QUIVIRA MINING COMPANY

AMBROSIA LAKE FACILITY

DISCHARGE PLAN - 169

JULY 19, 1996

DISCHARGE PLAN - 169

Quivira Mining Company provides the following information pursuant to discharge plan DP-169, approved on November 15, 1995. This discharge plan addresses the tailings disposal system at the Quivira's Ambrosia Lake facility.

The November 15, 1995, approval required Quivira to provide information on the following items:

1. Information relating to actions to be taken, or that have been taken, which will minimize the infiltration of precipitation and surface water into the tailings after cessation of operations.

2. A closure plan for pond 9 and the mill reservoir (radium precipitation pond) which will prevent the creation of leachate which may migrate directly or indirectly into ground water after cessation of operations.

3. Submittal of a plan for the remediation of contaminated ground water in the alluvium attributable to Quivira's operations based on the New Mexico Environment Department standards developed for the alluvium ground water.

For convenience, each issue is presented independently on the following pages.

NMED Condition #1

1. Within six months of receipt of this letter Quivira shall submit information relating to actions to be taken, or that have been taken, which will minimize the infiltration of precipitation and surface water into the tailings after cessation of operations. A narrative describing the actions to be taken, or that have been taken, will be acceptable in lieu of detailed plans, specifications and engineering cost estimates.

Quivira Response

Quivira has been in the process of diligently reclaiming the tailings impoundments for several years. Reclamation activities are being performed in accordance with the U.S. Nuclear Regulatory Commission (NRC) approved reclamation plan, originally approved in September 1990. The NRC approved design will assure that the tailings disposal system will provide reasonable assurance of effectively controlling hazards for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years.

Quivira has exhaustively analyzed the tailings disposal system to ensure that the NRC criteria will be met. The reclamation plan consists of several components, all of which contribute to the overall success of the comprehensive plan. These components are summarized below.

A. Engineered Barrier

To ensure that the tailings were disposed of appropriately, an engineered barrier system was designed for the facility. This engineered barrier was constructed with earth and soil materials whose of geotechnical properties will limit infiltration into the barrier and provide additional plasticity to protect against cracking of the engineered barrier.

The engineered barrier reaches a thickness of 6.3 feet upon impoundment #2 and 7.9 feet upon impoundment #1. For additional conservatism, during construction, Quivira placed an extra 1 foot of cover material upon the side slopes of impoundment #1.

Strict quality control oversight was maintained throughout placement of the engineered barrier. All barrier materials were placed at an overall average compaction of 97% of standard proctor and $\pm 2\%$ of optimum moisture.

As an additional measure, Quivira also placed a frost protection layer upon the designed

barrier, thereby adding additional assurances that the integrity of the engineered barrier remained intact.

The top surfaces of tailings impoundments are designed to achieve a free flow condition. The impoundments are graded such that precipitation will not accumulate on the top surface of the impoundments. Rather, the precipitation will be directed through a spillway at the southern end of impoundment #1 and will run off impoundment #2 as sheet flow. The spillway constructed on impoundment #1 will also contain riprap which will prevent erosion from the precipitation which is directed off the impoundment.

B. Erosion Protection

Quivira's NRC approved tailings reclamation plan incorporates a rock armoring to ensure that the tailings impoundments are adequately protected from erosion. The rock, which is a dark colored extrusive igneous rock (basalt malpais), has been successfully incorporated into the reclamation plans for three other uranium tailings reclamation plans in the area.

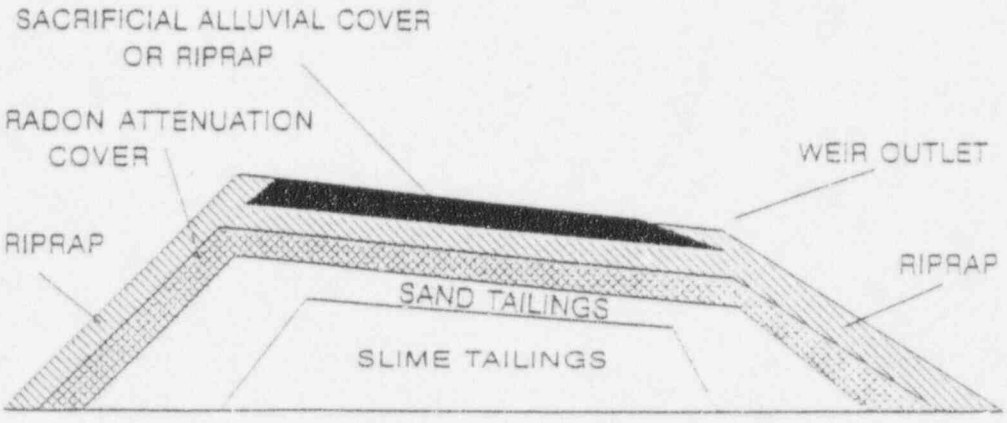
Quivira has overdesigned the basalt rock upon the side slopes of tailings impoundment #1; thereby providing additional protection against a probable maximum precipitation (PMP) event.

Quivira will also place a layer of similar quality basalt rock on the top surface of impoundments #1 and #2 which will result in added erosion protection.

A generalized schematic cross section of the engineered barrier utilized for tailings reclamation is presented within Figure 1.

FIGURE 1

Generalized Cross Section
Engineered Barrier



C. **Surface Water Runoff**

Quivira's approved reclamation plan incorporates engineering designs for the control of surface water in the vicinity of the tailings impoundments. This design includes the rock armoring upon the two impoundments, as discussed within the subsection entitled "*erosion protection.*"

Another facet incorporated into the reclamation plan for the control of surface water is the design and construction of a diversion channel along the southern boundary of the facility. This channel is designed to collect and divert surface water runoff from not only the top surfaces of the tailings impoundments; but also from the watershed located upstream from the impoundments.

This channel is a 5H:1V trapezoidal shaped channel will contain riprap with a D_{50} of 1 inch in all areas which are not excavated in rock. The diversion channel was designed to carry the PMP water safely around the tailings facilities, thereby preventing erosion along the base of the impoundments.

The NRC approved reclamation plan will not only result in achieving NRC closure requirements; but the plan will also ensure that the reclamation measures implemented will prevent an exceedence of the applicable ground water standards established for the facility.

D. Elimination of Recharge Sources

To complement the measures Quivira has undertaken in the tailings reclamation program, Quivira discontinued the use of all unlined evaporation ponds in 1983 and proceeded with reclamation of these ponds. Discontinuing the use of the ponds resulted in eliminating one of the sources of recharge to the alluvium. In conjunction with this, the removal of ponded solutions on the tailings impoundments contributed to the elimination of potential recharge to the alluvium.

As a result of eliminating these recharge sources, continued implementation of the present alluvial ground water remediation plan is expected to ensure compliance with the applicable ground water standards established for the facility.

NMED Condition #2

2. Within six months of receipt of this letter Quivira shall submit a closure plan for pond 9 and the radium precipitation pond which will prevent the creation of leachate which may migrate directly or indirectly into ground water after cessation of operations. A narrative describing the actions to be taken, or that have been taken, will be acceptabie in lieu of detailed plans, specifications and engineering cost estimates.

Quivira Response

The reclamation process to be taken for the closure of pond 9 and the mill reservoir (radium precipitation pond) are similar to those previously discussed for the tailings impoundments presented within Quivira response to NMED Condition #1. These actions will be implemented upon final cessation of all operations at the Ambrosia Lake facility.

Specifically, in regards to pond 9, upon final cessation of operations at the Ambrosia Lake facility, the solutions remaining within the lined pond will be allowed to evaporate. This will allow the residual materials to sufficiently dry thereby enabling heavy equipment to safely work in the area. The material will be characterized such that the appropriate radon attenuation cover can be designed and constructed to control radon emanation and to prevent the creation of leachate.

Upon sufficiently being dried to allow heavy equipment to safely work the material, the pond residue material will be placed within the present interceptor trench for final disposal. This location will provide a disposal location which is below grade in accordance with NRC's prime option as indicated within 10 CFR §40, Appendix A. As the material is being placed, it will be generally compacted to approximately 90% of standard Proctor.

Once the material has been placed within the disposal location, an impermeable earthen layer having a permeability in the range of 10^{-6} to 10^{-8} cm/second will be constructed to cover the placed material. This layer will prevent infiltration of precipitation into the material thereby preventing the creation of leachate.

Upon completion of the impermeable layer, the other layers of the radon attenuation barrier will be constructed to meet the generally desired geotechnical compaction specifications of 95% of standard Proctor and $\pm 2\%$ of optimum moisture. Upon completion, the necessary frost protection layer and erosion protection measures will be instituted to assure protection of the reclaimed site for a minimum of 1,000 years. Upon final conclusion of reclamation activities, in accordance with the Atomic Energy Act of 1954, as amended, the area will be

deeded to the State of New Mexico at its option or to the U.S. Department of Energy for perpetual care and maintenance.

In regards to closure of the mill reservoir, the process will be very similar except that portions of the mill facility are scheduled to be disposed of within the mill reservoir area. The materials to be disposed of within the mill reservoir area will be placed such that voids will be minimized to the extent practicable. To help minimize voids within the disposed material, the disposed material will be placed within the disposal area in approximately 3 to 4 feet increments with an earthen layer of approximately 1 to 2 feet thick placed between the layers of disposed material.

Upon completion of this activity, the necessary radon attenuation and frost protection barriers will be constructed to provide radon emanation and prevent infiltration into the material. These barriers will be constructed to meet the generally desired geotechnical compaction specifications of 95% of standard Proctor and $\pm 2\%$ of optimum moisture. Upon completion, erosion protection measures will be instituted to assure protection of the reclaimed site for a minimum of 1,000 years. Upon final conclusion of reclamation activities, in accordance with the Atomic Energy Act of 1954, as amended, the area will be deeded to the State of New Mexico at its option or to the U.S. Department of Energy for perpetual care and maintenance.

NMED Condition #3

3. Within six months of receipt of this letter Quivira Mining Company shall submit a plan for the remediation of contaminated ground water in the alluvium. The areas of contamination which are attributable to Quivira's operations shall be outlined on a topographic map of the area. If there are areas of alluvial contamination which Quivira does not consider attributable to their operations, Quivira shall support their conclusions by submitting documentation such as stiff diagrams, ion ratios and/or other supporting evidence for NMED review and approval. The standards for the alluvium ground water shall be based on the nine alluvial wells listed in the AOD dated April 15, 1984, and the standards listed in § 3-103 of the WQCC regulations. The existing concentration shall be established as the average concentration in the nine alluvial wells for contaminants specified in § 3-103 of the WQCC regulations.

Quivira Response

A. Background Information

The existing baseline concentrations for the alluvial unit at the Ambrosia Lake facility was developed as a result of the promulgation of the New Mexico Water Quality Control Commission (WQCC) regulations and in conjunction with the NMED agreement entered into with Quivira under the 1983 Assurance of Discontinuance (AOD). The existing baseline concentration was determined using nine (9) alluvial wells as being representative of existing concentrations within the alluvium. Analytical results for these nine wells, which were sampled on a quarterly basis for one year, were averaged to obtain the ground water standards for the alluvial unit. For those constituents whose existing concentration exceeded the WQCC numeric ground water standard, the existing concentration was established as the ground water standard. Otherwise, the numeric standard listed within the WQCC Regulations became the established ground water protection standard for the site. As a result of this process, the NMED ground water standards established for the alluvial unit for Quivira's Ambrosia Lake facility are presented within Table 1.

TABLE 1

NMED GROUND WATER STANDARDS FOR DISCHARGE PLAN DP-169
(all values in mg/l unless indicated)

PARAMETER	STANDARD
Ag	0.05
Al	5.0
As	0.18
B	0.75
Ba	1.0
Cd	0.02
CN	1.0
Co	0.05
Cr	0.06
Cu	1.0
Fe	40
F	1.6
Hg	0.002
Mn	2.6
Mo	1.0
Ni	0.2
Pb	0.16
Se	0.29
V	10.0
Zn	10.0
Cl	1343
SO_4	3865
TDS	8322
NO_3	54
U	5.0
Ra226/228	30.0 pCi/l
Benzene	0.01
pH	6-9

B. Hydrogeolgic Impacts

Prior to mining, historical information and records indicate that the alluvium within the Ambrosia Lake valley was essentially a dry formation. The present source of ground water within the Ambrosia Lake valley is the result of mine water discharge and tailings seepage. Mining operations commenced in the Ambrosia Lake area in 1957 with the initial dewatering of the underground mines. This dewatering resulted in the surface discharge of mine water which eventually infiltrated into the alluvium. Milling operations within the Ambrosia Lake area were initiated the following year (1958) by Kermac Nuclear Fuels and Phillips Petroleum. These operations involved the disposition of process solutions and tailings material into unlined tailings impoundments. The solutions from these impoundments seeped into the alluvium and commingled with the solutions from mine dewatering ultimately creating various ground water characteristics within the alluvium across the Ambrosia Lake valley. The location of these various operations are shown on Map 1. As indicated on the map, several mines and two mills operated within two miles of each other creating a mix of various ground water characteristics within the alluvial unit.

The alluvial material, unlike the bedrock formations which generally dip uniformly to the northeast and are typically consistent in thickness across the area, has a variable thickness with numerous and often indistinct layers within it related to soil profile formation and changing patterns of deposition. The historical erosional valley that developed on the Mancos shale and Tres Hermanos sandstone was subsequently filled with sediment through wind and water deposition to a maximum thickness of approximately 100 feet. An alluvium isopach map for the Ambrosia Lake valley is presented within Map 2.

As indicated on the map, solutions within the alluvial valley have generally migrated in two predominant directions prior to their commingling and their subsequent movement in a southerly direction through Section 5 as the ground water exits the valley. On the west side of the erosional valley which includes the Quivira site, alluvial solutions initially migrate northeast and east ultimately swinging south as they flow towards the deepest part of the alluvium along the erosional valley created in the underlying formations. Solutions from the east side of the valley in the vicinity of the Phillip's uranium tailings disposal area generally move in a southwesterly direction prior to veering south to follow the deepest part of the alluvial valley unit.

Due to the different effluent sources and the varied flow paths each follows within the historical erosional valley and its channels, the present day distribution of ground water characteristics is varied across the alluvium. This has caused distinct parameter concentrations to occur. Based on these distinct parameter concentrations and historical

knowledge of the area, the extent of contamination from the Quivira site is presented below.

C. Extent of Contamination

Quivira's mill facility is an acid leach process utilizing sulfuric acid and sodium chlorate for uranium recovery. The resultant waste stream consisting of the primary constituents chloride, sulfate, radium-226, and uranium. Utilizing these characteristics along with the flow regime in the alluvium, the extent of contamination from Quivira's mill facility is presented within Map 3.

As shown in Map 3, the extent of contamination from Quivira's mill is intrinsically influenced in large degree by the construction and maintenance of the alluvial interceptor trench. Construction of the interceptor trench, which was initiated in 1984 after the AOD agreement was reached between the State of New Mexico and Quivira, has maintained a hydrologic sink in the local area causing alluvial solutions in the region to migrate back towards the trench where they are being intercepted and removed from the system. The intercept trench was ultimately constructed to a depth of up to 36 feet and stretches over a distance of approximately 6200 feet.

The large hydrologic sink caused by the intercept trench, in combination with the fresh water recharge from the facility's NPDES permit channel, which is used as a hydrologic recharge to assist in sweeping solutions back towards the trench, has been successful in remediating the alluvium which was impacted by Quivira's acid leach process. This ground water sweep methodology has removed an estimated 530 million gallons of solutions to help remediate the alluvium. This action has significantly reduced the contamination concentrations as demonstrated by the overall reduction of the solution concentrations in the monitor wells along the influence of the intercept trench.

To assist in determining the extent of contamination caused by its tailings facilities, Quivira reviewed the distribution of the various chemical characteristics found within the alluvium. This review of the trends in the data clearly indicate that other sources have contributed to the contamination problem and thus, not all the impact is the result of Quivira's milling operation.

This review utilized various conservative parameter ratios which could indicate other possible effluent sources. The conservative parameters utilized to assist in this review were sulfate, chloride, and total dissolved solids (TDS). These parameters were selected as they are not usually subject to natural geochemical reactions, thereby making them good tracers for other potential sources which have different ion ratios from those

generated by Quivira's acid leach process. Quivira's tailings solutions which entered the alluvium have an approximate TDS/chloride ratio of near 4 and a sulfate/chloride ratio of approximately 2.

An examination of these ratios in the Ambrosia Lake alluvial unit across the valley clearly indicates the presence of other sources of solutions that affect water quality characteristics. This examination is seen in Maps 4 and 5, which plot the characteristics of these ratios. As shown on Map 4, the ion ratio of TDS/chloride concentrations indicates that the ratio dramatically increases with distance from Quivira's operation as the ratios increase from 4 to in excess of 30. The ground water characteristics and the associated impacts from seepage originating from an acid leach process would not show such a striking change as chloride is generally a conservative parameter and not geochemically reactive. Thus, the significant increase in the TDS/chloride ratio is indicative that another source(s) of solutions within the alluvial formation were necessary to create these ion ratios.

A review of potential sources indicates that TDS/chloride ratios in excess of 20 are indicative of typical carbonate (alkaline) leach processes.[1] The primary chemicals used in a carbonate leach process to recover uranium are sodium carbonate (Na_2CO_3) and sodium hydroxide (NaOH) followed sulfuric acid and ammonia in the precipitation process. This process also results in effluents having a basic pH. An analysis and reconnaissance of the area indicates that these higher TDS/chloride ratios are located in the eastern segment of the alluvial ground water regime where ground water movement is to the southwest.

Another ratio which can be utilized to differentiate sources is the sulfate/chloride ratio. Typically, the sulfate/chloride ratio at an acid leach process is approximately 2 while the sulfate/chloride ratio at a carbonate leach facility normally exceeds 20. A review of this indicator ratio concurs and supports the TDS/chloride analysis which shows other source(s) of solutions have affected the ion ratios. The sulfate/chloride ratio analysis is shown in Map 5.

A review of Quivira's wells located on the east side of the Ambrosia Lake alluvial valley regime and where solutions flow to the southwest bolster this conclusion. The TDS/chloride and sulfate/chloride ratios for monitor wells 32-57 and MW-30, both of

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[1] U.S. Department of Energy, "Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings at Ambrosia Lake, New Mexico," UMTRA-DOE/AL-050516.0000, December 1985, p. D-255.

which are located along the eastern reaches of Quivira's monitoring network, show ion ratios which are not indicative of acid leach solutions. Rather, these two wells contain ratios similar to those which would typically be associated with a carbonate leach process as their ion ratios for TDS/chloride and sulfate/chloride are each in excess of 20.

Quivira also reviewed the pH analysis at these wells. Presented within Table 2 are historical pH results which show that both wells in the early 1980's indicated a basic pH, opposite of solutions associated with an acid leach process. Table 2 provides a summary for the two wells indicating that the pH in well MW-30 has improved toward neutral conditions while well 32-57 continues to remain on the basic side of neutral.

Due to the many historical influences caused by the different mining and milling operations in the area, it is difficult to ascertain the exact impact each has had on the characteristics of the ground water present within the alluvial unit. Quivira, recognizing this fact, prepared Map 3 by analyzing and acknowledging available historical information. This map presents the areas of contamination in excess of the established NMED alluvial ground water standards for Quivira's Ambrosia Lake facility believed to be attributable to seepage from its tailings and evaporation ponds.

Table 2
Monitor Well Comparison: MW-30 and 32-57

WELL	DATE	pH	Chloride (mg/l)	TDS (mg/l)	Sulfate (mg/l)	TDS/Cl Ratio	Sulfate/Cl Ratio
MW-30	9/1980	7.9	41	3852	2450	90	60
	1/1991	7.3	72	3660	2390	50	33
	1/1996	7.2	76	3350	2190	50	29
	Average	7.5	63	3621	2343	57	37
32-57	4/1984	8.5	120	4429	1533	37	13
	5/1991	8.8	64	6300	4470	95	70
	10/1995	8.2	198	7090	4930	35	25
	Average	8.5	127	5940	3644	59	29

D. Corrective Actions

Quivira has implemented several corrective measures as part of its overall program to mitigate and remediate the impact to the alluvial unit caused by its operation. These include:

- Establishing the Assurance of Discontinuance (AOD) between Quivira and the Water Quality Control Commission;
- Re-alignment of the Arroyo del Puerto to divert surface water flows around the evaporation ponds and utilizing the fresh water recharge as a component of the alluvial ground water sweeping action;
- Discontinue the use of and the removal of ponded solutions from all unlined evaporation ponds;
- Removal of ponded solutions from the tailings impoundments;
- Elimination of all recharge waters into the impacted formations through the on-going tailings reclamation process;
- Construction and maintenance of the intercept trench for the collection and removal of tailings seepage and ground water sweep solutions; and
- Construction of an intercept trench/french drain system west of tailings impoundment #2 to collect and dewater the tailings.

These actions have been successful towards the remediation of the alluvial unit with the intercept trench continuing to be the major focus of the remediation efforts for the alluvium. The reverse hydraulic gradient created in the trench in conjunction with the NPDES discharge waters continue to flush and sweep solutions back towards the intercept trench resulting in improved water quality within the impacted alluvium.

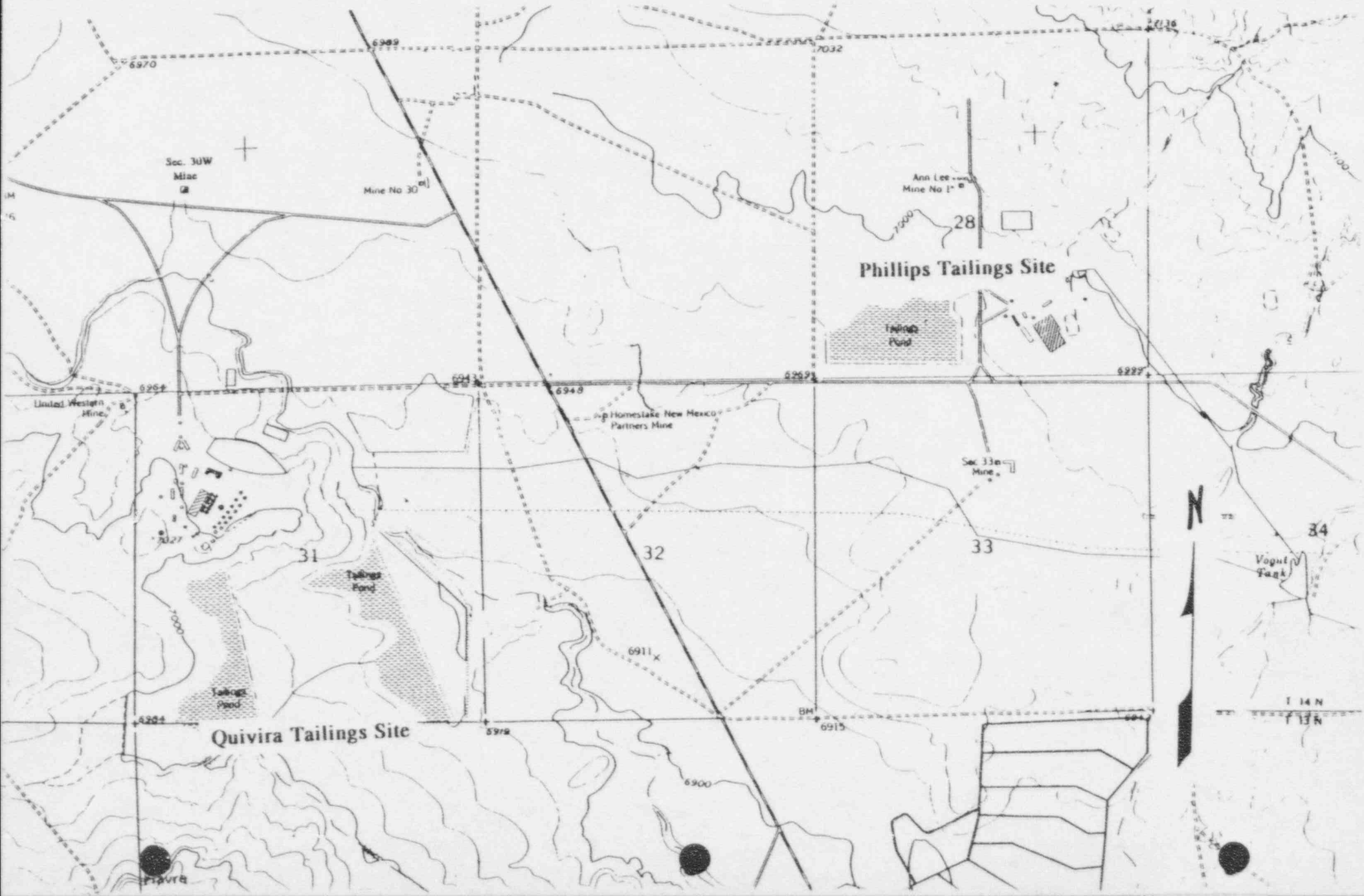
As part of its effort to optimize remediation and recognizing the limited influence of the intercept trench along its southern flank, Quivira is presently installing a series of smaller intercept trenches just south of the pond 9/10 area to collect and remove any solutions that may exist within the alluvium resulting from historical milling operations. These trenches are depicted on Map 6, and will have the affect of "dewatering" any residual alluvial water in this area to assure that these solutions are collected and removed from

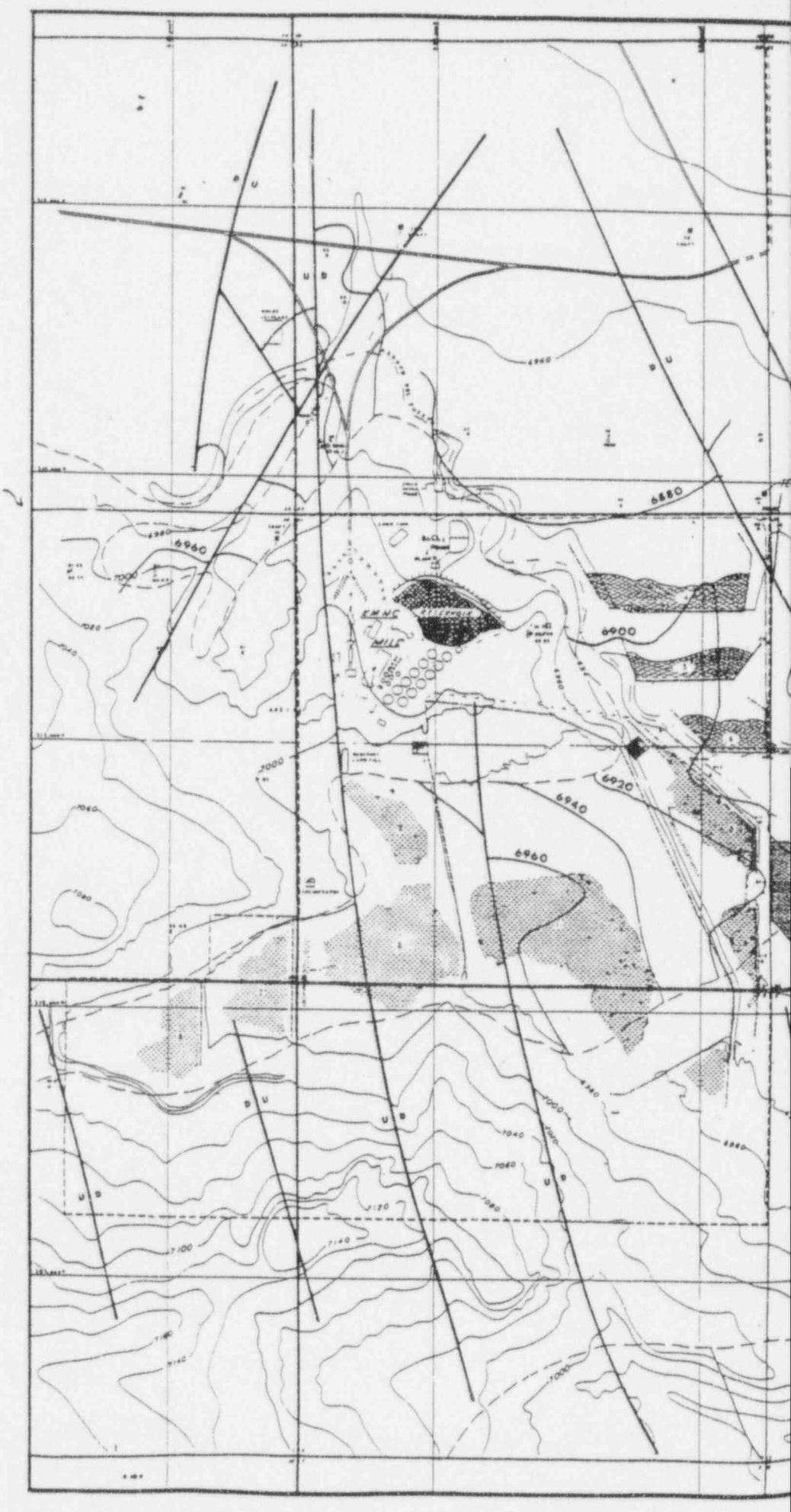
the alluvial unit so they do not impact waters beyond this area.

In conjunction with the construction of these mini-collection trenches to dewater the alluvium in this area, Quivira is in the process of upgrading the southern portion of the intercept trench by widening and deepening the trench to continue to provide assurances that any remaining seepage from the tailings impoundment is effectively being intercepted, collected, and removed from the system. The full results and analysis of these activities will be reported as part of the annual report. Quivira believes these planned activities along with the continued operation and maintenance of those corrective measures previously implemented will continue to effectively remediate the alluvial unit impacted by Quivira's mill operations.

M. . 1

AMBROSIA LAKE AREA

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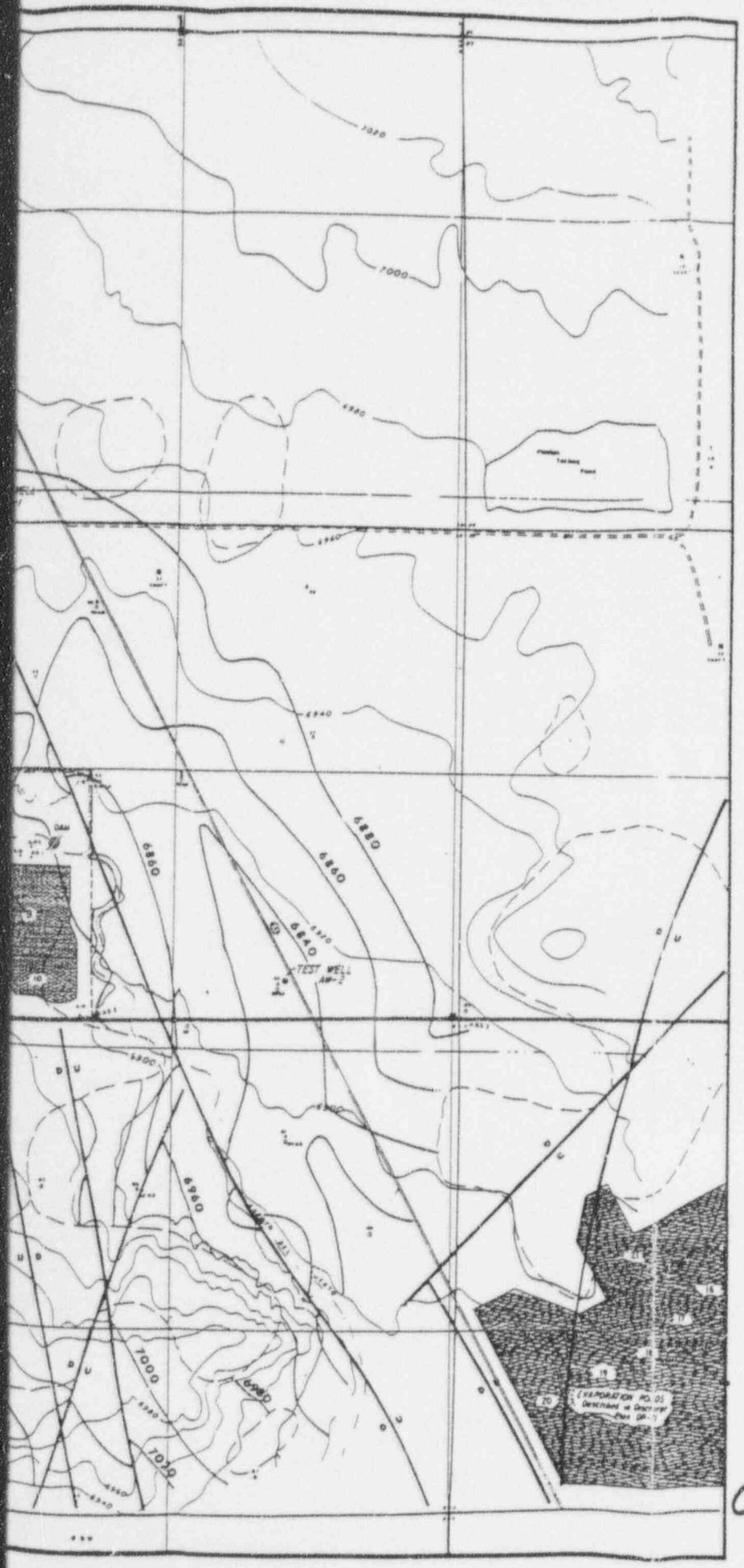

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Rev. No. 0 Date 10/1/86

EXPLANATION

6880 STRUCTURAL CONTOUR ON BASE OF ALLUVIUM. REFERENCE IN FEET TO MEAN SEA LEVEL. CONTOUR INTERVAL = 20 FT

D D FAULT IN BEDROCK WITH UP AND DOWN THROWN SIDES INDICATED.

SEE FIG. 3 FOR AN EXPLANATION OF ALL OTHER MAP SYMBOLS

SCALE

MAP 2

STRUCTURAL MAP FOR THE BASE OF THE ALLUVIUM

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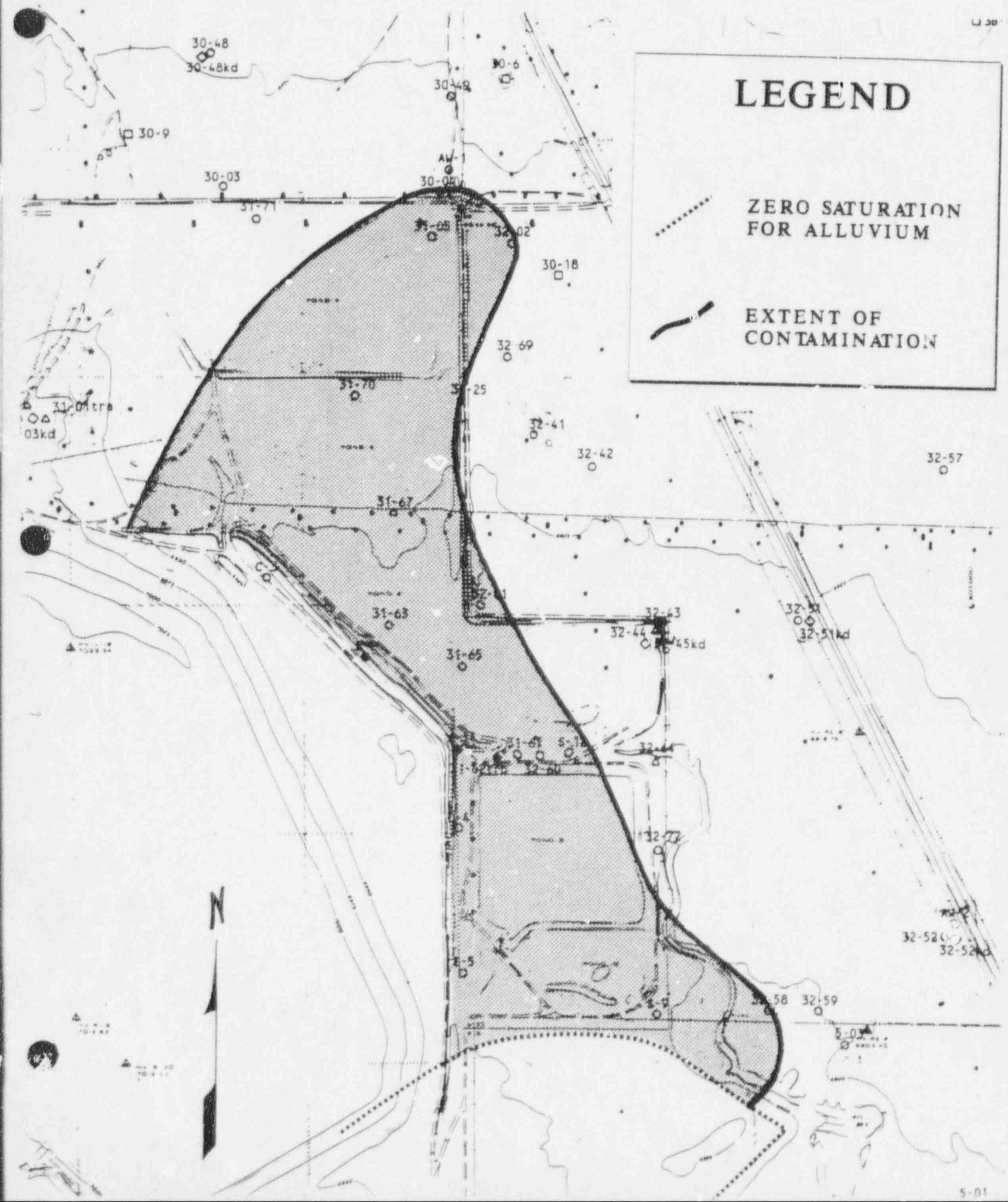
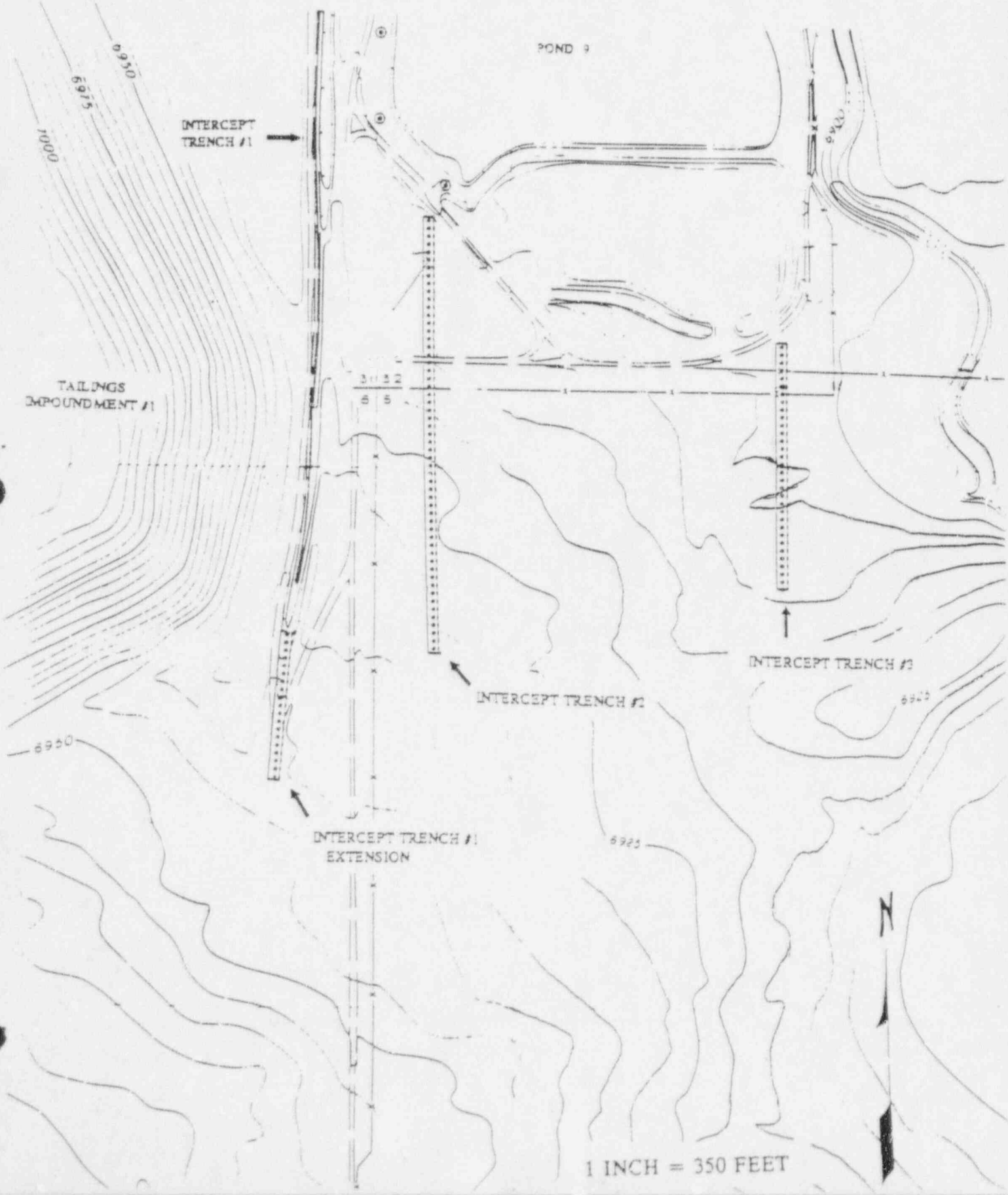
MAP 3

QUIVIRA MINING COMPANY
EXTENT OF ALLUVIAL GROUND WATER CONTAMINATION



MAP 6

GROUND WATER PROJECTS



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