0×10^{-5}
MW-4	291-296	Winnipeg	Shale	0.08	3.7×10^{-6}
MW-4A	102-105	Madison	Limestone	4.0	1.9×10^{-4}
MW-5	240-245	Madison	Limestone	3.6	1.7×10^{-4}
MW-6	142-147	Madison	Limestone	2.8	1.3×10^{-4}
MW-7	340-345	Porphyry	Qtz Monzonite	1.2	5.8×10^{-5}
MW-7A	91-96	Whitewood	Dolomite	17.8	8.3×10^{-4}
MW-9	260-265	Porphyry	Rhyolite	0.003	1.6×10^{-7}
MW-9A	235-240	Englewood	Limestone	25.4	1.2×10^{-3}
MW-10	153-158	Madison	Limestone	4.2	2.0×10^{-4}
MW-10A	128-133	Madison	Limestone	27.6	1.3×10^{-3}

4.0 HYDROGEOLOGY

4.1 Aquifer Characteristics

The main aquifer in the study area is the carbonate sequence which includes the Madison (Pahasapa) Formation, the Englewood Formation and Whitewood Dolomite. Although in places the Englewood contains a shale/siltstone sequence that separates the Whitewood aquifer from the Madison and upper Englewood, for the most part, these carbonates form a single aquifer which for the purposes of discussion will be referred to as the Pahasapa Aquifer.

The Pahasapa aquifer in the mine site area has a transmissivity of 6600 gpd/ft and a storage coefficient of 0.04 as obtained from a pump

?

test on HDH-11 (Klohn Leonoff, February 1986). A hydraulic conductivity of 22 gpd/ft^2 was calculated for the Pahasapa at HDH-11A.

Permeability testing completed in the recently installed piezometers gave hydraulic conductivities for the Pahasapa Aquifer in the range of 2.8 gpd/ft^2 (1.3×10^{-4}cm/s) to 53 gpd/ft^2 (2.5×10^{-3} cm/s). The permeability of the Pahasapa is mainly secondary (fracture) permeability and as such is expected to be relatively variable at different locations and depths.

The aquifer is likely unconfined or at best semi-confined as is indicated by the high value of storativity. The drilling results confirm this fact.

Information on the formations below the Pahasapa Aquifer is limited to the recently completed permeability testing. A single falling head test conducted on piezometer MW-4 completed within the Winnipeg shale, indicates a hydraulic conductivity of 0.08 gpd/ft^2 (3.7×10^{-6} cm/s). Falling head tests on piezometers completed in the porphyry intrusives indicate hydraulic conductivities of 0.003 gpd/ft^2 (1.6×10^{-7} cm/s) to 1.2 gpd/ft^2 (5.8×10^{-5} cm/s). The Deadwood Formation has a hydraulic conductivity of 3.4 gpd/ft^2 (1.6×10^{-4} cm/s) as indicated by a single falling head test.

These data would indicate that the main aquifer, the Pahasapa, has relatively high permeabilities whereas the underlying strata have low permeabilities. The porphyry intrusives which occur unpredictably in the stratigraphic sequence, have low to very low permeabilities.

4.2 Regional Hydrogeology

The Annie Creek Mine area, located on a high plateau, is part of a regional recharge area for the Spearfish Creek groundwater basin. Rahn and Gries (1973) have suggested that 25 to 30 percent of annual precipitation of 24 inches/year is available for groundwater recharge in the area.

Depths to water table in the vicinity of the Annie Creek Mine plant and office area are generally over 75 feet as indicated by monitoring wells and piezometers on site. Water level data were collected for water wells HDH-1, -2, -4, -8, -10, -11 and -12 from June 1984 to the end of 1985. These data are presented in Appendix II.

All the wells show a slight but steady decrease in water levels since July 1984. Wells HDH-8 and -10 showed an initial rise in water levels before the decline; however, this could be partially a result of stabilization of the wells following installation and testing. As the Pahasapa Aquifer is thought to be unconfined, the water level data are expected to show seasonal fluctuations. This is not apparent in the limited water level observation data. The area experienced severe drought conditions during the 1984 and 1985 seasons which may have flattened the peaks and created a general decline in water table levels.

Water level data from the water wells and recently installed piezometers indicate a significant downward flow of groundwater. The vertical groundwater gradients are estimated as follows:

	Head Difference (ft)	Elevation Difference Between Intakes (ft)	Vertical Gradients
HDH-4/HDH-9	47.8	58	0.82
HDH-9/HDH-10	93.7	138	0.68
HDH-4/HDH-10	141.5	196	0.72
MW-1/MW-1A	9.07	206	0.04
MW-4/MW-4A	9.66	189	0.05
MW-7/MW-7A	78.76	249	0.32
MW-9/MW-9A	5.5	25	0.22

The greatest downward components of groundwater flow are in the upland areas and in the upper portion of the aquifer. The downward component is less in the valley and in the lower portion of the aquifer.

The horizontal component of groundwater flow was estimated in our February 1986 report by comparing well water level elevations and spring discharge elevations. The data show groundwater flow in easterly, southeasterly and westerly directions from the mine site. The most recent data, presented in Table 4 confirm that groundwater flow is downward beneath the upland areas and laterally towards discharge areas such as Annie Creek, Ross Springs, Spearfish Creek and McKinley Gulch.

TABLE 4

HORIZONTAL GROUNDWATER GRADIENTS

	Elevation Difference (ft)	Horizontal Distance (ft)	Horizontal Gradient
HDH-4/Ross Springs	260	1900	0.14
HDH-4/Base of Madison on Spearfish Canyon	502	6200	0.08
HDH-4/Annie Spring	112	4700	0.02
HDH-4/HDH-11	53	450	0.12
MW-5/MW-9A	72	3450	0.02
MW-7A/Ross Springs	298	3700	0.08
MW-6/Ross Springs	163	1920	0.08

Using the hydraulic gradients calculated and the hydraulic conductivities determined from the falling head testing, relative groundwater velocities can be calculated using Darcy's Equation. For the Pahasapa Aquifer, relative groundwater velocities are in the range of 3 feet/year to over 1000 feet/year. For the underlying Winnipeg Formation, Deadwood Formation and porphyry intrusives velocities of less than one inch per year are likely.

Two hydrogeologic cross sections (Drawings D-0066.014 and .015) have been drawn (with exaggerated vertical scale), one north-south through Ross Valley and the second east-west from McKinley Gulch across Ross Valley. These sections illustrate schematically the directions of groundwater movement in the vicinity of the mine area.

Groundwater recharge to the Pahasapa aquifer moves downward unimpeded until it reaches the underlying low permeability Winnipeg shales or in some cases porphyry intrusives. Flow in the lower part of the aquifer then becomes more lateral in character. Where the Winnipeg shale subcrops, discharge to the surface in the form of springs may occur at the base of the aquifer. This is evident along the walls of Spearfish Canyon.

Groundwater flow is also impacted by geologic structure, particularly where faulting or folding has vertially displaced low permeability bedrock such as the shales and intrusives. Springs discharging along the Ross Valley appear to be related to such displacements.

4.3 Ross Valley Hydrogeology

The boreholes and piezometer nests installed in the Ross Valley area have provided hydrogeologic data which are illustrated in hydrogeologic sections A-A' and B-B'.

The cross sections show the groundwater regime in Ross Valley to be controlled by geologic structure, stratigraphy and topography.

Groundwater level data in the Ross Valley, as illustrated in section B-B', indicate that the elevation of the water table is highest under Ross Creek and gradually declines westerly as well as southerly. Thus, Ross Creek for much of its length serves as a source of groundwater recharge. Infiltration from stream flow moves downward into the Pahasapa Aquifer and away from the creek. Groundwater moving westerly and southerly through the aquifer is part of a regional flow system which probably eventually discharges to Spearfish Creek.

Exceptional groundwater flow behaviour occurs on a local scale due to structural and stratigraphic conditions. This local scale flow results in spring discharge at several locations in the Ross Valley. One of these locations is in the upper end of the valley, midway between MW-6 and MW-7 as shown on sections A-A'. Spring discharge occurs in the vicinity of a fault zone. Relative stratigraphic displacement along the fault has resulted in the low permeability Winnipeg Formation being upthrown north of the fault. Although hydrogeologic data north of the fault are somewhat limited, it is apparent from borehole MW-7 that the top of the Winnipeg Formation is at an elevation of about 6125 feet, or about the same level as the spring zone.

The water table in the Pahasapa Aquifer as measured in MW-7 is relatively deep (elevation 6140 feet), indicating that the aquifer is well drained. With a relatively thin saturated zone, flow in the aquifer is believed to be mainly horizontal and southerly toward the springs which are probably near the upper contact of the Winnipeg Formation.

The second notable location is Ross Springs, also illustrated on section A-A'. The origin of Ross Springs appears to be related to the occurrence of a low permeability porphyry instrusive body in this area. The intrusive also has disturbed the older stratigraphic sequence which appears to have been pushed upward and folded. The combination of the intrusion and folding has produced a permeability barrier to southerly groundwater flow, thus creating a local groundwater discharge zone in the form of the spring.

5.0 CONCLUSIONS

a) Ross valley is a north-south trending V-shaped valley which carries surface run-off and a minor amount of discharge from springs located at the head of the valley and from Ross Springs. For most of its length, Ross Creek is influent, serving as a source of groundwater recharge to the regional groundwater flow system.

b) The main aquifer in the valley area is the Pahasapa Aquifer which is the uppermost bedrock hydrogeologic unit. Water table depths in the valley are less than 60 feet from ground surface and are influenced in part by stratigraphic and structural controls related to igneous intrusions and faulting.

c) In the unlikely event of a leaching solution leak through the base of the liner system for the heap leach, there is little chance of containment within the valley. The solution would move down relatively quickly to the water table and then move in accordance with the hydraulic gradients to the south and west. Part of the groundwater moving south could be intercepted at Ross Springs, a point sink. Groundwater moving westerly however, will be difficult to collect. On a regional scale, westward moving contaminants in the groundwater would not be expected to discharge until reaching Spearfish Canyon some 7,000 ft. away. On the basis of the estimated velocities, contaminants are expected to take 7 to 2,300 years to report to Spearfish Canyon.

d) It is beyond the scope of this study to determine the effects of chemical and physical processes within the aquifer on contaminant transport. However, leaking solution will be diluted by mixing with the groundwater. In addition, the effects of dispersion and chemical/physical attenuation mechanisms will likely reduce the concentrations of cyanide in groundwater moving towards Spearfish Canyon. These effects may be significant and merit further investigation.

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Gries, J.P. 1982. Geology and Hydrology of the Annie Creek Leach Site. Submitted to Scholz Minerals Engineering Inc.

Hvorslev, M.J. 1951. Time Lag and Soil Permeability in Groundwater Observations. U.S. Army Corps Engineers. Waterways Exp. Sta. Bull 36, Vicksburg, Miss.

Klohn Leonoff Inc. 1986. Foley Ridge Heap Leach Design Comparison of Alternative Sites. Submitted to Wharf Resources (USA) Inc.

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APPENDIX II

Annie Creek Mine Water Level Data

WATER LEVEL DATA

WATER WELL NO. HDH-1

Depth of Well: 40 feet

Completion Interval: 20-40 feet

Ground Elevation: Unknown

Date	Depth to Water (ft.)	Elevation of Water (ft.)
July 7/82	40.69	
July 13/84	38.54	
Aug. 8/84	39.08	
Sept. 20/84	39.28	
Jan. 9/85	40.85	
Aug. 1/85	42.06	

WATER LEVEL DATA

WATER WELL NO. HDH-2

Depth of Well: 106 feet

Completion Interval: 66-106 feet

Ground Elevation: 6095

Date	Depth to Water (ft.)	Elevation of Water (ft.)
Sept. 22/83	93.69	
Dec. 16/83	94.71	
July 13/84	90.73	6004.27
Aug. 8/84	92.36	6002.64
Sept. 20/84	93.75	6001.25
Jan. 9/85	94.85	6001.15
Mar. 7/85	95.18	5999.82
Aug. 1/85	95.34	5999.66

WATER LEVEL DATA

WATER WELL NO. HDH-4

Depth of Well: 100 feet

Completion Interval: 55-99 feet

Ground Elevation: Unkown

Date	Depth to Water (ft.)	Elevation of Water (ft.)
July 8/82	90.36	
Dec. 16/83	92.51	
July 13/84	87.54	
Aug. 8/84	89.61	
Sept. 20/84	90.50	
Jan. 9/85	93.69	
Mar. 7/85	95.55	
Aug. 1/85	98.73	

WATER LEVEL DATA

WATER WELL NO. HDH-8

Depth of Well: 390 feet

Completion Interval: 315-390 feet

Ground Elevation: 6132

Date	Depth to Water (ft.)	Elev. of Water (ft.)	Date	Depth to Water (ft.)	Elev. of Water (ft.)
Jun. 14/84	262.54	5869.46	Nov. 6/84	259.96	5872.04
Jun. 20/84	261.26	5870.74	Nov. 13/84	260.16	5871.84
Jun. 22/84	260.65	5871.35	Nov. 20/84	260.56	5871.44
July 2/84	260.09	5871.91	Nov. 27/84	260.63	5871.38
July 10/84	259.71	5872.29	Dec. 7/84	261.01	5870.99
July 18/84	259.19	5872.81	Dec. 10/84	260.88	5871.12
July 24/84	259.09	5872.91	Jan. 4/85	262.10	5869.90
July 31/84	258.68	5873.32	Jan. 7/85	261.96	5870.04
Aug. 7/84	258.63	5873.78	Jan. 14/85	262.15	5869.85
Aug. 15/84	258.50	5873.50	Jan. 22/85	262.43	5869.57
Aug. 22/84	258.41	5873.59	Jan. 28/85	262.38	5869.62
Sept. 5/84	258.49	5873.51	Feb. 5/85	262.41	5869.59
Sept. 11/84	258.46	5873.54	Feb. 13/85	263.01	5868.99
Sept. 18/84	258.87	5873.13	Feb. 19/85	262.98	5869.02
Sept. 24/84	259.00	5873.00	Feb. 27/85	263.30	5868.70
Oct. 2/84	259.10	5872.90	Mar. 6/85	263.27	5868.73
Oct. 9/84	259.23	5872.77	Mar. 12/85	263.52	5868.48
Oct. 16/84	259.38	5872.63	Mar. 20/85	264.03	5867.97
Oct. 24/84	259.75	5872.25	Apr. 12/85	264.77	5867.23
Oct. 30/84	259.87	5872.13	Apr. 18/85	264.54	5867.46
			Jun. 25/85	266.75	5865.25

WATER LEVEL DATA

WATER WELL NO. HDH-10

Depth of Well: 340 feet

Completion Interval: 280-340 feet

Ground Elevation: 6116

Date	Depth to Water (ft.)	Elev. of Water (ft.)	Date	Depth to Water (ft.)	Elev. of Water (ft.)
Jun. 14/84	248.73	5867.27	Nov. 6/84	246.17	5869.83
Jun. 20/84	247.86	5868.14	Nov. 13/84	246.33	5869.67
Jun. 22/84	247.34	5868.66	Nov. 20/84	246.70	5869.30
July 2/84	246.79	5869.21	Nov. 27/84	246.95	5869.05
July 10/84	246.44	5869.56	Dec. 7/84	247.07	5868.93
July 18/84	245.94	5870.06	Dec. 10/84	246.83	5869.17
July 24/84	245.97	5870.03	Jan. 4/85	248.19	5867.81
July 31/84	245.75	5870.25	Jan. 7/85	248.02	5867.98
Aug. 7/84	245.39	5870.61	Jan. 14/85	248.20	5867.80
Aug. 15/84	245.25	5870.75	Jan. 22/85	248.43	5867.57
Aug. 22/84	246.35	5869.65	Jan. 28/85	248.32	5867.68
Sept. 5/84	245.18	5870.82	Feb. 5/85	248.44	5867.56
Sept. 11/84	245.15	5870.85	Feb. 13/85	249.13	5866.88
Sept. 18/84	245.53	5870.47	Feb. 19/85	248.98	5867.02
Sept. 24/84	245.65	5870.35	Feb. 27/85	249.38	5866.62
Oct. 2/84	245.61	5870.39	Mar. 6/85	249.30	5866.70
Oct. 9/84	245.59	5870.41	Mar. 12/85	249.46	5866.54
Oct. 16/84	245.65	5870.35	Mar. 20/85	249.97	5866.03
Oct. 24/84	245.91	5870.09	Apr. 12/85	250.33	5865.67
Oct. 30/84	246.97	5869.03	Apr. 18/85	249.94	5866.06
			Jun. 25/85	252.03	5863.97
			Sept. 24/85	254.63	5861.37

WATER LEVEL DATA

WATER WELL NO. HDH-11

Depth of Well: 475 feet

Completion Interval: 180-475 feet

Ground Elevation: 6047

Date	Depth to Water (ft.)	Elevation of Water (ft.)
Mar. 12/85	109.25	5937.75
Mar. 20/85	109.68	5937.32
Apr. 12/85	110.07	5936.93
Apr. 18/85	109.33	5937.67
Sept. 24/85	122.76	5924.24

WATER LEVEL DATA

WATER WELL NO. HDH-12

Depth of Well: 70 feet

Completion Interval: 20-70 feet

Ground Elevation: 5958

Date	Depth to Water (ft.)	Elevation of Water (ft.)
June 14/84	11.37	5946.63
June 20/84	11.44	5946.56
June 22/84	12.21	5945.79
July 2/84	13.17	5944.83
July 10/84	15.00	5943.00
Jan. 22/85	25.30	5932.70
Feb. 13/85	25.87	5932.13
Feb. 19/85	25.91	5932.09
Feb. 27/85	26.20	5931.80
Mar. 12/85	26.54	5931.46
Mar. 20/85	26.49	5931.51
Apr. 18/85	23.74	5934.26
Sept. 24/85	31.65	5926.35

APPENDIX I

Borehole Lithologs & Piezometer Completion Diagrams

DRILLING

The test holes were drilled using a down hole hammer. Each test hole was started at 8 3/4 inch diameter and progressed to 20-80 feet at which time a 7 inch diameter steel surface casing was set and cemented. Below the casing the test holes were reduced to 6 inch diameter. Circulation was maintained using water and foam.

The logs presented on the following paper provide lithology data only based on chip identification only. No attempt to obtain geotechnical information from these logs has been made.

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ▨ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND 5924	
HEIGHT DROP 30 inches					CO-ORD. LOCATION N 48576 E 47034	PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT X - - - - - - O - - - - - - X 10 20 30 40 50 60 70 80 %
DEPTH / ELEV	O.D / I.D.	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.						
10					CLAY AND GRAVEL - clay and gravel - numerous boulders - colluvium	
20						
30						
40						
50					LIMESTONE (MADISON OR PAHASAPA FM) - completey weathered - soft (chalk) - tan - making water @ approx. 45'	
60						
			V			
70						
			V			
80						
90						
100						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-1
DATE June 6/86	PLATE 1/4

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND 5924	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 48576 E 47034	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.						
110					LIMESTONE (ENGLEWOOD FM) - slightly dolomitic - fresh - red-brown	
120					SILTSTONE - calcareous - dark grey to dark reddish-grey - shaly layers from 130'	
130						
140						
150					LIMESTONE (WHITEWOOD DOLOMITE) - tan to orange - weathered - friable	
160						
170					dolomitic & silty from 170'	
180						
190					DOLOMITIC SILTSTONE (ROUGHLOCK SILTSTONE) - dark grey - sandy sections - hard - occasional quartzite lenses	
200						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-1
DATE	June 6/86 PLATE 2/4

TEST HOLE LOG

SAMPLE DATA	
WEIGHT HAMMER	140 lb
HEIGHT DROP	30 inches

ELEV COLLAR

ELEV GROUND 5924

CO-ORD LOCATION N 48576 E 47034

UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0
● FIELD VANE △ LAB VANE ■ UNCONF

PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X
10 30 50 70 90 %

DEPTH ELEV	O.D I.D	BLOWS FT	NO.	SYMBOL	DESCRIPTION OF MATERIAL
FT.					
210					DOLOMITIC SILTSTONE - as above
220					
230					SHALE (WINNIPEG FORMATION) - dark grey - friable
240					
250					
260					
270					
280					
290					SANDY LIMESTONE (DEADWOOD FM) - red - friable
					SHALE - dark grey
300					QUARTZITE - white to light grey

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-1
DATE June 6/86	PLATE 3/4

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND 5924	
HEIGHT DROP 30 inches					CO-ORD. LOCATION N 48576 E 47034	PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT X — O — X 10 30 50 70 90 %
DEPTH ELEV	O.D I.D	BLOWS FT	NO.		DESCRIPTION OF MATERIAL	
FT.					QUARTZITE - as above	
310					T.D. 304'	
					Piezometer MW-1 installed 301 - 304'.	
					Piezometer MW-1A installed 95 - 98'.	
					(See Completion Diagrams)	

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-1
DATE June 6/86	PLATE 4/4

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F
WEIGHT HAMMER 140 lb.					ELEV GROUND 5843	0 1.0 2.0 3.0 4.0 ⊙ FIELD VANE △ LAB VANE ■ UNCONF.
HEIGHT DROP 30 inches					CO-ORD LOCATION N 47812 E 46692	PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT
DEPTH / ELEV	O.D / I.D.	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	10 30 50 70 90 %
FT.					SANDY CLAY - some gravel - colluvium	
10					CLAYEY GRAVEL - colluvium	
20–30					LIMESTONE (MADISON OR PAHASAPA FM) - highly weathered & fractured - tan - occasional completely weathered sections	
40					QUARTZITE (DEADWOOD FM?) - grey - fresh - hard	
50–100					PORPHYRY (PHONOLITE?) - dark grey-green - very hard Hole making water @ 53'.	

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-2
DATE	June 3/86 PLATE 1/3

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 10 20 30 40 ⊙ FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND 5843	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 47812 E 46692	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D.	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	

FT.

110

120

130

140

150

160

170

180

190

200

PORPHYRY
- as above

Calcite Veinlets

DOLOMITIC LIMESTONE
- tan

SANDSTONE
- fine to medium grained
- slightly metamorphosed (almost quartzite)
- grey

Reddish color from 157'

Rusty brown from 172'.
- not metamorphosed

Dark grey from 175'.

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-2
DATE June 3/86	PLATE 2/3

TEST HOLE LOG

SAMPLE DATA	
WEIGHT HAMMER	140 lb.
HEIGHT DROP	30 inches

ELEV COLLAR

ELEV GROUND 5843

CO-ORD LOCATION N 47812 E 46692

UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF

PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %

DEPTH ELEV	O.D. I.D.	BLOWS FT	NO.	SYMBOL	DESCRIPTION OF MATERIAL
FT.					
210					SANDSTONE - as above
220					
230					
240					Occasional shale lense from 240'.
250					
260					Interbedded sandstone, siltstone, shale from 253'.
					QUARTZITE - light grey
270					SILTSTONE - dark grey - shaly
280					CALCAREOUS SILTSTONE - limestone lenses
					DOLOMITE - grey - coarse crystalline
290					PORPHYRY (QUARTZ MONZONITE?) - orange to tan
300					T.D. 296' Piezometer installed to 296'.

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-2
DATE	June 3/86
PLATE	3/3

TEST HOLE LOG

SAMPLE DATA	
WEIGHT HAMMER	140 lb.
HEIGHT DROP	30 inches

ELEV COLLAR

ELEV GROUND 5957

CO-ORD LOCATION N 49066 E 47130

UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %

DEPTH ELEV	O.D. T.D.	BLOWS FT	NO.	SYMBOL	DESCRIPTION OF MATERIAL
FT.					CLAY AND GRAVEL - boulders - colluvium
10					
20					
30					LIMESTONE (MADISON OR PAHASAPA FM) - highly to completely weathered with clayey lenses - tan
40					
50					
60					DOLOMITIC LIMESTONE - tan to grey - fresh
70					
80					
90					Making water @ 90'.
100					

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-4
DATE	June 8/86 PLATE 1/3

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR		UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND	5957	
HEIGHT DROP 30 inches					CO-ORD LOCATION	N 49066 E 47130	PLASTIC LIMIT X - - - - - - WATER CONTENT O - - - - - - LIQUID LIMIT X 10 30 50 70 90 %
DEPTH ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL		
FT.							
110					DOLOMITIC LIMESTONE - as above		
120							
130					DOLOMITE - brown - fresh - cherty from 135'		
140					LIMESTONE (ENGLEWOOD LST) - dark brown to red - silty - occasional shaly layers		
150							
160					CALCAREOUS SILTSTONE - dark grey		
170					LIMESTONE (WHITEWOOD DOLOMITE) - silty - reddish grey in colour - slightly dolomitic - yellow & less silt from 170'		
180					Red color from 182'		
190							
200					DOLOMITE - fine crystalline - dark grey-brown		

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-4
DATE	June 8/86 PLATE 2/3

TEST HOLE LOG

SAMPLE DATA	
WEIGHT HAMMER	140 lb.
HEIGHT DROP	30 inches

ELEV COLLAR

ELEV GROUND 5957

CO-ORD LOCATION N 49066 E 47130

UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0
● FIELD VANE △ LAB VANE ■ UNCONF

PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X
10 30 50 70 90 %

DEPTH ELEV	O.D / I.D	BLOWS / FT	NO.	SYMBOL	DESCRIPTION OF MATERIAL
FT.					
210					LIMESTONE - silty to sandy - dolomitic - orange - friable
220					
230					
240					CALCAREOUS SILTSTONE (ROUGHLOCK SILTSTONE) - dark grey
250					SHALE (WINNIPEG FORMATION) - dark grey - occasional siltstone lenses
260					
270					
280					
290					
300					T.D. 296' Piezometers MW-4 293'-296' MW-4A 104'-107'

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS VALLEY
HOLE No.	MW-4
DATE	June 8/86 PLATE 3/3

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF.
WEIGHT HAMMER 140 lb.					ELEV GROUND 6061	
HEIGHT DROP 30 inches					CO-ORD. LOCATION N 49142 E 46574	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D.	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.					CLAYEY SILT - boulders - colluvium	
10					LIMESTONE (MADISON OR PAHASAPA FM) - highly weathered - fractured & broken - white to tan	
20					LIMESTONE - dolomitic - buff to grey-brown - fresh Occasional cherty layers from 30'.	
30						
40						
50						
60						
70					Rust staining & weathering (fracturing) from 75'.	
80					No staining from 85'.	
90					Not dolomitic, softer.	
100						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS SPRINGS VALLEY
HOLE No.	MW-5
DATE	May 9/86 PLATE 1/3

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 10 20 30 40 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb					ELEV GROUND 6061	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 49142 E 46574	PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT X - - - - - - O - - - - - - X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.					Clay filled cavity 104' - 104.5'	
110					Dolomitic & hard from 110'.	
120						
130						
140						
150					Occasional weathered zones (fracturing?).	
160						
170						
180						
190						
200						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS SPRINGS VALLEY
HOLE No.	MW-5
DATE	May 9/86 PLATE 2/3

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ⊕ FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND 6061	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 49142 E 46574	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.						
210					LIMESTONE - as above	
220						
230					Fractured, weathered zone from 225'. Making approx. 3 gpm water from this zone.	
240						
250					T.D. 245' Install single piezometer @ 240-245'. (See Well Completion Diagram)	
260						
270						
280						
290						
300						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS SPRINGS VALLEY
HOLE No.	MW-5
DATE	May 9/86 PLATE 3/3

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ⊕ FIELD VANE △ LAB VANE ■ UNCONF.
WEIGHT HAMMER 140 lb.					ELEV GROUND 6003	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 49957 E 47497	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.					CLAYEY SILT - boulders - colluvium Cherty limestone boulders 4'-7'.	
10						
20						
30					LIMESTONE (MADISON OR PAHASAPA FM) - white to buff - highly weathered - very fractured	
40						
50					Extremely fractured, broken-up @ 50'. Making water, 5 - 8 gpm.	
60						
70					LIMESTONE - dolomitic - fresh - light grey-brown to tan	
80						
90						
100						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS SPRINGS VALLEY
HOLE No.	MW-6
DATE	May 5/86 PLATE 1/2

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND 6003	
HEIGHT DROP 30 inches					CO-ORD. LOCATION N 49957 E 47497	PLASTIC LIMIT x — WATER CONTENT o — LIQUID LIMIT x 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.						
110					LIMESTONE - as above	
120						
130						
140						
150					T.D. 147' Piezometer installed @ 142' - 147'. (See Well Completion Diagram)	
160						
170						
180						
190						
200						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS SPRINGS VALLEY
HOLE No.	MW-6
DATE	May 5/86 PLATE 2/2

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF.
WEIGHT HAMMER 140 lb.					ELEV GROUND	
HEIGHT DROP 30 inches					CO-ORD. LOCATION N 51688 E 48268	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D.	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.					CLAYEY SILT - some gravel - colluvium	
10						
					LIMESTONE (MADISON OR PAHASAPA FM) - highly weathered - very fractured - chalk white to buff with iron staining	
20						
					CHERTY LIMESTONE - fresh - buff - very hard	
30						
40					LIMESTONE (ENGLEWOOD FM) - weathered - silty laminations - tan to rust	
50						
60					LIMESTONE (WHITEWOOD DOLOMITE) - fresh - light grey-brown - dolomitic	
70						
80						
90					Hole making water, approx. 3 gpm.	
					LIMESTONE - red to mauve, highly weathered	
100					SILTSTONE (ROUGHLOCK SILTSTONE) - dark grey	

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS SPRINGS AREA
HOLE No	MW-7
DATE	May 2/86 PLATE 1/4

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 10 20 30 40 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 51688 E 48268	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.					SILTSTONE - as above	
110					SHALE (WINNIPEG FM) - dark grey to black - occasional light green layers - soft, friable	
120						
130						
140						
150						
160						
170						
180					SANDSTONE (DEADWOOD FM) - medium to coarse grained - salmon pink - argillaceous laminations - well indurated	
190						
200						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS SPRINGS AREA
HOLE No.	MW-7
DATE	May 2/86
PLATE	2/4

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 10 20 30 40 ⊕ FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 51688 E 48268	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.						
210					SANDSTONE - as above	
220						
230					Siliceous and very hard from 225'. - dark red	
240						
250					Occasional pale green soft shale lenses from 245'.	
260						
270					PORPHYRY (PHONOLITE?) - dark green - hard	
280						
290					SANDSTONE - medium to coarse grained - argillaceous layers - orange to red	
300					PORPHYRY (PHONOLITE?) - dark grey-green	

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS SPRINGS AREA
HOLE No.	MW-7
DATE	May 2/86 PLATE 3/4

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF.
WEIGHT HAMMER 140 lb.					ELEV GROUND	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 51688 E 48268	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH ELEV	O.D. / I.D.	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.						
310					SANDSTONE - medium to coarse grained - siliceous cementation (hard) - rust orange - numerous shale layers	
320					PORPHYRY (MONZONITE?) - tan to light orange with white phenocrysts - fresh - hard	
330						
340						
350					T.D. 345' Piezometer installations @ 340' - 345' & 91' - 96' (See Well Completion Diagram)	
360						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	ROSS SPRINGS AREA
HOLE No.	MW-7
DATE May 2/86	PLATE 4/4

TEST HOLE LOG

SAMPLE DATA	
WEIGHT HAMMER	140 lb.
HEIGHT DROP	30 inches

ELEV COLLAR
ELEV GROUND
CO-ORD. LOCATION

UNCONFINED COMPRESSION T.S.F. (0, 1.0, 2.0, 3.0, 4.0) ● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X (10, 20, 30, 40, 50 %)

DEPTH ELEV	O.D. T.D.	BLOWS FT	NO.	SYMBOL	DESCRIPTION OF MATERIAL
FT.					COLLUVIUM
10					DOLOMITE (MADISON OR PAHASAPA FM) - light tan - coarse crystalline - fresh
20					DOLOMITIC LIMESTONE - slightly weathered - yellow to grey
30					Cherty @ 35'.
40					Completely weathered (clayey) from 41' - 44'. Cherty @ 48'.
50					Layers of completely weathered limestone from 50' - 65'.
60					Fresh & hard from 65'.
70					
80					Weathered & friable from 82' - 85'.
90					
100					

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	MCKINLEY GULCH
HOLE No.	MW-8
DATE	June 10/86
PLATE	1/2

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND	
HEIGHT DROP 30 inches					CO-ORD. LOCATION	PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT X — O — X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.					LIMESTONE - as above Completely weathered (clayey) from 103' - 106'.	
110						
120						
130						
140					Hole making water @ 40 - 50 gpm. @ 135'.	
150					Weathered, friable zone 148' - 160'.	
160						
170						
180					T.D. 177' Piezometer installed @ 169' - 172'. (See Completion Diagram)	
190					NOTE: Problems with piezo. installation due to sloughing of borehole @ 140' at point where water was being produced.	
200						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	MCKINLEY GULCH
HOLE No.	MW-8
DATE	June 10/86 PLATE 2/2

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ▣ UNCONF.
WEIGHT HAMMER 140 lb.					ELEV GROUND 5983	
HEIGHT DROP 30 inches					CO-ORD. LOCATION N 49780 E 43180	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH ELEV	O.D. I.D.	BLOWS FT	NO.		DESCRIPTION OF MATERIAL	
FT.					COLLUVIUM	
10					DOLOMITIC LIMESTONE (MADISON FM) - tan - fresh with occasional weathered layers	
20						
30					DOLOMITE - tan to brown-grey - fresh	
40						
50						
60						
70						
80						
90						
100						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	MCKINLEY GULCH
HOLE No.	MW-9
DATE June 11/86	PLATE 1/3

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 10 20 30 40 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND 5983	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 49780 E 43180	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D.	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.						
110					DOLOMITE - as above - brown-grey	
120						
130						
140						
150						
160						
170						
180						
190						
200						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	MCKINLEY GULCH
HOLE No.	MW-9
DATE	June 11/86 PLATE 2/3

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 10 20 30 40 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND 5983	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 49780 E 43180	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT.					DOLOMITE - as above - brown-grey	
210						
220					Making water, 3 - 5 gpm. @ 220'	
230						
240					ARGILLACEOUS DOLOMITE (ENGLEWOOD LST) - to dolomitic siltstone - grey with occasional orange lenses - occasional cherty sections	
250					PORPHYRY (RHYOLITE?) - dark green	
260						
270					T.D. 265' Piezometer MW-9 262' - 265' MW-9A 237' - 240'	
280						
290						
300						

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	MCKINLEY GULCH
HOLE No.	MW-9
DATE	June 11/86 PLATE 3/3

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ⊙ FIELD VANE △ LAB VANE ■ UNCONF.
WEIGHT HAMMER 140 lb.					ELEV GROUND 5888	
HEIGHT DROP 30 inches					CO-ORD. LOCATION N 50238 E 43174	PLASTIC LIMIT X — WATER CONTENT O — LIQUID LIMIT X 10 30 50 70 90 %
DEPTH / ELEV	O.D / I.D.	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	
FT						
10					COLLUVIUM	
20						
30					LIMESTONE (MADISON OR PAHASAPA FM) - tan - highly fractured & weathered with occasional completely weathered (clay) layers	
40						
50						
60						
70					DOLOMITE - grey-brown - fresh	
80						
90						
100					Weathered zone 97' - 100'. - rusty orange	

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	MCKINLEY GULCH
HOLE No.	MW-10
DATE	June 13/86 PLATE 1/2

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F. 0 1.0 2.0 3.0 4.0 ● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT HAMMER 140 lb.					ELEV GROUND 5888	
HEIGHT DROP 30 inches					CO-ORD LOCATION N 50238 E 43174	PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT X — O — X 10 30 50 70 90 %
DEPTH ELEV	O.D. I.D.	BLOWS FT	NO.		DESCRIPTION OF MATERIAL	

FT.

Cherty

LIMESTONE
- tan to orange
- weathered
- friable
- making water @ 110'
- rusty color from 110'

Dolomitic & fresh from 145'.
- grey brown

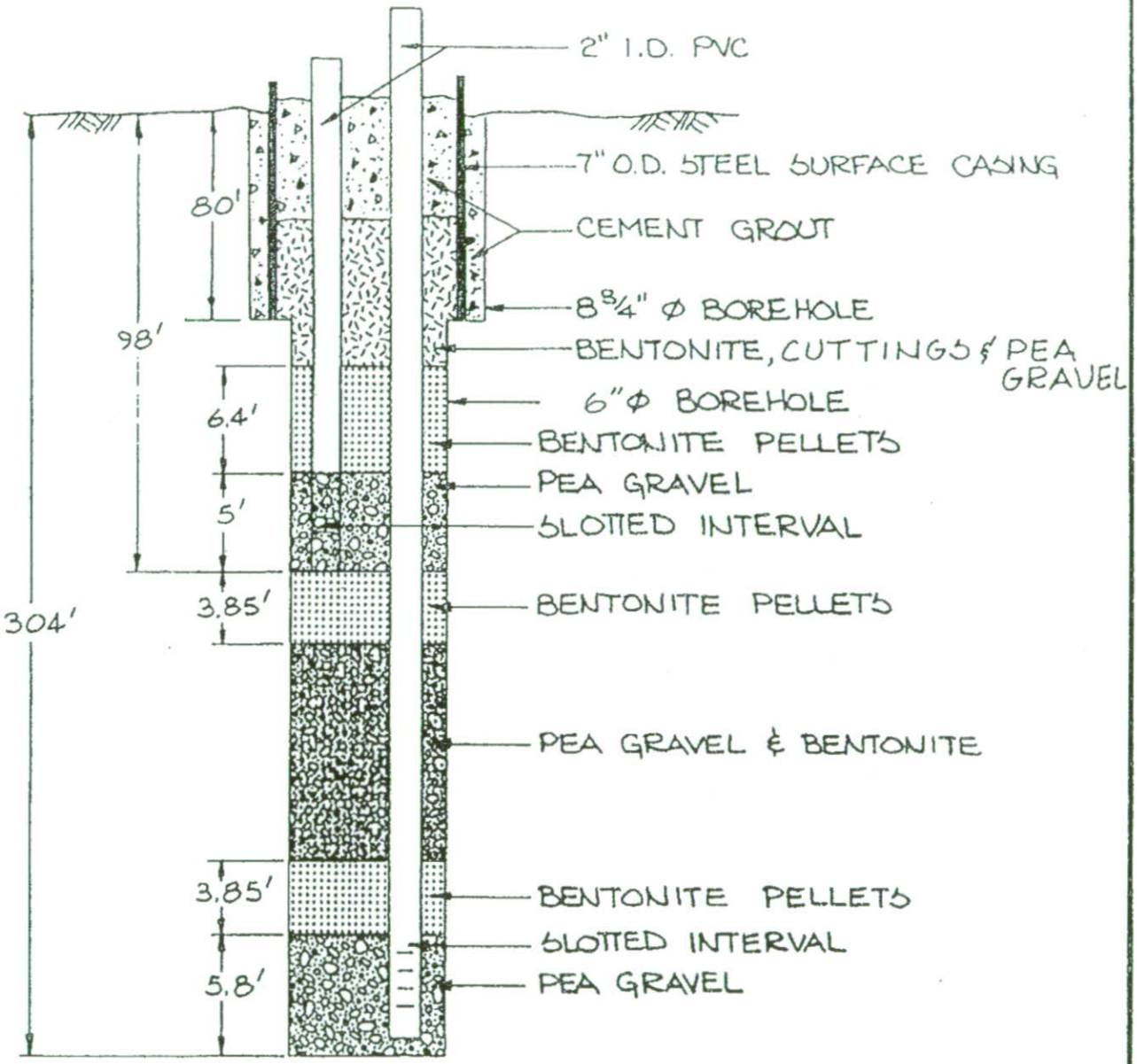
T.D. 158'

Piezometer MW-10 155' - 158'
MW-10A 130' - 133'
(See Completion Diagrams)

110 120 130 140 150 160 170 180 190 200

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No	PW 0066
PROJECT	FOLEY RIDGE MINE
LOCATION	MCKINLEY GULCH
HOLE No.	MW-10
DATE	June 13/86 PLATE 2/2



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SCALE N.T.S.

KLOHN LEONOFF INC.
CONSULTING ENGINEERS

PROJECT: FOLEY RIDGE MINE

TITLE: PIEZOMETER COMPLETION DETAILS WELL MW-1

CLIENT:	DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
WHARF RESOURCES (U.S.A.) INC.	18 SEPT 86	PW00066	A	
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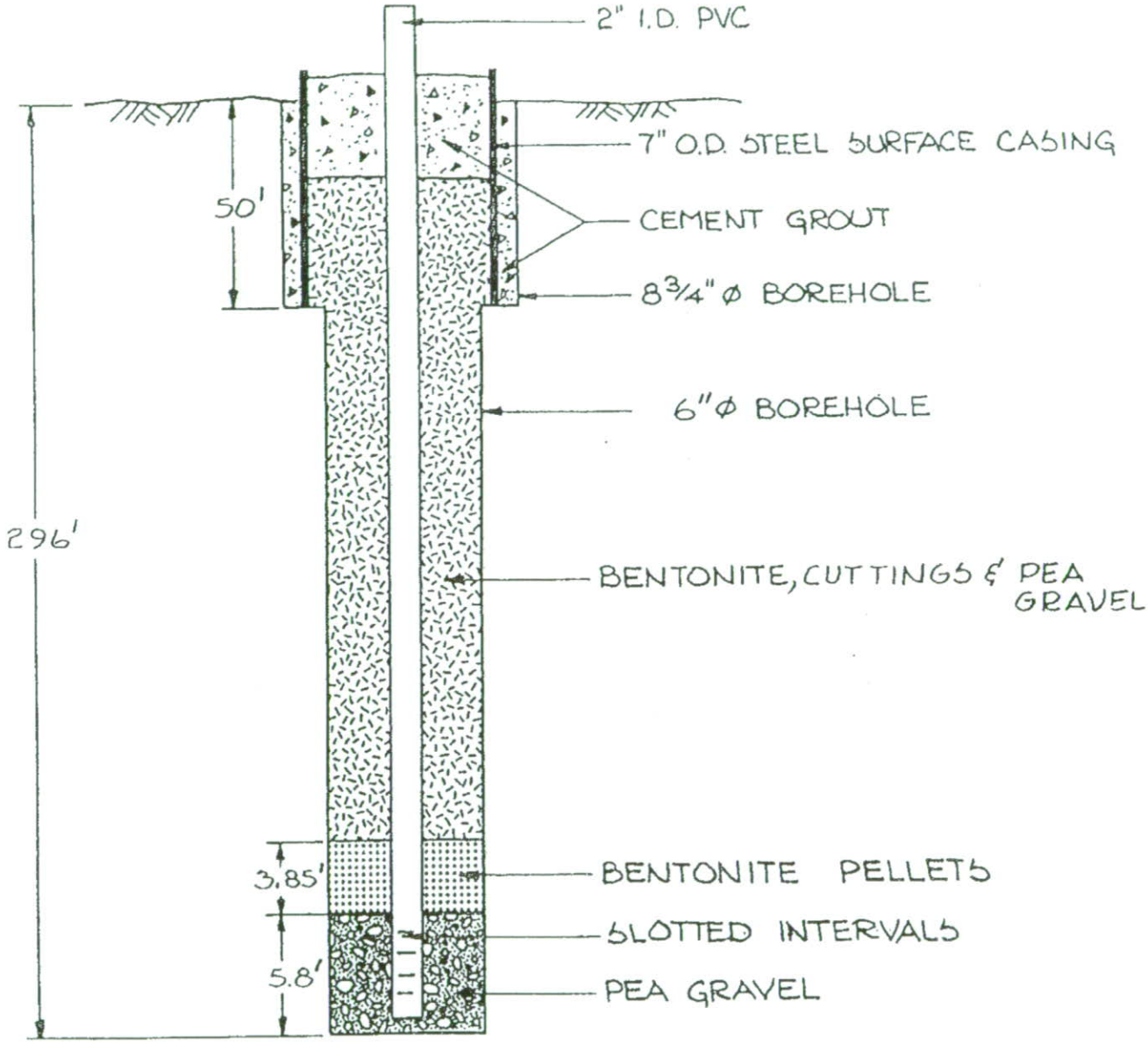

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SCALE N.T.S.

KLOHN LEONOFF INC.
CONSULTING ENGINEERS

PROJECT: FOLEY RIDGE MINE

TITLE: PIEZOMETER COMPLETION DETAILS WELL MW-2

CLIENT:	DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
WHARF RESOURCES (U.S.A.) INC.	18 SEPT. 86	PW0066	A	
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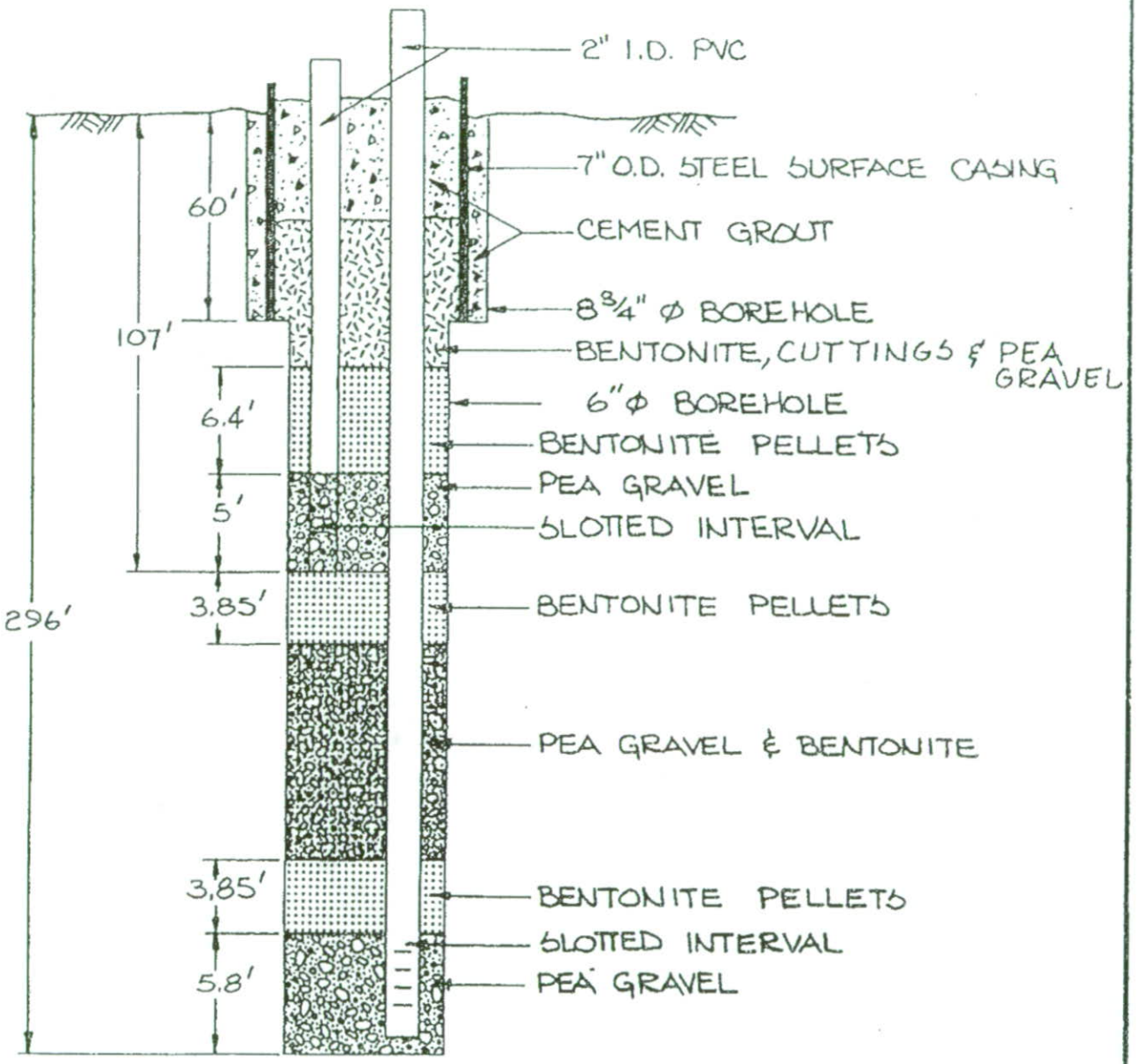

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SCALE N.T.S.

KLOHN LEONOFF INC.
CONSULTING ENGINEERS

PROJECT: FOLEY RIDGE MINE

TITLE: PIEZOMETER COMPLETION DETAILS WELL MW-4

CLIENT: WHARF RESOURCES (U.S.A.) INC.

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
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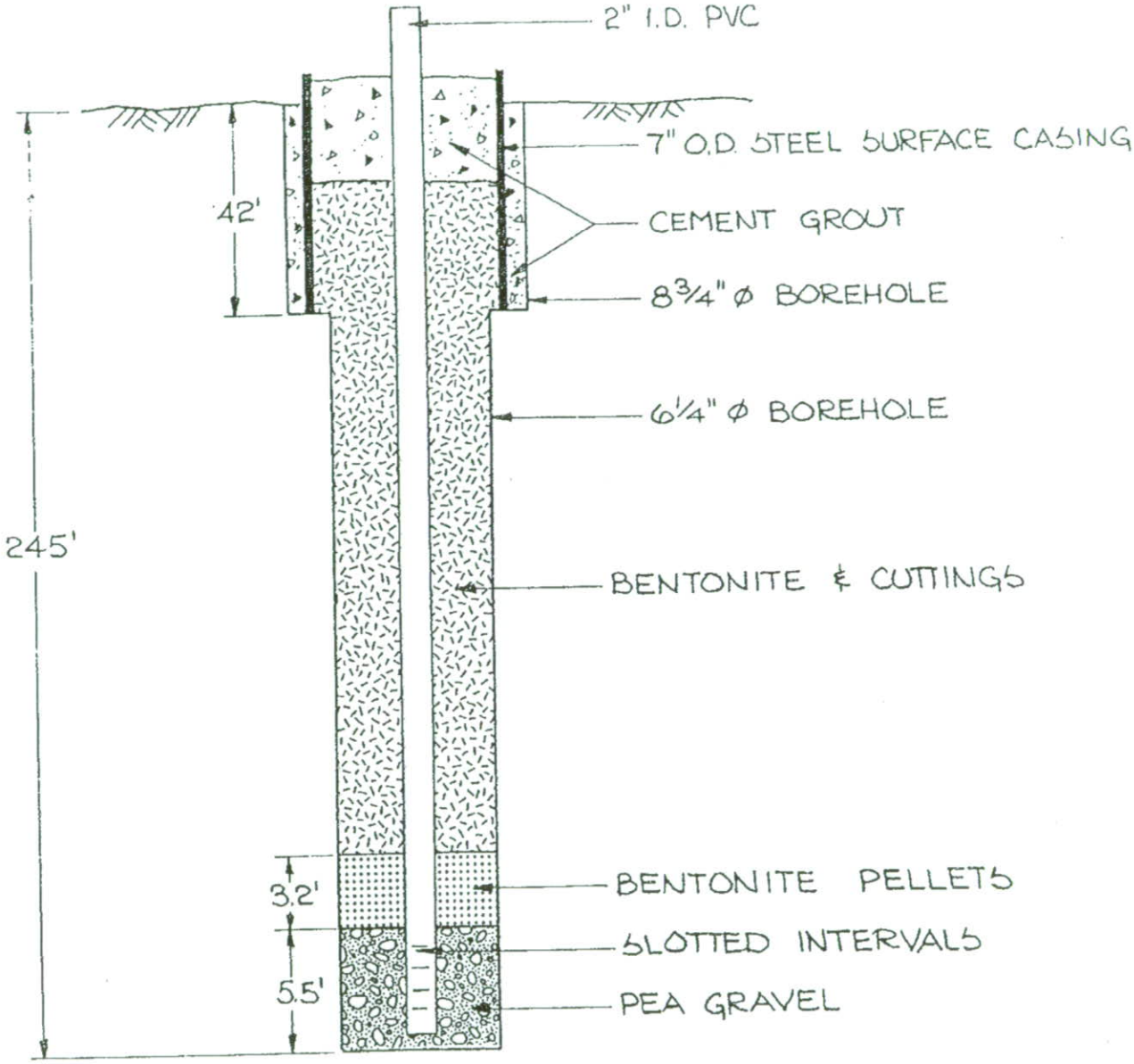

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SCALE N.T.S.

KLOHN LEONOFF INC.
CONSULTING ENGINEERS

PROJECT: FOLEY RIDGE MINE

TITLE: PIEZOMETER COMPLETION DETAILS WELL MW-5

CLIENT: WHARF RESOURCES (U.S.A.) INC.

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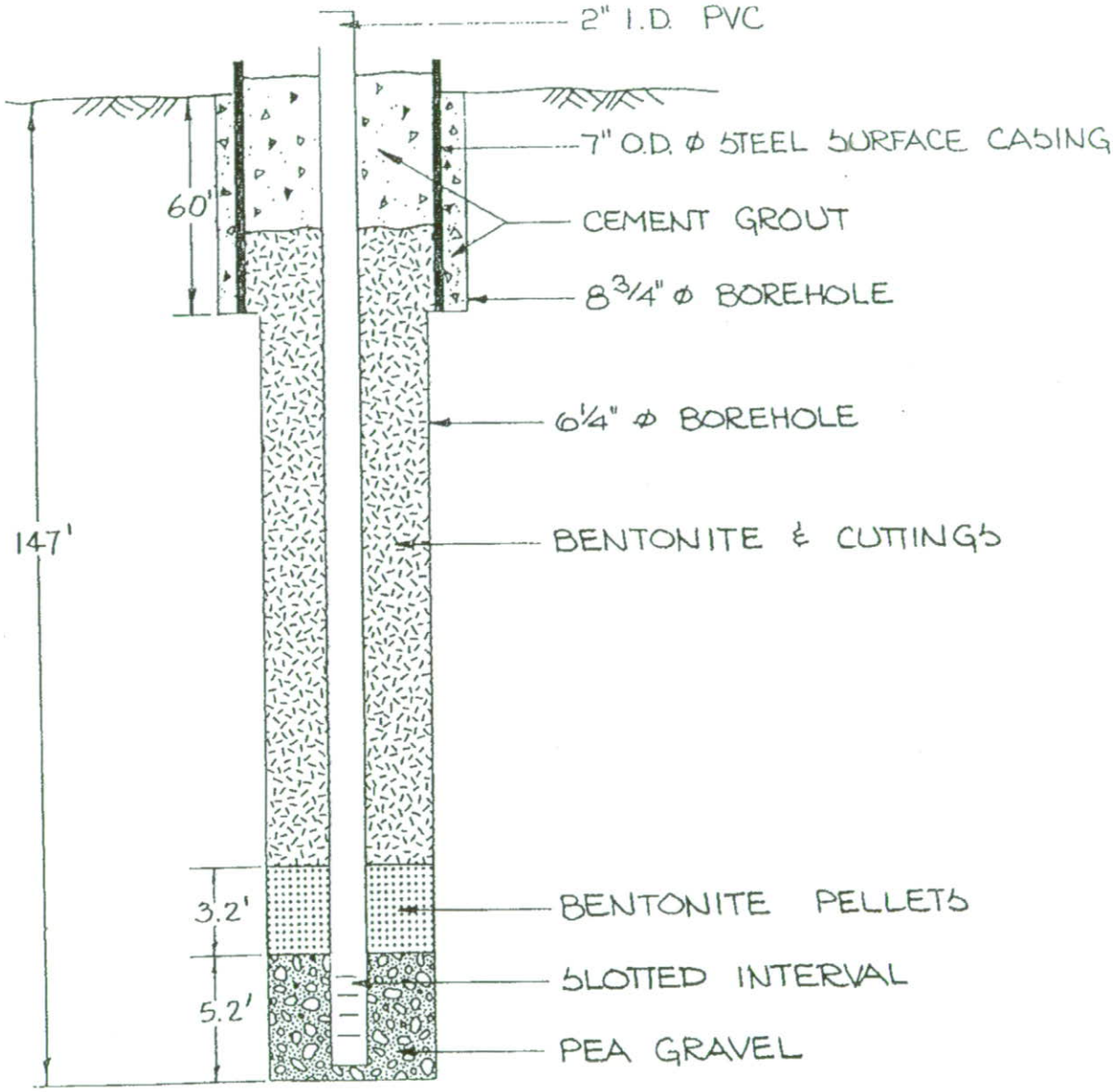

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KLOHN LEONOFF INC.
CONSULTING ENGINEERS

PROJECT: FOLEY RIDGE MINE

TITLE: PIEZOMETER COMPLETION DETAILS WELL MW-6

CLIENT: WHARF RESOURCES (U.S.A.) INC.

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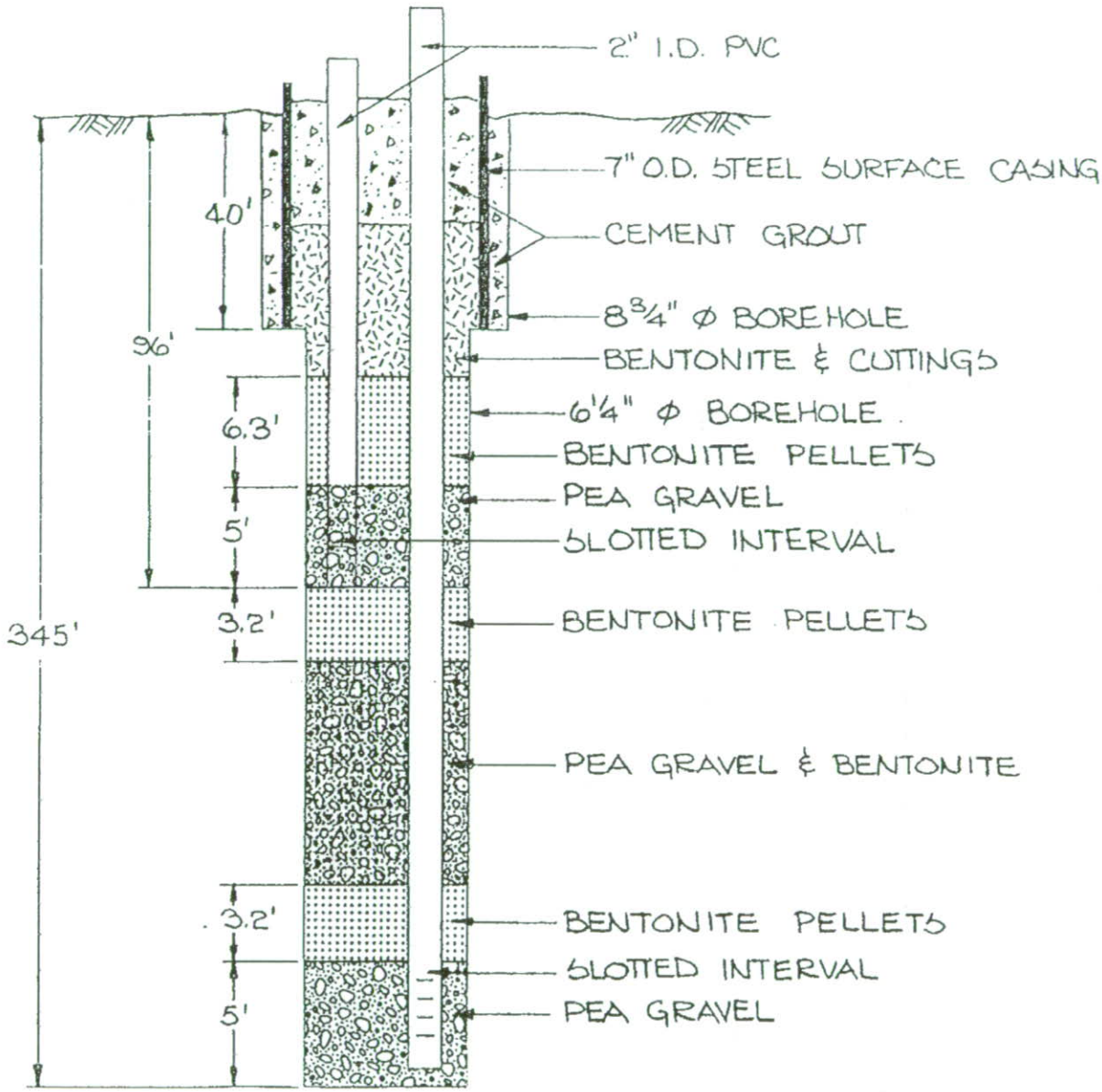

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KLOHN LEONOFF INC.
CONSULTING ENGINEERS

PROJECT: FOLEY RIDGE MINE

TITLE: PIEZOMETER COMPLETION DETAILS WELL MW-7

CLIENT:	DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
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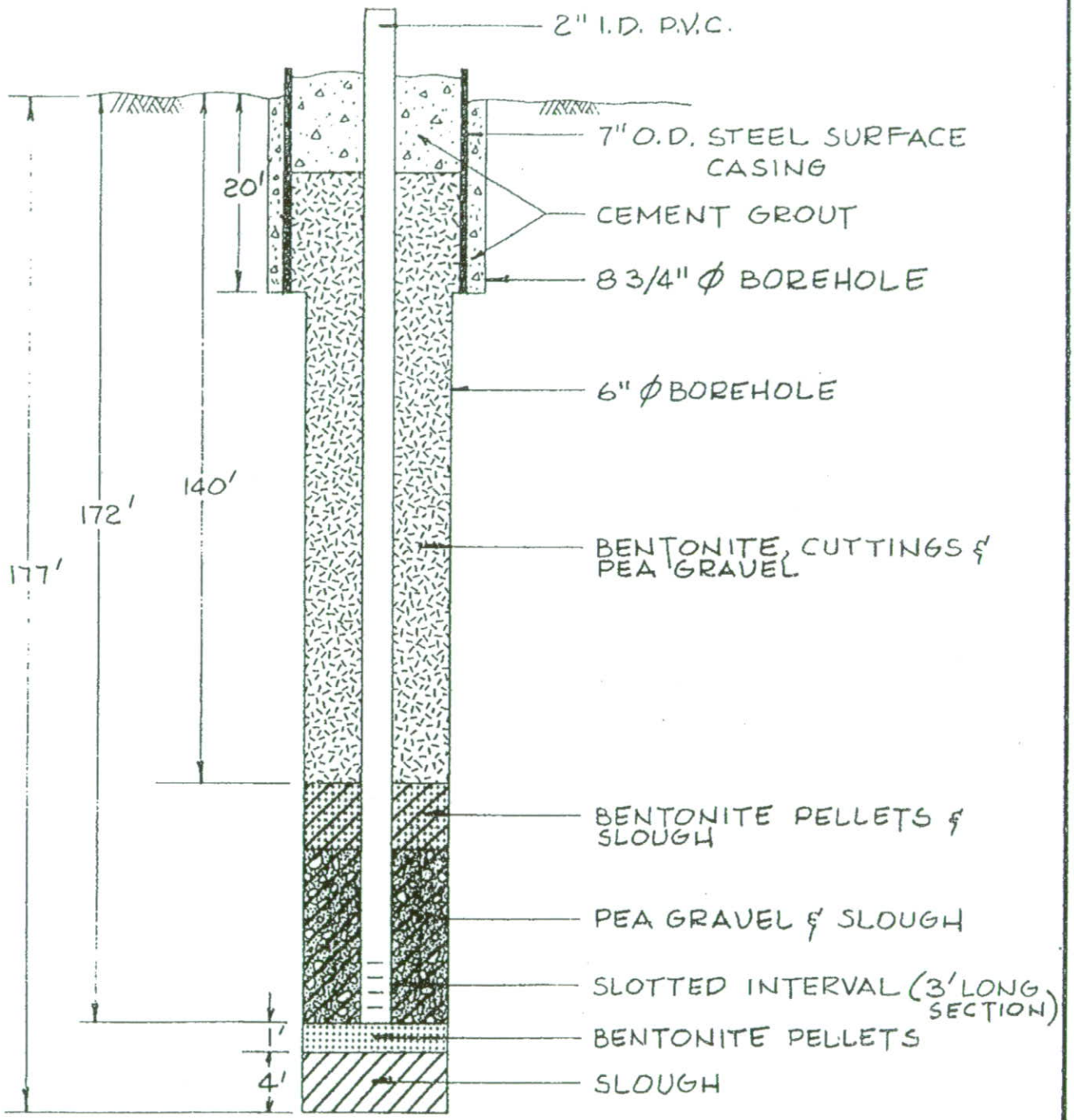

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KLOHN LEONOFF INC.
CONSULTING ENGINEERS

PROJECT: FOLEY RIDGE MINE

TITLE: PIEZOMETER COMPLETION DETAILS WELL MW 8

CLIENT: WHARF RESOURCES (U.S.A) INC.

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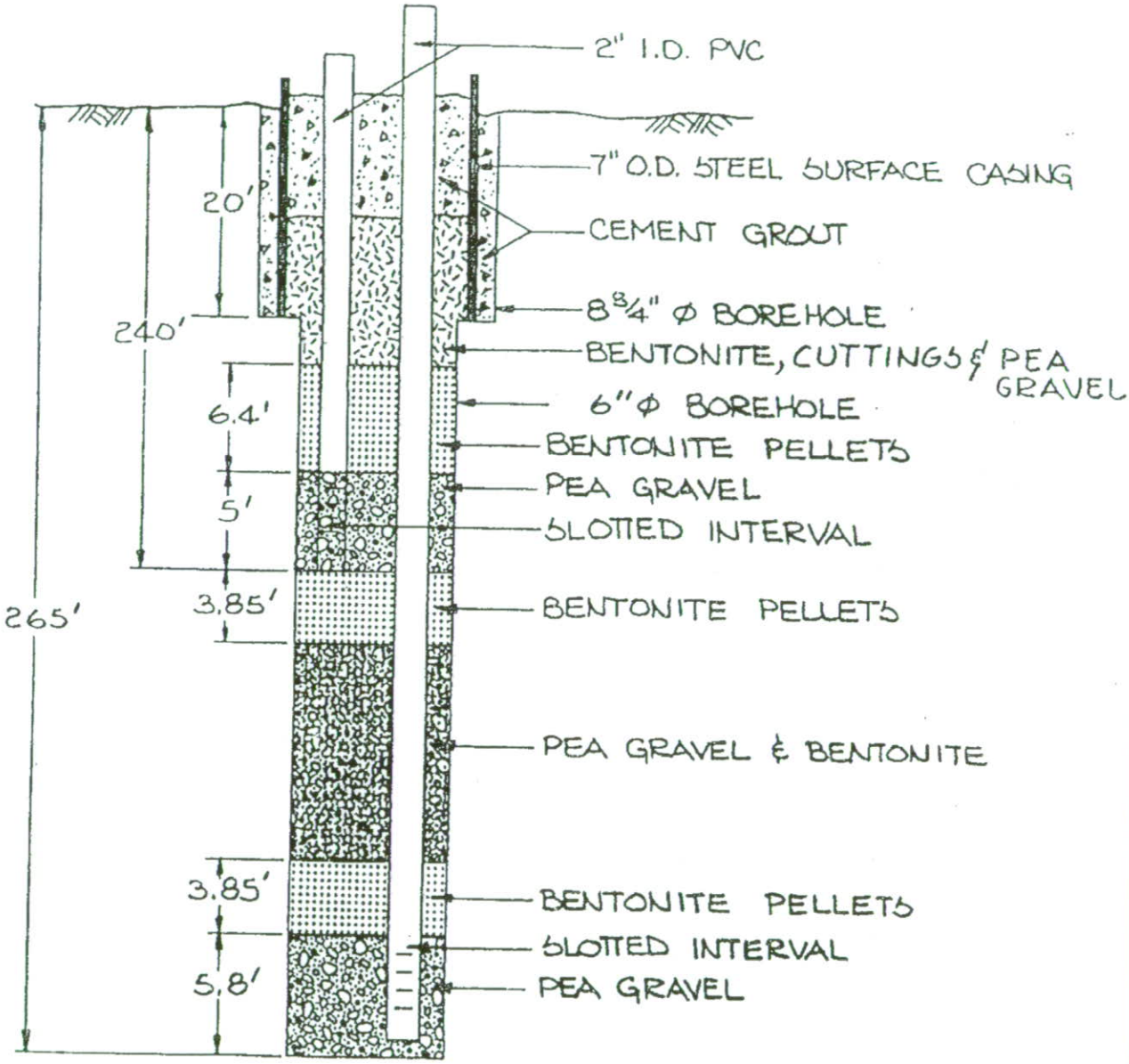

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SCALE N.T.S.

KLOHN LEONOFF INC.
CONSULTING ENGINEERS

PROJECT: FOLEY RIDGE MINE

TITLE: PIEZOMETER COMPLETION DETAILS WELL MW-9

CLIENT: WHARF RESOURCES (U.S.A.) INC.

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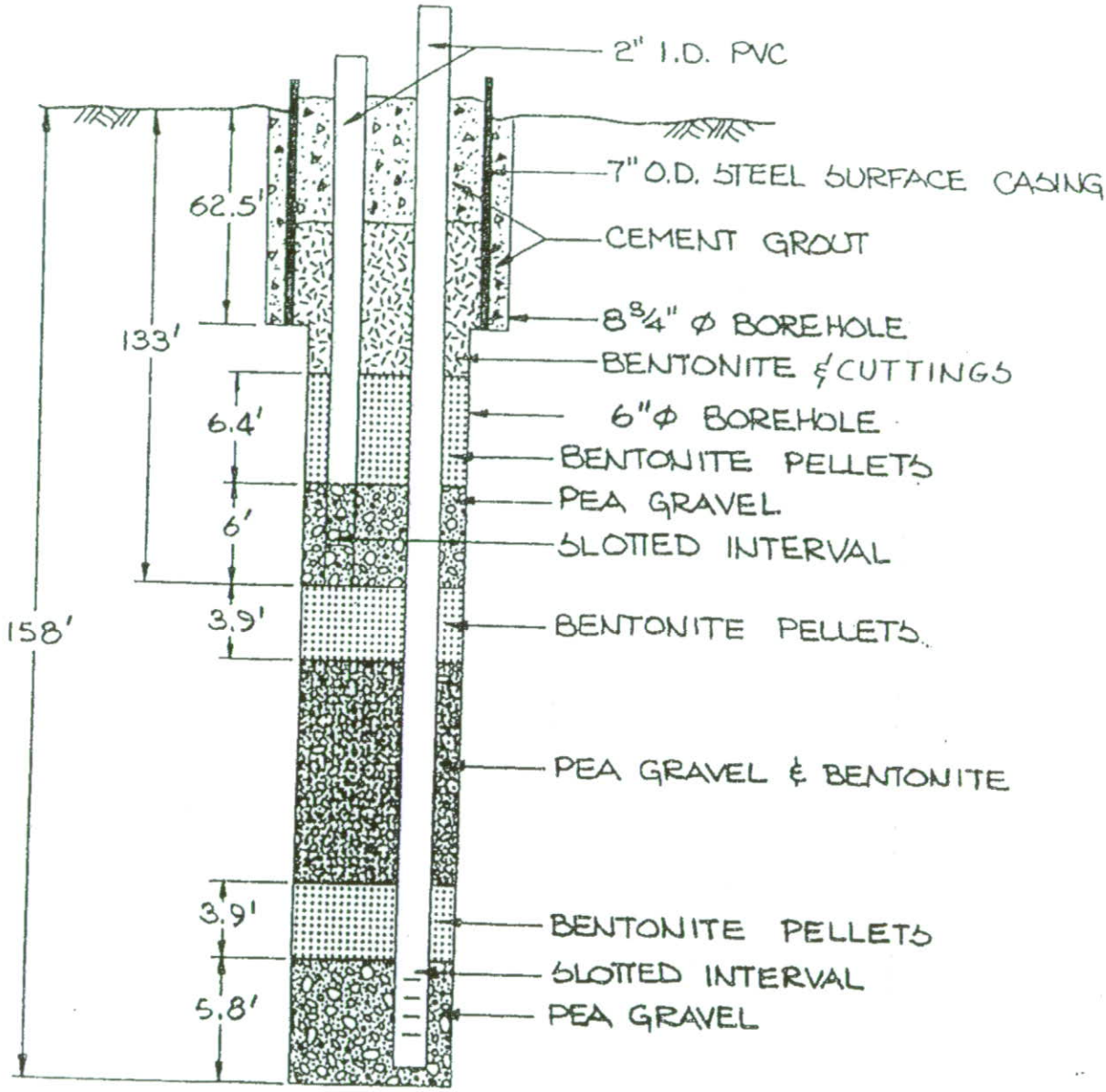

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KLOHN LEONOFF INC.
CONSULTING ENGINEERS

PROJECT: FOLEY RIDGE MINE

TITLE: PIEZOMETER COMPLETION DETAILS WELL MW-10

CLIENT: WHARF RESOURCES (U.S.A.) INC.

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