Dames & Moore Job Number 05467-030-06
Salt Lake City, Utah
March 5, 1982

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REPORT OF PHASE I WORK
GROUND WATER MONITORING PROJECT
URANIUM MILL TAILINGS IMPOUNDMENT
MOAB, UTAH
FOR ATLAS MINERALS

Dames & Moore

Dames & Moore

250 East Broadway, Suite 200
Salt Lake City, Utah 84111
(801) 521-9255
TWX: 910-925-5692 Cable address: DAMEMORE

March 5, 1982

Atlas Minerals
P. O. Box 1207
Moab, Utah 84532

Attention: Mr. Richard E. Blubaugh

Gentlemen:

Report of Phase I Work
Ground Water Monitoring Project
Uranium Mill Tailings Impoundment
Moab, Utah
For Atlas Minerals

INTRODUCTION

This letter summarizes the results of our Phase I work for the ground water monitoring of your mill tailings impoundment near Moab, Utah. Phase I consisted of the drilling, logging, sampling and completion of four wells within a single boring located southeast of the tailings impoundment. This work was authorized by your Professional Services Agreement dated September 1, 1981.

PURPOSE AND SCOPE

The purpose and scope of our study were outlined in your Request For Proposal dated July 16, 1981 and our proposal dated July 30, 1981. The purpose of Phase I was to complete and test two deep monitor wells specifically requested by the U.S. Nuclear Regulatory Commission in their letter dated June 24, 1981 (Attachment 1). The primary objectives outlined by NRC related to the Phase I work were evaluation of whether the Colorado River is a recharging or a discharging stream, whether any possible seepage is moving toward or away from the river or possibly downward and subsequently in some other direction and evaluation of the hydrogeologic characteristics of bedrock.

Specifically, the following Phase I scope of services has been conducted:

1. Recommendations on the drilling, construction and field procedures for installation of the Phase I monitor wells.

2. Inspection of the drilling and completion of the Phase I wells located between the tailings impoundment and the Colorado River.

3. Collection of lithologic samples and preparation of drilling and lithologic logs for the wells.

4. Supervision of geophysical logging and interpretation of the geophysical well logs.

5. Sieve analysis of lithologic samples and gravel pack; checking of screen slot sizes; and selection of screened, cased and grouted intervals.

6. Inspection of the completion operations of the wells, including grouting, surfacing casing placement, capping, and well development.

7. The pumping and sampling of water quality samples in accordance with NRC recommendations.

8. Preparation of this summary report listing, describing and interpreting all pertinent data collected in the Phase I program.

PHASE I FIELD STUDIES

The field program consisted of drilling, logging, completion and ground water quality sampling of four 2-inch diameter wells completed within a single boring located approximately 250 feet southeast of the tailings impoundment as shown on Plate 1, Plot Plan.

The NRC specifically requested, in their letter dated June 24, 1981 (see Attachment 1), that:

1. The well be drilled using a mud-rotary rig or hollow-stem augers.

2. The depth to bedrock be determined.

3. The first well be screened in bedrock.

As the use of hollow-stem augers is impractical in gravels and also impractical at the anticipated well depths, common rotary drilling methods were attempted. Rotary drilling methods failed to provide a clean stable boring below 40 feet (see Appendix 1) and, therefore, after consulting with the NRC the boring was redrilled using cable-tool methods. Due to the high cost of drilling and the questionable value of locating the bedrock surface at depths below 400 feet, drilling was discontinued at 406 feet and hence, the depth to bedrock was not determined and no well was completed within the bedrock. The NRC approved these changes subject to the provision that a new well would be drilled deeper if the deepest well showed any signs of contamination with tailing pond waters.

Water quality samples collected at the end of the field program were turned over to Atlas Minerals whereupon the samples were split and tested. For parameters with short hold times (ammonia, conductivity, nitrate, nitrite, and total dissolved solids) were flown to Salt Lake City for immediate analysis. The Phase I field studies and data obtained are summarized in detail in the attached Appendix A, Field Studies.

DATA INTERPRETATION

The lithologic character of the materials encountered in the well to the 406 feet of depth drilled was relatively uniform consisting of sand and gravel alluvial sediments. The upper 20 feet of alluvium was reddish brown fine to coarse sand and gravel probably derived from recent deposition from Moab Wash drainage. Below 20 feet, gray and brown fine to coarse gravel and coarse sand composed of diverse lithologies including limestone, granitic rock and sandstone predominate and represent deposition by the Colorado River rather than the Moab Wash. Somewhat finer materials generally consisting of well-graded sand with some gravel occur from 230 to 290 feet in depth and in several thin strata at greater depth. These apparently represent deposition under a lower velocity regime. Only a very few layers of reddish brown sand indicative of deposition from the Moab Wash drainage were noted in the boring below 20 feet. No low permeability confining stratum was noted over the entire interval drilled, either in the cuttings or the geophysical logs.

Table 1 summarizes average concentration determined by the various laboratories for the initial samples. The certificates of analyses listing the results from each of the laboratories are given in Attachment 2.

All monitor wells encountered ground water which would be classified as brine, having total dissolved solids concentrations exceeding 100,000 milligrams per litre (mg/l). The principal constituent in the ground water is sodium chloride.

Waters from the three shallowest wells (Well S, Well IS and Well ID) are quite similar and reflect an extremely small, if any, increase in salinity with depth. Well D is somewhat more saline than the shallower wells. Major and trace ions show a similar relationship to that of general salinity and generally show no indication of downward or vertical mixing of tailings effluent. Radium-226 shows a slight decreasing concentration with depth in the analyses by Hazen Research which might be construed to suggest vertical mixing of tailings pond effluent. Analyses by Atlas Minerals of radium-226 do not show this trend; however, analyses by Atlas are all less than one-tenth the values reported by Hazen.

Values of lead reported by Hazen Research appear to be impossibly high for dissolved concentrations (samples were filtered with a 0.45 micron filter prior to preservation) even though the values were rechecked and confirmed by Hazen. In addition, the wide range in reported radium-226 values should be resolved. We recommend that the wells be resampled and analyzed at the end of the Phase II work when new wells are sampled.

Water level elevations measured in the four wells are all within 1.1 feet of each other and indicate a slightly lower elevation with increasing depth of the wells. However, to measure the true relative potentiometric surfaces in the three wells, corrections must be made for the differences in salinity of the water in the piezometers (wells). Considering salinity variations, there is negligible difference in the potentiometric surface of the four wells as would be expected from the lack of confining beds. Due to differences in the density of the brine and fresh water, there is no potential for Colorado River water to move vertically downward without completely mixing with the deeper waters. Similarly, tailings pond seepage with a total dissolved solids concentration on the order of 60,000 mg/l (as reported by Atlas Minerals) would not be able to move vertically downward without mixing with and attaining the same density as the brine.

CONCLUSIONS

We conclude there is negligible potential for Colorado River water or for seepage to move vertically downward into the brine without mixing with and attaining the same density as the brine. Water quality data show no indication of mixing with tailings pond seepage.

The presence of brines in the alluvial sediments and the resulting hydrologic relationships alleviate the need to locate the bedrock surface as well as the need to regularly monitor water qualities below the fresh water-brine interface. These needs are eliminated because of the low probabilities of downward migration of tailings pond waters through the brine and the low environmental hazard that would result from undetected tailings pond seepage water into the brine. All future monitoring programs should be directed towards the monitoring of the fresh water zone above the brine.

oOo

We have enjoyed performing these services for you. If you have any questions, please contact us.

Yours very truly,

DAMES & MOORE

George C Toland

George C. Toland
Partner

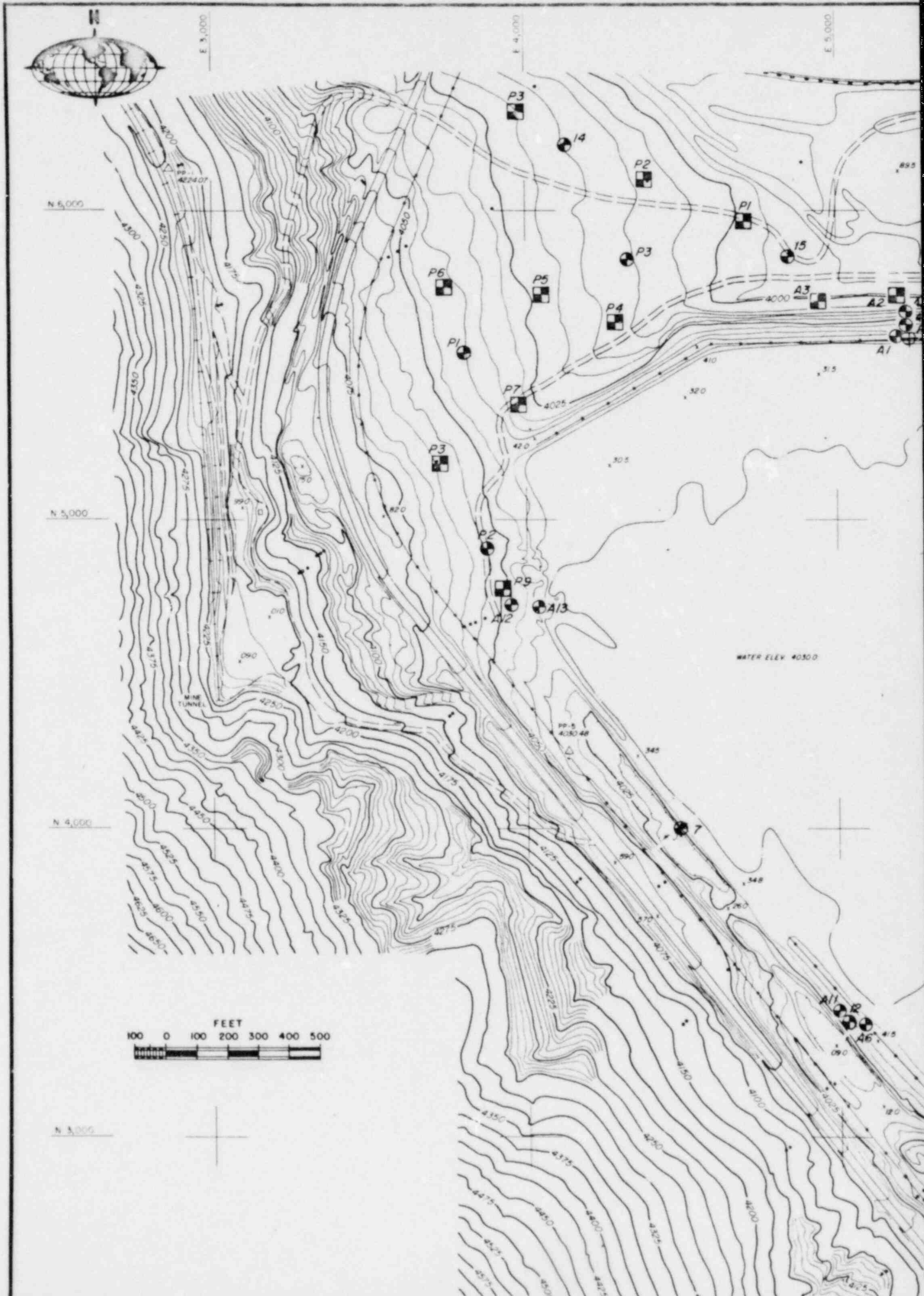
GCT/RLJ:fl

TABLE 1

SUMMARY OF WATER CHEMISTRY

	Well S	Well IS	Well ID	Well D
Screened Interval (ft)	145-155	219-229	300-310	394-396
Total dissolved solids (g/l)[1)]	111.1	112.6	112.6	125.2
Sodium (g/l)[2)]	30.1	32.5	30.0	34.0
Chloride (g/l)[2)]	51.8	54.3	54.5	55.7
Calcium (g/l)[3)]	1.6	1.5	1.5	1.5
Sulfate (g/l)[2)]	4.3	4.4	4.3	4.6
Field pH (units)	9.1	7.9	7.9	7.6
U-nat (pCi/l)[4)]	$<10^4$	$<10^4$	$<10^4$	$<10^4$
Ra-226 (pCi/l)[3)]	6.8	5.6	3.9	3.4
Ra-226 (pCi/l)[4)]	0.36	0.19	0.36	0.34
Th-230 (pCi/l)[2)]	0	0	0	0
Po-210 (pCi/l)[3)]	0.4	0.0	1.7	0.9
Arsenic[3)] (mg/l)	< .001	< .001	< .001	< .001
Barium[3)] (mg/l)	1.99	1.58	1.44	1.61
Cadmium[3)] (mg/l)	0.298	0.311	0.311	0.334
Chromium[3)] (mg/l)	0.13	0.14	0.14	0.14
Lead[3)] (mg/l)	1.26	1.32	1.24	1.34
Manganese[3)] (mg/l)	0.49	0.560	0.550	0.475
Molybdenum[3)] (mg/l)	0.12	0.14	0.14	0.27
Nickel[3)] (mg/l)	3.51	3.84	3.85	4.10
Vanadium[3)] (mg/l)	0.38	0.36	0.44	0.18
Nitrate[5)] (mg/l)	1.20	0.90	0.60	5.90
Ammonia[5)] (mg/l)	3.32	3.16	3.12	3.13

1) Average of values reported by Hazen Research, Atlas Minerals and Ford Chemical.
2) Average values reported by Atlas Minerals and Hazen Research.
3) Values reported by Hazen Research.
4) Value reported by Atlas Minerals.
5) Value reported by Ford Chemical.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MINE TUNNEL
WATER ELEV. 4030.0
FEET
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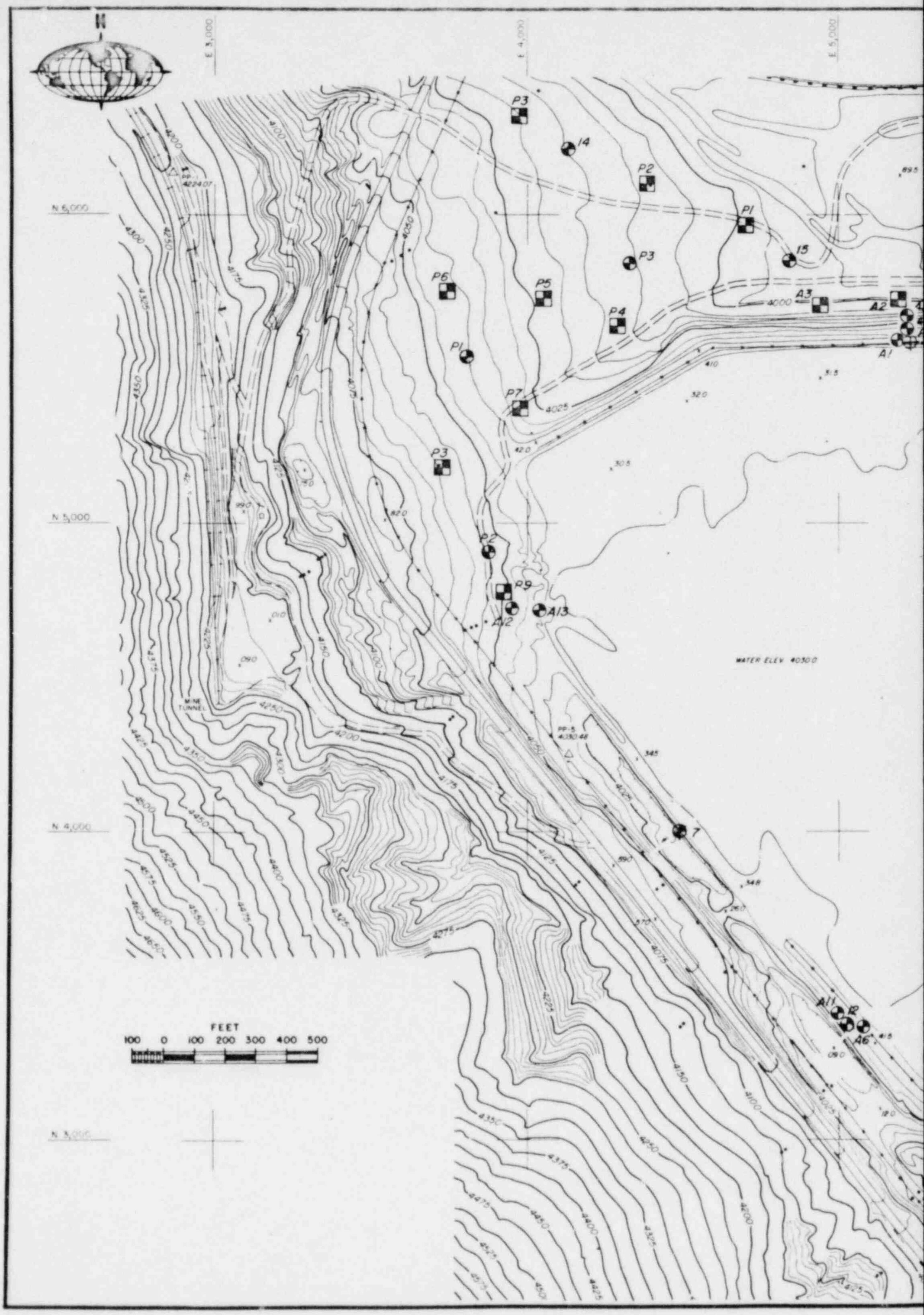
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WATER ELEV. 4030.0
MINE TUNNEL
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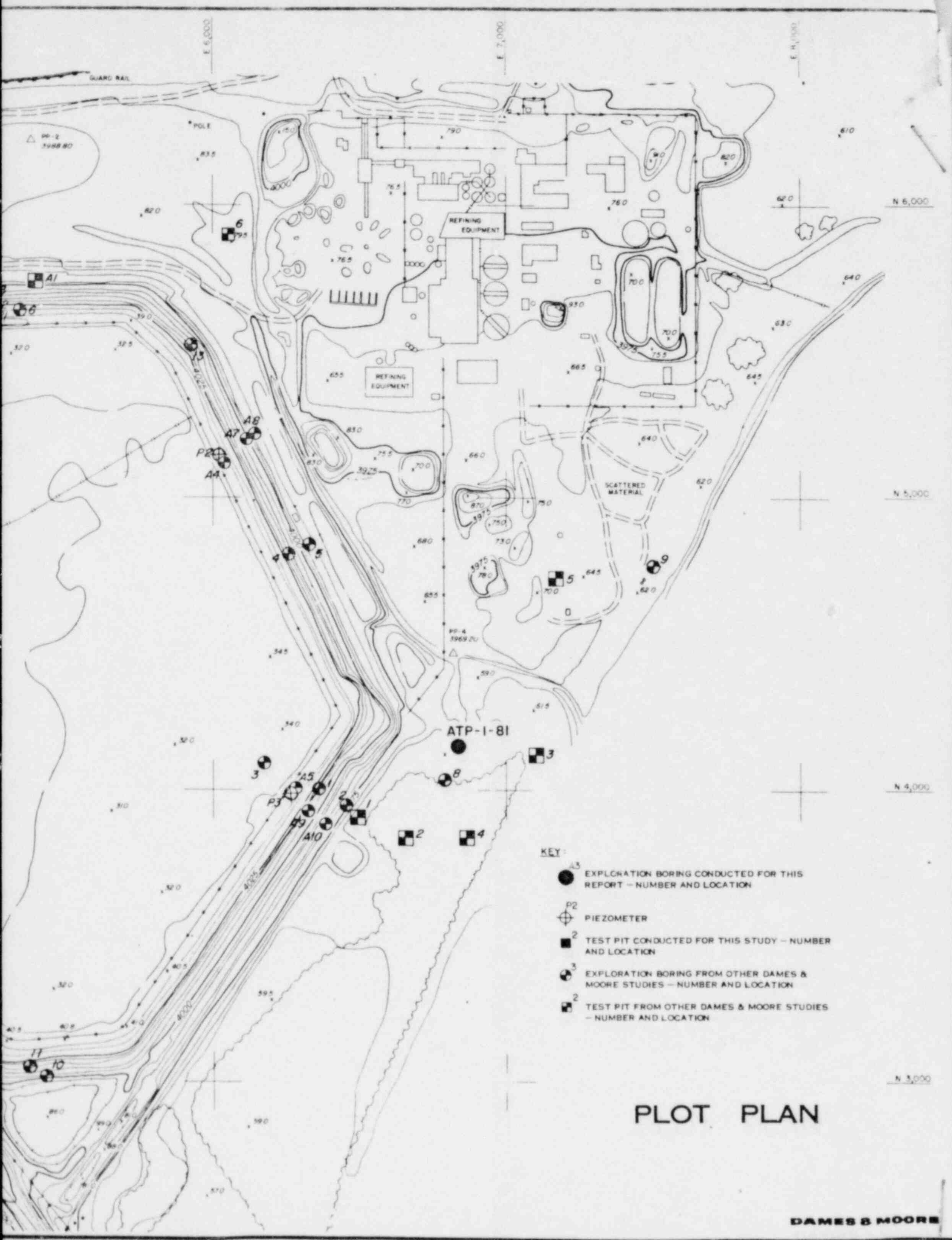


PLOT PLAN

DAMES & MOORE

PLATE 1

ATTACHMENT 1

Letter From U.S. Nuclear Regulatory Commission

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 24 1981

RECEIVED
JUN 29 1981
ATLAS MINERALS

Atlas Minerals
ATTN: Mr. Richard R. Weaver
P.O. Box 1207
Moab, Utah 84532

Gentlemen:

This letter constitutes the results of the NRC staff's review and recommendations pertaining to Atlas' proposal "Groundwater Study", dated March 25, 1981.

Comments and recommendations, relative to the proposed study, are as follows:

1. At this time, we are unable to determine in which direction seepage, if any, is moving away from the tailings pond. Therefore, we recommend that initially wells should be placed on all sides of the pond to define the direction and rate of flow of groundwater and possible seepage. The actual placement of the first wells is somewhat discretionary. However, we do recommend that emphasis be placed on locating wells, at closely spaced intervals, between the pond and the Colorado River.

2. We do not know whether the Colorado River is a recharging stream or a discharging stream, and we do not know whether seepage from the existing tailings pond is moving toward or away from the river or possibly downward to the water table and subsequently in some direction other than toward the river. One possible method that may be helpful in establishing the location of initial monitor wells would be to perform a resistivity survey. A resistivity survey could provide valuable information on the direction, orientation and depth of a seepage plume.

3. Since the depth to and characteristics of the bedrock are not known, (i.e., if the bedrock is impermeable, seepage may be confined to the alluvial material above the bedrock and if the bedrock is not impermeable, the seepage may have penetrated to depths below the bedrock surface), wells need to be drilled both to and into bedrock. It is recommended that at least two monitor wells be installed southeast of the tailings pond and perpendicular to the river.

   The first well should be drilled to bedrock approximately halfway between the Colorado River and the toe of the southeast embankment of the pond. During drilling the elevation of the water table should be measured. The depth to bedrock should be measured. The well should be logged with a natural gamma log, a resistance log, an SP log, a caliper log, a gamma gamma log, and a neutron-epithermal-neutron log. The well should be drilled with a mud rotary rig so that the log can be obtained in an open hole. Interpretation of these logs above bedrock will provide an accurate analysis of the hydrostratigraphy at the site. Permeable lenses can be identified for future monitoring. Subsequently, the well should be cased with the casing set in bedrock and allowances made for future slotting of the casing as required by interpretations of the geophysical logs along with the well cuttings. It is not sufficient simply to examine well cuttings as they are returned to the surface from drilling. It is not possible to obtain a reliable hydrostratigraphic section using well cuttings alone.

The alternative to the borehole geophysical logging program is to drill the well to bedrock with a hollow-stem auger and extract continuous samples with a shelby tube or a split-spoon sampler. However, this alternative will be difficult to implement if gravels are present as reported in the proposed study document. Gravels tend to plug the openings of split-spoon samplers or shelby tube samplers and prevent the acquisition of reliable undisturbed samples.

On the basis of the information obtained from the geophysical logs, the well cuttings and/or the shelby tube or split-spoon samples, decisions can be made regarding which sections of the casing should be slotted. Subsequently, decisions can be made regarding pump testing of the alluvial aquifer above the bedrock for purposes of defining the migration of the seepage plume. These data can be used also for the design of the remainder of the monitoring wells.

The second well should be drilled with mud rotary in the vicinity of the well described above. The purpose of this well should be to determine the hydrostratigraphy of the bedrock at the site and along with the first well, to establish the lateral hydraulic gradient and the extent of the seepage plume, if one exists, toward the river. This well should be drilled to bedrock and cased. The casing should be installed so as to seal off the alluvial aquifer above the bedrock. Drilling should continue into bedrock until it is determined that the bedrock is either an aquifer, an aquiclude, or an aquitard. Drilling should continue until an aquitard or an aquiclude has been encountered. This should be determined by an experienced hydrogeologist utilizing the geophysical logging techniques described above and observations during drilling. The aquiclude should be completely penetrated or drilled to a depth sufficient to verify the hypothesis that its thickness constitutes a barrier boundary to downward migration of seepage. A thickness of 30 to 40 feet should verify this hypothesis. If a bedrock aquifer exists either above or below a confining layer, the bedrock portion of the well should be designed so that the bedrock aquifer can be sampled separately from the alluvial aquifer.

These two wells should be developed and pumped and a sample withdrawn from each of them and submitted to a laboratory prior to continuation of drilling. It should be possible to utilize the specific electrical conductance, sulfate and pH to determine whether contamination exists in bedrock and whether additional monitor wells in bedrock are necessary.

The elevations of water levels in both wells, after casings have been slotted, should be measured so that the direction of the vertical component of the hydraulic gradient can be determined.

The location and design of additional monitoring wells along the southeast embankment of the impoundment should be based on the aforementioned resistivity survey, if one is conducted, and at the least, on the results of the two wells discussed above.

4. Due to the probability of seepage we recommend the placement of monitor wells around the other sides of the pond as well. A resistivity survey might be used to locate initial monitoring wells on the other sides of the pond. These initial wells should also be designed and constructed according to Item 3 above so that they could also be used for aquifer pump tests, if appropriate. Such aquifer pump tests would provide the necessary hydraulic parameters prerequisite to predicting the size and rate of migration of the contaminated plume, if such a plume exists.

5. All well casing elevations must be determined so that the elevation of the water table in the alluvial aquifer can be contoured. Such a contour map will provide a description of the impact of the tailings pond on the water table and the direction and rate of groundwater movement in the vicinity of the site.

6. Prior to the collection of water quality samples from wells, all wells should be pumped until specific electrical conductance has stabilized during pumping.

7. Water quality samples shall be field filtered and preserved as indicated on Page 3 of the March 25, 1981 proposal, and uranium, vanadium, and gross beta added to the list, and gross gamma deleted. The first set of water quality samples should be sent to a laboratory that follows EPA recommended analytical procedures as well as to Atlas' laboratory, to ensure from the beginning of this study, that Atlas' water quality analysis techniques and data results are correct.

8. Atlas' response dated December 8, 1980 to NRC questions dated October 24 indicated that you were checking into the status of wells A, B, C, and the embar oil well, which are listed as abandoned in table 2.3-4 of the report entitled "Safety Analysis Report," by Dames and Moore. Please indicate whether these wells are plugged and submit any available lithologic and hydrogeologic data on these wells.

The implementation of the aforementioned analytical hydrogeological procedures has become reasonably standard at other sites licensed by the NRC. Such studies, conducted by qualified hydrogeologists, have been successful in delineating contaminated plumes produced by uranium mill tailings ponds that were constructed prior to the implementation of groundwater protection technologies such as clay or synthetic liners. The probability of significant seepage at the Atlas-Moab site is reasonably high. The significance of the occurrence of seepage lies in the fact that seepage may be discharging into the Colorado River either directly southeast of the tailings pond or some distance downgradient therefrom. If this is the case, a pump back system to intercept seepage prior to its entry into the river may be required. If this is not the case (i.e., if the Colorado River is a losing stream at this location), then it is important to determine in what direction and at what depths the seepage plume is moving.

If you have any questions on our comments, please contact Mr. Pete Garcia of my staff.

Sincerely,

Harry J. Pettengill

Harry J. Pettengill, Section Leader
Operating Facilities Section II
Uranium Recovery Licensing Branch
Division of Waste Management

File:
7/15/81 Discussed need for all logs and use of mud rotary rig with H. Pettengill and P. Garcia. Pete to contact Rez Williams and get back to me

ATTACHMENT 2

Certificates of Analyses

Ford Chemical
LABORATORY, INC.
Bacteriological an ' Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 466-8761

DATE: 01/27/82

CERTIFICATE OF ANALYSIS

DAMES & MOORE, ENG.
250 E. BROADWAY
SALT LAKE CITY, UT
84111

82-009050

SAMPLE: WELL WATER SAMPLES FROM ATLAS PROJECT, JOB #05467-030-06
COLLECTED 1-19-82, RECEIVED 1-20-82 FOR ANALYSIS.
UNDER P.O. #SL 1510.

	WELL D 13:00	WELL S 13:00
Ammonia as NH3-N mg/l	3.13	3.32
Conductivity umhos/cm	192,000	170,000
Nitrate as NO3-N mg/l	5.90	1.20
Nitrite as NO2-N mg/l	.32	.18
Total Diss. Solids Mg/l	144,500	125,380

FORD CHEMICAL LABORATORY, INC.

Ford Chemical
LABORATORY, INC.
Bacteriological and Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 466-8761

DATE: 01/26/81

CERTIFICATE OF ANALYSIS

DAMES & MOORE, ENG.
250 E. BROADWAY
SALT LAKE CITY, UT
84111

82-009060

SAMPLE: WELL WATER SAMPLE FROM ATLAS PROJECT, JOB #05467-030-06
RECEIVED 1-20-82 FOR ANALYSIS.

	ATP 1-IS 81	ATP 1-ID 81
Ammonia as NH3-N mg/l	3.16	3.12
Nitrate as NO3-N mg/l	.90	.60
Nitrite as NO2-N mg/l	.12	.08
Total Diss. Solids Mg/l	125,000	127,500

FORD CHEMICAL LABORATORY, INC.

SALT LAKE CITY
JAN 27'82
GCT | GWG | PTC
WJG

Hazen Research, Inc.
4601 Indiana St • Golden, Colo 80401
Tel (303) 279-4501 • Telex 45-860

REPORT OF ANALYSIS

Atlas Minerals

Date February 11, 1982
HRI Project No. 4893
HRI Series No. 23111-2
Date Received 1/27/82
Customer P.O. A-10162

Element Found	S	Atlas
Arsenic, recoverable, mg/l	<0.001	– <.01 PPM
Barium, recoverable, mg/l	1.99	—
Cadmium, recoverable, mg/l	0.298	—
Calcium, recoverable, mg/l	1570	—
Chromium, recoverable, mg/l	0.13	—
Copper, recoverable, mg/l	0.18	– .19 PPM
Iron, recoverable, mg/l	1.22	– 1.2 PPM
Lead, recoverable, mg/l	1.26	—
Magnesium, recoverable, mg/l	472	– 615 PPM
Manganese, recoverable, mg/l	0.490	– .15 PPM
Molybdenum, recoverable, mg/l	0.12	—
Nickel, recoverable, mg/l	3.51	—
Potassium, recoverable, mg/l	749	– 1580 PPM
Sodium, recovereable, g/l	35.2	– 25 G/L
Vanadium, recoverable, mg/l	0.38	—
Zinc, recoverable, mg/l	0.21	—
Carbonate as $CaCO_3$, mg/l	<5	—
Bicarbonate as $CaCO_3$, mg/l	40	—
Chloride, g/l	59.2	44.5 G/L
Specific Conductance µmho/cm 25°C	152,600	– 143,600
Fluoride, mg/l	0.98	—
Solids, dissolved, g/l	100.3	– 107.6 G/L
Sulfate as SO_4, mg/l	4420	– 4150 ± 20 PPM
Selenium, recoverable, mg/l	0.002	– <.1 PPM
Uranium, recoverable, mg/l	<0.002	– SAME AS Blank

By: *Robert Rostad* (signature)
Robert Rostad
Manager, General Analytical

mem

Hazen Research, Inc.
4601 Indiana St • Golden, Colo 80401
Tel (303) 279-4501 • Telex 45-860

REPORT OF ANALYSIS

Atlas Minerals

Date February 11, 1982
HRI Project No. 4893
HRI Series No. 23111-4
Date Received 1/27/82
Customer P.O. A-10162

Element Found	IS	
Arsenic, recoverable, mg/l	<0.001	<.01 PPM
Barium, recoverable, mg/l	1.58	—
Cadmium, recoverable, mg/l	0.311	—
Calcium, recoverable, mg/l	1500	
Chromium, recoverable, mg/l	0.14	—
Copper, recoverable, mg/l	0.19	.213 PPM
Iron, recoverable, mg/l	3.30	2.5 PPM
Lead, recoverable, mg/l	1.32	—
Magnesium, recoverable, mg/l	582	578 PPM
Manganese, recoverable, mg/l	0.560	— .22 PPM
Molybdenum, recoverable, mg/l	0.14	—
Nickel, recoverable, mg/l	3.84	—
Potassium, recoverable, mg/l	895	1615 PPM
Sodium, recoverable, g/l	37.6	37.5 G/L
Vanadium, recoverable, mg/l	0.36	—
Zinc, recoverable, mg/l	0.20	—
Carbonate as $CaCO_3$, mg/l	<5	—
Bicarbonate as $CaCO_3$, mg/l	119	—
Chloride, g/l	61.5	46.9 G/L
Specific Conductance µmho/cm 25°C	160,200	— 120,000
Fluoride, mg/l	1.67	—
Solids, dissolved, g/l	105.1	107.9 G/L
Sulfate as SO_4, mg/l	4690	— 4174 PPM
Selenium, recoverable,	0.001	<.1 PPM
Uranium, recoverable, mg/l	<0.002	Same as Blank

By: [signature]
Robert Rostad
Manager, General Analytical

mem

HAZEN

Hazen Research, In
4601 Indiana St • Golde Colo 80401
Tel (303) 279-4501 • Telex 45-860

REPORT OF ANALYSIS

Atlas Minerals

Date February 11, 1982
HRI Project No. 4893
HRI Series No. 23111-3
Date Received 1/27/82
Customer P.O. A-10162

Element Found	ID
Arsenic, recoverable, mg/l	<0.001 – .01 PPM
Barium, recoverable, mg/l	1.44 –
Cadmium, recoverable, mg/l	0.311 –
Calcium, recoverable, mg/l	1510
Chromium, recoverable, mg/l	0.14 –
Copper, recoverable, mg/l	0.20 – .205 PPM
Iron, recoverable, mg/l	3.20 – 3.0 PPM
Lead, recoverable, mg/l	1.24 –
Magnesium, recoverable, mg/l	577 – 857 PPM
Manganese, recoverable, mg/l	0.550 – .17 PPM
Molybdenum, recoverable, mg/l	0.14 –
Nickel, recoverable, mg/l	3.85 –
Potassium, recoverable, mg/l	789 – 1450 PPM
Sodium, recoverable, g/l	39.1 – 25.0 PPM
Vanadium, recoverable, mg/l	0.44 –
Zinc, recoverable, mg/l	0.21 –
Carbonate as $CaCO_3$, mg/l	<5 –
Bicarbonate as $CaCO_3$, mg/l	98 –
Chloride, g/l	62.0 – 47.0 PPM
Specific Conductance, µmho/cm 25°C	161,200 – 135,000
Fluoride, mg/l	1.37 –
Solids, dissolved, g/l	106.3 – 103.9 G/L
Sulfate as SO_4, mg/l	4600 – 3986 PPM
Selenium, recoverable, mg/l	0.002 – <.1 PPM
Uranium, recoverable, mg/l	<0.002 – same as Blank

By: [signature]
Robert Rostad
Manager, General Analytical

mem

HAZEN

Hazen Research, Inc.
4601 Indiana St. • Golden, Colo 80401
Tel (303) 279-4501 • Telex 45-860

REPORT OF ANALYSIS

Atlas Minerals

Date February 11, 1982
HRI Project No. 4893
HRI Series No. 23111-1
Date Received 1/27/82
Customer P.O. A-10162

Element Found	D	Atlas
Arsenic, recoverable, mg/l	<0.001	- .01 PPM
Barium, recoverable, mg/l	1.61	—
Cadmium, recoverable, mg/l	0.334	—
Calcium, recoverable, mg/l	1550	- 879 PPM
Chromium, recoverable, mg/l	0.14	—
Copper, recoverable, mg/l	0.21	- .22 PPM
Iron, recoverable, mg/l	9.48	- 9.6 PPM
Lead, recoverable, mg/l	1.34	—
Magnesium, recoverable, mg/l	604	- 857 PPM
Manganese, recoverable, mg/l	0.475	- .16 PPM
Molybdenum, recoverable, mg/l	0.27	—
Nickel, recoverable, mg/l	4.10	—
Potassium, recoverable, mg/l	891	- 1555 PPM
Sodium, recoverable, g/l	39.6	- 28.5 G/L
Vanadium, recoverable, mg/l	0.18	—
Zinc, recoverable, mg/l	0.34	—
Carbonate as $CaCO_3$, mg/l	<5	—
Bicarbobate as $CaCO_3$, mg/l	107	—
Chloride, g/l	62.4	- 48.97 G/L
Specific Conductance, µmho/cm 25°C	166,600	- 150,400
Fluoride, mg/l	2.02	—
Solids, dissolved, g/l	110.3	- 120.7 G/L
Sulfate as SO_4, mg/l	4720	- 4441 PPM
Selenium, recoverable, mg/l	<0.001	- <.1 PPM
Uranium, recoverable, mg/l	<0.002	- Same As Blank

By: [signature]
Robert Rostad
Manager, General Analytical

mem

Hazen Research, Inc.
4601 Indiana St • Golden, Colo 80401
Tel (303) 279-4501 • Telex 45-860

REPORT OF ANALYSIS

Atlas Minerals
North Highway 163 Mill Site
Moab, Utah 84532

Date February 11, 1982
HRI Project No. 4893
HRI Series No. 23111
Date Received 1/27/82
Customer P.O. A-10162

Analysis No.	Sample Designation	pCi/l recoverable Ra^{226} ± Precision*	
23111-1	D	3.4 ± 2.2	= .034 $\times 10^{-8}$ μci/ml
-2	S	6.8 ± 2.5	= .019 $\times 10^{-8}$ μci/ml
-3	ID	5.6 ± 2.7	= .036 $\times 10^{-8}$ μci/ml
-4	IS	3.9 ± 1.9	= .026 $\times 10^{-8}$ μci/ml

By: Robert Rostad
Robert Rostad
Manager, General Analytical

mem

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96σ.

NOTE: Lead 210 results to follow.

Hazen Research, Inc.
4601 Indiana St • Golden, Colo 80401
Tel (303) 279-4501 • Telex 45-860

REPORT OF ANALYSIS

Atlas Minerals

Date February 11, 1982
HRI Project No. 4893
HRI Series No. 23111
Date Received 1/27/82
Customer P.O. A-10162

Analysis No.	Sample Designation	pCi/l recoverable Po^{210} ± Precision*		
23111-1	D	0.9	±	2.4 0.0 Pci/ml
-2	S	0.4	±	2.2 0.0 Pci/ml
-3	ID	1.7	±	2.7 .00015 Pci/ml
-4	IS	0.0	±	1.9 0.0 Pci/ml

By: [signature]
Robert Rostad
Manager, General Analytical

mem

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96σ.

HAZEN

Hazen Research, Inc.
4601 Indiana St • Golden Colo 80401
Tel (303) 279-4501 • Telex 45-860

REPORT OF ANALYSIS

Atlas Minerals

Date February 11, 1982
HRI Project No. 4893
HRI Series No. 23111
Date Received 1/27/82
Customer P.O. A-10162

Analysis No.	Sample Designation	pCi/l recoverable Th^{230} ± Precision*			
23111-1	D	0	±	16	0 ± 0 x10⁻⁶ µci/ml
-2	S	0	±	20	0 ± 0 x10⁻⁶ µci/ml
-3	ID	0	±	16	0 ± 0 x10⁻⁶ µci/ml
-4	IS	0	±	20	0 ± 0 x10⁻⁶ µci/ml

By: Robert Rostad
Robert Rostad
Manager, General Analytical

mem

*Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 1.96σ.

MONITOR WELL REPORTS

_______Quarter______

Well # Well S

Date and time sample was collected January 20, 1982

Location of sample ________________

Sampling method used (bailed or pumped) Pumped

The amount of water to be removed prior to sampling ________________

Radionuclide	M.P.C.	Concentration uci/ml	Error Estimate
Gross Beta-Gamma		Nil x 10^{-6} uci/ml	±0
U-Nat	3 x 10^{-5} uci/ml	Nil x 10^{-5} uci/ml	±0
Ra^{226}	3 x 10^{-8} uci/ml	.026 x 10^{-8} uci/ml	±.06
Th^{230}	2 x 10^{-6} uci/ml	0 x 10^{-6} uci/ml	±0
Pb^{210}	1 x 10^{-7} uci/ml		
Po^{210}	7 x 10^{-7} uci/ml	0.0 Pci/ml	±.0009

Common Ions and Trace Metals	Concentration	Error Estimate
K^+	1580 PPM	±0
Na^+	25000 PPM	±0
Cl^-	44,485 PPM	±481
$SO^=$	4150 PPM	±200
NO^4-	.011 G/L	±.009
Fe^3	1.2 PPM	±0
Mn	.15 PPM	±0
As	<.01 PPM	±0
Se	<.1 PPM	±0
TDS	107,638	±4236
Conductivity	143,600	umhos
Ph	9.0	
Cu	.193 PPM	±.02

MONITOR WELL REPORTS

______Quarter______

Well # Well S1

Date and time sample was collected January 20, 1982

Location of sample ________________

Sampling method used (bailed or pumped) Pumped

The amount of water to be removed prior to sampling ________________

Radionuclide	M.P.C.	Concentration uci/ml	Error Estimate
Gross Beta-Gamma		Nil x 10^{-6} uci/ml	±0
U-Nat	3 x 10^{-5}uci/ml	Nil x 10^{-5} uci/ml	±0
Ra^{226}	3 x 10^{-8}uci/ml	.019 x 10^{-8} uci/ml	±035
Th^{230}	2 x 10^{-6}uci/ml	0 x 10^{-6} uci/ml	±0
Pb^{210}	1 x 10^{-7}uci/ml		
Po^{210}	7 x 10^{-7}uci/ml	.00015 Pci/ml	±.0004

Common Ions and Trace Metals	Concentration	Error Estimate
K^{+}	1615 PPM	±45
Na^{+}	27,500 PPM	±4492
Cl^{-}	46,985 PPM	±319
$SO^{=}$	4174 PPM	±314
NO^{4}-	.015 g/L	±.0046
Fe^{3}	2.5 PPM	±.44
Mn	.22 PPM	±.04
As	<.01 PPM	±0
Se	<.01 PPM	±0
TDS	107,859	±2412
Conductivity	121,250	umhos
Ph	7.9	
Cu	.213 PPM	±.02

MONITOR WELL REPORTS

______Quarter______

Well # Well D1

Date and time sample was collected January 20, 1982

Location of sample ____________________

Sampling method used (bailed or pumped) ____________________

The amount of water to be removed prior to sampling ____________________

Radionuclide	M.P.C.	Concentration uci/ml	Error Estimate
Gross Beta-Gamma		1.13×10^{-6} uci/ml	±.17
U-Nat	3×10^{-5} uci/ml	Nil $\times 10^{-5}$ uci/ml	[illegible]
Ra^{226}	3×10^{-8} uci/ml	$.036 \times 10^{-8}$ uci/ml	±.058
Th^{230}	2×10^{-6} uci/ml	0×10^{-6} uci/ml	±0
Pb^{210}	1×10^{-7} uci/ml		
Po^{210}	7×10^{-7} uci/ml	.0.0 Pci/ml	±0

Common Ions and Trace Metals	Concentration	Error Estimate
K^+	1450 PPM	±90
Na^+	25,000 PPM	±0
Cl^-	47,017 PPM	±1182
$SO^=$	3986 PPM	±136
NO^4-	.010 g/l	±0
Fe^3	3.0 PPM	±.45
Mn	.17 PPM	±0
As	<.01 PPM	±0
Se	<.01 PPM	±0
TDS	103,982 PPM	±10,927
Conductivity	120,000	umhos
Ph	7.9	
Cu	.205 PPM	±0

MONITOR WELL REPORTS

_______Quarter______

Well # Well D

Date and time sample was collected January 20, 1982

Location of sample ________________________________

Sampling method used (bailed or pumped) Pumped

The amount of water to be removed prior to sampling ______________________________

Radionuclide	M.P.C.	Concentration uci/ml	Error Estimate
Gross Beta-Gamma		Nil $\times 10^{-5}$ uci/ml	±0
U-Nat	3×10^{-5} uci/ml	Nil $\times 10^{-5}$ uci/ml	[illegible]
Ra^{226}	3×10^{-8} uci/ml	.034 $\times 10^{-8}$ uci/ml	±.14
Th^{230}	2×10^{-6} uci/ml	0 $\times 10^{-6}$ uci/ml	±0
Pb^{210}	1×10^{-7} uci/ml		
Po^{210}	7×10^{-7} uci/ml	0.0 Pci/ml	±.0009

Common Ions and Trace Metals	Concentration	Error Estimate
K^{+}	1555 PPM	±90
Na^{+}	28,500 PPM	±4492
Cl^{-}	48,974 PPM	±988
$SO^{=}$	4441 PPM	±263
$NO^{4}-$	.0145 g/L	±0
Fe^{3}	9.6 PPM	±.9
Mn	.16 PPM	±.04
As	.01 PPM	±0
Se	<.1 PPM	±0
TDS	120,671 PPM	±7333
Conductivity	150,400	umhos
Ph	7.6	
Cu	.22 PPM	±0

APPENDIX A

FIELD PROGRAM

INTRODUCTION

The field program consisted of drilling, logging, completion, and ground water quality sampling of four wells completed within a single boring. The boring was drilled using both rotary and cable-tool drilling methods and was located approximately 250 feet southeast of the tailings impoundment. The boring was drilled to a total depth of 406 feet in the Colorado River alluvium. Each of the wells installed within the boring were completed using 2-inch PVC casing and screen and were hydraulically isolated from each other through the use of grout seals. All field operations were conducted and supervised by an experienced Dames & Moore hydrogeologist.

DRILLING METHODS

GENERAL

The drilling was done by Zimmerman Drilling, Inc. of Moab, Utah, using both a Speedstar SS-15 rotary and a Backus Erie cable-tool drilling rig.

ROTARY DRILLING

As open-hole geophysical logs of the boring were desired, our first attempt at drilling the boring was made using rotary-wash drilling techniques. Prior to drilling, a mud pit was dug and an organic polymer drilling fluid was mixed. The mixing of drilling fluids and the control of mud viscosities were supervised by drilling mud engineers furnished by Nova Mud Corporation.

The Marsh Funnel Viscosity of the drilling mud was adjusted to approximately 60 seconds prior to the start of drilling. Drilling to 30 feet proceeded without difficulty; however, drilling after 30 feet failed to produce a clean stable hole. The Marsh Funnel Viscosity was then increased to over 100 seconds and drilling continued to 40 feet.

During the drilling within the interval between 40 and 60 feet, the problems of hole stability increased. The drilling mud viscosity was raised to 230 seconds (Marsh Funnel). The sample cuttings returned to the surface indicated that the sediments drilled were very coarse gravels and that the drilling mud was of sufficient viscosity to carry the drill cuttings. Caving of the hole, however, continued. In an attempt to stabilize the caving, a solution was added to the drilling mud that caused the mud to gel within the formation. This procedure also failed to stabilize the boring. At 60 feet the driller started to loose circulation to the formation. At this point the use of rotary drilling methods was discontinued.

It was the opinion of the personnel from Zimmerman Drilling, Nova Mud Corporation, and Dames & Moore that the use of other drilling mud types such as bentonite would also fail to produce a clean, stable boring and that the use of cable-tool drilling methods was required.

CABLE-TOOL DRILLING

Drilling using the cable-tool method was continued at the same location. A 10-3/4-inch surface casing was driven to 12 feet and bailed clean. The drive casing was 8-7/8-inch with a 8-inch drive shoe. The casing was alternately driven and bailed clean. Casing drive rates varied from approximately one foot per minute to one foot per hour. The bailing of cuttings from the boring was generally done within the casing as the hole generally caved when the boring was advanced more than a foot beyond the bottom of the casing. The casing was still capable of being advanced when the decision was made to stop drilling at 406 feet.

GEOLOGIC AND GEOPHYSICAL LOGGING

GENERAL

During the drilling phase, cutting samples were collected and saved at five foot intervals. Rotary drill cuttings were obtained by settling the cuttings obtained in the returned drilling muds. Cuttings from the cable-tool drilling were obtained from the bailer. After completion of the boring, the hole was geophysically logged through the steel casing.

GEOLOGIC LOG

The cutting samples collected during the drilling phase were visually analyzed and then describei. These cuttings are the basis for the geologic log presented in Plate A-1, Log of Boring, and the following discussion. The sample classifications and descriptions given on Plate A-1 are based on the terminology and methods of classification recommended in the Unified Soil Classification System. A summary of this classification system is presented in Plate A-2, Unified Soil Classification System.

The boring penetrated only alluvial sediments composed primarily of gravels and coarse sands. As both rotary and cable-tool methods tended to crush the individual grains of gravel, few grains larger than two centimeters were found in the drill cuttings. However, based on observations of fractured and unfractured surfaces, the approximate grain size could be estimated.

The upper 25 feet of the boring was composed of sands and gravels. In this interval the sediments were generally reddish brown and individual gravel grains tended to be angular. The grains consisted primarily of reddish brown sandstone and shale fragments. Below 25 feet the sediments were generally light brownish gray and individual gravel grains tended to be rounded to well-rounded and were composed primarily of granite, gniess, quartzite, and limestone rock fragments. A few beds of coarse sand were also present.

The differences between the sediments of the upper 25 feet and the rest suggests that two different source areas and alluvial systems have provided sediments into this area. The upper 25 feet appear to have been the result of sediment deposition in the Moab Wash alluvial system. The sediments deeper than 25 feet appear to be related to sediment deposition along the Colorado River alluvial system.

GEOPHYSICAL LOGS

Three cased hole geophysical logs were run in the boring by Professional Logging Services, Inc. These logs were natural gamma, gamma-gamma density, and neutron-neutron logs. These geophysical logs are shown on Plate A-1.

NATURAL GAMMA RAY LOG

The natural gamma ray log responds to the presence of gamma ray radiation in the formational materials surrounding the bore hole. In alluvial materials, such as those present at this site, the majority of the natural gamma radiation is produced by the radioactive elements commonly found in and absorbed to the clay minerals, in particular, radioactive potassium found in illitic clays. Hence, in general, the presence of clay layers are represented by high counting rates, while clean sands and gravels are generally associated with low gamma counting rates.

The natural gamma log for this well shows little, if any, significant change in the natural gamma intensity for sediments located below the water table (13 feet). This lack of change indicates that there are no clay layers of sufficient thickness to be considered a confining bed.

GAMMA-GAMMA DENSITY LOG

The gamma-gamma density log provides a measure of the insitu density of formational materials. In this log gamma rays are emitted into the formation from a gamma ray source in the logging tool. The percentage of this gamma ray radiation returning from the formation to the detector, is measured. In general, the percentage of radiation returned to the tool is a function of the density of formational materials, as the absorption of gamma radiation is a function of density. However, because the borehole is cased, the density of the casing is also interpreted by the logging tool as part of the formation. Hence, quantitative measurement of formation density cannot be made with the log.

The gamma-gamma density log obtained from this boring shows little, if any, significant change over its entire depth. This probably results from both the lack of any significant formational changes and also the attenuating effects of the steel casing.

NEUTRON-NEUTRON LOG

The neutron-neutron log provides a measure of the formation porosity. In this tool, epithermal neutrons are emitted from a neutron source into the formation and the number of neutrons returning from the formation to the detector, are counted. As the hydrogen atom is the principal absorber of epithermal neutrons, the number of neutrons returning is related principally to the concentration of hydrogen atoms in the formational material. For alluvial sediments such as those found in this boring, the majority of the hydrogen atoms present are located within the sediment pore water, and hence, the neutron-neutron log is an indirect measurement of the formation porosity.

The neutron-neutron log of this boring shows few significant changes, if any, in the intensity of the returned neutron as a function of depth. The changes in intensity appear to be related to changes in the sediment porosity; however, the actual change in porosity of the granular aquifer is likely only a few percent.

WELL COMPLETION

The 8-7/8-inch steel drive casing was perforated at four separate intervals and four monitor wells were installed in these perforated zones. Each well was separately sand-packed and sealed to prevent the migration of ground water between wells. The location and construction details for each of these wells are shown graphically on Plate A-1 and are discussed below.

The 8-7/8-inch steel drive casing inplaced while drilling the well, was perforated at selected intervals using a mechanical knife casing perforator. Each perforation cut by the perforating knife was approximately three inches long and one-quarter inch wide. The locations of the perforations are shown graphically on Plate A-1. Development of the well was done by bailing the perforated casing after the perforations were cut.

Four 2-inch diameter casing and screen assemblies were then sequentially set, sand-packed and grouted into place. The screen and casing pipe used was 2-inch Schedule 40 PVC pipe. The screen was manufactured by Hydrophyllic, Inc. of Tacoma, Washington and had 0.020 inch wide saw-cut perforations. Each pipe joint was properly glued prior to installation. Glued pipe joints that were not allowed more than one hour to set were given additional strength through the installation of two, 3/16-inch stainless steel screws, screwed through the glued joint.

Each casing-screen assembly was sand-packed and grouted immediately after its installation. The sand-pack used was a Number 4-10 sand manufactured by Colorado Silica Sand, Inc., Pueblo, Colorado. The grout mixture was a neat cement grout made by mixing 5.2 gallons of water and 2 pounds of calcium chloride with each bag of Type V portland cement. The calcium chloride was added to accelerate the grout setting time. The grout was tremied into place and allowed a minimum of eight hours to set prior to the installation of the next casing-screen assembly. The locations of all casings, screens, sand-pack, and grout seals are shown graphically on Plate A-1.

Following the construction of all wells, each well was individually tested for the presence of a hydraulic interconnection between other casing-screen assemblies. These tests were conducted by measuring the water levels of each piezometer and then pumping one of the piezometers for approximately 30 minutes and again measuring the water levels. No significant changes in the water levels of the unpumped wells were noted while pumping any of the other wells. The pumping level in the pumped wells varied from 2 to 8 feet.

WATER QUALITY SAMPLING

Each of the wells were pumped prior to sampling until it was determined that there was no longer any significant change in the specific conductivity of the ground water being pumped. The wells were pumped until three successive measurements of the ground water's specific conductivity showed no significant change. A minimum of 1,500 gallons was pumped from each well. The volumes of water pumped, specific conductivity, pH, temperature and water level measurements for each of the wells prior to sampling are given in Table A-2A through A-2D, Ground Water Sampling Forms.

Samples for parameters with short-hold times (ammonia, nitrate, nitrite, and total dissolved solids) were immediately shipped by air for analysis by Ford Chemical Laboratories, Inc., Salt Lake City, Utah. Ground water samples for other parameters were split and analyzed by Hazen Research, Inc., Golden, Colorado, and by Atlas Minerals, Moab, Utah. The results of the analyses are given in Attachment 2.

TABLE A-1A

GROUND WATER QUALITY SAMPLING FORM

Well No.: ATP-1-S-81

Owner: Atlas Minerals

Date/Time 1/19/82 / 1:00 Sampled By: Dale Edwards (Atlas Minerals)

Appearance: Clear
(clear, colored, turbid, sediment, etc.)

Remarks: Well had been pumped on the previous day at 12 gpm for approximately two hours (pumped 1,500 gal).

Field Measurements and Sample Collection[a]

Static Water Level: 14.26 (16.86 from TOC) (in feet below land surface)

Pumping Rate: 8 gpm (in gallons per minute)

Duration of Pumping: from 10:30 to 1:00, Total Time = 170 (in minutes)

Volume of Water Pumped Prior to Sampling[b]: 1,400 (in gallons)

Method of Pumping: Centrifugal pump

Electrical Conductivity (E.C.) Measurements

Meter No.: YSI #1

Time Sampled: 10:43 pH 9.9 (E.C.) 158,000 (in micromhos/cm, corrected to 25°C)
Time Sampled: 11:01 pH 9.2 (E.C.) 172,000 (in micromhos/cm, corrected to 25°C)
Time Sampled: 11:05 pH 9.0 (E.C.) 158,000 (in micromhos/cm, corrected to 25°C)
Time Sampled: 11:15 pH 9.1 (E.C.) 130,000 (in micromhos/cm, corrected to 25°C)
Time Sampled: 12:15 pH 9.1 (E.C.) 130,000 (in micromhos/cm, corrected to 25°C)
Time Sampled: 12:45 pH 9.1 (E.C.) 145,000 (in micromhos/cm, corrected to 25°C)

Meter No.: Digital pH Meter #609 standardized to pH 10

Temperature: 18 °C

(a) Field measurements and sample collection made in accordance with Dames & Moore Technical Memorandum for the pre-operational ground water.

(b) A minimum of two (2) casing volumes of water shall be pumped from the well prior to sample collection.

TABLE A-1B

GROUND WATER QUALITY SAMPLING FORM

Well No.: ATP-1-IS-81

Owner: Atlas Minerals

Date/Time 1/20/82 / 11:00 Sampled By: Dale Edwards (Atlas Minerals)

Appearance: Clear

(clear, colored, turbid, sediment, etc.)

Remarks: 3,000 gallons pumped from the well on 1-19-82

Field Measurements and Sample Collection[a]

Static Water Level: 14.71 (17.46 from TOC) (in feet below land surface)

Pumping Rate: 15 (in gallons per minute)

Duration of Pumping: from 9:06 to 11:15, Total Time = 129 (in minutes)

Volume of Water Pumped Prior to Sampling[b]: 1,935 (in gallons)

Method of Pumping: Centrifugal pump

Electrical Conductivity (E.C.) Measurements

Meter No.: Yellow Spring Instrument #1

Time Sampled: 9:55 pH 7.9 (E.C.) 115,000 (in micromhos/cm, corrected to 25°C)

Time Sampled: 10:15 pH 7.9 (E.C.) 120,000 (in micromhos/cm, corrected to 25°C)

Time Sampled: 10:25 pH 7.9 (E.C.) 125,000 (in micromhos/cm, corrected to 25°C)

Time Sampled: 10:45 pH 7.9 (E.C.) 125,000 (in micromhos/cm, corrected to 25°C)

Time Sampled 11:00 pH 7.9 (E.C.) 125,000 (in micromhos/cm, corrected to 25°C)

Time Sampled: ______ pH ______ (E.C.) ______ (in micromhos/cm, corrected to 25°C)

Meter No.: Digital pH Meter #609 standardized to pH 7

Temperature: 15 °C

(a) Field measurements and sample collection made in accordance with Dames & Moore Technical Memorandum for the pre-operational ground water.

(b) A minimum of two (2) casing volumes of water shall be pumped from the well prior to sample collection.

TABLE A-1C

GROUND WATER QUALITY SAMPLING FORM

Well No.: ATP-1-ID-81

Owner: Atlas Minerals

Date/Time 1/20/81 / 10:30 Sampled By: Dale Edwards (Atlas Minerals)

Appearance: Clear
(clear, colored, turbid, sediment, etc.)

Remarks: Well had been pumped on the previous day at approximately 10 gpm for 1.5 hours (volume pumped was 1,500 gallons)

Field Measurements and Sample Collection[a]

Static Water Level: 14.65 (17.55 from TOC) (in feet below land surface)

Pumping Rate: 12 (in gallons per minute)

Duration of Pumping: from 8:50 to 10:31, Total Time = 101 (in minutes)

Volume of Water Pumped Prior to Sampling[b]: 1,200 (in gallons)

Method of Pumping: Centrifugal pump

Electrical Conductivity (E.C.) Measurements

Meter No.: Yellow Springs Instrument #1

Time Sampled: 9:45 pH 7.4 (E.C.) 135,000 (in micromhos/cm, corrected to 25°C)

Time Sampled: 10:00 pH 7.7 (E.C.) 135,000 (in micromhos/cm, corrected to 25°C)

Time Sampled: 10:16 pH 7.9 (E.C.) 130,000 (in micromhos/cm, corrected to 25°C)

Time Sampled: ______ pH ____ (E.C.) ______ (in micromhos/cm, corrected to 25°C)

Time Sampled: ______ pH ____ (E.C.) ______ (in micromhos/cm, corrected to 25°C)

Time Sampled: ______ pH ____ (E.C.) ______ (in micromhos/cm, corrected to 25°C)

Meter No.: Digital pH Meter #609 standardized to pH 7.0

Temperature: 15 °C

(a) Field measurements and sample collection made in accordance with Dames & Moore Technical Memorandum for the pre-operational ground water.

(b) A minimum of two (2) casing volumes of water shall be pumped from the well prior to sample collection.

GROUND WATER QUALITY SAMPLING FORM

Well No.: ATP-1-D-81

Owner: Atlas Minerals

Date/Time 1/19/82 / 1:05 **Sampled By:** Dale Edwards (Atlas Minerals)

Appearance: Clear
(clear, colored, turbid, sediment, etc.)

Remarks: 1,500 gallons pumped from the well on 1-18-82

Field Measurements and Sample Collection[a]

Static Water Level: 14.95 (18.40 from TOC) (in feet below land surface)

Pumping Rate: 2.5 gpm (in gallons per minute)

Duration of Pumping: from 10:15 to 1:05, Total Time = 110 (in minutes)

Volume of Water Pumped Prior to Sampling[b]: 425 (in gallons)

Method of Pumping: Centrifugal pump

Electrical Conductivity (E.C.) Measurements

Meter No.: YSI #1

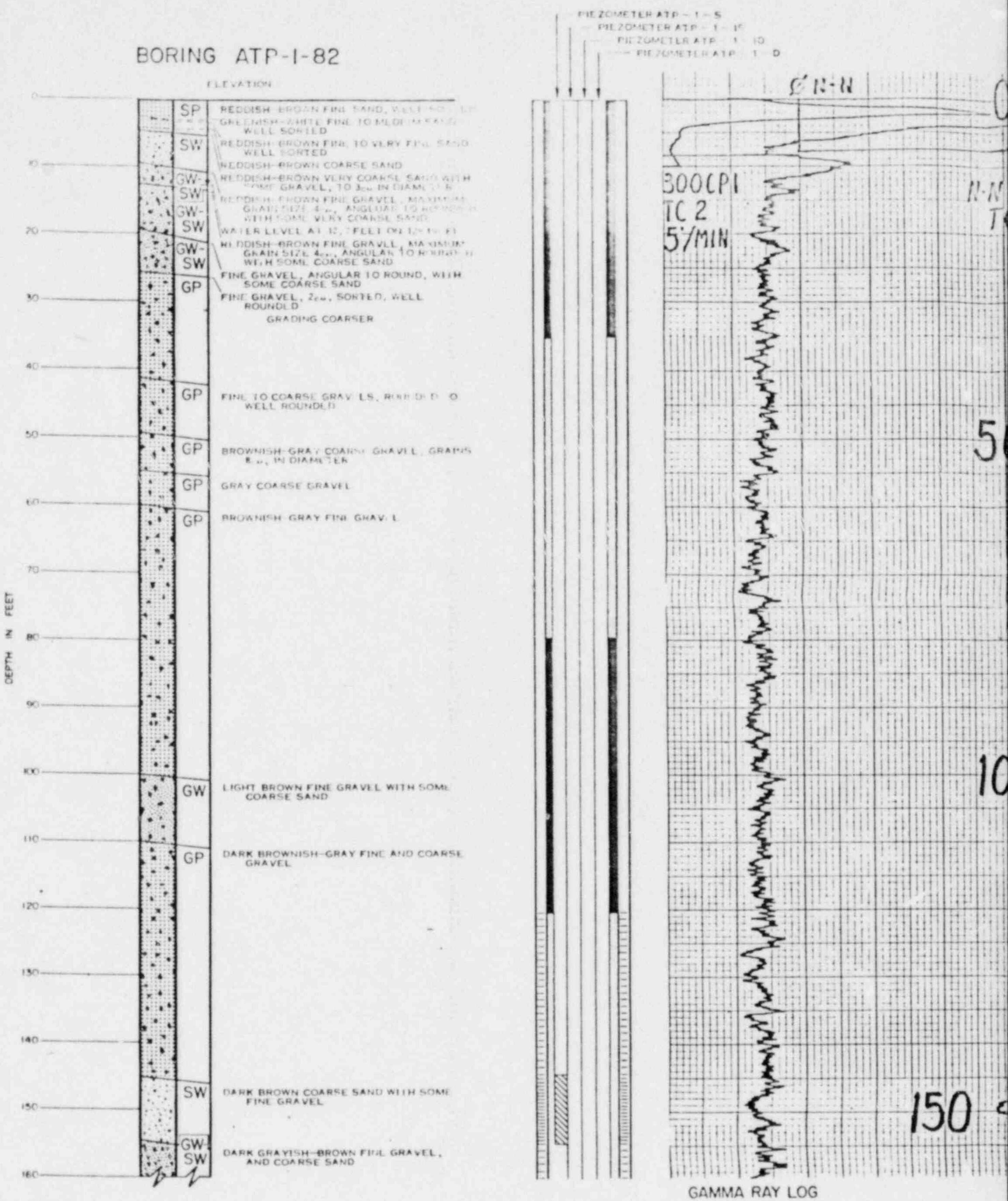
Time Sampled: 10:30 pH 7.6 (E.C.) 150,000 (in micromhos/cm, corrected to 25°C)
Time Sampled: 11:15 pH 7.6 (E.C.) 130,000 (in micromhos/cm, corrected to 25°C)
Time Sampled: 12:00 pH 7.6 (E.C.) 130,000 (in micromhos/cm, corrected to 25°C)
Time Sampled: 12:30 pH 7.6 (E.C.) 150,000 (in micromhos/cm, corrected to 25°C)
Time Sampled: ______ pH ____ (E.C.) ______ (in micromhos/cm, corrected to 25°C)
Time Sampled: ______ pH ____ (E.C.) ______ (in micromhos/cm, corrected to 25°C)

Meter No.: Digital pH Meter #609 standardized to pH 10 Buffer solution

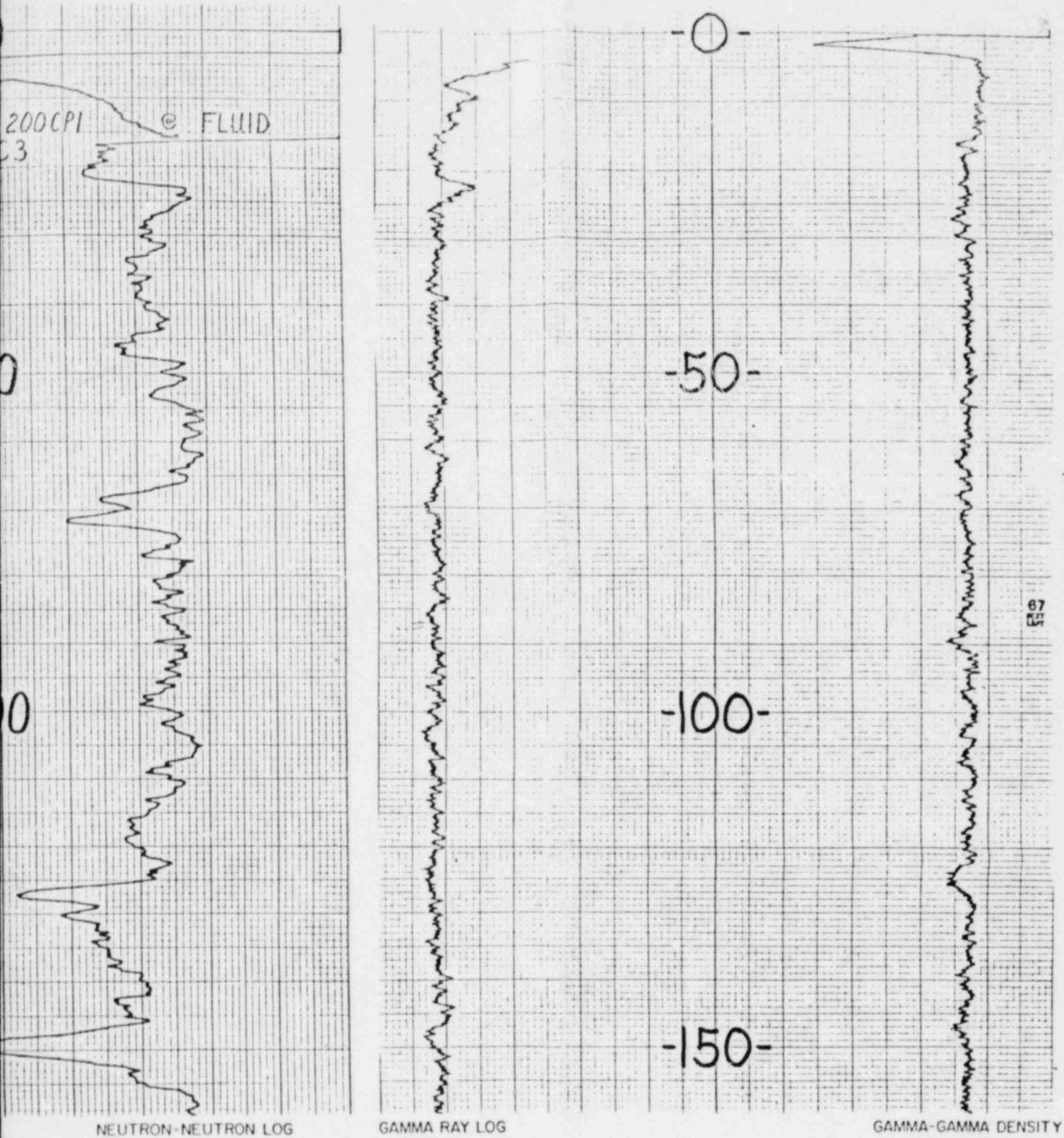
Temperature: 18 °C

(a) Field measurements and sample collection made in accordance with Dames & Moore Technical Memorandum for the pre-operational ground water.

(b) A minimum of two (2) casing volumes of water shall be pumped from the well prior to sample collection.

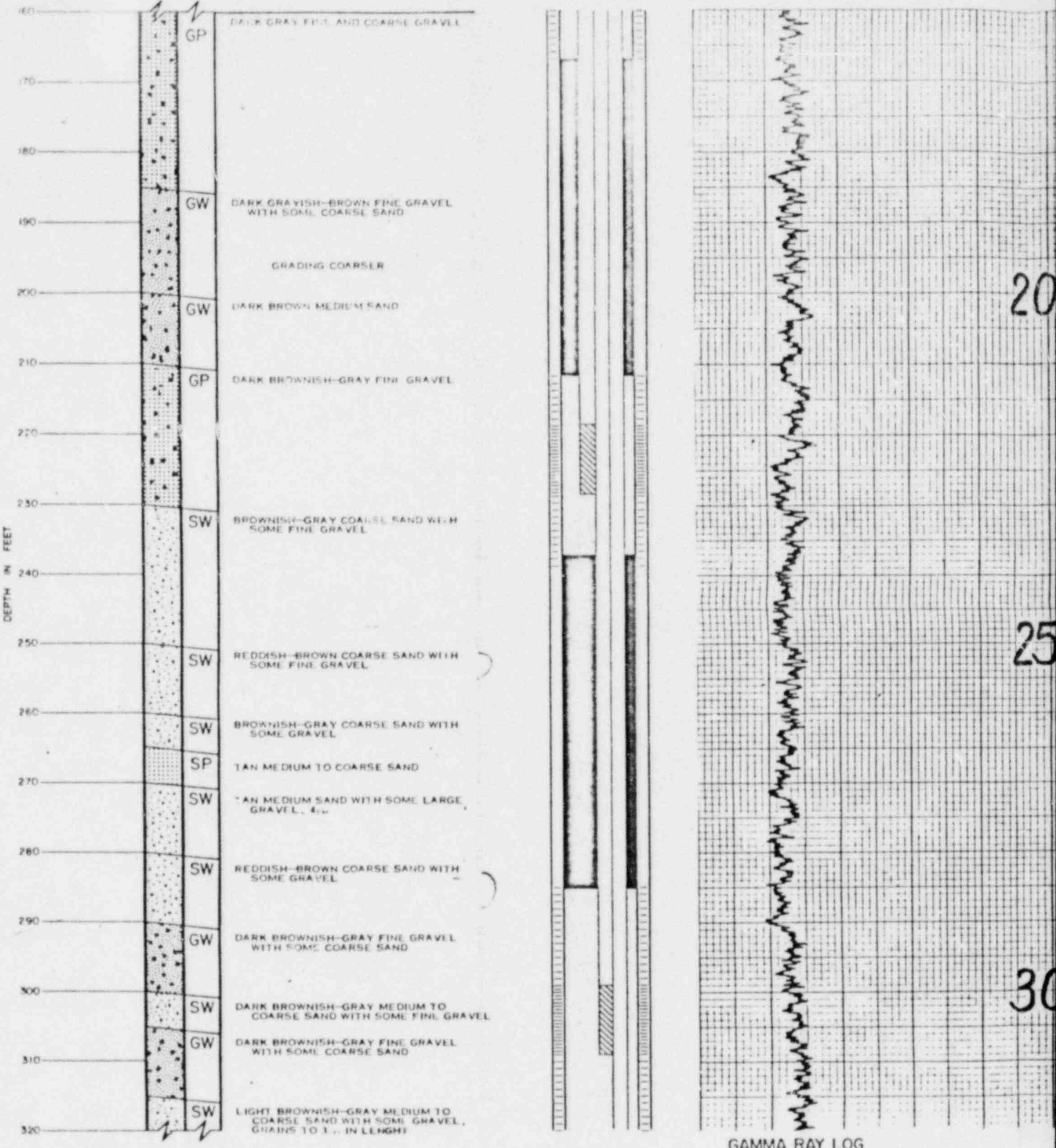


LOG OF BORING



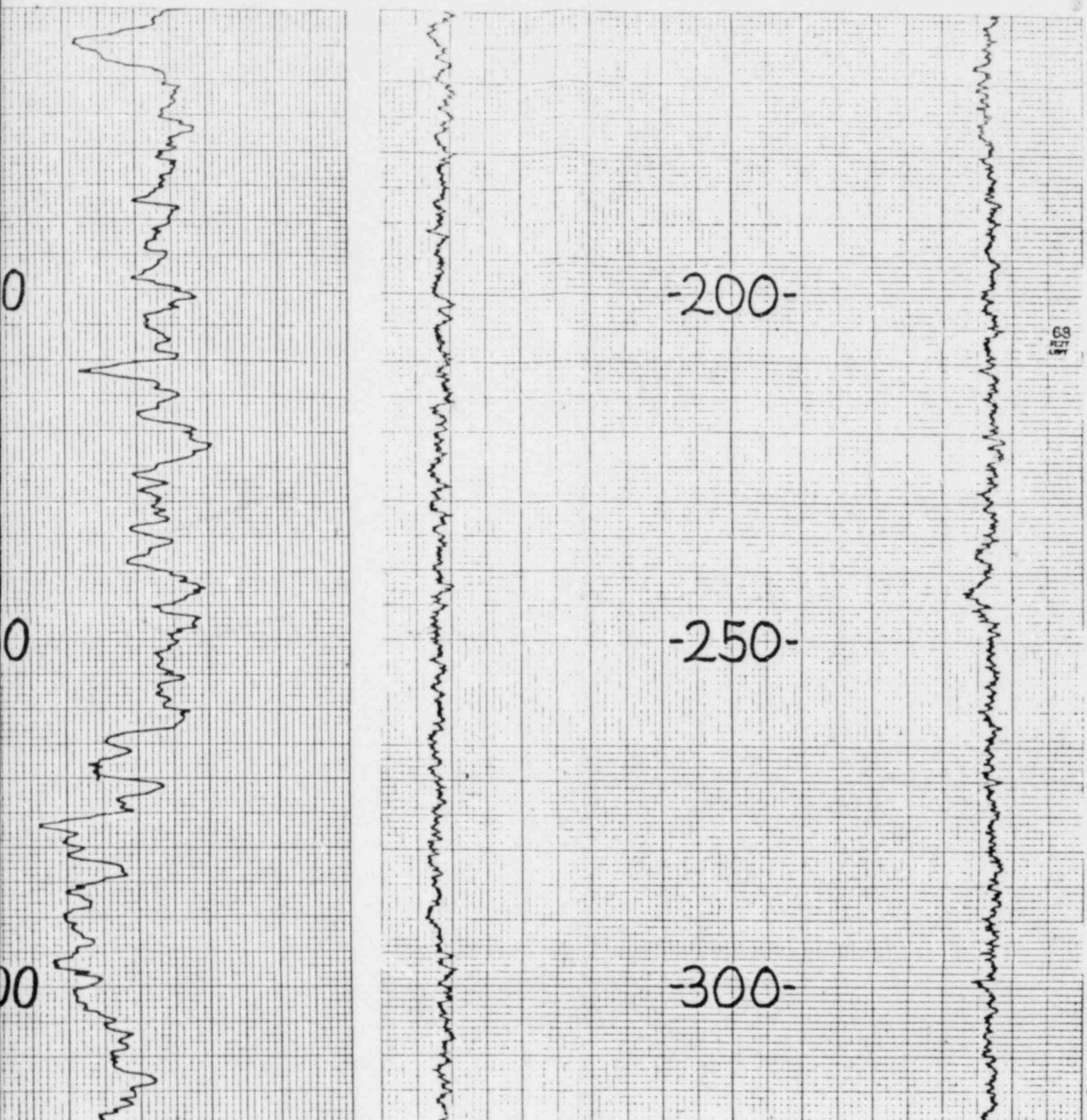
GEOPHYISICAL LOGS

BORING ATP-1-82 (CONTINUED)



WELL COMPLETION LOG

LOG OF BORING

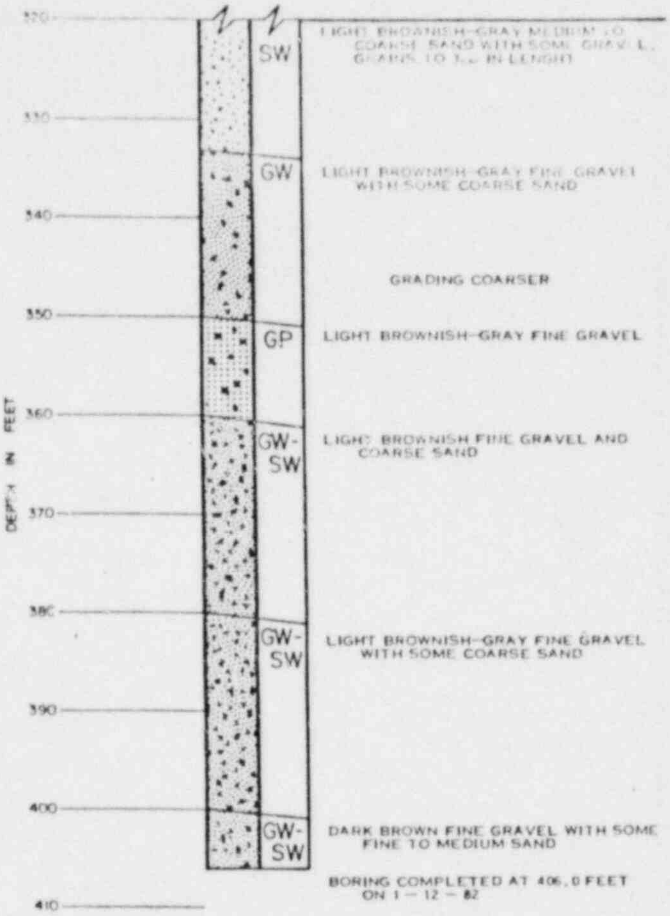


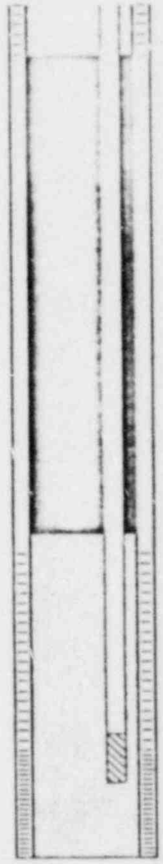
NEUTRON-NEUTRON LOG   GAMMA RAY LOG   GAMMA-GAMMA DENSITY

GEOPHYISICAL LCGS

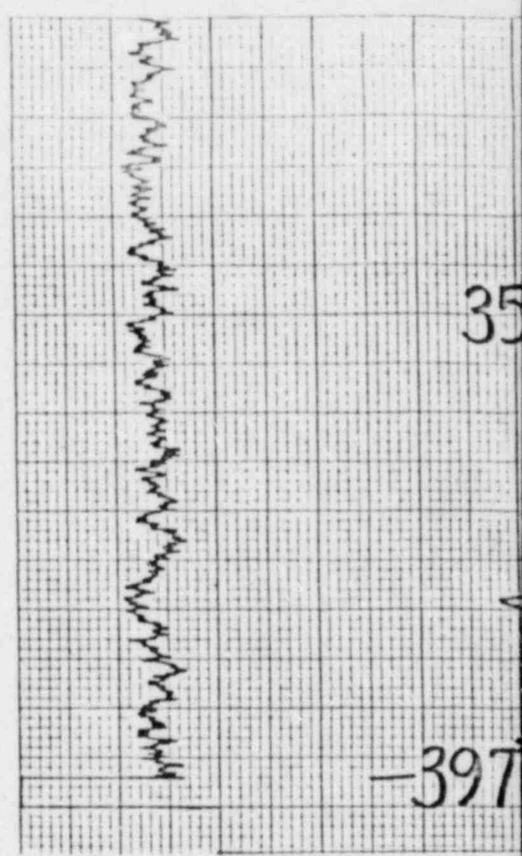
Dames & Moore

BORING ATP-1-82 (CONTINUED)





WELL COMPLETION LOG



GAMMA RAY LOG

LOG OF BORING

KEY :

- 8⅝ INCH STEEL CASING
- 8⅝ INCH STEEL CASING WITH 2 PERFORATIONS PER FOOT
- 8⅝ INCH STEEL CASING WITH 4 PERFORATION PER FOOT
- 2 INCH SCHEDULE 40 PVC CASING
- 2 INCH SCHEDULE 40 PVC SLOTTED SCREEN
- GROUT SEAL
- SAND PACK

PLS PROFESSIONAL LOGGING SERVICES, IN

Clifton, Colorado 81520

HOLE NO: ATP-1-82

CLIENT: ATLAS MINERALS | DATE: 01-1

AREA: MILL

COUNTY: GRAND | STATE: UTAH

SECTION: | TOWNSHIP: | RANGE:

ELEVATION: | DEPTH REFERENCE: XTAL @ GROUND LEVEL | GEOLOGIST:

PROBE NO: 1809 | INITIAL RUN | LOG: GAMMA

K FACTOR: 1.19X10⁻⁵ | DEAD TIME: 6.65 μsec | T.D. DRILLED: 406 | RANGE: 300 CPS/I

WATER FACTOR: 1.15 | AIR FACTOR: 1.00 | T.D. LOGGED: 397 | TC: 2 | RATE: 5'/M

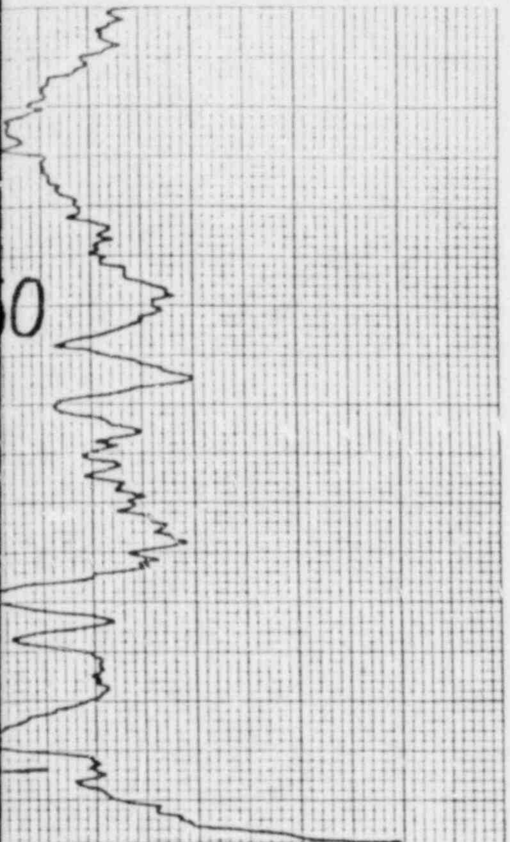
DETECTOR TYPE AND SIZE: XTAL ⅞ x 1⅝ | NATURAL GAMMA RANGE: 25 CPS/IN | FROM: 10'

CALIBRATION RANGE TC | TC: 2 | RATE: 20'/MIN | TO: 0'

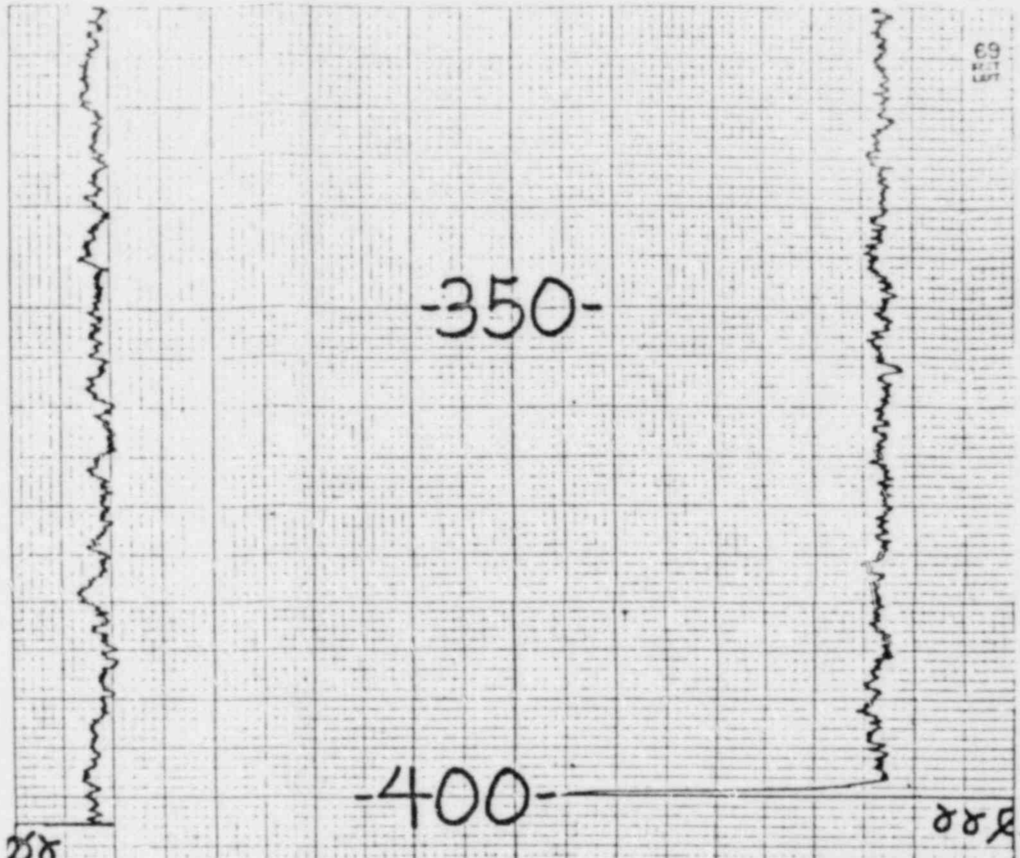
CALIBRATION SOURCE | SP RANGE: NA | TOTAL: 10'

SOURCE: 113 | SN: 1G | ACTIVITY | TYPE: $Am^{241}Be$ | RES RANGE: NA | TAPE: 01-25-04A

TEST PIT DATA: DOE GJO 11-30-81 | OTHER: BOTTOM @ 405' | TOTAL FOOTAGE LOG: 416

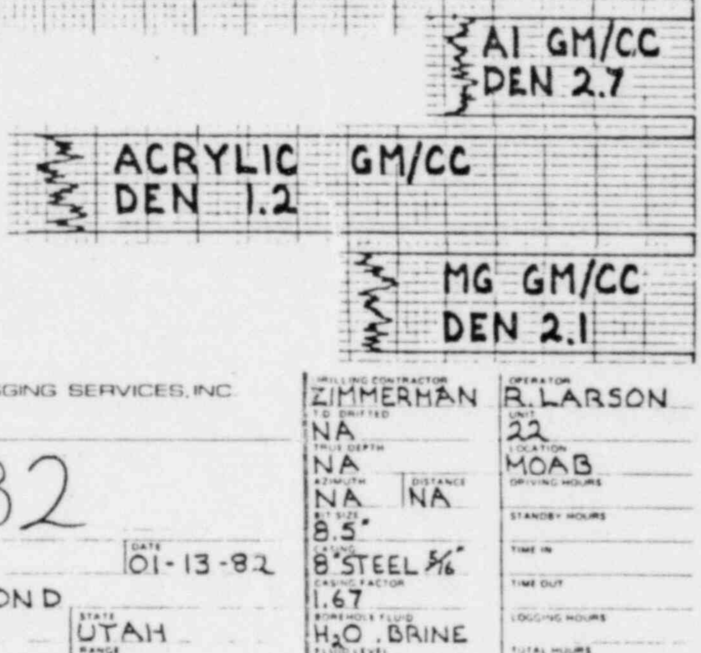


NEUTRON-NEUTRON LOG



GAMMA RAY LOG

GEOPHYISICAL LOGS



PLS PROFESSIONAL LOGGING SERVICES, INC.
Clifton, Colorado 81520

DRILLING CONTRACTOR	ZIMMERMAN
OPERATOR	JIM GENTRY
T.D. DRIFTED	NA
UNIT	25
TRUE DEPTH	
LOCATION	MOAB
AZIMUTH	
DISTANCE	
DRIVING HOURS	
STANDBY HOURS	
BIT SIZE	8½ IN
CASING	8" STEEL 5/16" THK
TIME IN	
CASING FACTOR	1.67
TIME OUT	
BOREHOLE FLUID	H_2O - BRINE
LOGGING HOURS	
FLUID LEVEL	16'
TOTAL HOURS	
VISCOSITY	
DENSITY	
ROUND TRIP MILEAGE	

LOG	NEUTRON	NEUTRON	LOG
RANGE	100CPS/IN	200CPS/IN	
TC	3	3	
RATE			
FROM	404	16	
TO	16	7	
TOTAL			
TAPE			

HOLE NO. ATP-1-82

CLIENT	ATLAS
DATE	01-13-82
AREA	ATLAS TAILINGS POND
COUNTY	GRAND
STATE	UTAH
SECTION	
TOWNSHIP	
RANGE	
ELEVATION	
DEPTH REFERENCE	γγ XTL @ GL
GEOLOGIST	
PROBE NO.	2103-2228
K FACTOR	1.49×10^{-5}
DEAD TIME	5.17 μsec
WATER FACTOR	1.15
AIR FACTOR	1.00
DETECTOR TYPE AND SIZE	XTL ½ × 2½
CALIBRATION / RANGE / TC	γγ Den. 200 CPS/IN
CALIBRATION SOURCE	Al Mg ACRYLIC
SOURCE / SP ACTIVITY / TYPE	B319 20mCi Am^{241}
TEST PIT DATA	DOE G.J. Co. 11-30-81
INITIAL RUN	
T.D. DRILLED	406'
T.D. LOGGED	400'
NATURAL GAMMA RANGE	25 CPS/IN
TC	2
RATE	15 FPM
SP RANGE	NA
RES RANGE	NA
OTHER	BOTTOM OF PROBE @ 405'

LOG	γγ DENSITY	LOG	LOG	LOG
RANGE	200 CPS/IN			
TC	2			
RATE	15 FPM			
FROM	400'			
TO	0'			
TOTAL	400'			
TAPE	01-25-04A			

TOTAL FOOTAGE LOGGED: 400'

DRILLING CONTRACTOR	ZIMMERMAN
OPERATOR	R. LARSON
T.D. DRIFTED	NA
UNIT	22
TRUE DEPTH	NA
LOCATION	MOAB
AZIMUTH	NA
DISTANCE	NA
DRIVING HOURS	
BIT SIZE	8.5"
STANDBY HOURS	
CASING	8" STEEL 5/16"
TIME IN	
CASING FACTOR	1.67
TIME OUT	
BOREHOLE FLUID	H_2O . BRINE
LOGGING HOURS	
FLUID LEVEL	16'
TOTAL HOURS	
VISCOSITY	
DENSITY	
ROUND TRIP MILEAGE	

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION <u>RETAINED</u> ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS <u>LARGER</u> THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION <u>PASSING</u> NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT <u>LESS</u> THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS <u>SMALLER</u> THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT <u>GREATER</u> THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

DAMES & MOORE