

Report on Hydrological Connection
Associated With Molycorp Mining Activity,
Questa, New Mexico

Prepared for:

USEPA, Region 6
NPDES Permits Branch (6WQ-P)

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EXECUTIVE SUMMARY

This study was initiated following a request from the EPA Region 6 National Pollution Discharge Elimination Systems (NPDES) Permits Branch for assistance in determining if mining activities at the Union Oil of California Molycorp (Molycorp) Questa Molybdenum Mine and associated tailings ponds are a source of contamination to the Red River. Specifically, the request was to determine if these mining activities are resulting in the discharge of acidic, metal laden ground water to surface water via seeps along the Red River through a ground water hydrological connection. The study was conducted by the EPA Region 6 Ground Water Center of Excellence (GWCE). The NPDES Permits Branch supplied several technical reports and correspondence pertaining to the Molycorp site for review. Additional information was acquired from the New Mexico Environment Department (NMED), Molycorp, conservation groups, and a site visit.

With respect to this report, the Molycorp site consists of the actual mine located between the towns of Red River and Questa, New Mexico; and the Questa Valley tailings pond area, located approximately 10 miles downstream from the mine area near the town of Questa. This study focuses on river seeps (ground water flowing gently from the river bank above river water level) in reaches of the Red River adjacent to the Molycorp mining operations and tailings ponds. The seeps are the primary non-point source discharge relative to the NPDES program at these sites. For this investigation, the GWCE evaluated the available geologic, water quality and well test data to determine 1) if ground water and adjacent Red River seep water contamination exist, 2) the probable source for ground water contamination, and 3) if a ground water hydrological connection exists between the source and the contaminated ground water discharged by seeps to the river. As with all reports reviewed during this study, some conclusions in this report are based on the application of scientific principles relative to the issues.

The Red River has 21 perennial tributaries which originate as very high quality mountain streams. Those tributaries which are not near sulfide rich outcrops or historic or recent mining areas remain high quality streams until their confluence with the Red River. The NMED reported that long-time residents considered the Red River pristine prior to mining operations. However, Molycorp contends that its mining operations cannot be the only source for the acidic, high metals seep discharge due to the fact that place names such as Sulphur Gulch, Bitter Creek and Red River allude to the conditions that existed when the region was settled. River water quality in some areas up-river of the mine site is periodically affected by storm events which deliver elevated metals concentrations (above surface water standards) to the river. The NMED states that there are a number of ground water related nonpoint sources of contamination to the river, and that sampling shows that the greatest impact is from acidic, high metals seeps.

Seeps discharge acid rock drainage (ARD) into the river in the mountainous region of the Red River watershed. ARD is characterized by low pH, and elevated concentrations of metals and total dissolved solids (TDS) which typically exceed New Mexico Ground Water Standards (NMGWS). The most common mechanism for its formation involves the oxidation and hydration of sulfide minerals (e.g., pyrite, or iron sulfide) resident in the source rock (volcanic rhyolite).

This chemical reaction results in the generation of sulfuric acid and elevated concentrations of iron. Rhyolite is found in naturally occurring erosional scars within the watershed, and in Molycorp's waste rock dumps (WRDs). The primary metals involved in contaminant transport include; aluminum, magnesium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, and zinc.

There are two general modes of contaminant transport in the mountainous region (which incorporates the mining area) of the Red River watershed: steady-state, and pulse loading. In pulse loading, large volumes of weathered sulfide rock are periodically transported to stream channels by storm events. Regional sampling conducted by the NMED revealed that metal loading problems associated with pulse events are

largely temporal, and that in most cases a degree of equilibrium is restored to affected stream reaches within a few days. Molycorp has recently constructed a surface water collection system to capture and redirect most of the runoff within the mining area. This system is designed to reduce pulse loading to this reach of the river. Steady-state refers to the relatively continuous discharge of ground water to the river.

At the mine site, the erosional scar and WRD geochemistry are correlative to the adjacent ground water quality. Constituent correlation also exists between ground water and the discharge at seeps along the river. Data from several monitor wells indicate that the shallow alluvial aquifers are saturated, and that these aquifers have the potential to transport low pH ground water with high metals concentrations to surface water. In addition, United States Geological Survey (USGS) data indicate that this particular reach of the Red River is a gaining stream supplied by ground water. Therefore, the erosional scars and WRDs are most probably hydrologically connected through a shallow alluvial aquifer conduit to the Red River seeps within the mine property.

The tailings ponds contain spent slurry from the mine site. Surface water runoff, which contains ARD, is collected and used for milling operations. The milling operations generate the spent slurry which is then piped to the ponds for disposal. The pond fluid is characterized by low pH and high metals concentrations (i.e., ARD). Although Molycorp has constructed a surface water drainage system to divert runoff from entering the pond area, sulfate and metals concentrations found in ground water below and down gradient of the tailings ponds exceed NMGWS due to infiltration of pond slurry water containing ARD. Due to the area's gentle surface gradient and the surface water collection system, steady-state (i.e., ground water) appears to be the only mode of transport within the tailings pond area.

A ground water hydrological connection via the shallow alluvial aquifer exists between the tailings ponds and seeps adjacent to the Red River. Seep discharges in this area are characterized by sulfate concentrations slightly above ground water background. However, metals concentrations do not exceed NMGWS or NMSWS at these seeps. River water quality adjacent to the tailings ponds appears to meet New Mexico Surface Water Standards (NMSWS).

According to the NMED, the seeps down gradient of the tailings ponds are part of a continuing Molycorp monitoring program, which indicates that seep water quality is not deteriorating. Molycorp has constructed a shallow ground water collection system to capture pond leachate being transported to the river; however, some contaminants bypass this system. Molycorp is presently installing extraction wells to capture leachate that bypasses the collection system.

In summary, this investigation concluded that the possible sources for the high metals and sulfate concentrations discharged to the river at the mine site are: 1) historic and recent mine waste rock, 2) erosional scars, 3) remnant deposits of tailings resulting from pipeline breaks, 4) a landfill area at the head of Spring Gulch, 5) the Moly tunnel, (6) the caved area in Goathill Gulch, and 7) runoff directed to the underground workings for collection. Of these, the most probable sources are considered to be the WRDs and the erosional scars based upon the results of material analysis and water quality; and that the acidic seeps and these two sources are wide spread while other sources are localized. The only probable source of ground water contamination at the tailings ponds area are the ponds.

The NPDES Program regulates point sources. NPDES regulations (40 CFR, §122.2) define point source as "any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, - from which pollutants are or may be discharged..." A documented ground water hydrological connection between a source and surface water discharge may be viewed as a conduit; or a discernible, confined, and discrete conveyance. To identify the source for surface water contamination, proper sampling and monitor wells are required to verify constituent correlation and a ground water hydrological connection between the source and the discharge to surface water. Support exists for a ground water hydrological connection between a source and surface water

discharge if water quality analysis and monitor well data determine that 1) there is reasonable constituent correlation between surface discharge, source leachate, and ground water; 2) the ground water gradient is to surface water (gaining stream); and 3) aquifer characteristics support a connection. The most probable sources (erosional scars, waste rock dumps, and the tailings ponds) satisfy these requirements. The tailings ponds supply water and elevated metals concentrations to the ground water through infiltration, but no documentation exists for the ponds being a source of river metals concentrations. Therefore, it appears that contaminants in ground water are attenuated prior to the discharge of ground water and pond water to the river in this area. At the mine site, the percentage of metals concentrations or discharge volume supplied to a particular seep by each probable source (erosional scar or waste rock dump) could not be determined using the available information.

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1.0

INTRODUCTION

The objective of this report is to determine the source for the acidic, high metals seeps (ground water flowing gently from the soil) along the Red River bank and to determine if sufficient documentation exists to substantiate a ground water or surface water hydrological connection between the source and seep discharge to the river. Surface water drainage pathways were evaluated to determine if surface water runoff could supply contaminants to the seeps. Monitor well tests and ground water quality data were evaluated to determine if subsurface pathways existed between the source and the seeps.

The Amigos Bravos and New Mexico Citizens for Clean Air and Water conservation groups (hereafter referred to as Amigos et al) contend that the Union Oil of California Molycorp (or Molycorp) excavation and disposal activities at the mine site are the cause for the increase in metals concentrations delivered to the river through a ground water hydrological connection to seeps located along the river bank. Amigos et al, have requested that the Region 6, National Pollution Discharge Elimination System (NPDES), Permits Branch require Molycorp to obtain a permit for this ground water discharge. The New Mexico Environment Department (NMED) considers the acidic, high metals seeps, which exist within the Molycorp mine boundary, the principal cause for metals loading to this reach. In contrast, Molycorp considers the erosion and surface water transport of sulfide rich naturally occurring erosional scar material as the major source of metals loading to the river. Therefore, although all possible sources were evaluated as to their relative metals contribution to surface water, this report concentrates on historic and recent mine sites and natural factors which may be a source for the continuing degradation of the Red River.

The Red River watershed is located in north central New Mexico, Taos County. Studies by the United States Geological Survey (USGS) and others have documented that for most of its length, the Red River is a gaining stream supplied by groundwater. As indicated in Appendix 1, the river is classified in the New Mexico Standards for Interstate and Intrastate Streams from the Rio Grande upstream to the mouth of Placer Creek with the following uses: coldwater fishery, fish culture, irrigation, livestock watering, wildlife habitat, and secondary contact. It has been documented (NMED, March 1996) that Red River standards are most often not attained due to various non-point sources. Its impairment is mainly due to the influx of low pH levels, metals, biological toxins, septic tank effluent, municipal sludge, petroleum products, and sediment loading due to storm events. The most incessant and wide-spread effect to river water quality is from the influx of fluids with low pH and high metals concentrations, which are delivered to the river via ground water transport to seeps along the river and surface water runoff.

As illustrated by [Figure 1](#) and [\[Figure\] 2](#), the Molycorp mining operations include the open pit, old and new underground mining areas, waste rock dumps (WRDs), a mill site and associated tailings piles. The Molycorp mine property is located north of the Red River and Highway 38 between the towns of Red River and Questa and incorporates approximately five square miles. Molycorp began the underground mine workings in 1923 for molybdenum, an element used in strengthening steel. In 1941, mining had extended to such depths that a mile-long tunnel (hereafter referred to as the Moly Tunnel) was constructed to facilitate drainage of the underground workings into the Red River. In 1965, Molycorp abandoned the underground working and switched to open pit operations over the existing underground mine. Within this period, the Moly Tunnel was closed by placing concrete plugs at each end. To obtain access to the subsurface molybdenum deposits, during open pit operations the overlying surface material was excavated and deposited progressively down gradient in canyons as WRDs. Molycorp has covered approximately 500 surface acres near the operations with hundreds of feet of this waste rock material. In 1983, Molycorp ceased open pit operations and commenced new underground mining approximately 4,000 feet southwest of the old location. Mining operations were temporarily suspended from 1986 to 1989 and from 1992 to 1995 due to general economic conditions.

To alleviate the low pH and high metals loadings to the Red River adjacent to the Molycorp mine site, Molycorp (with NMED assistance) dug trenches and installed a series of anoxic alkaline (limestone) filters in

early 1996 at a site along the river (Capulin Canyon) where NMED considers several of the seeps particularly active. Prior to limestone placement, the NMED determined that ground water quality from the trenches was correlative to the adjacent Red River seep water quality. However, after a short period of time, these filters became ineffective in modifying the pH and metals content.

The tailings impoundment is located approximately six miles west of the mine near the town of Questa and incorporates approximately 640 acres. After the molybdenite is extracted at the mine site through milling operations, the spent slurry is pumped out of the mining area through a ten mile pipeline constructed along the Red River to the tailings ponds at Questa. Since 1965, Molycorp has discharged approximately 95 million tons of tailings into the Questa impoundments.

The tailings impoundment, as illustrated on [Figure 3](#), consists of several inactive and two active unlined ponds. The ponds were constructed consecutively within two arroyos by placing earthen dams at the down gradient end of each pond. South Pass Resources (April 13, 1995) reported that the slurry delivered to the ponds consists of 38 percent solids and 62 percent liquids. Standing water in the ponds was originally collected by surface drains and directed to Pope Lake, which is located south of Dam No.4, and then to the Red River. In the 1970's Molycorp installed seepage barriers to intercept seepage and shallow ground water south of Dam No.1 and southeast of Dam No.4. Vail (September 24, 1993) states that these barriers were effective for some time but recent evidence indicates they are less effective in decreasing metals concentrations. In 1983, Molycorp installed an ion exchange facility to process the water at Pope Lake prior to discharging it to the river. An additional drainage system has been installed beneath both dams which consists of chimney drains connected to under drains at the base of the dam. Vail (September 24, 1993) states that Molycorp is presently investigating the feasibility of constructing additional seepage barriers and/or other facilities to substantially reduce the seepage flow down gradient of the tailings ponds in this area.

Several private wells located down gradient of the ponds were used by residents for drinking water purposes. In 1976 Molycorp plugged several of these wells and re-routed service from the Questa community well system due to elevated sulfate and Total Dissolved Solids (TDS) concentrations making private well water unacceptable as a drinking or irrigation source.

The NMED (March, 1996) states that in 1966, in response to Molycorp operations, the United States Department of Health, Education and Welfare conducted a baseline water quality survey of the Red River. The survey revealed that although there was periodic metals loading due to storm events from small historic mine sites adjacent to the river, the overall river water quality was determined to be good to exceptional. In 1971, the EPA determined the chemical water quality of the river remained good except for contamination resulting from occasional breaks in the tailings pipeline. However, in the same time period, the New Mexico Department of Game and Fish discovered the absence of a once thriving fish population in the reach adjacent to the mine. A 1982 EPA study concluded that the river was substantially impaired from metal loading, but no definitive source was determined. The NMED (March, 1996) reports that in 1984, the Bureau of Land Management documented pollution sources and found a downstream increase of various constituents, which at times exceeded water quality standards, and determined the major impacts on water quality were due to mining activities.

As indicated by [Figure 2](#), there are three National Pollution Discharge Elimination System (NPDES) permitted point sources (outfalls) within the Red River watershed: the town of Red River treatment plant, the trout hatchery at Questa, and one permit for four Molycorp discharges (two outfalls at the tailings ponds (Questa) and two at the mine site). The NMED (March 1996) concluded that only the waste treatment plant discharges upstream of the most impacted reach of the river, with the effluent considered good quality. The hatchery is downstream of the impacted portion of the river, with its effluent apparently improving river water quality through dilution.

Molycorp operates within two topographically diverse areas of the Red River watershed. As illustrated by [Figure 4](#) and [\[Figure\] 5](#), the mining operations are located within a mountainous region. The tailings ponds are located within the Questa valley, which is an area of low relief ([Figure 3](#)). Due to differing depositional environments; aquifers in each area have different relief, intrinsic characteristics (grain size, porosity, etc.) and ground water chemistry. In addition, surface gradient and vertical hydraulic conductivity dictate the percentage of precipitation which will infiltrate to recharge ground water. Therefore, the tailings ponds and mining area were evaluated separately.

Reports on sample studies and historic observations from Molycorp, conservation groups, and the NMED were reviewed to determine if sampling methodology, surface/subsurface geology and historic research were adequate to identify the probable sources for the acidic, high metals Red River seeps in these areas. Available data for this evaluation consisted of 1) pre and post-mining topographic maps; 2) ground water data (well tests, depth to water, and quality); 3) whole rock and soils geochemistry; 4) water quality analysis of, selected natural spring and Red River seeps (historic data limited); 5) historic and recent Red River water quality data (historic data limited); 6) subsurface lithologic data; and 7) climatological data. Historic and recent aerial photographs were not available for review. The NMED states that aerial surveys are sparse and do not indicate any relevant data. Chemical constituents found in ground water and surface water samples were compared to New Mexico Ground Water Standards (NMGWS) and New Mexico Surface Water Standards (NMSWS) in establishing if ground water or surface water contamination did exist (see Appendix 1 and Appendix 2 for relevant data on NMGWS and NMSWS). In so doing, it was assumed that acceptable sampling methodology was employed and that samples are representative of the immediate area.

The NMED (March, 1996) reports that acidic, high metals seeps at the mine site exist only on the north side of the Red River. The majority of seep and spring discharge and field drainage occurs north of the river at the tailings ponds. Therefore, although a general evaluation was conducted in the Red River watershed to determine the source location, this investigation concentrated on the geology and hydrology north of the river. The following investigative approach was the most appropriate in determining the source for high metals and sulfate buildup within the Red River watershed:

- 1) Red River water quality was evaluated to determine the general area of the source. Degradation of a particular reach of a drainage system, or a marked decrease (spike) in water quality at a specific sample location along the river would indicate that the source exists in the general area. Degradation of a small portion of the river would indicate a specific source. However, if contamination was discovered to be wide spread, more than one source or a large source could be expected. A concentration of seeps in a particular area was used as an additional indicator of source location.
- 2) Surface topography, within the general area of the source, was evaluated to define surface water pathways to the Red River. All possible sources within surface flow paths (i.e., subwatersheds) to the river were evaluated to determine their possible metals contribution to the river.

- 3) Available source leachate quality was evaluated to determine the geochemical fingerprint of each possible source. A geochemical assessment of each source was performed to determine its capability to discharge high metals concentrations to ground water, and in concert with a geochemical assessment of ground water and seep discharge, determine the specific source location.
- 4) Near-surface geology and subsurface strata and hydrogeology were evaluated to determine if a ground water hydrological connection exists between the probable source and the river. A knowledge of the local depositional environments leads to a better understanding of an aquifer's capability to deliver ground water to surface water.
- 5) Spring and seep water quality, monitor well tests, and ground water quality are of particular interest in documenting a hydrological connection between a most probable source and seep discharge. Background surface water and ground water samples were evaluated to determine if only natural sources are the cause of degradation to the water system. Monitor well tests were used to characterize the aquifer's ability to act as a conduit for transport of contaminants from a source to surface water. Spring, seep and ground water samples were utilized to identify a chemical correlation to a particular source.

3.0

TAILINGS PONDS AREA

Documentation for several geologic and hydrologic conclusions were omitted from some of the reports reviewed for this study. Therefore, a concentrated evaluation of pond water and associated metals concentrations (hereafter referred to as leachate), ground water and Red River water quality was considered the principal approach in determining if pond leachate has impacted the ground water and the river. Water samples from pond leachate and ground water down gradient of the ponds were evaluated to determine if a chemical correlation existed, and therefore, establish a tailings pond source for immediate ground water contamination. Seep, spring, field drainage and ground water quality, which are summarized on [Table 1](#) and [\[Table\] 2](#), were evaluated to determine if a correlation existed, and if so, establish a ground water hydrological connection between the source, and seep, spring (artesian) and field drainage (groundwater seeping onto the surface of the ground). Attenuation is a factor in ground water transport. Therefore, utilizing background ground water quality, and seep/spring/field drainage water quality was evaluated to determine if pond leachate still affected the water quality at the seep/spring/field drainage locations.

Ground water data from MolyCorp's piezometers and shallow alluvium monitor wells indicated that tailings pond leachate has affected the ground water quality down gradient (towards the Red River) of the ponds. Piezometers have documented infiltration of ponds leachate to the shallow aquifers below the ponds and dams. Although attenuation through ground water transport is a factor in this area, monitor wells document ground water flow from the ponds to the river. As a consequence, MolyCorp is presently installing capture wells to intercept ground water between the tailings ponds and the river.

Data concerning the question of whether or not the tailings ponds are hydrologically connected to the Red River were limited to those found in Vail (September 24, 1993) and South Pass Resources, Inc. (April 13, 1995). The South Pass Resources, Inc. (SPRI) report contained monitor well test and ground water quality data and descriptions of the lithology encountered by a select number of wells. Screened intervals for several wells were not supplied in the report. However, focusing on wells with complete information

regarding separate aquifer systems; ground water chemistry, velocity, and direction; and barriers to ground water flow; the shallow aquifers were determined to be the primary conduit to the river. A few monitor well tests discussed within the narrative of the SPRI report were not available within the study for review. Vail conducted a hydrological study of the area using USGS stream data; surface, seep, and monitor well water quality data; and tailings pond leachate quality data. Vail has identified volumes and quality of tailings pond leachate delivered to the Red River, and therefore, has documented a hydrological connection between the ponds and Red River.

In reviewing the previously mentioned investigative approach, more weight was given to a geochemical assessment in determining a ground water hydrological connection to the river. The reason for this is related to several factors which affect the water level and water quality results for all monitor wells, and therefore, the geochemical assessment was deemed to be more reliable. These factors include: 1) ground water chemical reactions with materials used for construction of monitor wells; 2) monitor wells screened in hydraulically separated aquifers, which lead to problems in defining area aquifer systems; 3) location of monitor wells relative to barriers (i.e., faults, etc.), which may re-direct or impede ground water flow; 4) different sample periods (e.g., spring, winter, etc.), which lead to ground water quality and elevation differences; 5) hydraulic head in the ponds relative to the dilution potential of the underlying aquifers; and 8) sampling methodology.

3.1 GENERAL AREA OF SOURCE

As illustrated on [Figure 3](#) and summarized in [Table 1](#) and [\[Table\] 2](#), river water samples, collected by Vail (September 4, 1993), were collected from up to down gradient of the tailings ponds. The permitted discharge from outfall 002 and 003 was considered in evaluating river water quality. No definitive change or spike in sulfate or metals concentrations was observed from up to down gradient of the ponds, which indicated that river water quality could not identify the source location. However, as indicated by [Table 1](#) and [\[Table\] 2](#), a correlation did exist between seep/spring/field water quality, ground water quality, and pond leachate chemistry; which indicated the tailings ponds as the probable ground water contaminant source.

3.2 POTENTIAL SURFACE PATHWAYS FOR CONTAMINATION

The surface topography is a sloping alluvial plain, with surface gradient being generally to the Red River. It appears that no surface runoff avenues to the Red River exist south of the tailings ponds due to the construction of dams and barriers. Drainage ditches were constructed up gradient of the tailings ponds to divert natural runoff from entering the pond area.

3.3 SOURCE GEOCHEMICAL CHARACTERIZATION

As evidenced by surface discharge and ground water samples collected by SPRI (April 13, 1995), the area's alluvial and volcanic deposits, which include the aquifers considered hydrologically connected to the river, cannot geochemically account for the metals and sulfate concentrations observed in ground water down gradient of the ponds, or the sulfate concentrations observed at the seeps/springs/field discharge. The ground water at monitor well number 10 (MW-10), as seen on [Figure 6](#), is the best water quality within the area (TDS 150 mg/l, sulfate 35 mg/l). Because of this, and the fact that the well is located east of the ponds, where it is evidently outside of the influence of pond infiltrate due to a ground water flow direction to the southwest, samples taken from this well are considered to be indicative of ground water quality before mining activities took place (i.e., background). In comparison to the samples taken at MW-10, several ground water samples south of the ponds show moderately elevated concentrations of sulfate, TDS, manganese and molybdenum. In addition, there exists no natural source for the elevated molybdenum concentrations found in ground water at MW-2 and MW-C; however, tailings are derived directly from the milling operations for molybdenum. Therefore, the elevated sulfate

and metals concentrations found in ground water are considered to be from the tailings ponds and not from natural sources.

3.4 SURFACE AND SUBSURFACE GEOLOGY AND HYDROGEOLOGY

Establishing a hydrological connection between a source and contaminated surface water requires the evaluation of several hydrogeological parameters. It must be determined that ground water below the source has been affected by infiltration of source leachate and that conduits exist for the ground water transport of this leachate to surface water.

The surface geology was characterized to determine the erosional and depositional factors which may affect the flow directions within the subsurface aquifers. The subsurface was evaluated through monitor well tests and lithologic samples to determine which aquifers may be conduits for ground water flow from a source to surface water. Monitor well tests and lithologic samples were utilized to define individual aquifers (vertical hydraulic separation), aquifer lateral continuity, and to determine the transport capabilities of the aquifers.

3.4.1 SURFACE AND SUBSURFACE GEOLOGY

Surface topography and subsurface geology characterize the area as one of active structural deformation, deposition, and erosion. The structurally active nature of the area is represented by several faults which displace the shallow alluvial and deeper basaltic aquifer deposits. However, this displacement does not appear to halt ground water flow to the river, which is apparently due to the juxtaposition of different but permeable aquifers or juxtaposed impermeable aquifers redirecting ground water flow to the south (to the river).

SPRI (April 13, 1995) used borehole and geophysical logs to characterize the subsurface. The area consists of volcanic rocks, and sedimentary and lacustrine deposits. The upper alluvial and lacustrine deposits (Santa Fe Group) consist of an Upper Aquifer Unit (UAU), Middle Aquitard Unit (MAU), Lower Aquifer Unit (LAU), and Basal Aquitard Unit (BAU). SPRI states that each unit exhibits vertical variation in lithology; each unit containing clay, gravel and sand lenses. The Santa Fe Group overlies a major regional aquifer which exists in the basalts and volcanics (basalt/andesite unit (BAAU)). The UAU (upper Santa Fe Group) underlies Dam No.1. However, only 50 feet of the lower Santa Fe Group exists immediately down gradient of Dam No. 4 because of the erosion of some upper Santa Fe Group units.

3.4.2 HYDROGEOLOGY

Monitor well placement and aquifer tests were used to determine several aquifer parameters including ground water gradient, if vertical hydraulic separation exists between aquifer units, if aquifers have lateral continuity, and if barriers exist to redirect ground water flow. Vertical hydraulic separation would indicate that a basal aquitard does exist. An aquitard would indicate no further migration of contaminants into deeper aquifers, and substantiate ground water transport of pond leachate down gradient. The lateral continuity of a hydrologic unit (one aquifer or juxtaposed aquifers) must be determined to define the conduit (i.e., that the hydrologic unit exists from the ponds to the river) for the ground water transport of pond leachate to the Red River. If hydraulic separation or lateral continuity is established at monitor wells, it is assumed that they exist within the general area of the wells.

3.4.2.1 GROUND WATER GRADIENT AND BARRIERS

SPRI (April 13, 1995) conducted aquifer tests on 3 wells (EW-2, EW-3, and MW-7), which are completed (screened) in separate units of the Santa Fe Group ([Figure 6](#)). Analyses of well tests indicate good conductivity, recharge and localized barriers to flow. Recharge and barriers to flow may be caused by changes in hydraulic conductivity or faults. Monitor well ground water elevations indicate that the ground water flow direction is generally to the southwest in the UAU and the BAAU. Ground water flow

direction for the LAU is unknown; however, it is expected to flow to the southwest because the LAU lies between the UAU and BAAU. SPRI (April 13, 1995) states that USGS stream gage data indicate an overall gain (approximately 30 cfs) between the Questa ranger station and the fish hatchery. Therefore, although faults and juxtaposed units may locally redirect ground water flow, flow is still directed to the river.

SPRI (April 13, 1995) reports that the underdrains (connected to the chimney drains), which were installed to intercept leachate below each dam, would rest on a shallow upper aquifer unit beneath Dam No.1 and probably on the upper sandy member of the basalt aquifer unit at Dam 4 ([Figure 6](#)). Piezometers were installed into the dams to measure the saturated surface to determine the infiltration rate to the underlying aquifers. However, SPRI has only submitted information on the pond leachate infiltration capacity below Dam No.1. The slope of the saturated surface showed discharge to the under drain system beneath Dam No.1. As illustrated on [Figure 6](#) and [\[Figure\] 7](#), piezometers within Dam No.1 and monitoring wells south of the dam document that ground water gradient is to the south from Dam No.1 to at least MW-7. Because the ponds are unlined, the drain system apparently captures some but not all of the seepage through the dam. The remaining leachate enters the underlying shallow aquifer over the area of the ponds and moves down gradient towards the river, thus bypassing the drain collection system.

Ground water levels from monitor wells located south of Dam No.1 and 4 were evaluated to determine the ground water elevation relative to the Red River to establish which portions of the river were a gaining or losing stream. MW-11, located south of Dam No.4, showed water levels below the adjacent Red River level. SPRI (April 13, 1995) states that this situation may indicate river recharge to ground water in this area but not enough to impact the overall gain recorded by stream gages. It must be noted that only one monitor well exists in this area, therefore, ground water gradient in this immediate area cannot be substantiated. For the segment of the Red River between Big Springs and Pope Lake, the water table in the basalt unit appears to be just above river level. MW-1, located south of Dam No.1, showed water levels above the level of the river, indicating ground water recharge to the river. Ground water elevations do establish ground water flow in a general southwest direction (to the river).

3.4.2.2 VERTICAL HYDRAULIC SEPARATION

Vertical hydraulic separation of aquifers was investigated to determine basal aquitards, and in so doing, define the hydrologic unit capable of transporting contaminants to the river. Separate flow systems (vertical hydraulic separation), due to confining clay beds, occur within the Santa Fe Group (shallow alluvial aquifers) and the underlying basalt aquifer. Monitor wells screened in different aquifers show different depths to water indicating vertical hydraulic separation to some degree. Local vertical hydraulic separation can be supported by a pump test conducted by SPRI (April 13, 1995) at monitor well EW-2, which is illustrated on [Figure 6](#). During the EW-2 (screened in upper portion of LAU) pump test, water levels in MW-7C (screened in lower portion of LAU) were monitored. SPRI reports that only minor water level fluctuations (range of 3.2 inches), which SPRI attributes to barometric changes, were observed in MW-7C, indicating that these wells are apparently screened in hydraulically separated lenses of the LAU.

3.4.2.3 LATERAL CONTINUITY

Lateral continuity must be established to document a continuous conduit for ground water flow from the source to surface water. Establishing lateral continuity over a great distance for a specific hydrologic unit is not possible due to the present monitor well scheme. However, local lateral continuity has been demonstrated by the EW-3 pump test. Water levels within MW-7A were monitored during the EW-3 pump test (both screened in the lower UAU). Observed water level fluctuations in MW-7A established a lateral ground water hydrologic connection between MW-7A and EW-3. These tests indicate good hydraulic conductivity and local lateral continuity. The perched nature of some aquifers suggests lateral discontinuity most probably caused by juxtaposition, due to fault displacement, of different aquifers with differing conductivity. Although juxtaposition is assumed due to faulting, ground water flow through the

fault cannot be documented due to the present monitor well scheme. However, fault trend is north-northeast to south-southwest and ground water gradient is to the river, and therefore, ground water flow direction is to the river. In addition, studies of USGS gage station data indicate the river to be a gaining stream supplied by ground water, which indicates that ground water flow is to the river within a major portion of the tailings area.

3.5 RIVER, SPRING, SEEP AND GROUND WATER QUALITY

Pond, river, spring, seep and ground water quality were evaluated to determine if a water quality correlation existed. In doing so, documentation could be established for a hydrological connection from the ponds to the river via ground water transport.

Vail (September 24, 1993) states that tailings pond water and associated contaminants (leachate) seep to the ground water which flows generally in a southwesterly direction and discharges to Red river. This seepage contains elevated concentrations of sulfates (840+-mg/l), molybdenum (2+-mg/l), manganese (1.4+-mg/l), and total dissolved solids (1700+-mg/l). In his discussion of pond leachate avenues below Dam No.1, Vail concluded that this seepage flow is generally in the shallow alluvium. Vail believes that a large percentage of the seepage from Pond No.4 is transported by ground water flow in the volcanic formations and that most of this ground water flow is discharged to Red River at the numerous springs along the Red River Gorge. SPRI (April 13, 1995) reports that the section of the Red River that may be impacted by the tailings ponds is 1.84 miles in length (roughly from the 002/003 Outfall west to the area of the Fish Hatchery)."

3.5.1 RIVER

As illustrated on [Figure 3](#), Vail collected seep/spring and river water samples at several locations between State Road 522 and the Red River State Fish Hatchery. Comparisons of up-river metals concentrations with river water samples adjacent to the ponds suggests that river water quality is not affected by a pond source. For example, river water samples collected from up to down gradient of the ponds show that only a small difference in river metals concentrations, with the most up river sample normally having the greater concentrations. There is a slight influence on river water quality down gradient of outfall 002 and 003 ([Figure 3](#)) due to the permitted discharge. This influence was considered in the evaluation of river water quality. Analysis of submitted river water samples, as summarized on [Table 1](#), and conversations with the State of New Mexico and EPA surface water staff indicate that river water quality is within surface water standards.

3.5.2 SPRINGS

Some Red River springs have sulfate concentrations below NMGWS. Questa Springs, as seen on [Figure 6](#), is most likely due to a north-northeast to south-southwest trending fault which redirects a portion of the total southwesterly flow of ground water to the south (to Questa Springs). Questa Springs water quality has a TDS of 173 mg/l and a sulfate concentration of 80 mg/l, which is just above background (TDS 150 mg/l, sulfate 35 mg/l) and below NMGWS (TDS 1000 mg/l, sulfate 600 mg/l). Questa Springs TDS and sulfate concentrations are lower than ground water concentrations below Dam No.1, which indicates that attenuation through ground water transport is a factor in concentrations delivered to seeps and springs along the river.

3.5.3 SEEPS

Seep water quality (collected by Vail, September 24, 1993, and summarized in [Table 1](#)) was used to some degree as a ground water quality indicator to evaluate the general ground water quality in the immediate area. Two field drainage (field surface seepage) sites immediately south of Dam No. 1 have moderately elevated TDS concentrations; one has elevated sulfate and the other elevated iron concentrations above

NMGWS. One field drainage sample, located midpoint of Dam No.1 and the river, has molybdenum concentrations above NMGWS. These field drainage samples indicate a tailings source. Although sulfate concentrations discharged at Red River seeps are just above ground water background concentrations, which indicate a probable tailings source, they are below NMGWS. These observations are an additional indication that attenuation of pond leachate through ground water transport is a factor in decreasing sulfate and metals concentrations in ground water delivered to seeps and springs along the river.

3.5.4 GROUND WATER QUALITY

Analyses of ground water samples collected below and down gradient of the ponds establishes a correlation between pond leachate, and ground water and seeps/springs/field discharges south of the ponds. Several ground water samples show moderately elevated concentrations of sulfate, TDS, manganese, and molybdenum. The ground water at MW-10 ([Figure 6](#)) is the best water quality within the area (TDS 150 mg/l, sulfate 35 mg/l). South of the ponds, the UAU and upper portion of the MAU usually have high TDS and high sulfate concentrations. The highest sulfate concentrations were detected at MW-C (970 mg/l), a shallow piezometer at the toe of the Dam No.1. The down gradient MW-A has lower sulfate concentrations (560 mg/l) indicating dilution. Piezometer MW-9A, located approximately 1200 feet down gradient (south) of MW-A, has greater sulfate concentrations (680 mg/l) than MW-A. Apparently, inconsistencies between ground water flow direction and ground water quality indicate local attenuation, interflow between aquifer members (dilution), and/or redirection of ground water flow paths. This redirection is most likely due to faults and/or changes in hydraulic conductivity. However, ground water gradient and quality indicate that pond leachate does infiltrate to the UAU and moves down gradient towards the river.

3.6 SUMMARY

A water quality comparison of pond leachate, ground water and seep/spring/field drainage down gradient of the ponds indicates that the only probable source for elevated sulfate and metals concentrations found in ground water are the ponds. However, the available information indicates that ground water discharge via seeps along the river and river water quality are within NMGWS and NMSWS. A complete summary of the tailings ponds and the MolyCorp mine site is found at the end of this report.

4.0

MOLYCORP MINE SITE

The mine site is located in a more complex geologic setting than the tailings pond area. The mine property is located in a mountainous region, which is cut by deep canyons. The extreme topographic gradient was formed through erosion of volcanic flows associated with the Questa caldera (a large crater formed by the collapse of a volcanic cone). As indicated by [Figure 4](#) and [\[Figure\] 5](#), the surface gradient directs surface water runoff, and shallow ground water, to the Red River.

Historic and recent mining operations and natural sources, within the MolyCorp mine area and upriver of the mine, were investigated to determine their potential contribution of metals to the river. Investigations revealed that the possible sources are: 1) historic and recent mine waste rock, 2) naturally occurring erosional scars, 3) remnant deposits of tailings resulting from pipeline breaks, 4) the landfill area at the head of Spring Gulch, 5) the Moly tunnel, (6) the caved area in Goathill Gulch, 7) runoff directed to the underground workings for collection, and 8) the mill site. Of these, the most probable sources are considered to be the WRDs and the erosional scars because of source material and water quality (leachate and ground water) analysis results. An additional indicator of source location is that the acidic seeps and these two sources are wide spread and other possible sources (land fill, Moly tunnel, etc.) are localized.

Approximately 59 historic mine sites exist within seven tributaries of the upper Red River watershed. All of these mines were fairly small operations, with associated waste rock piles being relatively minor. The NMED (March, 1996) states that although these sites contribute some contamination to the river through surface water runoff associated with storm events, none appear to be a significant source of metals loading to ground water or surface water.

4.1 GENERAL AREA OF SOURCE

The most significant water quality degradation occurs within the middle reach of the Red River from Questa to the town of Red River ([Figure 2](#)), which contains the Molycorp mine and most of the major scar areas. River surveys have documented declines in river water quality progressing downstream from the town of Red River. The most acceptable method for determining the general area of the source was the river water analysis for sulfate gain, which used sulfate as a proxy for metals to examine how the loading of metals to the Red River has changed over time.

As illustrated in [Figure 8](#) and summarized in [Table 3](#), Red River water quality data, collected in May 1994 by SPRI (April 21, 1995), indicate a spike in sulfate concentrations. A Red River sample collected just up river of the confluence with Columbine Creek (RR-12) indicates a twofold gain in sulfates compared to up river samples from Hot-N-Tot Creek to just up river of Portal Springs (RR-5 to RR-10). Sample RR-13 shows a decrease in sulfate concentrations due to inflow from Columbine Creek. However, RR-13 concentrations remain greater than up river samples. Red River sulfate concentrations down river of sample RR-13 are generally the same as the RR-12 sample. This area of increased sulfate concentrations is most probably due to the numerous seeps located within and just down river of the Molycorp boundary.

Seeps are considered the primary and most incessant source for metals loading to the river. Consequently, an additional indicator of source location is that the greater percentage of and most active acidic, high metals seeps exist in the vicinity of the Molycorp mine. Therefore, Red River water quality data and seep locations indicate the source to be within the general area of the Molycorp mine property.

4.2 POTENTIAL SURFACE PATHWAYS FOR CONTAMINATION

Surface avenues to the Red River were evaluated to determine the probability of surface water runoff supplying a portion of or the total metals load and ground water discharge to the river via seeps. The surface topography ranges in elevation from approximately 7600 to 10,800 feet within the mining area. Most of the topography consists of very steep slopes. Major tributary canyons have gradients on the order of 11 to 15 degrees. Due to the topographic gradient, unconsolidated nature of the area alluvium, and storm events; sediment and surface water runoff is directed to the river.

As can be seen by comparing [Figure 4](#), [\[Figure\] 5](#) and [\[Figure\] 9](#), the steep gradient within the mountainous region facilitates the formation of erosional scars. Erosional scars are so easily eroded that mudflows are produced by heavy precipitation, creating debris aprons where tributaries enter the Red River. Mudflows have at times dammed the river. However, the NMED (March, 1996) has determined through water quality analysis that metals loading problems associated with these events are largely temporal, and that in most cases river water quality is restored within a few days.

Molycorp has implemented a water management and sediment collection program at the mine site, which incorporates the majority of the mine property ([Figure 4](#)). Surface water within the majority of the mine boundary is redirected to the open pit and caved area (a surface depression within Goathill Gulch canyon caused by the collapse of a portion of the roof of the underground mine) and collected in the underground

mine workings. Apparently, due to the collection system, sediment loading and surface water runoff to the river adjacent to the mine property is not the principal factor in metals loading to this reach of the river.

Molycorp's collection system captures surface water runoff, and spring discharge in unlined catchment basins. The unlined basins undoubtedly allow infiltration to the underlying aquifers. Although a surface system has been installed to intercept surface water runoff and spring discharge, ground water has the potential to bypass the system and flow down gradient to the river. Therefore, the shallow upper valley fill aquifer has the potential to transport high metals concentrations to the Red River. Subwatersheds (canyons), as described below, were individually evaluated to determine if they could function as contamination pathways.

Surface water runoff and seepage from the Capulin Canyon WRDs and erosional scars ([Figure 1](#), [\[Figure\] 4](#), and [\[Figure\] 9](#)) are collected in surface impoundments. However, ground water flow has not been affected by the collection system and has the potential to transport high metals concentrations to the river.

The Goathill Gulch topography indicates surface and ground water flows to the river. However, a sink, the caved area ([Figure 1](#)), within Goathill Gulch canyon may restrict surface and ground water flow. Apparently, the caved area is a vertical rubble zone of displaced aquifers and bedrock material, which extends from the surface to the underground mine workings. This rubble zone acts as a conduit between the surface and the underground mine. The caved area may capture most of the surface water runoff from upper Goathill Gulch canyon. The caved area captures and directs surface water to the underground mine, where it is redirected to the mill for milling operations. The caved area may also capture ground water within the immediate area, and in so doing, cause a local cone of depression (not to be confused with the cone of depression caused by the dewatering of the open pit and underground workings).

All Goathill Gulch ground water, up gradient of the caved area, may be captured by the caved area. However, no information is available to indicate whether the shallow aquifers have been sufficiently displaced (due to the collapse of the stratigraphic section) such that all up gradient ground water is captured by this area. SPRI (April 21, 1995) states that mounding of the water table surface may occur due to redirection of surface runoff to the caved area, and that the water mound might extend to the valley fill in Goathill Gulch from which it could more easily reach the river. Surface water runoff down gradient of the caved area is intercepted by the surface water collection system. However, no subsurface collection system exists down gradient of the caved area. Therefore, if up gradient ground water is captured by the caved area, subsurface flow is still probable from the caved area to the river. However, the area of ground water available for discharge to the river would be defined by the location of the down gradient outer rim of the local cone of depression, which forms due to the ground water being captured by the caved area. The location of the outer rim is dependent on the depth to the area's undisturbed basement rock, vertical hydraulic conductivity of the rubble (i.e., discharge rate), hydraulic conductivity of lithologic members, and the canyon gradient within the vicinity of the caved area to the river. Therefore, the area of ground water available for discharge to the river, and contaminants from sources within that area, would be from the local depression's southern outer rim location to the river. However, no information exists to define the location of the local cone of depression's outer rim, or in fact, indicate that a local cone of depression does exist.

Surface water runoff from the Sugar Shack South and Middle WRDs is collected in unlined catchment basins. Due to the unlined nature of these catchment basins, leachate from these sources, and the erosional scars which underlie these WRDs, has the potential to infiltrate to the shallow alluvial aquifer and move down gradient to the river.

Natural drainage has been drastically altered in the Sulphur Gulch subwatershed by the placement of Spring Gulch WRD, and Spring and Sulphur Gulch WRD. Surface water runoff is assumed to be captured by the Molycorp collection system. However, surface water can potentially migrate down to the shallow aquifers through infiltration.

There are other unnamed tributary canyons which exist within the Molycorp boundary and direct surface and ground water flow to the river. MW-7 ([Figure 1](#)) is located within a tributary valley which extends up gradient to the Capulin Canyon and Sugar Shack West WRDs. MW-11 and 13 are within minor tributary valleys which were overlaid by the Sugar Shack South and Middle WRDs.

As summarized above, surface water runoff to the river, via canyons, has generally been intercepted by the surface water collection system. Therefore, surface runoff is not considered the primary transport mechanism for metals loading to the Red River.

4.3 SOURCE GEOCHEMICAL CHARACTERIZATION

Mining operations were evaluated to determine the most probable source for the high metals concentrations delivered to the river. In addition, the geochemistry of different rock types within the mine area was evaluated to identify the source with the potential to generate the acidic waters necessary for the leaching of metals. The only whole rock, ground water and seep water quality geochemical data available for review were collected by SPRI (April 21, 1995) and Steffen, Robertson and Kirsten (SRK) (April 13, 1995). The geochemical assessment of possible source leachate and ground water chemistry revealed that the most probable source for the generation of acidic, high metals waters (or ARD) is the WRDs and the naturally occurring erosional scars.

ARD is characterized by low pH and elevated concentrations of metals and TDS. The most common mechanism for its formation involves the oxidation and hydration of sulfide minerals (e.g., pyrite, or iron sulfide), resulting in the generation of sulfuric acid. The mine area rhyolite consists primarily of the mineral pyrite. Rhyolite is exposed north of the Red River as erosional scars. The upper Sulphur Gulch erosional scar (rhyolite) and other non-acid generating rock types were excavated during open pit mining and placed in several WRDs. Therefore, each WRD was evaluated to determine which WRDs contained the rhyolitic material.

A search was conducted to determine if comprehensive WRD disposal records existed to identify WRDs which were composed primarily of rhyolite, and consequently, determine the most acidic, high metals generating WRDs. However, Molycorp has indicated that historical records concerning the development of the WRDs are limited. Generally, mixed volcanic waste rock (rhyolite and andesite) was excavated from the Sulphur Gulch erosional scar area and deposited in the Blind Gulch, Goathill, Sugar Shack South, Sugar Shack West and Middle WRDs and the western portion of Spring and Sulphur Gulch WRD. The remaining waste rock was derived from black andesite, aplite and granite, which are considered to have low potential to generate acidic waters. The majority of this waste rock was placed in the western portion of Spring and Sulphur Gulch, in Spring Gulch and within the pit. SRK (April 13, 1995) states that later in the open pit operations, this waste rock was used to encase the lower faces of the Middle, Sugar Shack South and Spring and Sulphur Gulch WRDs. The rhyolite appears to exist in all WRDs. However, the volume of rhyolite within each WRD could not be determined from the available data.

Other minor waste rock areas were also evaluated for acid generating potential. SRK (April 13, 1995) reports that waste rock from the new underground mine workings, considered non-acid generating, was placed in lower Goathill Gulch, adjacent to the surface facilities. The historic tailings piles at the mine's mill site exhibit acid generating potential, and therefore, have the potential to generate ARD.

The NMED (March, 1996) and SRK (April 13, 1995) conducted a geochemical analysis of waste rock pile, erosional scar, and soils material for metals concentrations. Sugar Shack South WRD has the greatest metals concentrations. ARD from the waste rock is similar in composition to drainage from erosional scar areas. However, leachate analysis, conducted by NMED revealed that average metals concentrations were greater in WRD leachate than scar leachate. SRK states "Over time, ongoing acid generation in the waste rock disposal areas adjacent to the Red River, and the consumption of the neutralizing potential of the

waste rock, and consumption of the remaining attenuation capacity in the alluvium in seepage flow paths has the potential to increase sulfate and metal loads in local springs and seeps. Seepage of water impacted by the hydrothermal scars that underlie the waste rock disposal areas will likely continue" (page 35).

SRK's (September 13, 1995) geochemical analysis of soils outside the influence of erosional scars or WRDs indicates that these soils have low metals leaching potential. Therefore, the dissolved metals contribution to the local environment by these soils is low compared to erosional scars and WRDs. SRK collected soil samples from within the mine area and concluded that the alluvium has the potential to contribute sulfate to surface or ground water, however, the potential for acidic waters is low. Mud and debris from erosional scars outside the mine surface water collection system are considered a localized source of intermittent river contamination through surface flows during periods of high runoff.

Most investigators acknowledge that waste rock material and erosional scars have similar geochemical properties, and that weathering of sulfide-rich erosional scars is associated with acidic, high metals storm water runoff. Although an increase in excavation activity (historic and recent mining, unpaved roads, etc.) appears to be related to the metals buildup in the watershed, the natural processes of weathering are the primary cause for the leaching of high metals into the local watershed environment. Natural weathering of sulfide-rich erosional scar material is relatively slow due to its compacted nature. However, when this material is excavated and placed in thick unconsolidated piles (i.e., WRDs), a large sulfide rich surface area is exposed to oxidation. The unconsolidated WRDs undoubtedly allow greater infiltration rates than the more consolidated natural soils or erosional scars. Therefore, the WRDs should have greater acid generation potential, storage capacity, metals transport capability; and consequently, greater recharge to the underlying aquifers than erosional scars. The upper valley fill aquifer should be saturated below and down gradient of the WRDs due to the recharge.

4.4 SURFACE AND SUBSURFACE GEOLOGY AND HYDROGEOLOGY

An evaluation of the surface geology and topography was performed in order to understand the erodibility and depositional factors at work in the area. Surface geology was evaluated to determine the erodibility and infiltration capabilities of differing rock types to define their relative contribution of alluvium within the subwatershed and recharge potential to ground water. The subsurface geology was evaluated to define the limits and avenues to ground water flow. Monitor well tests were used to determine the hydrogeological controls which influence flow direction and volumes delivered to seeps.

4.4.1 SURFACE AND SUBSURFACE GEOLOGY

The mine area geology is characterized as volcanic. Precambrian granite is exposed south of the Red River. The outcrops north of the river are primarily exposed Tertiary rhyolitic intrusive plugs (erosional scars). The primary hydrologic units north of the river are the fractured Tertiary volcanic bedrock (encountered by monitor wells between 60 - 120 feet below surface) and the overlying lower and upper valley fill alluvium. Several studies indicate that the Precambrian, which underlies these units, acts as an aquitard precluding any deeper ground water infiltration.

The rhyolitic erosional scar is a brecciated rock, which is easily eroded due to a lack of cementation and its highly fractured nature. Its erodibility is one source of alluvial deposits down gradient of scars. Molycorp drilled several 90 foot holes into erosional scars within the area (see SPRI April 21, 1995), apparently to determine the scar's discharge, storage and infiltration capacity. Molycorp found that the scars were either dry or produced very little discharge (less than one gallon per minute), which indicated near surface storage, with little to no infiltration at depth. The infiltration rates for the highly unconsolidated WRD material therefore exceeds that of the more consolidated erosional scar material. Thus, due to the similar geochemical properties of erosional scars and WRDs, the unconsolidated WRDs pose a greater ground water contamination potential than scars.

The steep slopes within the area encompass a greater surface area than the canyon floor. Runoff and ground water flow from the slopes are directed to the canyon floor deposits. The canyon aquifers are saturated due to infiltration through the unconsolidated alluvium. The shallow alluvial aquifers presumably have good lateral flow due to their unconsolidated gravel/sand mix and gradient, and less downward flow due to a basal clay aquitard. Therefore, surface water should infiltrate to the shallow aquifer and move down gradient along the clay aquitard to the river.

4.4.2 HYDROGEOLOGY

Twelve monitor wells were installed in July and August of 1994 ([Figure 1](#) and [\[Figure\] 4](#)). All wells are located within the Molycorp property and between 400 to 700 feet north of the Red River. The wells were installed to determine: 1) aquifer characteristics, 2) ground water gradient and barriers, and 3) ground water quality. A number of these wells indicate separate hydrologic units, and a possible cone of depression created by the dewatering of the open pit and underground mine workings. In addition, studies of USGS gage station data, and ground water elevations (relative to river elevation) obtained from monitor wells and two mine shafts, indicate that the river is supplied by ground water (i.e., gaining stream) throughout most of its length.

It appears that all investigators agree that there are two aquifers in the mine area: a valley fill and an underlying shallow fractured bedrock aquifer. Based on analysis of monitor well data supplied by SPRI (April 21, 1995), EPA believes that at times three different ground water aquifer systems may exist: a shallow fractured bedrock, an overlying lower valley fill, and an upper valley fill aquifer. It must be noted that monitor well tests only determine the hydrologic parameters within the immediate area of the well. However, considering that the alluvial deposits are confined to a relatively small canyon area, an assumption that the hydrologic parameters determined from monitor well tests are indicative of the general lower canyon area is acceptable.

Well tests confirm a weak hydraulic separation between the bedrock and lower valley fill stratigraphic units. Although bedrock and lower valley fill ground water elevations indicate these units may act as one hydrologic unit (one aquifer), well tests also confirm that the valley fill has greater horizontal hydraulic conductivity than the bedrock unit. Therefore, the lower valley fill may act to some degree as an independent aquifer during periods of high recharge. Well tests support some vertical hydraulic separation of the upper valley fill and lower valley fill aquifers by an intermediate clay layer. The clay layer retards further downward flow of upper valley fill ground water. The gradient on the upper surface of the clay layer is apparently to the river due to the depositional environment, and therefore, ground water flow is towards the river.

Monitor well ground water elevations relative to river elevations indicate that a cone of depression, centered on the open pit or underground mine, may exist north of the river. As discussed in Section 4.4.2.1, the cone of depression may affect the bedrock and lower valley fill aquifers between the monitor wells and the open pit and new underground workings, but not the upper valley fill aquifer. Therefore, the upper valley fill has the potential to transport contaminants to the Red River. The bedrock and lower valley fill ground water located outside the influence of the suspect cone of depression, still has the potential to flow to the river.

The NMED (March, 1996) states that shallow bedrock fractures support preferential ground water flow to Red River seeps. Although geologic observations imply fracture orientation, faults intersecting the shallow bedrock aquifer may redirect ground water flow. Ground water elevations in MW-7 indicate a perched nature to the fractured bedrock aquifer in the immediate area. Therefore, support exists for faults or other geologic impediment to retard or redirect ground water flow.

Monitor well data and the steep surface topography support a distinct ground water flow system to the river via the upper valley fill aquifer. Although monitor well data indicate that a cone of depression may exist in an area north of the river, and that the cone of depression may affect the bedrock and lower valley

fill aquifers, ground water south of that area still has the potential to flow to the river via all aquifers. However, the upper valley fill aquifer is a separate system, apparently unaffected by the cone of depression, and therefore, has the potential to transport acidic, high metals concentrations from a large portion of the mine site to the Red River.

4.4.2.1 GROUND WATER GRADIENT AND BARRIERS

Monitor well ground water elevation and river elevation data were compared to establish if the ground water gradient is to the river, which would indicate that ground water would flow to the river, and consequently, transport contaminants to the river. The presence of seeps, in general, indicates that the ground water gradient for at least one of the aquifers is to the river in the immediate area. In addition, studies of USGS gage station data indicate that throughout most of its length, the Red River is a gaining stream supplied by ground water; therefore, the ground water gradient is to the river. A comparison of monitor well ground water and river water elevations, in the eastern portion of the mine site, may imply sporadic recharge to ground water in this area. Therefore, monitor well data and river water levels in this area were evaluated to define the ground water gradient.

Previous investigators have generally compared monitor well ground water elevations to adjacent river elevations in establishing the ground water gradient. Investigators conclude that ground water and river elevations in the eastern portion of the mine property, in the vicinity of MW-13, 14 and 16, indicate ground water to be at or just below the river level. Ground water elevations below river elevation would indicate that the river is recharging ground water, and therefore, contaminants in ground water would not be discharged to the river. Although not stated, these comparisons of ground water elevation to river elevation may have been made in a direction perpendicular from the monitor well to the river. However, due to the Red River gradient (obtained from submitted topographic maps) within the mine area (approximately 1.2/45 feet, east to west), a comparison of monitor well ground water elevation at a right angle to the river may yield inaccurate information by several feet. Ground water flows down gradient along the axis of the canyon; however, the canyon gradient is not the controlling factor for ground water flow direction in the fan delta deposits. The lower limits of the fan delta deposits conform to the river gradient, which is perpendicular to the canyon gradient. Therefore, ground water flow within the fan delta deposits will not be directly to the river as the canyon gradient would imply; but more along a resultant of the angles of the river and canyon gradients, which is more down-river of the canyon axis. Therefore, a conclusion, based on monitor well water levels, that the river may periodically recharge the ground water in the immediate area may be inaccurate. Although there is insufficient data to document a change in ground water flow direction due to a combination of river and fan delta gradients, it is likely, based on a qualitative examination of the gradient of the river and fan delta deposits, that ground water in fact always flows to the river in the eastern portion of the mine site, and therefore, throughout the mine site. However, because the methodology of the gradient measurements was not supplied, it is not known if this correction was applied. Granted, ground water flow velocity and the size of the fan delta are factors which determine the degree the river gradient would have on diverting the ground water flow direction from the canyon axis.

Subsurface barriers exist which impede or re-direct ground water flow. The ground water elevation in MW-7 indicates a perched nature to the bedrock aquifer, which indicates a barrier to ground water flow, possibly caused by faulting. The low pH and high metals concentrations found in MW-7 indicate a long ground water residence time, which is most probably due to faults. Although barriers may impede flow, ground water does flow to the river.

4.4.2.1.1 CONE OF DEPRESSION

Ground water elevations appear to support a cone of depression (not to be confused with the possible cone of depression caused by the caved area) within the bedrock aquifer which is apparently caused by the dewatering of the open pit and underground mine workings. If the cone of depression does exist, it

would indicate that the ground water gradient (ground water flow direction) for a portion of the mine site would be towards the open pit and underground workings (to the north, away from the river). The cone of depression's outer rim, which defines the point at which ground water flows to and from the center of the depression, appears to exist just north of the monitor wells in the eastern portion of the mine site, near the Middle and Spring, and Sulphur Gulch WRDs. Monitor wells in the western and middle portion of the mine site do not appear to have encountered the cone of depression. Ground water elevations and the very active nature of seeps in these areas indicate that the outer rim of the cone of depression should be north of the river, between the new underground workings or open pit and the monitor wells. However, although a cone of depression may exist north of the river and within the mine site, studies of USGS gage station data and seeps indicate that overall the Red River is a gaining stream supplied by ground water; therefore, ground water flow for at least one aquifer is to the river.

An attempt was made to define the outer rim of the suspect cone of depression and its affect on the hydrologic units within the mine area utilizing monitor well/mine shaft data and historic mine dewatering data. There is insufficient historic dewatering information and monitor well data to define the location of the outer rim of the cone of depression. However, subsequent to the monitor well installations, which are illustrated on [Figure 1](#) and [\[Figure\] 4](#), ground water elevations appeared to indicate that the cone of depression may only affect the bedrock aquifer. This interpretation is supported by the following observations:

- 1) Molycorp contends that the water level within the mine defines the lower limit of the cone of depression at that point. However, there is no indication as to the shallowest elevation ground water is entering the mine. If ground water enters the mine from the shallowest aquifers, the radius of influence of the cone of depression would be closer to the entry point than if water was entering at a deeper point (i.e., less drawdown, less area encompassed by the cone of depression). Therefore, the cone of depression would not have as great an influence on the upper aquifers as the observed mine water levels may suggest. SPRI (April 21, 1995) states that a steep sided cone of depression would probably develop over the deep mine due to the lower hydraulic conductivity at depth. SPRI also concluded that the cone probably did not extend to the river.
- 2) Ground water elevations, from existing monitor wells, for the period February, 1996, to August, 1997, were obtained from Molycorp to evaluate the effects dewatering of the mine had on aquifers. As summarized in [Table 4](#), observed fluctuations in monitor well ground water elevations show an influence from seasonal infiltration. MW-8, 2, 3, 11 and 10 are outside of the cone of depression. Bedrock wells MW-13, 14 and 16 may define the outer rim of the cone. However, subsequent to SPRI's installation and evaluation of these wells (which can be found in SPRI's April 21, 1995 report), MW-13 showed the valley fill saturated but the bedrock aquifer dry, indicating that the cone of depression may affect the bedrock aquifer but not the shallow alluvial aquifer. Therefore, the valley fill is to some degree unaffected by the cone of depression and has the potential to deliver ground water to the river in the immediate area.
- 3) Seeps and springs occur at the upper elevations, which are apparently within the cone of depression. Considering that shallow ground water supplies these seeps and springs, the cone of depression does not affect the shallow aquifers to a great extent. Therefore, ground water gradient for the shallow aquifer, throughout a major portion of the mine site, must be to the river.

The cone of depression apparently does not adversely affect the upper valley fill aquifer. Dewatering of the underground workings ceased between 1992 to 1994. SPRI (April 21, 1995) states that during post-1994 dewatering of the new underground mine workings, there was no noticeable effect on the rates of ground water recharge to the Red River in the vicinity of the mine and that most of the ground water recharge to the river may have come from the upper part of the ground water system. Stability of water levels in monitor wells, as post-1994 dewatering proceeded, supports a steep cone of depression existing over the mine, and that the outer rim of the cone is north of the river. Accepting that the cone of depression exists and that ground water recharge to the Red River is not significantly affected by dewatering of the mine, it is concluded that the shallow upper valley fill aquifer is the most probable conduit between the source and the acidic, high metals discharged to the Red River.

4.4.2.2 VERTICAL HYDRAULIC SEPARATION

Local vertical hydraulic separation between the upper valley fill and underlying aquifers is supported by well test data from MW-2, 11, 13 and 10. MW-13 shows the valley fill aquifer saturated but the bedrock aquifer dry, which establishes vertical hydraulic separation. Aquifer tests at MW-10A (completed in the lower valley fill aquifer) established some vertical hydraulic connection between the lower valley fill aquifer and the underlying bedrock aquifer (MW-10B). However, the aquifer test indicated that the upper valley fill aquifer (MW-10C) appears to be separated from the lower aquifers to some degree due to an intermediate clay layer. This clay layer retards the downward flow of upper valley fill ground water to some degree, allowing two different and sustainable flow systems to exist: the upper valley fill and the lower valley fill/bedrock aquifer. WRD and erosional scar leachate should move downward to the upper valley fill aquifer, along the clay layer, and to the Red River. The lower valley fill and bedrock aquifer may receive some of the leachate over time due to the degree of upper valley fill and lower valley fill hydraulic separation within the immediate area.

4.4.2.3 LATERAL CONTINUITY

Lateral continuity, and good hydraulic conductivity, have been established for the lower valley fill aquifer through pump tests conducted on a select number of monitor wells. However, as previously mentioned, the upper valley fill aquifer is considered the primary conduit for Red River contamination through a ground water hydrological connection. No pump tests have been conducted on the upper valley fill aquifer to determine if lateral continuity exists. However, the upper and lower valley fill deposits (i.e., alluvium) are similar, more so than the bedrock aquifer; and therefore, it is assumed that the hydraulic conductivity and lateral continuity are similar.

SPRI (April 21, 1995) states that most of the bedrock wells went dry during development. This indicates that although lateral conductivity may exist in the fractured bedrock aquifer, the hydraulic conductivity was insufficient to supply recharge to these well. However, the bedrock aquifer well MW-11 was pumped at a rate of approximately 60 gallons per minute (gpm). The MW-10A, lower valley fill well, was pumped at a rate of 140 gpm with little drawdown, indicating recharge balanced discharge. A comparison of these two tests indicates that the lower valley fill aquifer has greater hydraulic conductivity than the bedrock aquifer. The fact that the lower valley fill has good hydraulic conductivity and that it exists above the bedrock aquifer (i.e., nearer the source), the lower valley fill (and consequently, the upper valley fill) has a higher potential than the bedrock aquifer to receive and transport metals to the river in the immediate area of the wells.

4.5 RIVER, SPRING, SEEP AND GROUND WATER QUALITY

Ground water, seep and spring water quality, as shown on [Figure 8](#) and summarized in [Table 3](#) and [Table 5](#), was evaluated to determine if a water quality correlation exists between WRD or erosional scar leachate and ground water, spring, and Red River seep discharge. Attenuation was considered a factor in water quality delivered to the seeps. However, background samples were compared to all samples evaluated to determine if WRD or erosional scar leachate was present in the seep, spring or ground water samples.

4.5.1 RIVER

Review of the (NMED March, 1996) and Vail (July 9, 1993) studies indicated that although most seep constituent concentrations are usually above NMGWS, mixing of seep and Red River water results in dissolved metals concentrations that are at times diluted below NMSWS. However, during storm events, river metals concentrations are above State standards due to pulse loading. During base flow, river metals concentrations increase due to seep discharge, with some metals precipitating out onto the river bed.

4.5.2 SPRINGS

Although background ground water quality appears to have been excluded from the sampling events, the spring drainage sample CCS-2 ([Figure 8](#)) has relatively low metals concentrations and neutral pH. Therefore, the CCS-2 sample was selected as background ground water quality for evaluating ground water within the mine site.

4.5.3 SEEPS

The NMED (March, 1996) has identified more than twenty seeps along the north side of the Red River between the towns of Questa and Red River. Investigations continue to discover additional seeps along the north side of the river. The Portal Springs seep was discovered by an NMED field survey in January 1994, even after numerous earlier surveys. The most recent river survey found the Milk seep (seep at Waldo Curves) approximately one-half mile up river of the mill site. Utilizing the CCS-2 sample as background ground water quality, available Red River seep water chemistry data appear to correlate to WRD and erosional scar leachate chemistry.

The NMED apparently has identified all seeps within the general area of the Molycorp mine property, and has determined that seeps exist only on the north side of the river, with the most active seeps existing within the Molycorp boundary. Both sides of the river have similar topography; therefore, if seeps exist only on the north side of the river, it must be due to other than natural factors which increase recharge to ground water. The major concentrations of erosional scars ([Figure 9](#)) and historic and recent mining activity are located on the north side of the river. One iron rich seep was located near the town of Red River (approximately 6 miles up gradient of the mine), which the NMED (March, 1996) believes is due to anthropogenic factors. If a connection can be substantiated between anthropogenic factors and the formation of seeps, it may be assumed that subsequent excavation activities could add to the contamination of the watershed.

As illustrated on [Figure 1](#) and [Figure 2](#), several seeps exist within and just down river of the Molycorp property. However, the NMED (March, 1996) reports that there are three principal seeps which exhibit concentrated discharge and appear to have the most impact on Red River water quality: Capulin Canyon, Portal Spring, and Cabin Spring. The NMED states that water chemistry varies between seeps. However, all are acidic and contain elevated concentrations of TDS, including sulfates, Al, Fe, Mn, Co, Cu, Ni, Zn, Cd, and F, which exceed NMGWS. The most dominant metals in all seeps are Ca, Al, Mg, and Fe, respectively.

Ground water samples, as summarized on [Table 5](#), were collected from monitor wells and compared to the Portal Springs, Cabin Springs and Capulin Canyon seeps. Portal Springs and Capulin Canyon waters appear to be more similar to ground water in the valley fill aquifer than to the underlying bedrock aquifer. All ground water samples have TDS and sulfate concentrations above the concentrations in the Red River seeps, and exhibit a pH lower than seep discharge. The following is a water quality evaluation of each seep and its possible source location.

Portal Springs seep is characterized as calcium sulfate waters with a pH of 4.5 and TDS of 1800. Some correlation is apparent between this seep and well MW-10C (upper valley fill, calcium sulfate waters, pH of 4.7, TDS 1400). However, the correlation between MW-10C ground water and Portal Springs seep waters is not clearly defined. Ground water within the upper valley fill aquifer is expected to flow southwest in this area, following the surface topography. Therefore, the ground water supplied to the Portal Springs seep may originate further east of MW-10 and 11, in close proximity to the Moly Tunnel. No closure data on this mine drainage tunnel were available to determine if it may be a probable source for the Portal springs seep.

There exists no up gradient monitor well to attempt a correlation between ground water and the Cabin Springs seep. This seep is located southwest of the nearest WRD and may be caused by preferential flow paths within the bedrock aquifer. No Cabin Springs seep water quality analysis was available for review.

The Capulin Canyon seeps are located west of the main mining operations and appear to be out of the influence of any probable source (WRD or erosional scar). However, the Capulin Canyon seeps and MW-2 (completed in valley fill) have similar low pH values, with sulfates and metals concentrations being greater in MW-2. This suggests the source for the seeps to be up gradient of MW-2. The most probable source for the Capulin Canyon seep is the Capulin Canyon WRD and scars located within this canyon.

Molycorp contends that erosional scars are the primary cause for metals loading to the Red River. Therefore, erosional scars and seeps outside the influence of WRD leachate were evaluated to determine their potential for the discharge of high metals concentrations to ground water and surface water. As illustrated on [Figure 8](#), three water samples collected from erosional scars and seeps outside of the Molycorp mine boundary (HTS-1, from an erosional scar; and HCS-1 and 2, from ground water seeps) exhibit low pH, moderate to high TDS values, and high metals concentrations. The upper Hanson Creek seep (HCS-1, near a scar) has lower pH and higher metals concentrations than the down gradient (HCS-2) seep, indicating attenuation. Although the weathering of excavated rhyolitic material may be a source for high metals buildup within the Red River watershed, the available information does not indicate whether historic mine sites are located near these erosional scars or seeps. Therefore, erosional scars have the potential to release high metals concentrations to the local watershed. Red River samples, down gradient of the Hanson Creek tributary, showed that dilution had decreased metals concentrations and increased pH.

The unconsolidated WRD material appears to deliver greater concentrations of dissolved metals to the ground water than the consolidated erosional scars. The GHS-3 seep ([Figure 8](#)) at Goathill Gulch is from an erosional scar and near the Capulin canyon WRD. SPRI (April 21.1995) states that this erosional scar extends below the Capulin Canyon WRD, and that the GHS-3 chemistry may reflect a mixture of erosional scar and WRD seepage. The HCS-1 and HTS-1 seeps are also within erosional scars. The GHS-3 seep has greater TDS concentrations, and higher metals concentrations; with sulfates, aluminum and magnesium concentrations being two to nine times greater than the HCS-1 and HTS-1 (erosional scar) seeps. This indicates that the additional WRD material increases the concentrations delivered to the underlying aquifer, well above those concentrations contributed by the erosional scar. Although WRD leachate can supply greater metals concentrations to ground water than erosional scars, erosional scars can also release high metals concentrations to ground water which may discharge to local surface water.

Water samples GHS-1, from Capulin Canyon WRD seepage (considered the worst water quality sample reviewed); GHS-2, from a nearby borehole; and GHS-3 are similar. This correlation supports a hydrological connection between waste rock dump seepage and the immediate ground water.

Hutchison (April 23, 1997) contends that natural factors cause the Red River seeps and if ground water contamination did exist, it would not effect the river due to attenuation. Samples GHS-1, GHS-2 and GHS-3 appear to substantiate ground water contamination from Capulin Canyon WRD infiltration. Red River seep water quality indicates that although attenuation appears to be a factor in seep discharge concentrations, seeps considered hydrologically connected to the probable sources (WRD and erosional scar) discharge high metals concentrations to the river. In addition, ground water samples from monitor wells and anoxic alkaline trenches (located immediately up gradient of seeps) document that ground water has a lower pH and higher concentrations of metals than the hydrologically connected seep discharge, indicating that seep discharge is not a true indication of immediate ground water quality.

4.5.4 GROUND WATER QUALITY

Generally within the valley fill aquifer, ground water acidity, sulfates, and metals concentrations increase down gradient along the river. However, bedrock well MW-7 has the lowest pH and highest sulfate, TDS, and metals concentrations recorded; with much greater values than the other ground water wells. The MW-7 water quality values are similar to the Capulin Canyon and Goathill Gulch (CCS-1 and GHS-1) waste rock seepage concentrations. The perched nature of the bedrock aquifer in the immediate area apparently causes a longer ground water residence time, and therefore, greater concentrations.

The remaining bedrock wells have a pH around 7.0, with the exception of MW-11 (pH 5.6), which is completed below the South Sugar Shack waste rock dump. MW-10B (bedrock well, 7.9 pH) is located immediately down gradient of MW-11 and exhibits lower concentrations of metals than MW-11. The low pH and high metals concentrations for MW-11 is probably a result of infiltration from the WRD. MW-10C (upper valley fill aquifer) water quality (pH 4.7) and ground water level indicate that the upper valley fill aquifer appears to be hydraulically separated from the lower aquifers to some degree. Therefore, there exists support for a ground water flow direction toward the topographic low (the Red River) within the upper valley fill aquifer.

5.0

CONCLUSIONS

The most probable sources for the continuing degradation of the Red River watershed through seep discharge of high metals concentrations are the Molycorp WRDs and the naturally occurring erosional scars. The "most probable" source, indicating that it is the source within a reasonable degree of certainty, has been a defensible argument in the past through specific sampling for verification. Verification of a source requires a comparison of a suspect facility's product or waste stream constituents with contaminants found in ground water and/or surface water. If a correlation exists between facility constituents and contamination, additional support for a hydrological connection is required through water quality, geological and monitor well evidence.

5.1 TAILINGS PONDS

Water quality samples collected from tailings pond leachate, ground water, and Red River seeps indicate that the only probable source for elevated sulfate and metals concentrations found in ground water in this area are the tailings ponds. Ground water samples, which were collected from up and down gradient of the tailings ponds, document infiltration of pond leachate to the underlying shallow alluvial aquifer. A correlation exists between ground water quality below and down gradient of the ponds. Monitor well ground water elevations show a ground water gradient to the river. USGS gage station data indicate the reach adjacent to the tailings ponds is a gaining stream supplied by ground water. Therefore, support

exists for a ground water hydrological connection between the ponds and the river. However, although several ground water samples taken immediately down gradient of the ponds show sulfate and metals concentrations above NMGWS, seeps along the river discharge concentrations below NMGWS and NMSWS. There is insufficient information to document a ground water discharge of metals concentrations above NMGWS and NMSWS to the river in this area.

5.2 MOLYCORP MINE SITE

Naturally occurring erosional scars (exposed and located below some WRDs) and WRDs are the most probable sources of low pH and high metals discharge to the local watershed environment. Red River water quality and a localized concentration of acidic, high metals seeps indicate that the general area of the source is within the Molycorp boundary. Geochemical analysis of erosional scar and WRD leachate indicates similar geochemical signatures. Monitor well ground water samples support a correlation between ground water chemistry and WRD and erosional scar leachate chemistry. USGS gage station data indicate ground water flow to the river. Although attenuation appears to be a factor for seep discharge, a correlation exists between seep and ground water quality. Therefore, verification has been adequately established to support a ground water hydrological connection between the two sources and Red River seep discharge. However, the percentage of constituent concentrations or discharge volume supplied by each probable source to a specific seep could not be determined using the available data.

6.0

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TABLE 1 (1 OF 2) (TAKEN FROM VAIL, October 1994)

WATER QUALITY SURVEY ALONG RED RIVER
BETWEEN STATE ROAD 522 AND FISH HATCHERY
APRIL 12, 1993

<u>SAMPLE SOURCE</u>	<u>PH</u>	<u>TOT ALK</u>	<u>F</u>	<u>TDS</u>	<u>SO4</u>	<u>TSS</u>	<u>MO</u>	<u>DIS. AL</u>	<u>CD</u>	<u>SUS. AL</u>	<u>FE</u>	<u>PB</u>	<u>CU</u>	<u>ZN</u>	<u>MN</u>
#1 R/R Below Highway Bridge	7.23	38	0.84	255	119	31	<.03	<.5	<.005	7.80	0.594	<.1	0.036	0.250	[unk]
#2 Spring N. Side R/R	6.76	90	0.55	247	92	20	<.03	<.5	<.005	0.50	0.543	<.1	0.007	0.021	0.020
#3 Field Drainage to R/R 500' E. of 002	7.44	99	0.60	246	92	7	0.20	<.5	<.005	<.5	0.405	<.1	<.005	0.047	0.050
#4 Field Drainage to R/R 450' E. of 002	8.22	94	0.46	648	172	6	<.03	<.5	<.005	<.5	0.115	<.1	0.008	0.012	0.050
#5 R/R 300' E of 002	7.60	43	0.90	240	118	22	<.03	<.5	<.005	8.00	0.569	<.1	0.028	0.222	0.880
#6 Outfall 002	7.26	152	1.90	1764	840	2.0	1.80	<.5	<.005	<.5	0.102	<.1	<.005	0.010	1.400
#7 Field Drainage 75'W of 002	7.20	165	0.80	727	228	39	0.20	<.5	<.005	2.70	1.090	<.1	0.009	0.017	0.030
#8 R/R above Questa Spring	7.14	50	0.88	268	141	21	<.03	<.5	<.005	6.20	0.573	<.1	0.029	0.207	0.880
#9 Near Questa Springs SE of Conc. Box	7.02	158	0.38	1094	504	88	<.0	<.5	<.005	8.50	2.940	<.1	0.016	0.047	0.070
#10 Near Questa Springs End of Old Pipe	7.50	177	0.60	576	210	7	<.03	<.5	<.005	<.5	<.05	<.1	0.005	0.010	0.010
#11 R/R 500' W of Questa Springs	7.45	54	0.90	269	138	22	<.03	<.5	<.005	3.10	0.618	<.1	0.033	0.215	0.880

TABLE 1 (2 OF 2) (TAKEN FROM VAIL, October 1994)

WATER QUALITY SURVEY ALONG RED RIVER
BETWEEN STATE ROAD 522 AND FISH HATCHERY
APRIL 12, 1993

<u>SAMPLE SOURCE</u>	<u>PH</u>	<u>TOT ALK</u>	<u>F</u>	<u>TDS</u>	<u>SO4</u>	<u>TSS</u>	<u>MO</u>	<u>DIS. AL</u>	<u>CD</u>	<u>SUS. AL</u>	<u>FE</u>	<u>PB</u>	<u>CU</u>	<u>ZN</u>	<u>MN</u>
#12 Spring - N Side R/R Sta. 47 + 20	6.94	82	0.80	271	115	47	<.03	<.5	<.005	1.70	2.360	<.1	0.011	0.046	0.130
#13 R/R sta. 47 + 70 Above Hatchery	7.45	51	0.90	259	128	22	<.03	<.5	<.005	3.00	0.590	<.1	0.026	0.206	0.830
#14 Spring S. Side R/R Sta. 36 + 80	8.14	82	0.80	304	126	<1	<.03	<.5	<.005	<.5	<.05	<.1	<.005	0.005	0.010
#15 Spring N. Side R/R Sta. 36 + 40	7.26	80	1.10	145	20	<1	<.03	<.5	<.005	<.5	<.05	<.1	<.005	<.005	<.0
#16 R/R Sta.	7.80	49	0.90	247	129	24	<.03	<.5	<.005	3.10	0.527	<.1	0.024	0.191	0.781
#17 Hatchery Inlet Cold Water	7.14	43	0.64	176	80		<.03	<.5	<.005	<.5	0.138	<.1	<.005	<.005	<.0
#18 Hatchery Inlet Warm Water	7.87	77	1.10	284	63		<.03	<.5	<.005	<.5	0.181	<.1	<.005	0.010	<.0
#19 Seep Water in Irrigation Ditch Above 002 Line X @ Road	7.73	174	0.54	1304	660		<.03	<.5	<.005	<.5	0.160	<.1	<.005	0.013	0.050
#20 Molycorp Drain Below Culver Above Ditch	8.10	153	1.90	1702	790		1.70	<.5	<.005	4.00	2.400	<.1	0.016	0.010	2.000

TABLE 2
1994 MONITOR WELL WATER QUALITY DATA FOR TAILINGS AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
 (Page 1 of 3)

MONITOR WELL	SAMPLE DATE 1994	WELL TD (feet)	Corrected DEPTH TO WATER (feet)	DEPTH TO PUMP INTAKE (feet)	pH(1)	CONDUCTIVITY (1) (µmhos)	TEMP (1) (°C)	CARBO-NATE (mg/L)	BICARBO-NATE (mg/L)	HYDR-OXCIDE (mg/L)	TOTAL ALK (mg/L)	CHLORIDE (mg/L)	FLUORIDE (mg/L)	NITRATE (mg/L)	SULFATE (mg/L)
EW-1	7-Nov	157	83.00	102	7.50	1,460	NA	<1	156	<1	156	23	0.25	0.72	620
EW-2	8-Nov	204	147.91	170	7.48	850	12.9	<1	122	<1	122	4.8	0.49	0.2	96
EW-2	17-Nov	NA	NA	NA	NA	NA	NA	<1	118	<1	118	4.6	0.5	0.38	90
EW-3	8-Nov	78	57.74	70	7.48	1,135	11.4	<1	110	<1	110	17	0.16	0.6	440
EW-3	19-Nov	NA	NA	NA	NA	NA	NA	<1	136	<1	136	18	0.19	0.49	410
EW-4	7-Nov	58	18.49	50	7.78	650	11.6	<1	152	<1	152	26	0.21	0.35	150
EW-4	16-Nov	NA	NA	NA	NA	NA	NA	<1	156	<1	156	26	0.2	0.36	160
MW-1	7-Nov	100	53.17	80	7.28	1,322	NA	<1	136	<1	136	14	0.27	0.45	610
MW-2	7-Nov	80	22.07	60	7.96	1,701	NA	<1	80	<1	80	15	0.96	<0.06	860
MW-3	8-Nov	60	19.97	55	7.38	1,679	12.4	<1	183	<1	183	18	0.44	0.31	780
MW-4	8-Nov	96	40.77	65	7.61	1,157	12.3	<1	184	<1	184	7.3	0.73	0.24	460
MW-7A	7-Nov	90	58.84	80	7.50	1,565	11.9	<1	126	<1	126	16	0.18	0.72	730
MW-7C	9-Nov	146	111.79	135	7.10	2,160	12.4	<1	124	<1	124	16	0.17	0.32	790
MW-9A	8-Nov	44	26.30	35	7.32	1,021	13.1	<1	174	<1	174	20	0.44	0.33	680
MW-10	8-Nov	129	26.23	100	8.16	236	12.3	<1	77	<1	77	1.6	0.36	0.27	35
MW-11	9-Nov	249	191.93	210	7.00	440	19.8	<1	82	<1	82	10.3	1.28	0.39	58
MW-11AB	9-Nov	NA	NA	NA	NA	NA	NA	<1	79	<1	79	10.1	1.29	NA	58
MW-12	7-Nov	234	128.11	210	NA	NA	NA	<1	120	<1	120	5.1	0.46	NA	66
MW-A	7-Nov	38	30.58	NA	7.28	1,332	NA	<1	154	<1	154	14	0.35	0.37	560
MW-C	7-Nov	14.5	1.80	NA	7.24	1,901	NA	<1	185	<1	185	19	1.16	<0.06	970
CH	8-Nov	NA	NA	NA	7.97	539	13.5	<1	206	<1	206	2.3	0.71	0.44	75

NOTES:
 (1)pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED
 SOURCE: SAMPLES TAKEN BY SPRI ANALYTICAL RESULTS FROM MOLYCORP.
 NA - NOT AVAILABLE

TABLE 2
1994 MONITOR WELL WATER QUALITY DATA FOR TAILINGS AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
 (Page 2 of 3)

MONITOR WELL	TDS (mg/L)	SILVER (mg/L)	ALUMINUM (mg/L)	ARSENIC (mg/L)	BARIUM (mg/L)	BERYLLIUM (mg/L)	CALCIUM (mg/L)	CADMIUM (mg/L)	COBALT (mg/L)	CHROMIUM (mg/L)	COPPER (mg/L)	IRON (mg/L)	MERCURY (mg/L)
EW-1	1,200	<0.10	<0.05	<0.005	0.053	<0.004	240	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-2	240	<0.10	<0.05	<0.005	0.068	<0.004	59.4	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-2	290	<0.010	<0.05	<0.005	0.065	<0.004	57.8	0.0036	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-3	830	<0.10	<0.05	<0.005	0.074	<0.004	179	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-3	750	<0.010	<0.05	<0.005	0.054	<0.004	158	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-4	440	<0.10	<0.05	<0.005	0.065	<0.004	101	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-4	450	<0.010	<0.05	<0.005	0.068	<0.004	104	<0.0005	<0.010	<0.010	0.012	<0.050	<0.0002
MW-1	1,100	<0.10	<0.05	<0.005	0.025	<0.004	207	<0.0005	<0.010	<0.010	<0.010	0.068	<0.0002
MW-2	1,400	<0.10	<0.05	<0.005	0.022	<0.004	241	<0.0005	<0.010	<0.010	<0.010	4.6	<0.0002
MW-3	1,400	<0.10	<0.05	<0.005	0.032	<0.004	264	<0.0005	<0.010	<0.010	<0.010	0.07	<0.0002
MW-4	890	<0.10	<0.05	<0.005	0.084	<0.004	166	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-7A	1,300	<0.10	<0.05	<0.005	0.028	<0.004	273	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-7C	1,300	<0.10	<0.05	<0.005	0.028	<0.004	279	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-9A	1,200	<0.10	<0.05	<0.005	0.061	<0.004	247	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-10	150	<0.10	<0.05	<0.005	0.038	<0.004	28.2	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-11	200	<0.10	<0.05	<0.005	0.014	<0.004	28.6	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-11AB	220	<0.10	<0.05	<0.005	0.015	<0.004	28.5	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-12	260	<0.10	<0.05	<0.005	0.096	<0.004	47.1	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-A	1,000	<0.10	<0.05	<0.005	0.03	<0.004	214	<0.0005	<0.010	<0.010	<0.010	0.066	<0.0002
MW-C	1,700	<0.10	<0.05	<0.005	0.04	<0.004	334	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
CH	340	<0.10	<0.05	<0.005	0.059	<0.004	48.5	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002

NOTES:
 (1) pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.
 SOURCE: SAMPLES TAKEN BY SPRI. ANALYTICAL RESULTS FROM MOLYCORP.
 NA - NOT AVAILABLE

TABLE 2
1994 MONITOR WELL WATER QUALITY DATA FOR TAILINGS AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
 (Page 3 of 3)

MONITOR WELL	POTASSIUM (mg/L)	MAGNESIUM (mg/L)	MANGANESE (mg/L)	MOLYBDENUM (mg/L)	SODIUM (mg/L)	NICKEL (mg/L)	LEAD (mg/L)	ANTIMONY (mg/L)	SELENIUM (mg/L)	SILICON (mg/L)	THALLIUM (mg/L)	VANADIUM (mg/L)	ZINC (mg/L)
EW-1	3.7	47.9	0.017	<0.02	41.7	<0.020	<0.002	<0.05	<0.005	13.8	<0.005	<0.010	<0.050
EW-2	3.3	10.4	0.169	<0.02	20.0	<0.020	<0.002	<0.05	<0.005	15.7	<0.005	<0.010	<0.050
EW-2	3.6	10	0.138	<0.02	19.6	<0.020	<0.002	<0.05	<0.005	17.3	<0.005	<0.010	0.091
EW-3	2.6	31.8	0.056	<0.02	28.6	<0.020	<0.002	<0.05	<0.005	12.4	<0.005	<0.010	0.364
EW-3	2.2	27.8	0.036	<0.02	28.9	<0.020	<0.002	<0.05	<0.005	11.9	<0.005	<0.010	<0.050
EW-4	1.5	17.8	<0.010	<0.02	15.5	<0.020	<0.002	<0.05	<0.005	12.4	<0.005	<0.010	0.364
EW-4	2.1	18.1	0.019	<0.02	16	<0.020	<0.002	<0.05	<0.005	12.7	<0.005	<0.010	<0.050
MW-1	3.0	41.2	0.035	0.04	55.4	<0.020	<0.002	<0.05	<0.005	11.9	<0.005	<0.010	<0.050
MW-2	3.1	52.2	0.37	1.7	95.6	<0.020	<0.002	<0.05	<0.005	1.8	<0.005	<0.010	<0.050
MW-3	1.5	48.6	0.032	<0.02	71.6	<0.020	<0.002	<0.05	<0.005	10.3	<0.005	<0.010	<0.050
MW-4	1.1	32.7	<0.010	0.21	64.2	<0.020	<0.002	<0.05	<0.005	10.3	<0.005	<0.010	<0.050
MW-7A	2.6	47.1	<0.010	<0.02	39.5	<0.020	<0.002	<0.05	<0.005	12.3	<0.005	<0.010	<0.050
MW-7C	3.9	48.4	<0.010	<0.02	45.1	<0.020	<0.002	<0.05	<0.005	12.1	<0.005	<0.010	<0.050
MW-9A	1.7	45.5	0.111	<0.02	66.0	<0.020	<0.002	<0.05	<0.005	10.5	<0.005	<0.010	<0.050
MW-10	1.3	4.4	<0.010	<0.02	14.7	<0.020	<0.002	<0.05	<0.005	10.8	<0.005	<0.010	<0.050
MW-11	2.8	8.6	<0.010	0.06	25.8	<0.020	<0.002	<0.05	<0.005	15.5	<0.005	<0.010	<0.050
MW-11AB	2.6	8.6	<0.010	0.06	25.7	<0.020	<0.002	<0.05	<0.005	15.5	<0.005	0.01	<0.050
MW-12	2.9	8.5	<0.010	0.02	24.5	<0.020	<0.002	<0.05	<0.005	13.6	<0.005	<0.010	<0.050
MW-A	2.8	35.7	0.04	0.63	50.6	<0.020	<0.002	<0.05	<0.005	10.9	<0.005	<0.010	<0.050
MW-C	2.1	56.1	0.774	1.12	82.2	<0.020	<0.002	<0.05	<0.005	11.6	<0.005	<0.010	<0.050
CH	1.2	9.4	<0.010	<0.02	57.8	<0.020	<0.002	<0.05	<0.005	9.8	<0.005	<0.010	0.946

NOTES:
 (1)pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.
 SOURCE: SAMPLES TAKEN BY SPRI. ANALYTICAL RESULTS FROM MOLYCORP.
 NA - NOT AVAILABLE

TABLE 3
WATER QUALITY DATA FOR THE RED RIVER - (SPRI, MAY 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 1 of 4)

Sample ID	Sample Description	pH Meter	pH Strip	Temp (°F)	Conductivity (µmhos)	Total Alkalinity (mg/L)	TDS (mg/L)	TSS (mg/L)	Aluminum Susp. (mg/L)	Aluminum Dis. (mg/L)	Fluoride (mg/L)	Iron (mg/L)
BC-1	BC 75' N of High St. bridge	6.40	5.0	44.9	49.8	20	82	26	0.75	0.60	0.15	2.70
BC-2	BC 500' S of Spring flow from BCS-1	6.55	5.5	43.6	66.2	18	78	10	<.5	0.60	0.12	1.00
BCS-1	Spring, 1.2 mi. N High St.	4.42	5.0	44.7	478.0	0	530	<1	<.5	5.20	0.30	<.01
BOS-1	Spring, W side of Bobita Campground	-	6.0	61.0	605.0	44	737	8	<.5	<.5	0.32	0.16
CCS-1	Middle sump Capulin Canyon	-	3.0	50.9	13,440	0	24,950	8	1.00	1,310	53.30	258.30
CCS-2	Spring drainage W side Capulin Canyon	-	7.0	56.9	260.0	54	416	107	2.80	2.2	0.62	11.72
CCS-3	Adit W side Capulin Canyon	-	4.0	45.1	2,960	0	2,686	295	1.60	53.6	12.00	25.20
CCS-4	Seep, Capulin Canyon S of adit	-	4.0	48.2	1,775	0	1,193	12.7	<.5	23.2	5.70	2.35
CCS-5	Culvert drain W side of Capulin Canyon	-	4.0	66.7	1,700	0	1,896	3.7	<.5	74.8	9.80	0.21
CCS-6	Seep, 200' E Capulin Canyon	-	3.0	73.7	2,430	0	2,673	6.4	<.5	116.2	13.00	7.68
CLB-1	Columbine Creek-200' up from confluence	-	6.5	57.7	134.0	49	70	3	<.5	<.5	0.18	0.34
ECCS-1	Seep near river, E of Capulin Canyon	-	6.5	60.5	580.0	26	413	8	<.5	<.5	1.50	0.32
ECCS-2	Seep S of Hwy 38, E of Capulin Canyon	-	4.0	62.0	1,752	0	913	1	<.5	73	5.20	0.79
EGHS-1	Seep S of Hwy 38, E of Goathill	-	7.0	55.6	810.0	47	843	1.2	<.5	<.5	0.47	0.15
GHS-1	Seepage Goat Hill Dump	-	2.0	69.1	11,140	0	23,890	39	0.97	1,183	36.70	257.00
GHS-2	Seep from bore hole +GHS1	-	2.0	73.0	11,350	0	17,623	29	1.70	1,125	43.30	252.00
GHS-3	Natural seep from volcanic rock	-	-	-	-	0	11,980	94	1.30	645	26.00	250.00
HCS-1	seeps, Upper Hanson Creek Canyon	-	2.5	44.2	5,520	0	6,493	13.6	<.5	185.4	15.00	177.90
HCS-2	seep, downgradient from HCS-1	-	2.5	50.6	5,390	0	6,230	7.6	<.5	154	15.60	164.80
HCS-3	Seep S of Hwy 38, W of Hanson Creek	-	4.0	77.0	1,232	0	1,773	<1	<.5	2.6	1.40	0.43
HTS-1	Upper Hot-N-Tot Canyon	2.86	2.3	48.2	2,670	0	2,610	43	<.5	97.8	2.30	212.80
MC-1	Mallette Creek-alpine Lodge	6.86	6.0	52.2	80.4	22	96	16	0.65	0.60	0.25	1.20
PC-1	Pioneer Creek, Arrowhead Lodge	7.34	7.0	45.1	107.0	43	94	15	<.5	0.50	0.10	0.70
POS-1	seep, Portal Springs W of mine portal	-	4.5	54.4	1,900	10	1,800	34	<.5	21.3	153.00	8.24
RR-1	RR W of confluence w/BitCrk	7.40	6.0	43.8	99.3	43	82	4	<.5	0.50	0.86	1.10
RR-2	RR 50' E of BC Confluence	7.58	6.5	45.9	108.0	70	88	18	<.5	0.50	0.08	0.80
RR-3	RR behind Alpine Lodge	7.53	6.0	48.2	93.7	51	92	22	0.5	0.50	0.10	2.10
RR-4	RR, Goose Lake Rd/East RR	7.73	7.0	43.5	130.0	47	98	13	<.5	<.5	0.10	0.70
RR-5	RR, Hot-N-Tot Creek/upstream	7.45	7.0	47.0	144.0	59	100	32	0.75	0.50	0.11	2.20

TABLE 3
WATER QUALITY DATA FOR THE RED RIVER - (SPRI, MAY 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 2 of 4)

Sample ID	Sample Description	pH Meter	pH Strip	Temp (°F)	Conductivity (µmhos)	Total Alkalinity (mg/L)	TDS (mg/L)	TSS (mg/L)	Aluminum Susp. (mg/L)	Aluminum Dis. (mg/L)	Fluoride (mg/L)	Iron (mg/L)
RR-6	RR, Hot-N-Tot Creek/dwnstream	7.52	6.5	48.0	145.0	43	92	34	0.60	<.5	0.11	1.90
RR-7	RR down from Sulphur Gulch	7.48	7.0	62.0	122.0	48	108	49	0.75	<.5	0.16	2.10
RR-8	RR upstream from mill gate	7.53	6.5	57.0	129.0	56	106	57	0.50	0.60	0.12	2.14
RR-9	RR 200' up from Hanson Creek confluence	7.46	7.0	54.5	144.0	53	104	31.2	<.5	<.5	0.13	1.70
RR-10	RR, downstream of Portal Springs	7.46	7.0	54.5	196.0	48	112	31.2	1.60	<.5	0.20	2.41
RR-11	RR, down from Hanson Creek confluence	7.51	6.5	51.5	177.0	61	104	17.6	<.5	<.5	0.11	1.29
RR-12	RR 100' E of Columbine Creek Confluence	-	6.5	55.5	196.0	48	213	58	0.54	0.6	0.30	2.35
RR-13	RR, highway bridge W of Columbine Creek	-	6.5	55.5	196.0	50	163	54	0.54	<.5	0.20	1.80
RR-14	RR up from Goathill Gulch	-	6.5	58.1	241.0	42	123	52	0.72	<.5	0.32	2.05
RR-15	RR down from Goathill Gulch	-	7.0	57.0	224.0	52	130	62	0.83	<.5	0.32	2.24
RR-16	RR Questa Ranger Station	-	6.5	54.0	171.0	41	150	106	0.83	<.5	0.35	2.72
SGS-1	Sulphur Gulch-spring pond	6.65	7.0	75.5	753.0	83	620	6.5	<.5	<.5	1.30	0.75
SSC-1	seep, S of west end Sugar Shack South	-	5.0	55.0	2,350	33	2,017	214	2.20	5.3	92.00	<.01

NOTES:

Sampling by SPRI; analytical results from Molycorp, Inc.
(1)-pH Strip, temperature and conductivity were measured field measurements.
All samples are total metals except alum. Suspended and Slum. Dissolved
<symbols are detection limits.

TABLE 3
WATER QUALITY DATA FOR THE RED RIVER - (SPRI, MAY 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 3 of 4)

Sample ID	Ferrous Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Copper (mg/L)	Molybdenum (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Silica (mg/L)	Chlorine (mg/L)	Cadmium (mg/L)	Sulfate (mg/L)
BC-1	-	0.003	0.041	0.025	0.03	<.02	2.5	<1.0	6	1.6	20	2.5	<.005	12
BC-2	-	0.002	0.034	0.025	0.02	<.02	2.7	<1.0	12.5	3.5	22	3	<.005	13.7
BCS-1	-	<.002	1.360	0.491	0.18	<.02	9.4	1.5	48.9	27.2	46	5	0.005	171
BOS-1	-	<.002	<.01	0.060	0.01	<.02	13.1	1.2	85.2	21.5	20	20	<.005	217
CCS-1	7.0	<.002	416.20	146.00	15.3	<.02	23.7	<1.0	504	1,032	92.4	30	0.75	11,996
CCS-2	-	0.036	0.213	0.149	0.024	<.02	9.5	2.6	20.2	4.2	46.6	7.5	<.005	56.8
CCS-3	<1.0	0.078	12.600	6.960	0.162	<.02	70.3	9.6	348	84	76	14.5	0.021	1,736
CCS-4	-	<.002	10.300	2.620	0.21	<.02	30.9	2	145	38.5	52	9.5	0.007	541.7
CCS-5	-	0.004	28.900	7.600	1.21	<.02	19.1	1.7	118	76.9	112	9.5	0.036	1,152
CCS-6	-	0.003	13.600	4.470	0.998	<.02	30	3.5	233	65	62	35	0.017	1,649
CLB-1	-	<.002	<.01	0.022	0.008	<.02	1.5	<1.0	17	1.8	14	2.5	<.005	1.7
ECCS-1	-	<.002	<.01	0.115	0.01	<.02	9.8	1.2	52.8	12.7	28	18.5	<.005	128.3
ECCS-2	-	0.003	8.740	2.820	0.921	<.02	55.7	3.5	138	41	28	95	0.015	669
EGHS-1	-	<.002	<.01	0.042	0.009	<.02	9.5	1.7	104.4	23.1	18	10.5	<.005	190
GHS-1	8.0	<.010	239.50	82.70	8.6	<.02	11.7	<1.0	444	760	104	37	0.381	13,312
GHS-2	10.0	<.010	263.80	86.40	8.5	<.02	18.4	<1.0	432	704	96.7	40	0.409	11,667
GHS-3	1.0	0.017	22.00	4.22	1.58	<.02	32.6	<1.0	504	405	102	15	<.005	7,763
HCS-1	2.0	0.004	20.300	3.740	0.512	<.02	17.8	<1.0	504	274	63.5	10	0.012	3,876
HCS-2	-	<.002	17.100	3.880	0.629	<.02	17.2	<1.0	454	199	75.9	16	0.013	3,436
HCS-3	-	0.004	0.445	0.183	0.025	<.02	48	2.6	156	18	22	90	<.005	377
HTS-1	7.0	0.009	6.250	2.960	1.14	<.02	2.1	<1.0	55.9	43.5	100	16	0.012	848
MC-1	-	<.002	0.054	0.043	0.02	<.02	3.9	1.4	8.2	3.1	32	4.5	<.005	16.4
PC-1	-	<.002	0.036	0.014	0.02	<.02	2	<1.0	19.8	2.4	15	5	<.005	20
POS-1	-	<.002	6.830	2.490	0.05	<.02	26.2	3.4	206	16.6	32	27	0.01	622
RR-1	-	<.002	0.033	0.048	0.02	<.02	2.2	<1.0	15	2.5	14	4	<.005	8
RR-2	-	<.002	0.039	0.012	0.01	<.02	2	<1.0	17.7	2.4	14	2.5	<.005	3
RR-3	-	0.004	0.086	0.018	0.02	0.003	2.3	<1.0	15.7	2.5	17	4	<.005	13.8
RR-4	-	<.002	0.030	0.006	0.01	<.02	1.9	<1.0	17	2.2	12	5	<.005	2.2
RR-5	-	0.003	0.065	0.022	0.02	<.02	2.3	<1.0	17	2.5	14	5	<.005	17.4

TABLE 3
WATER QUALITY DATA FOR THE RED RIVER - (SPRI, MAY 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 4 of 4)

Sample ID	Ferrous Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Copper (mg/L)	Molybdenum (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Silica (mg/L)	Chlorine (mg/L)	Cadmium (mg/L)	Sulfate (mg/L)
RR-6	-	0.003	0.080	0.034	0.02	<.02	2.3	<1.0	16.6	2.4	14	5	<.005	17.7
RR-7	-	0.004	0.080	0.030	0.02	<.02	2.8	<1.0	20	3.1	16	5	<.005	15.9
RR-8	-	0.004	0.082	0.027	0.02	<.02	2.8	<1.0	19.1	3	24	4.5	<.005	19.5
RR-9	-	0.003	0.064	0.202	0.01	<.02	2.6	<1.0	18.6	3.4	14	5	<.005	14.5
RR-10	-	0.004	0.109	0.018	0.02	<.02	2.9	<1.0	20.4	3.9	17	5	<.005	17.4
RR-11	-	0.004	0.048	<.005	0.02	<.02	2.6	<1.0	18.5	3.3	20	4	<.005	11.4
RR-12	-	0.004	0.126	0.042	0.018	<.02	3	<1.0	21.4	4.6	64	2.5	<.005	33.6
RR-13	-	0.004	0.078	0.031	0.016	<.02	2.9	<1.0	21	4.4	18	3	<.005	23.5
RR-14	-	0.006	0.242	0.067	0.02	<.02	3	1	23	5	18	3	0.007	29.7
RR-15	-	0.004	0.213	0.062	0.018	<.02	3	<1.0	22.8	4.9	20	3.5	<.005	34.7
RR-16	-	0.014	0.290	0.073	0.024	<.02	2.7	<1.0	22.1	4.5	14	6.5	<.005	28.9
SGS-1	-	<.002	0.252	0.099	0.01	0.19	17.6	4	119	17.7	24	22.5	<.005	160
SSC-1	-	0.026	12.300	2.920	0.213	0.88	58.7	5.3	298	13.5	30	72.5	0.02	679.8

TABLE 4
MINE SITE MONITOR WELL GROUND WATER ELEVATIONS
(FROM MOLYCORP)

MOLYCORP, INC. - QUESTA DIVISION

MMW WATER ELEVATIONS

WELL	REFERENCE ELEVATION	H2O ELEV 2/22/96	H2O ELEV 3/13/98	H2O ELEV 4/18/96	H2O ELEV 5/23/96	H2O ELEV 6/21/96	H2O ELEV 7/25/96	H2O ELEV 8/21/96	H2O ELEV 9/20/96	H2O ELEV 1/27/97	H2O ELEV 2/17/97	H2O ELEV 3/7/97	H2O ELEV 3/31/97	H2O ELEV 4/25/97	H2O ELEV 5/21/97	H2O ELEV 6/25/97	H2O ELEV 7/22/97	H2O ELEV 8/20/97
MMW-2	7700.05	7665.59	7665.60	7665.47	7665.10	7665.52	7665.10	7665.52	7665.73	665.41	7665.49	-	7665.95	7665.88	7665.92	7665.26	7665.04	7665.28
MMW-3	7701.07	7669.10	7669.14	7669.10	7668.69	7669.08	7668.69	7669.08	7669.17	7668.79	7668.89	-	7669.44	7669.24	7669.36	7668.78	7668.50	7668.72
MMW-7	8090.16	8028.41	8028.58	8028.80	8028.26	8029.00	8029.00	8028.26	8028.69	8028.71	8028.59	-	8028.46	8028.59	8028.74	8028.58	8028.46	8028.66
MMW-8A	7858.22	7761.69	7761.8	7761.77	7762.06	7762.60	7762.06	7762.60	7762.77	7762.07	7761.80	-	7761.99	7761.41	7762.56	7762.62	7762.05	7761.91
MMW-8B	7859.47	7763.73	7763.84	7763.87	7764.14	7764.51	7764.14	7764.51	7764.63	7763.76	7763.57	-	7763.75	7764.14	7764.53	7764.72	7763.52	7763.88
MMW-10A	7939.33	7917.58	7917.37	7917.36	7918.19	7917.55	7918.19	7917.55	7916.64	7911.40	7909.49	7907.48	7907.17	7906.45	7907.87	7915.41	7916.10	7914.09
MMW-10B	7939.20	7917.52	7917.32	7917.31	7918.05	7917.53	7918.05	7917.53	7916.57	7911.25	7909.32	7907.24	7906.90	7905.85	7905.60	7915.20	7916.00	7913.90
MMW-10C	7939.44	7917.18	7916.99	7916.99	7917.75	7917.23	7917.75	7917.23	7916.31	7911.29	7909.48	7907.47	7907.10	7906.29	7907.72	7914.94	7915.99	7914.00
MMW-11	8004.93	7917.50	7915.3	7915.28	7916.11	7915.57	7916.11	7915.57	7914.64	7909.74	7908.07	7906.09	7905.61	7904.77	7906.05	7913.82	7914.43	7912.50
MMW-13	8072.45	7963.75	7963.32	7963.25	7965.05	7965.19	7965.05	7965.19	7961.17	7947.13	7945.30	7942.75	7941.86	7941.35	7942.41	7954.32	7956.64	7953.50
MMW-14	8166.50	0	0	-	-	-	0	0	0	8106.14	8106.28	8106.28	8106.28	8106.25	8106.27	8106.27	8106.28	8106.27
MMW-16	8139.66	8057.03	8056.86	8056.66	8057.32	8056.05	8057.32	8056.05	8053.86	8053.33	8053.24	DRY	DRY	MUD	MUD	MUD	MUD	MUD
P-1	7827.08	-	-	-	-	-	-	-	-	-	7805.43	-	7804.46	7805.08	-	7804.08	7806.80	7807.56
P-2	7822.34	-	-	-	-	-	-	-	-	-	7806.24	-	7805.56	7805.88	-	7804.99	7807.34	7807.95
P-3	7842.71	-	-	-	-	-	-	-	-	-	7811.46	-	7810.86	7811.44	-	7816.15	7813.77	7813.78
P-4A	7834.36	-	-	-	-	-	-	-	-	-	7810.72	-	7810.23	7810.41	-	7814.36	7812.21	7812.45
P-4B	7834	-	-	-	-	-	-	-	-	-	7809.89	-	7809.27	7809.74	-	7813.89	7811.58	7811.85
P-5A	7840.37	-	-	-	-	-	-	-	-	-	7872.07	-	7818.86	7819.68	-	7823.82	7822.07	7821.43
P-5B	7840.18	-	-	-	-	-	-	-	-	-	7817.68	-	7817.65	7818.28	-	7821.83	7820.08	7819.69
P-5C	7840.29	-	-	-	-	-	-	-	-	-	7816.19	-	7816.26	7816.79	-	7819.66	7818.17	7817.89

TABLE 5
1994 MONITOR WELL WATER QUALITY DATA FOR MINE AREA
 MOLYCORP, INC. - QUESTA, NEW MEXICO
 (Page 1 of 3)

MONITOR WELL	SAMPLE DATE 1994	WELL TD (feet)	Corrected DEPTH TO WATER (feet)	DEPTH TO PUMP INTAKE (feet)	pH(1)	CONDUCTIVITY (1) (µmhos)	TEMP (1) (°C)	CARBO-NATE (mg/L)	BICARBO-NATE (mg/L)	HYDR-OXIDE (mg/L)	TOTAL ALK (mg/L)	CHLORIDE (mg/L)	FLUORIDE (mg/L)	SULFATE (mg/L)
MMW-2	8-Nov	68	31.69	50	4.90	3,680	7.9	<1	<1	<1	<1	6.8	24.0	2,100
MMW-3	7-Nov	140	27.76	80	7.50	3,970	10.9	<1	222	<1	222	5.8	2.59	1,700
MMW-7	7-Nov	161	61.11	120	4.40	9,490	17.2	<1	<1	<1	<1	21	1.12	10,400
DUP-11A(2)	7-Nov	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	21	0.98	10,500
MMW-8A	8-Nov	178	96.77	140	7.00	2,860	8.4	<1	165	<1	165	8.7	2.72	1,300
MMW-8B	8-Nov	129	96.03	112	6.40	1,780	7.1	<1	19	<1	19	5.6	1.83	730
MMW-10A	8-Nov	144	21.70	100	5.80	2,400	7.8	<1	<1	<1	<1	27	11.2	1,100
DUP-12B (3)	8-Nov	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	26	7.96	1,100
MMW-10A (4)	19-Nov	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	26	8.28	1,200
MMW-10B	7-Nov	189	21.57	140	7.90	2,250	10.1	10	<1	66	76	28	12.2	1,100
MMW-10C	8-Nov	50	21.80	40	4.70	2,000	11.8	<1	<1	<1	<1	20	15.4	880
MMW-11	7-Nov	184	86.71	150	5.60	2,450	15.7	<1	<1	<1	<1	22	17.6	1,300
MMW-13	8-Nov	145	105.98	130	7.90	2,280	8.9	<1	200	<1	200	14	1.67	770

NOTES:

(1) pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.

(2) - Dup 11A = DUPLICATE SAMPLE FOR MMW-7

(3) - Dup 12B = DUPLICATE SAMPLE FOR MMW-10A

(4) - SAMPLED AFTER AQUIFER TEST

NA - Not Available

SOURCE: SAMPLES TAKEN BY SPRI, ANALYTICAL RESULTS FROM MOLYCORP.

TABLE 5
1994 MONITOR WELL WATER QUALITY DATA FOR MINE AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
 (Page 2 of 3)

MONITOR WELL	TDS (mg/L)	SILVER (mg/L)	ALUMINUM (mg/L)	ARSENIC (mg/L)	BARIUM (mg/L)	BERYLLIUM (mg/L)	CALCIUM (mg/L)	CADMIUM (mg/L)	COBALT (mg/L)	CHROMIUM (mg/L)	COPPER (mg/L)	IRON (mg/L)	MERCURY (mg/L)
MMW-2	3,400	<0.10	63.5	<0.005	<0.010	0.015	501	0.024	0.280	<0.010	0.088	50.8	<0.0002
MMW-3	2,900	<0.10	0.75	<0.005	0.047	<0.004	567	0.0024	0.089	<0.010	<0.010	0.076	<0.0002
MMW-7	16,000	<0.50	943	<0.05	0.108	0.104	544	0.096	4.91	0.193	4.84	384	<0.0002
DUP-11A (2)	16,000	<0.50	961	<0.05	0.074	0.122	534	0.092	4.99	0.17	5.04	375	<0.0002
MMW-8A	2,200	<0.10	<0.05	<0.005	0.103	<0.004	466	0.002	<0.010	<0.010	<0.010	2.84	<0.0002
MMW-8B	1,100	<0.10	0.44	<0.005	0.016	<0.004	206	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MMW-10A	1,700	<0.10	33.4	<0.005	<0.010	0.008	275	0.028	0.148	<0.010	0.558	<0.050	<0.0002
DUP-12B (3)	1,700	<0.10	34.2	<0.005	<0.010	0.008	270	0.024	0.137	<0.010	0.58	<0.050	<0.0002
MMW-10A (4)	1,700	<0.010	31.6	<0.005	<0.010	0.006	245	0.0224	0.141	<0.010	0.534	0.086	<0.0002
MMW-10B	1,800	<0.10	8.74	<0.005	0.034	0.007	347	0.025	0.074	<0.010	0.179	0.101	<0.0002
MMW-10C	1,400	<0.10	31.1	<0.005	0.014	0.007	204	0.0026	0.106	<0.010	0.38	<0.050	<0.0002
MMW-11	2,000	<0.10	56.3	<0.005	0.016	0.013	276	0.036	0.266	0.036	0.919	0.129	<0.0002
MMW-13	1,400	<0.10	<0.05	<0.005	0.036	<0.004	316	<0.0005	0.013	<0.010	<0.010	0.198	<0.0002

NOTES:

(1) pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.

(2) - Dup 11A = DUPLICATE SAMPLE FOR MMW-7

(3) - Dup 12B = DUPLICATE SAMPLE FOR MMW-10A

(4) - SAMPLED AFTER PUMP TEST

SOURCE: SAMPLES TAKEN BY SPRI, ANALYTICAL RESULTS FROM MOLYCORP.

TABLE 5
1994 MONITOR WELL WATER QUALITY DATA FOR MINE AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
 (Page 3 of 3)

MONITOR WELL	POTASSIUM (mg/L)	MAGNESIUM (mg/L)	MANGANESE (mg/L)	MOLYBDENUM (mg/L)	SODIUM (mg/L)	NICKEL (mg/L)	LEAD (mg/L)	ANTIMONY (mg/L)	SELENIUM (mg/L)	SILICON (mg/L)	THALLIUM (mg/L)	VANADIUM (mg/L)	ZINC (mg/L)
MMW-2	10.8	137	52.1	<0.02	64.6	0.61	<0.002	<0.05	<0.05	20.3	<0.005	<0.010	9.48
MMW-3	7.5	96.2	34.5	<0.02	103	0.236	<0.002	<0.05	<0.005	7.6	<0.005	<0.010	1.36
MMW-7	12.0	1250	72.1	<0.10	175	10.5	0.10	<0.25	<0.025	22.7	<0.005	0.104	11.7
DUP-11A (2)	12.1	1230	73.3	<0.10	178	10.7	0.06	<0.25	<0.025	22.6	<0.005	0.106	11.9
MMW-8A	3.8	85.6	7.15	<0.02	41.5	<0.020	<0.002	<0.05	<0.005	11.1	<0.005	<0.010	<0.050
MMW-8B	2.9	55.5	0.202	<0.02	33.9	0.059	<0.002	<0.05	<0.005	17.3	<0.005	<0.010	0.211
MMW-10A	2.8	77.9	13.8	<0.02	26.5	0.325	<0.002	<0.05	<0.005	14.3	<0.005	<0.010	2.29
DUP-12B (3)	2.5	76.7	12.8	<0.02	26.4	0.293	<0.002	<0.05	<0.005	14.0	<0.005	<0.010	2.07
MMW-10A (4)	3.7	69.7	13.1	<0.02	25.6	0.279	0.004	<0.05	<0.005	14.1	<0.005	<0.010	2.68
MMW-10B	3.5	80.3	8.5	<0.02	25.8	0.201	0.021	<0.05	<0.05	12.8	<0.005	<0.010	1.5
MMW-10C	2.8	75.2	16.3	<0.02	20.2	0.0347	<0.002	<0.05	<0.005	9.9	<0.005	<0.010	3.2
MMW-11	3.4	133	31.7	<0.02	25.5	0.593	0.086	<0.05	<0.005	14.2	<0.005	<0.010	5.0
MMW-13	5.4	38.7	1.02	0.05	30	<0.020	<0.002	<0.05	<0.005	8.8	<0.005	<0.010	0.222

NOTES:

- (1) pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.
- (2) - Dup 11A = DUPLICATE SAMPLE FROM MMW-7
- (3) - Dup 12B = DUPLICATE SAMPLE FOR MMW-10A
- (4) - SAMPLED AFTER PUMP TEST

SOURCE: SAMPLES TAKEN BY SPRI, ANALYTICAL RESULTS FROM MOLYCORP

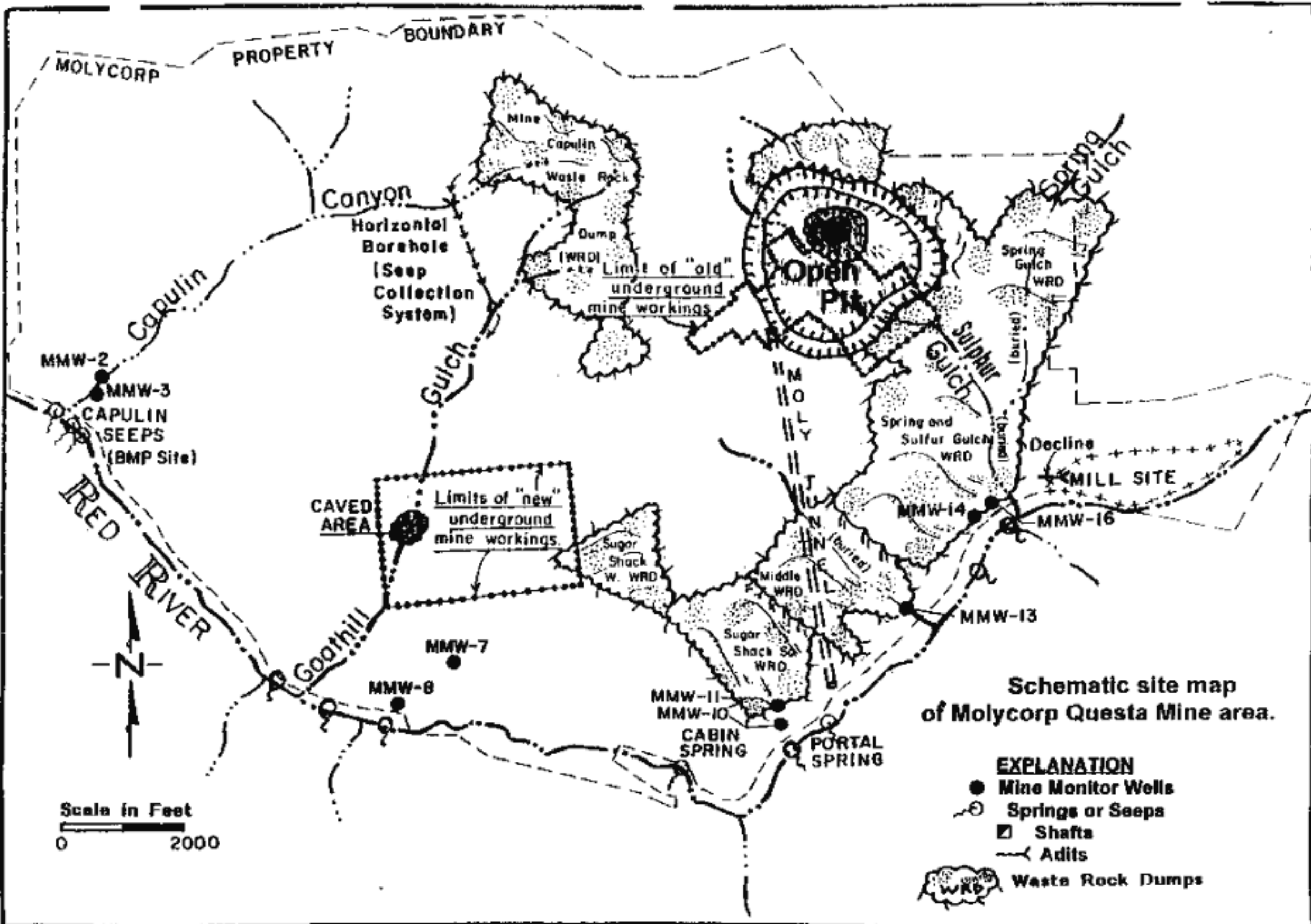
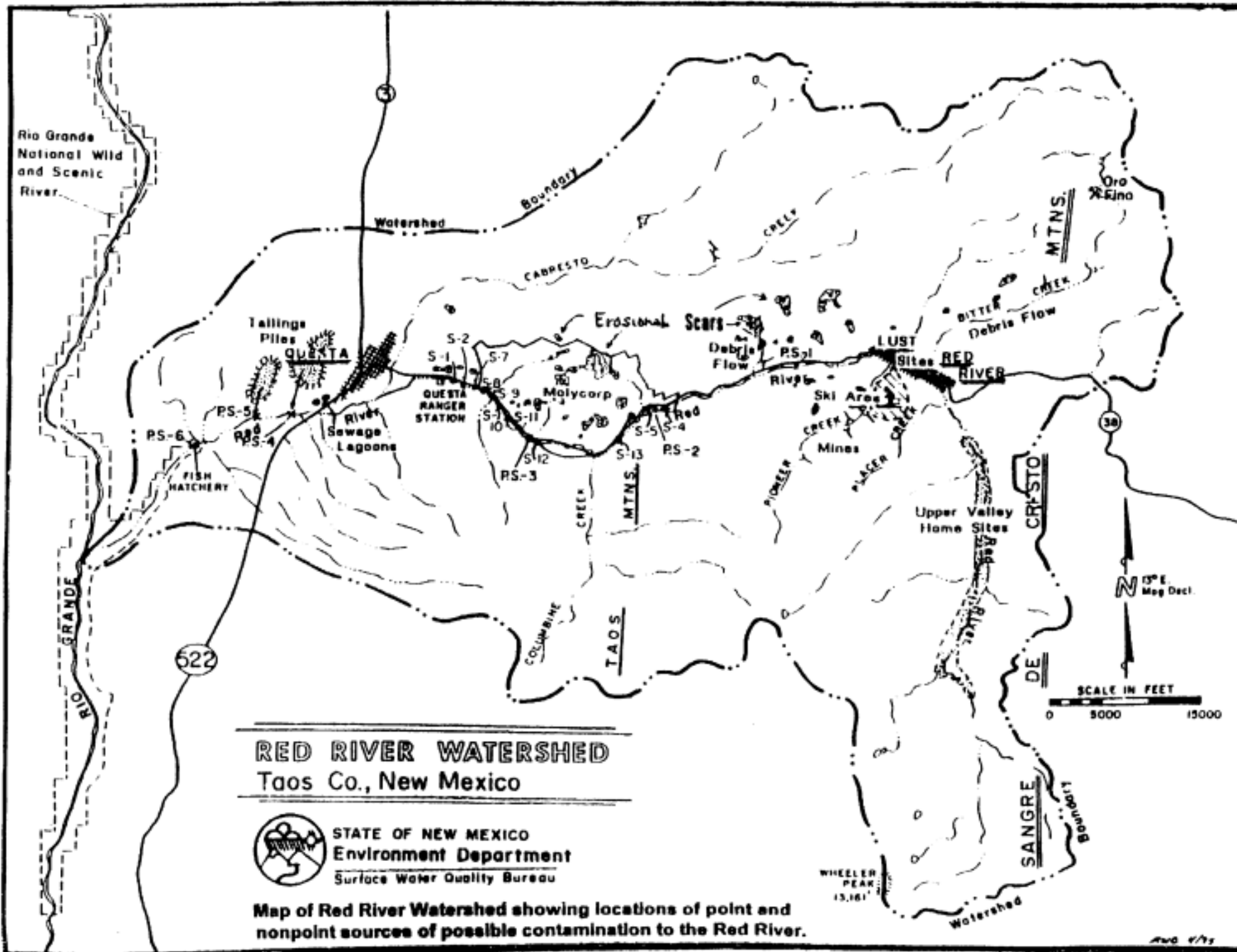


FIGURE 1

(MODIFIED FROM NMED, March 1996)

FIGURE 2

(MODIFIED FROM NMED, March 1996)



EXPLANATION

POINT SOURCE POLLUTION:

- PS-1: Town of Red River Wastewater Treatment Plant
- PS-2: Molycorp Mill Site Outfall #005
- PS-3: Molycorp Mine, Goathill Gulch Outfall #004
- PS-4: Molycorp East Tailings Pile Outfall #002
- PS-5: Molycorp Pope Lake/W. Tailings Outfall #001
- PS-6: Red River Fish Hatchery (NMDG&F)

NONPOINT SOURCE POLLUTION:

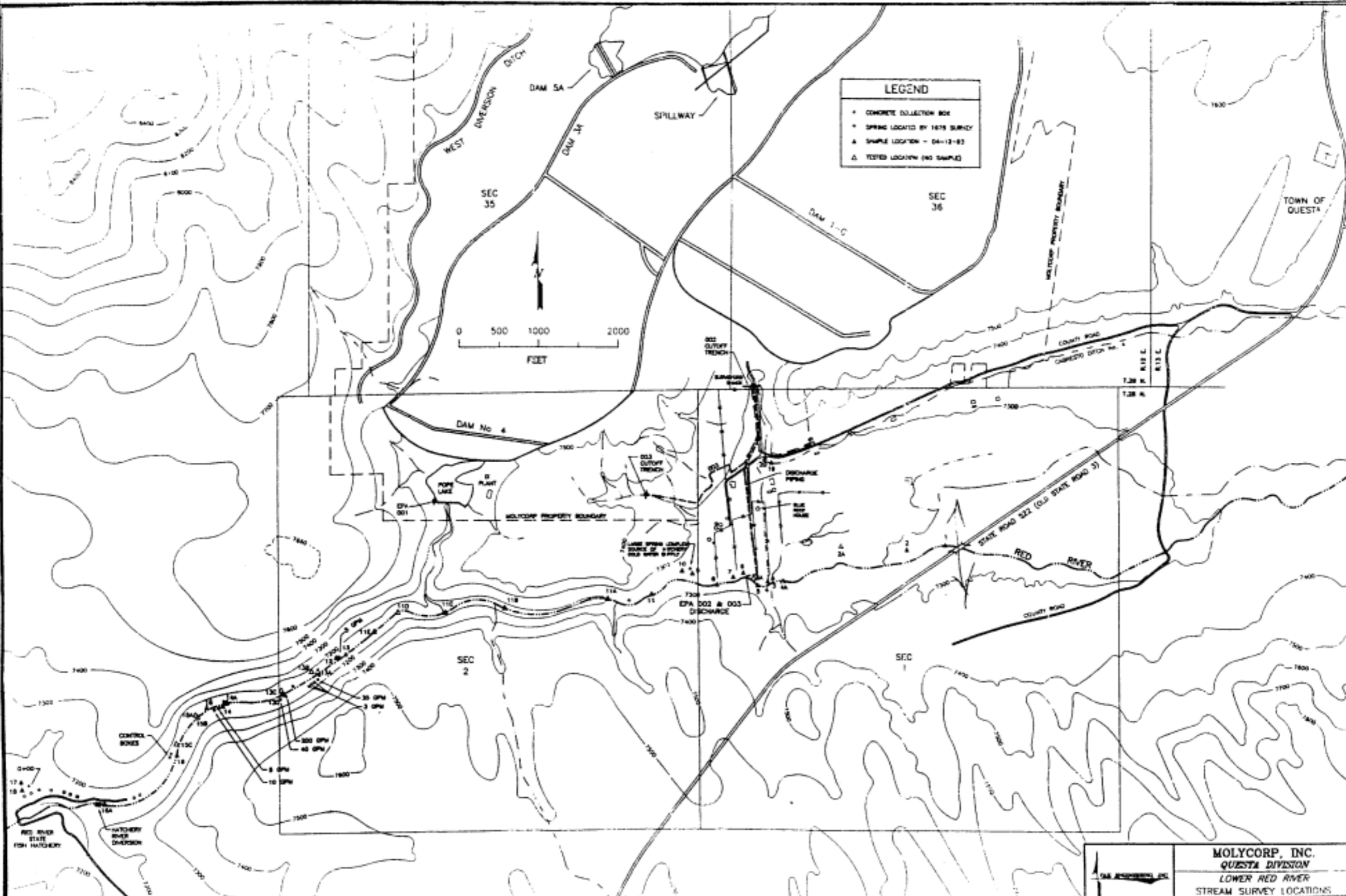
- E-1 to E-13: Red River Groundwater Seeps (ARD)
- Hydrothermally Altered Volcanic Rock Scars
- Molycorp Mine
- Scattered Abandoned Mine and Mill Sites (Esp. Pioneer and Bitter Creeks)
- Upper RR Valley Home Sites: septic tanks, leach fields
- Town of Red River: Leaking Underground Storage Tanks (LUST)
- Red River Ski Area
- Town of Questa Sewage Lagoons
- Landslide/Debris Flow Gravels and Bediment (Bitter, Hansen and Hotentot Creeks)

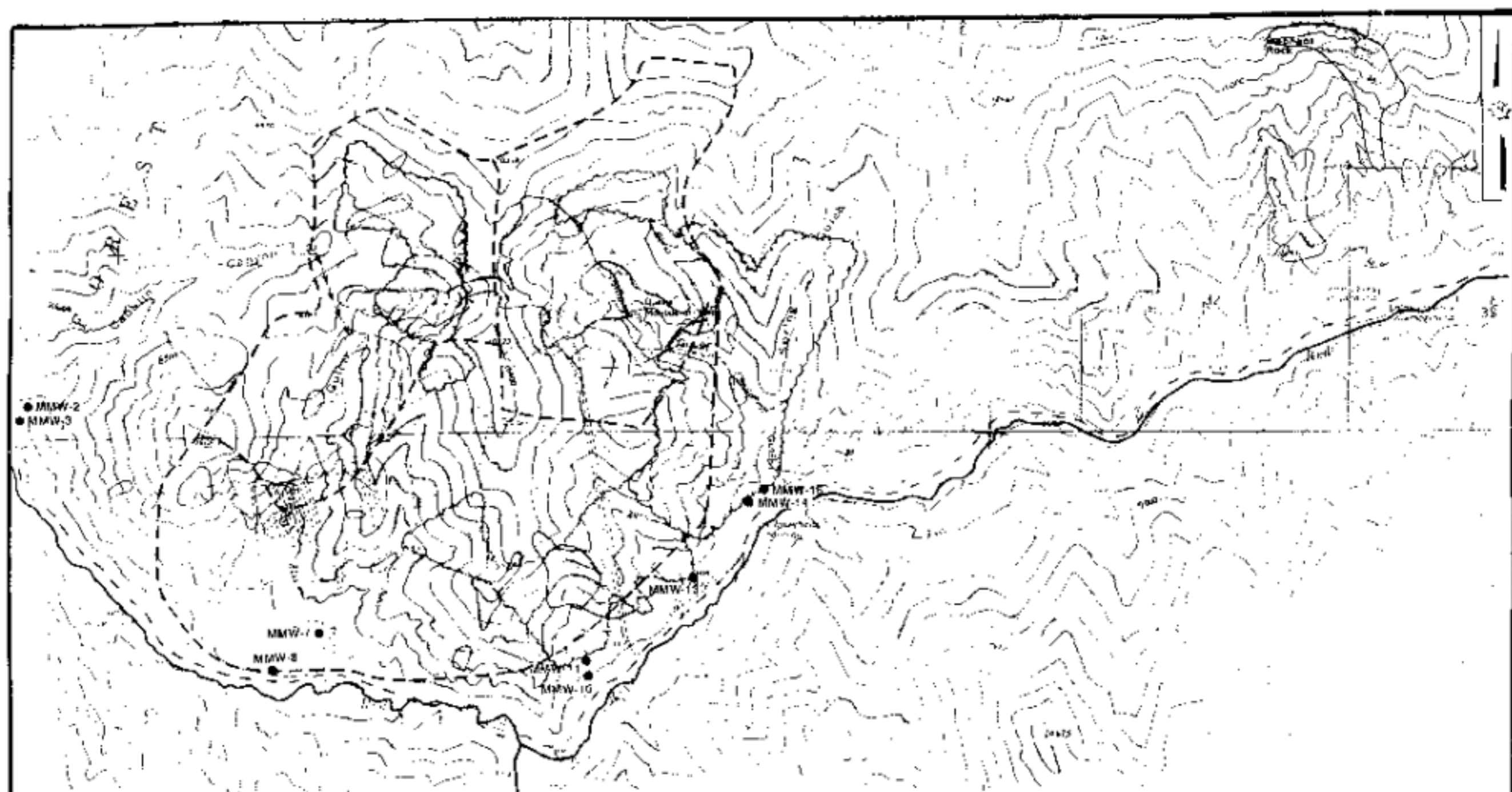
FIGURE 3

TAILINGS PONDS

Topography and Sample Locations

(TAKEN FROM VAIL, October 1994)





(MODIFIED FROM NRED, March 1996)

FIGURE 4

**MINE SITE TOPOGRAPHY
Erosional Scars and WRDs**

--- Approximate Surface Water
Collection System Boundary

SCARF AND READ 1960
BURDEN AND SPURR 1964

0 500 1000
SCALE

U.S. GEOLOGICAL SURVEY
U.S. GEOGRAPHIC MAPS OF OIL-FIELD AREAS
MAP 10711 NEW MEXICO DATA 1964

MOLYCORP MINE SITE

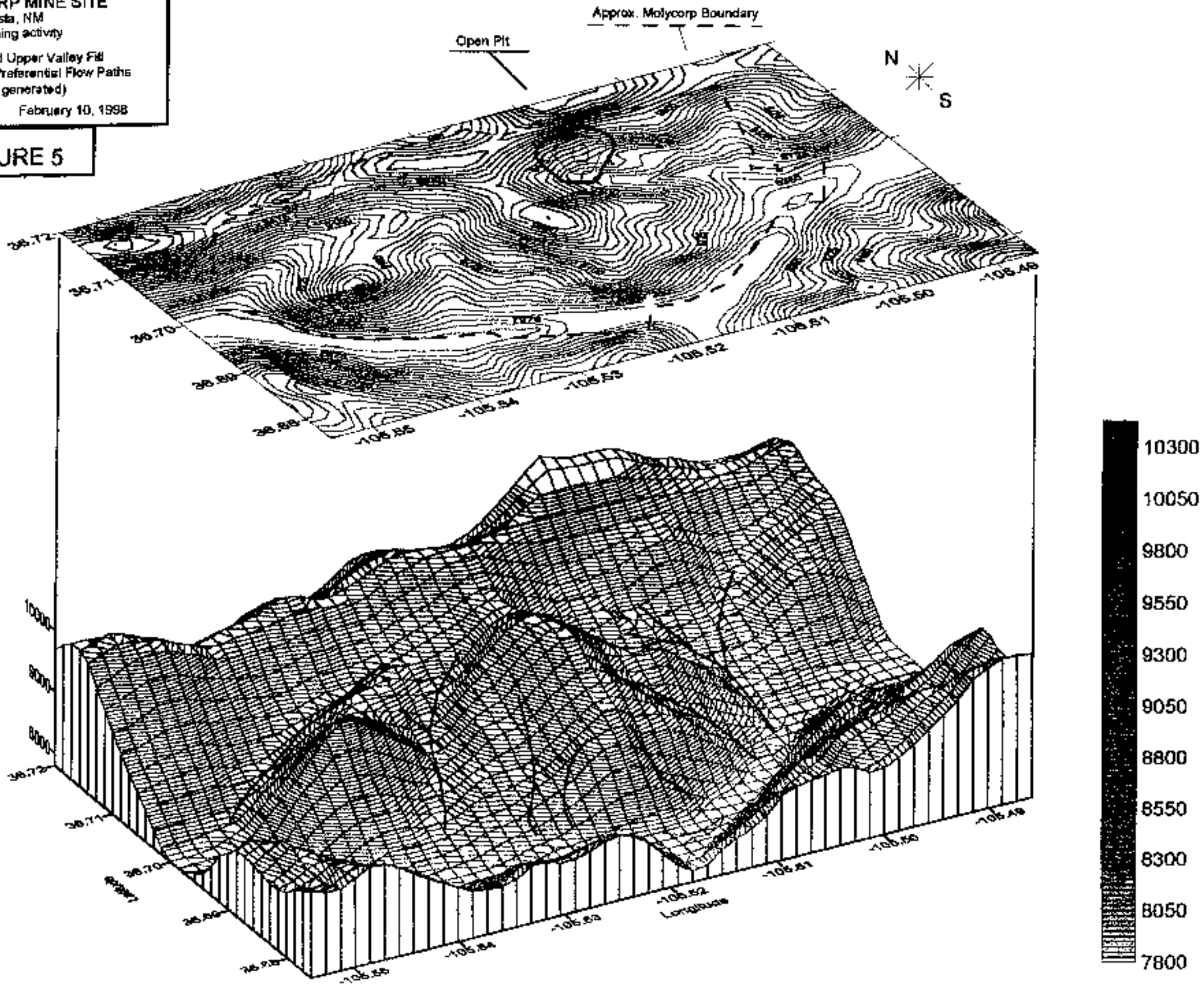
Questa, NM

Pre-mining activity

Surface and Upper Valley Fill
Groundwater Preferential Flow Paths
(Surfer generated)

USEPA February 10, 1998

FIGURE 5



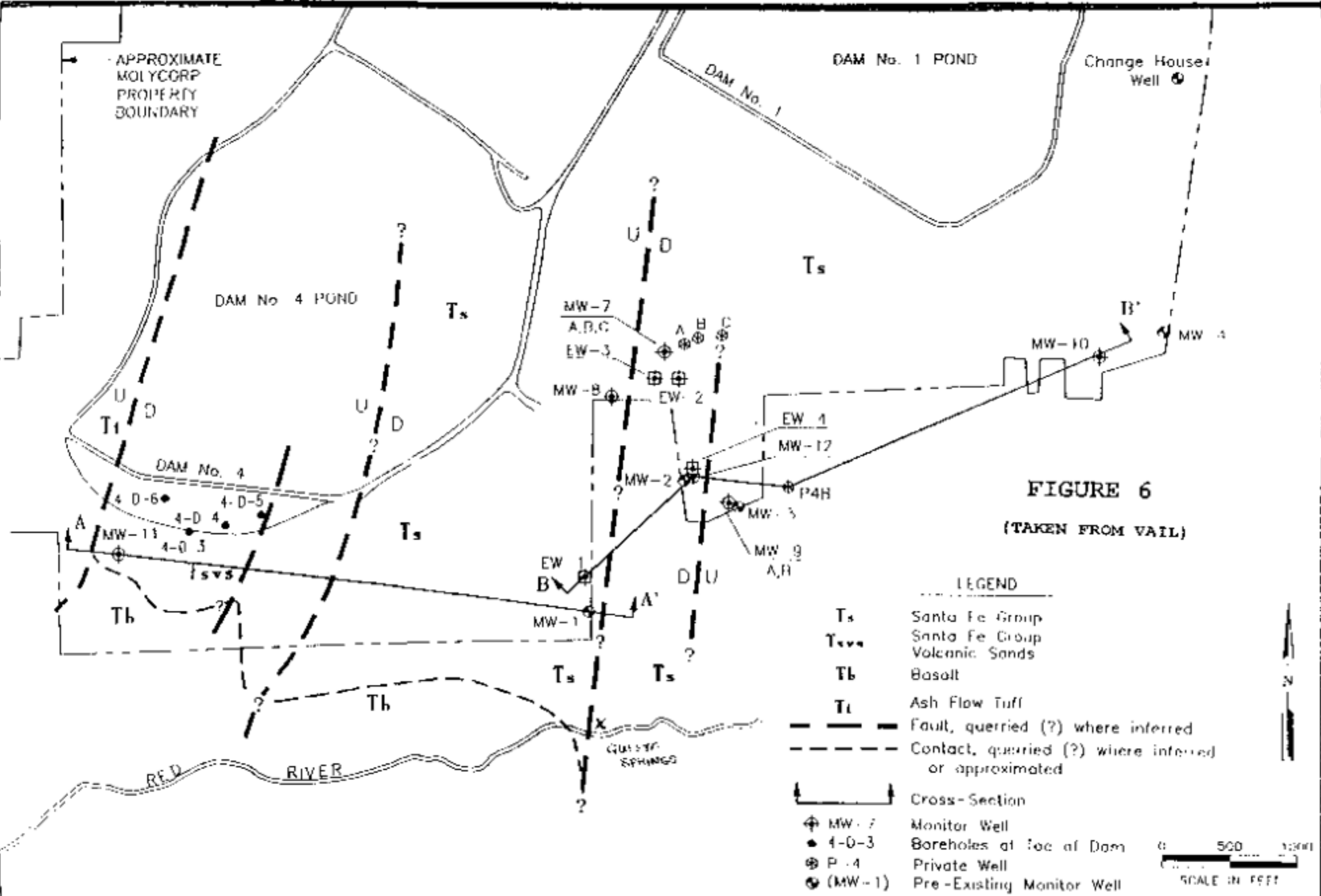


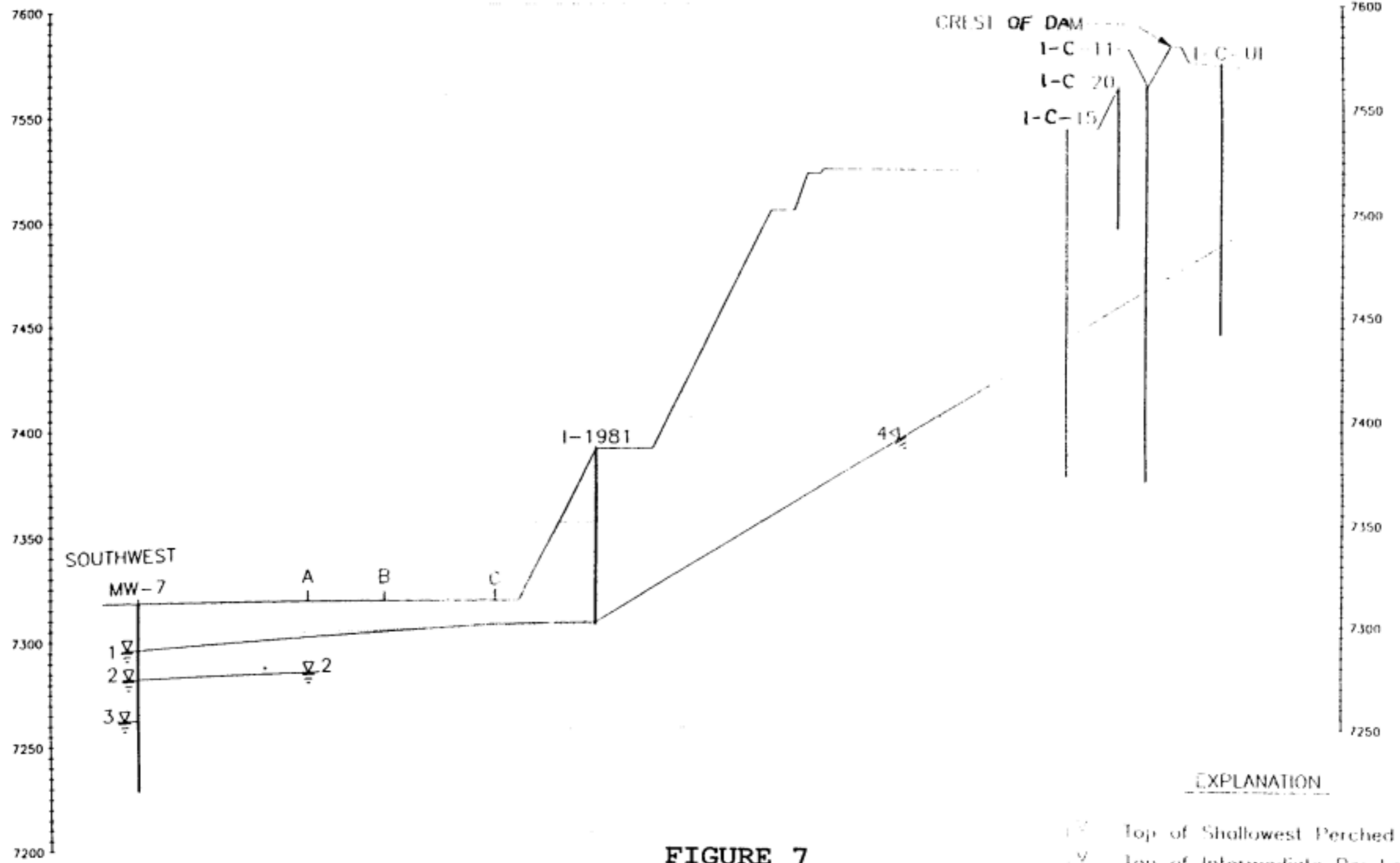
FIGURE 6
(TAKEN FROM VAIL)

- LEGEND**
- Ts Santa Fe Group
 - Tsvs Santa Fe Group Volcanic Sands
 - Tb Basalt
 - Tl Ash Flow Tuff
 - Fault, queried (?) where inferred
 - - - Contact, queried (?) where inferred or approximated
 - ↔ Cross-Section
 - ⊕ MW-7 Monitor Well
 - 4-D-3 Boreholes at foot of Dam
 - ⊕ P-4 Private Well
 - ⊕ (MW-1) Pre-existing Monitor Well
- 0 500 1000
SCALE IN FEET

SOUTH PASS RESOURCES, Inc.
 PROJECT No. 001-06 DATE 3/31/95
 AUTHOR M.O.M. DRAWN BY M.O.M.

GEOLOGIC MAP - TAILINGS AREA
 Molycorp, Inc.
 Questa, New Mexico

UPPER PORTION OF UAU AT DAM No. 1



EXPLANATION

- ▽ Top of Shallowest Perched Zone
- ▽ Top of Intermediate Perched Zone
- ▽ Top of Main Perched Zone
- ▽ Water Level in Tailings Dam
- Piezometers projected into line of section

FIGURE 7

(TAKEN FROM SOUTH PASS RESOURCES, April 13, 1995)

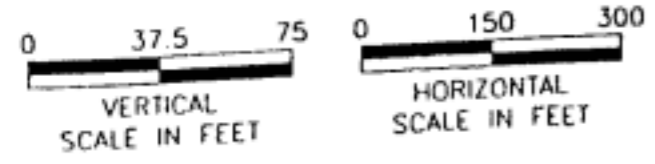
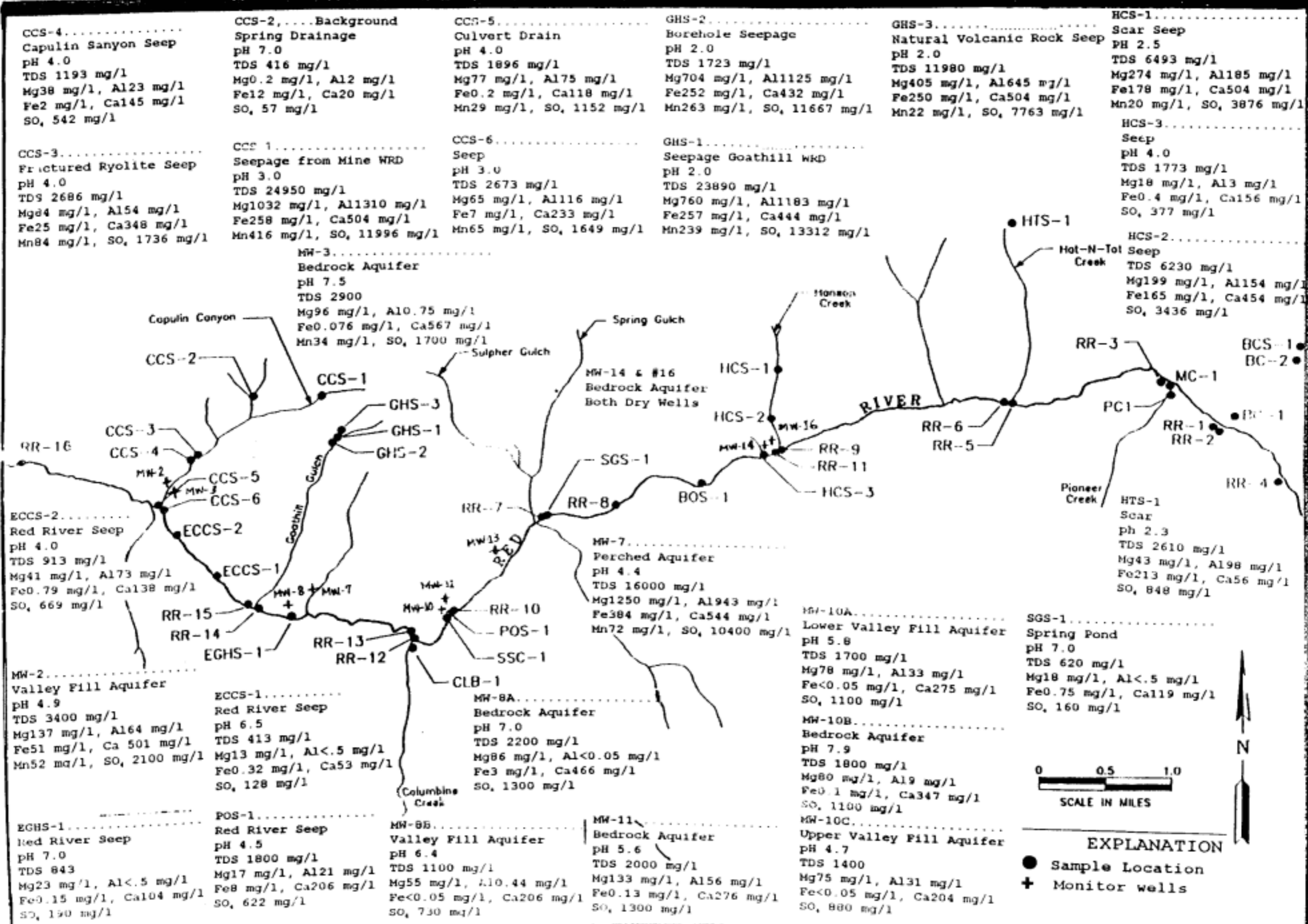


FIGURE	SOUTH PASS RESOURCES, Inc.			WATER LEVELS FOR PERCHED ZONES (APRIL 1993)	
	Tailings Area - PolyCorp, Inc. Questa, New Mexico				
	PROJECT No: 001-06	DATE: 3/31/95	AUTHOR:	DRAWN BY: M.O'M.	



CCS-4.....
Capulin Sanyon Seep
pH 4.0
TDS 1193 mg/l
Mg38 mg/l, Al23 mg/l
Fe2 mg/l, Ca145 mg/l
SO, 542 mg/l

CCS-2,....Background
Spring Drainage
pH 7.0
TDS 416 mg/l
Mg0.2 mg/l, Al2 mg/l
Fe12 mg/l, Ca20 mg/l
SO, 57 mg/l

CCS-5.....
Culvert Drain
pH 4.0
TDS 1896 mg/l
Mg77 mg/l, Al75 mg/l
Fe0.2 mg/l, Ca118 mg/l
Mn29 mg/l, SO, 1152 mg/l

GHS-2.....
Borehole Seepage
pH 2.0
TDS 1723 mg/l
Mg704 mg/l, Al1125 mg/l
Fe252 mg/l, Ca432 mg/l
Mn263 mg/l, SO, 11667 mg/l

GHS-3.....
Natural Volcanic Rock Seep
pH 2.0
TDS 11980 mg/l
Mg405 mg/l, Al645 mg/l
Fe250 mg/l, Ca504 mg/l
Mn22 mg/l, SO, 7763 mg/l

HCS-1.....
Scar Seep
PH 2.5
TDS 6493 mg/l
Mg274 mg/l, Al185 mg/l
Fe178 mg/l, Ca504 mg/l
Mn20 mg/l, SO, 3876 mg/l

CCS-3.....
Fractured Rhyolite Seep
pH 4.0
TDS 2686 mg/l
Mg84 mg/l, Al54 mg/l
Fe25 mg/l, Ca348 mg/l
Mn84 mg/l, SO, 1736 mg/l

CCS 1.....
Seepage from Mine WRD
pH 3.0
TDS 24950 mg/l
Mg1032 mg/l, Al1310 mg/l
Fe258 mg/l, Ca504 mg/l
Mn416 mg/l, SO, 11996 mg/l

CCS-6.....
Seep
pH 3.0
TDS 2673 mg/l
Mg65 mg/l, Al116 mg/l
Fe7 mg/l, Ca233 mg/l
Mn65 mg/l, SO, 1649 mg/l

GHS-1.....
Seepage Goathill WRD
pH 2.0
TDS 23890 mg/l
Mg760 mg/l, Al1183 mg/l
Fe257 mg/l, Ca444 mg/l
Mn239 mg/l, SO, 13312 mg/l

HCS-3.....
Seep
pH 4.0
TDS 1773 mg/l
Mg18 mg/l, Al3 mg/l
Fe0.4 mg/l, Ca156 mg/l
SO, 377 mg/l

HCS-2.....
Hot-N-Tot
Creek Seep
TDS 6230 mg/l
Mg199 mg/l, Al154 mg/l
Fe165 mg/l, Ca454 mg/l
SO, 3436 mg/l

HTS-1
Scar
pH 2.3
TDS 2610 mg/l
Mg43 mg/l, Al98 mg/l
Fe213 mg/l, Ca56 mg/l
SO, 848 mg/l

ECCS-2.....
Red River Seep
pH 4.0
TDS 913 mg/l
Mg41 mg/l, Al73 mg/l
Fe0.79 mg/l, Ca138 mg/l
SO, 669 mg/l

ECCS-1.....
Red River Seep
pH 6.5
TDS 413 mg/l
Mg13 mg/l, Al<.5 mg/l
Fe0.32 mg/l, Ca53 mg/l
SO, 128 mg/l

MW-7.....
Perched Aquifer
pH 4.4
TDS 16000 mg/l
Mg1250 mg/l, Al1943 mg/l
Fe384 mg/l, Ca544 mg/l
Mn72 mg/l, SO, 10400 mg/l

MW-10A.....
Lower Valley Fill Aquifer
pH 5.8
TDS 1700 mg/l
Mg78 mg/l, Al33 mg/l
Fe<0.05 mg/l, Ca275 mg/l
SO, 1100 mg/l

SGS-1.....
Spring Pond
pH 7.0
TDS 620 mg/l
Mg18 mg/l, Al<.5 mg/l
Fe0.75 mg/l, Ca119 mg/l
SO, 160 mg/l

MW-10B.....
Bedrock Aquifer
pH 7.9
TDS 1800 mg/l
Mg80 mg/l, Al9 mg/l
Fe0.1 mg/l, Ca347 mg/l
SO, 1100 mg/l

MW-2.....
Valley Fill Aquifer
pH 4.9
TDS 3400 mg/l
Mg137 mg/l, Al64 mg/l
Fe51 mg/l, Ca 501 mg/l
Mn52 mg/l, SO, 2100 mg/l

MW-8A.....
Bedrock Aquifer
pH 7.0
TDS 2200 mg/l
Mg86 mg/l, Al<0.05 mg/l
Fe3 mg/l, Ca466 mg/l
SO, 1300 mg/l

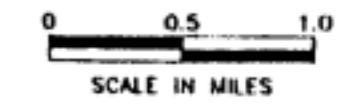
MW-11.....
Bedrock Aquifer
pH 5.6
TDS 2000 mg/l
Mg133 mg/l, Al56 mg/l
Fe0.13 mg/l, Ca276 mg/l
SO, 1300 mg/l

MW-10C.....
Upper Valley Fill Aquifer
pH 4.7
TDS 1400
Mg75 mg/l, Al31 mg/l
Fe<0.05 mg/l, Ca204 mg/l
SO, 880 mg/l

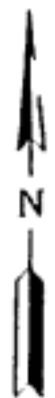
EGHS-1.....
Red River Seep
pH 7.0
TDS 843
Mg23 mg/l, Al<.5 mg/l
Fe0.15 mg/l, Ca104 mg/l
SO, 190 mg/l

POS-1.....
Red River Seep
pH 4.5
TDS 1800 mg/l
Mg17 mg/l, Al21 mg/l
Fe8 mg/l, Ca206 mg/l
SO, 622 mg/l

MW-8B.....
Valley Fill Aquifer
pH 6.4
TDS 1100 mg/l
Mg55 mg/l, Al0.44 mg/l
Fe<0.05 mg/l, Ca206 mg/l
SO, 730 mg/l



EXPLANATION
● Sample Location
+ Monitor wells



EROSIONAL SCAR AREAS PERCENTAGE BY REACH

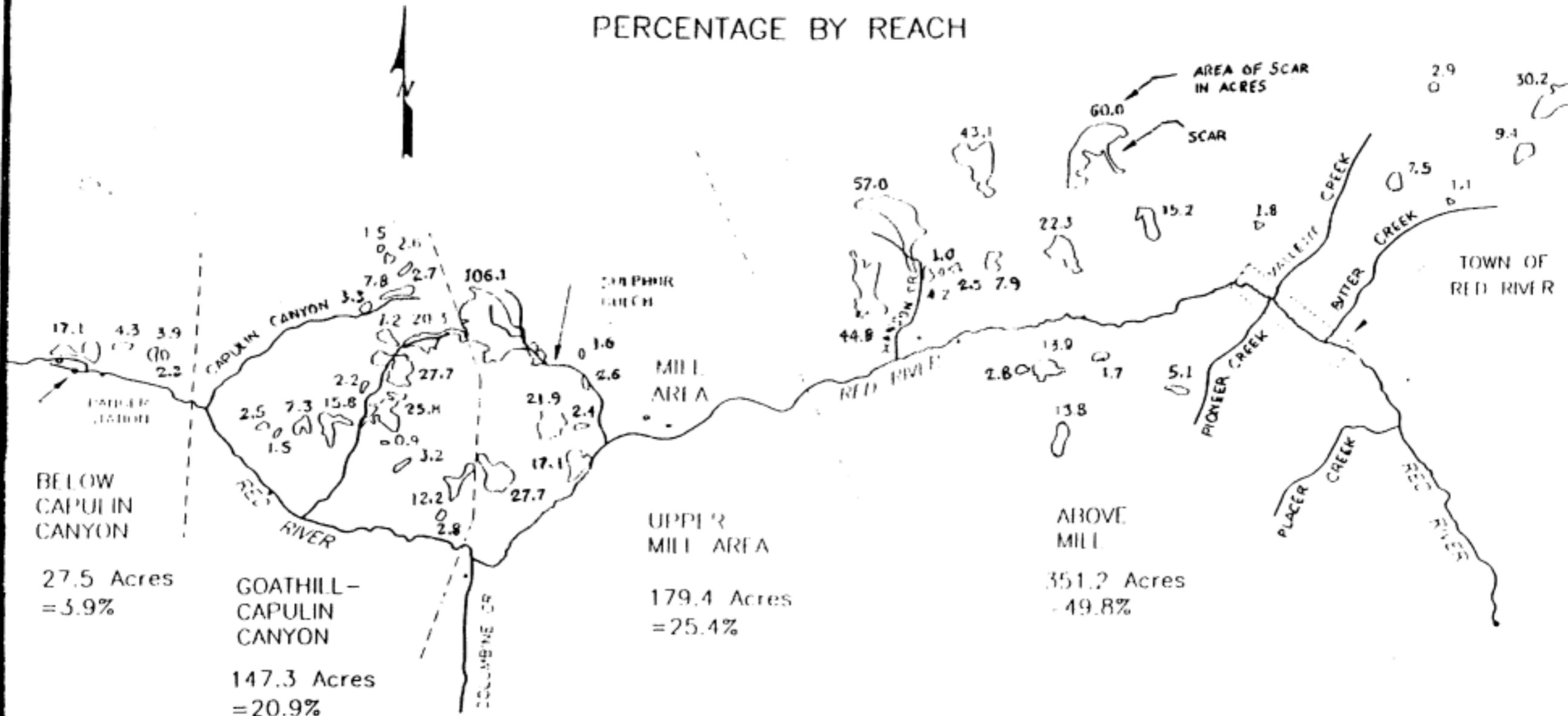


FIGURE 9

EROSIONAL SCAR AREAS
(MODIFIED FROM VAIL, July 9, 1993)

APPENDIX 1

Appendix 1 is an excerpt from the State of New Mexico Standards for Interstate and Intrastate Streams [effective January 23, 1995].

B. Standards:

1. In any single sample: conductivity shall not exceed 300 µmhos, pH shall be within the range of 6.6 to 8.8, temperature shall not exceed 20 C (68 F), and turbidity shall not exceed 10 NTU. The use-specific numeric standards set forth in Section 310 are applicable to the designated uses listed above in Section 2118.A.

2. The monthly geometric mean of fecal coliform bacteria shall not exceed 100/100 ml; no single sample shall exceed 200/100 ml (see Section 1 103.B).

2119. The main stem of the Rio Grande from Taos Junction Bridge upstream to the New Mexico-Colorado line, the Red River from its mouth on the Rio Grande upstream to the mouth of Placer Creek, and the Rio Pueblo de Taos from its mouth on the Rio Grande upstream to the mouth of the Rio Grande del Rancho.

A. Designated Uses: coldwater fishery, fish culture, irrigation, livestock watering wildlife habitat, and secondary contact.

B. Standards:

1. In any single sample: pH shall be within the range of 6.6 to 8.8 temperature shall not exceed 20 C (68 F) and turbidity shall not exceed 50 NTU. The use-specific numeric standards set forth in Section 3101 are applicable to the designated uses listed above in Section 2119.A.

2. The monthly geometric mean of fecal coliform bacteria shall not exceed 100/100 ml; no single sample shall exceed 200/100 ml (see Section 1 103.B).

2120. The Red River upstream of the mouth of Placer Creek all tributaries to the Red River, and all other perennial reaches of tributaries to the Rio Grande in Taos and Rio Arriba counties unless included in other segments.

A. Designated Uses: domestic water supply, fish culture, high quality coldwater fishery, irrigation, livestock watering, wildlife habitat, and secondary contact.

B. Standards:

1. In any single sample: conductivity shall not exceed 400 µmhos (500 µmhos for the Rio Fernando de Taos), pH shall be within the range of 6.6 to 8.8, temperature shall not exceed 20 C (68 F), and turbidity shall not exceed 25 NTU. The use-specific numeric standards set forth in Section 3101 are applicable to the designated uses listed above in Section 2120.A.

2. The monthly geometric mean of fecal coliform bacteria shall not exceed 100/100 ml; no single sample shall exceed 200/100 ml (see Section 1 103.B).

2200. PECOS RIVER BASIN.

2201. The main stem of the Pecos River from the New Mexico-Texas line upstream to the mouth of the Black River.

A. Designated Uses: irrigation, livestock watering, wildlife habitat, secondary contact, and warmwater fishery.

B. Standards:

1. In any single sample: pH shall be within the range of 6.6 to 8.8 and temperature shall not exceed 32.2 C (90 F). The use-specific numeric standards set forth in Section 3101 are applicable to the designated uses listed above in Section 2201.A.

2. The monthly geometric mean of fecal coliform bacteria shall not exceed 200/100 ml; no single sample shall exceed 400/100 ml (see Section 1103.B).

3. At all flows above 50 cfs: TDS shall not exceed 20,000 mg/l, sulfate shall not exceed 3,000 mg/l, and chloride shall not exceed 10,000 mg/l.

2202. The main stem of the Pecos River from the mouth of the Black River upstream to Lower Tansil Dam,¹ including the Black River, the Delaware River and Blue Spring.

A. Designated Uses: industrial water supply, irrigation livestock watering, wildlife habitat, secondary contact, and warmwater fishery.

B. Standards:

1. In any single sample: pH shall be within the range of 6.6 to 9.0, and temperature shall not exceed 34 C (93.2 F). The use-specific numeric standards set forth in Section 3101 are applicable to the designated uses listed above in Section 2202.A.

2. The monthly geometric mean of fecal coliform bacteria shall not exceed 200/100 ml; no single sample shall exceed 400/100 ml (see Section 1 103.B).

3. At all flows above 50 cfs: TDS shall not exceed 8,500 mg/l, sulfate shall not exceed 2,500 mg/l, and chloride shall not exceed 3,500 mg/l.

¹ Diversion for irrigation frequently limits summer flow in this reach to that contributed by springs along the watercourse.

3101. STANDARDS¹ APPLICABLE TO ATTAINABLE OR DESIGNATED USES UNLESS OTHERWISE SPECIFIED IN SUBPART II OF THESE STANDARDS (SECTIONS 2100 through 2805).

A. Coldwater Fishery: Dissolved oxygen shall not be less than 6.0 mg/l temperature shall not exceed 20 C (68 F), and pH shall be within the range of 6.6 to 8.8. The acute and chronic standards set out in Section 3101 .J are applicable to this use. The total ammonia standards set out in Section 3101 .N are applicable to this use.

B. Domestic Water Supply: Waters designated for use as domestic water supplies shall not contain substances in concentrations that create a lifetime cancer risk of more than one cancer per 100,000 exposed persons. The following numeric standards shall not be exceeded:

Dissolved arsenic	0.05	mg/l
Dissolved barium	1.	mg/l
Dissolved cadmium	0.010	mg/l
Dissolved chromium	0.05	mg/l
Dissolved lead	0.05	mg/l
Total mercury	0.002	mg/l
Dissolved nitrate (as N)	10.	mg/l
Dissolved selenium	0.05	mg/l
Dissolved silver	0.05	mg/l
Dissolved cyanide	0.2	mg/l
Dissolved uranium	5.0	mg/l
Radium-226 + radium-228	30.0	pCi/l
Tritium	20,000	pCi/l
Gross alpha	15	pCi/l

C. High Quality Coldwater Fishery: Dissolved oxygen shall not be less than 6.0 mg/l. temperature shall not exceed 20 C (68 F), pH shall be within the range of 6.6 to 8.8, total phosphorus (as P) shall not exceed 0.1 mg/l, total organic carbon shall not exceed 7 mg/l, turbidity shall not exceed 10 NTU (25 NTU in certain reaches where natural background prevents attainment of lower turbidity), and conductivity (at 25 C) shall not exceed a limit varying between 300 μ hos/cm and 1,500 μ hos/cm depending on the natural background in particular stream reaches (the intent of this standard is to prevent excessive increases in dissolved solids which would result in changes in stream community structure). The acute and chronic standards set out in Section 3101.J are applicable to this use. The total ammonia standards set out in Section 3101.N are applicable to this use.

D. Irrigation: The monthly geometric mean of fecal coliform bacteria shall not exceed 1,000/100 ml; no single sample shall exceed 2,000/100 ml. The following numeric standards shall not be exceeded:

Dissolved aluminum	5.0	mg/l
Dissolved arsenic	0.10	mg/l
Dissolved boron	0.75	mg/l
Dissolved cadmium	0.01	mg/l
Dissolved chromium	0.10	mg/l
Dissolved cobalt	0.05	mg/l
Dissolved copper	0.20	mg/l
Dissolved lead	5.0	mg/l
Dissolved molybdenum	1.0	mg/l

Dissolved selenium	0.13	mg/l
Dissolved selenium in presence of >500 mg/l SO ₄	0.05	mg/l
Dissolved vanadium	0.1	mg/l
Dissolved zinc	2.0	mg/l

E. Limited Warmwater Fishery: Dissolved oxygen shall not be less than 5 mg/l, pH shall be within the range of 6.5 to 9.0, and on a case by case basis maximum temperatures may exceed 32.2 C. The acute and chronic standards set out in Section 3101.J are applicable to this use. The total ammonia standards set out in Section 3101.M are applicable to this use.

F. Marginal Coldwater Fishery: Dissolved oxygen shall not be less than 6 mg/l on a case by case basis maximum temperatures may exceed 25 C and the pH may range from 6.6 to 9.0. The acute and chronic standards set out in Section 3101.J are applicable to this use. The total ammonia standards set out in Section 3101.N are applicable to this use.

G. Primary Contact: The monthly geometric mean of fecal coliform bacteria shall not exceed 200/100 ml, no single sample shall exceed 400/100 ml, pH shall be within the range of 6.6 to 8.8 and turbidity shall not exceed 25 NTU.

H. Warmwater Fishery: Dissolved oxygen shall not be less than 5 mg/l temperature shall not exceed 32.2 C (90 F), and pH shall be within the range of 6.5 to 9.0. The acute and chronic standards set out in Section 3101.J are applicable to this use. The total ammonia standards set out in Section 3101.M are applicable to this use.

I. Fish culture, secondary contact, and municipal and industrial water supply and storage are also designated in particular stream reaches where these uses are actually being realized. However, no numeric standards apply uniquely to these uses. Water quality adequate for these uses is ensured by the general standards and numeric standards for bacterial quality, pH and temperature which are established for all stream reaches listed in Subpart II of these standards (Sections 2100 through 2805).

J. The following schedule of numeric standards and equations for the substances listed shall apply to the subcategories of fisheries identified in Section 3101 of these standards:

1. Acute Standards

Dissolved aluminum	750	µg/l
Dissolved beryllium	130	µg/l
Total mercury	2.4	µg/l
Total recoverable selenium	20.0	µg/l
Dissolved silver ⁴	$e(1.72[\ln(\text{hardness})]-6.52)$	µg/l
Cyanide, amenable to chlorination	22.0	µg/l
Total chlordane	2.4	µg/l
Dissolved cadmium	$e(1.128[\ln(\text{hardness})]-3.828)$	µg/l
Dissolved chromium ⁵	$e(0.819[\ln(\text{hardness})]+3.688)$	µg/l
Dissolved copper	$e(0.9422[\ln(\text{hardness})]-1.464)$	µg/l
Dissolved lead	$e(1.273[\ln(\text{hardness})]-1.46)$	µg/l
Dissolved nickel	$e(0.8460[\ln(\text{hardness})]+3.3612)$	µg/l
Dissolved zinc	$e(0.8473[\ln(\text{hardness})]+0.8604)$	µg/l
Total chlorine residual	19	µg/l

2. Chronic Standards³

Dissolved aluminum	87.0	µg/l
Dissolved beryllium	5.3	µg/l
Total mercury	0.012	µg/l
Total recoverable selenium	2.0	µg/l
Cyanide, amenable to chlorination	5.2	µg/l
Total chlordane	0.0043	µg/l
Dissolved cadmium ⁴	$e(0.7852[\ln(\text{hardness})]-3.49)$	µg/l
Dissolved chromium ⁵	$e(0.819[\ln(\text{hardness})]+1.561)$	µg/l
Dissolved copper	$e(0.8545[\ln(\text{hardness})]-1.465)$	µg/l
Dissolved lead	$e(1.273[\ln(\text{hardness})]-4.705)$	µg/l
Dissolved nickel	$e(0.846[\ln(\text{hardness})]+1.1645)$	µg/l
Dissolved zinc	$e(0.8473[\ln(\text{hardness})]+0.7614)$	µg/l
Total chlorine residual	11	µg/l

K. Livestock Watering: The following numeric standards shall not be exceeded:

Dissolved aluminum	5.0	mg/l
Dissolved arsenic	0.2	mg/l
Dissolved boron	5.0	mg/l
Dissolved cadmium	0.05	mg/l
Dissolved chromium ⁵	1.0	mg/l
Dissolved cobalt	1.0	mg/l
Dissolved copper	0.5	mg/l
Dissolved lead	0.1	mg/l
Total mercury	0.01	mg/l
Dissolved selenium	0.05	mg/l
Dissolved vanadium	0.1	mg/l
Dissolved zinc	25.0	mg/l
Radium-226 + radium-228	30.0	pCi/l
Tritium	20,000.00	pCi/l
Gross alpha	15	pCi/l

L. Wildlife Habitat: The following narrative standard shall apply:

1. Except as provided below in Paragraph 2 of this section, no discharge shall contain any substance, including, but not limited to selenium, DDT, PCB's and dioxin, at a level which, when added to background concentrations, can lead to bioaccumulation to toxic levels in any animal species. In the absence of site-specific information, this requirement shall be interpreted as establishing a stream standard of 2 g/l for total recoverable selenium and of 0.012 g/l for total mercury.

2. The discharge of substances that bioaccumulate in excess of levels specified above in Paragraph 1, is allowed if, and only to the extent that, the substances are present in the intake waters which are diverted and utilized prior to discharge, and then only if the discharger utilizes best available treatment technology to reduce the amount of bioaccumulating substances which are discharged.

3. Discharges to waters which are designated for wildlife habitat uses, but not for fisheries uses, shall not contain levels of ammonia or chlorine in amounts which reduce biological productivity and/or species diversity to levels below those which occur naturally, and in no case shall contain chlorine in excess of 1 mg/l nor ammonia in excess of levels which can be accomplished through best reasonable operating practices at existing treatment facilities.

4. A discharge which contains any heavy metal at concentrations in excess of the concentrations set forth in Section 3101.J.1 of these standards shall not be permitted in an amount, measured by total mass, which exceeds by more than 5 percent the amount present in the intake waters which are diverted and utilized prior to the discharge, unless the discharger has taken steps (an approved program to require industrial pretreatment; or a corrosion program) appropriate to reduce influent concentrations to the extent practicable.

APPENDIX 2

NEW MEXICO GROUND WATER STANDARDS AND U.S. EPA DRINKING WATER STANDARDS FOR ALUMINUM, MANGANESE, MOLYBDENUM, AND SULFATE

Christopher A. King
U.S. EPA Region 6 Ground Water/UIC Section
November, 1997

Currently there are no national ambient ground water quality standards. The United States Environmental Protection Agency (U.S. EPA) drinking water Maximum Contaminant Levels (MCL's) are frequently used as a reference by State and federal agencies when determining clean up levels for individual contaminated sites. The MCL's are for finished drinking water quality, not for raw water quality. States have the authority to develop their own ground water standards related to ambient water quality. Some State ground water standards are the same as U.S. EPA MCL's for finished drinking water. If a U.S. EPA primary or secondary MCL does not exist, a health advisory limit is often used. The State of New Mexico has developed ambient ground water standards for certain inorganic and organic contaminants. These standards represent the maximum allowable concentration of contaminants in the ground waters of New Mexico.

U.S. EPA Drinking Water Standards:

In March 1975 the U.S. EPA proposed the National Interim Primary Drinking Water Regulations under provisions of the Public Health Service Act as amended by the Safe Drinking Water Act. Based in part on Public Health Service regulations developed in 1946 and 1962 and later modified, the interim regulations became final in June 1977, but are continually under review. These federal regulations specify MCL's for finished drinking water supplies and apply to all public water systems. At the recommended maximum contaminant levels, no adverse health effects are known to exist.

MCL's were established for finished drinking water by the Safe Drinking Water Act in two different categories: primary and secondary. Primary MCL's are federally enforceable and based on health risk. The secondary MCL's represent reasonable goals for drinking water quality, but are not federally enforceable. Instead, states are encouraged to implement these standards. Contaminants covered by secondary MCL's are those which may adversely affect the aesthetic qualities of drinking water such as taste, odor, color, and appearance and which thereby may deter public acceptance of drinking water provided by public water systems. Contaminants found at concentrations considerably higher than the secondary MCL may also be associated with adverse health implications (Driscoll, 1989).

New Mexico Ground Water Standards:

Aluminum:

The State of New Mexico maximum allowable concentration for aluminum in ground water is 5.0 mg/l. The U.S. EPA currently does not have a primary MCL for aluminum in drinking water, but instead has a secondary MCL of 0.05 to 0.2 mg/l.

Manganese:

The State of New Mexico maximum allowable concentration for manganese in ground water is 0.2 mg/l. The U.S. EPA secondary MCL for manganese is 0.05 mg/l, in order to avoid manganese staining. Stains caused by manganese in plumbing fixtures and laundry are more objectionable and harder to remove than those from iron.

Molybdenum:

The State of New Mexico maximum allowable concentration for molybdenum in ground water is 1.0 mg/l. The U.S. EPA currently does not have a primary or secondary MCL for molybdenum in drinking water, but has issued a health advisory limit of 0.05 mg/l.

Sulfate:

The State of New Mexico maximum allowable concentration for sulfate in ground water is 600.0 mg/l. The U.S. EPA secondary MCL for sulfate is currently 250 mg/l, based upon the laxative effects of sulfate in high concentrations. The secondary MCL for sulfate is under debate, and the U.S. EPA has proposed a primary MCL of 500 mg/l (Federal Register, December 20, 1994).

Sulfate in ground water is derived principally from the evaporite minerals gypsum and anhydrite; it may also come from the oxidation of pyrite, which is an iron sulfide mineral. Ground water in igneous or metamorphic rocks generally contains less than 100 mg/l sulfate (Davis and DeWiest, 1966).

Table 1: Comparison of New Mexico Ground Water Standards and U.S. EPA'S Drinking Water Standards for Finished Water Quality (note: concentrations in mg/l).

CONTAMINANT	New Mexico Standard for Ground Water	U.S. EPA Primary MCL	U.S. EPA Secondary MCL
Aluminum	5.0	none	0.05 - 0.2
Manganese	0.2	none	0.05
Molybdenum	1.0	none	none
Sulfate	600.0	none	250

References:

Davis, S.N., and DeWiest, R.J.M., 1966. Hydrogeology. John Wiley Sons, Inc., New York, NY, 463 p.

Driscoll, F.G., 1989. Ground Water and Wells, Second Edition. Johnson Filtration Systems, St. Paul, MN, pp. 99 - 109.

Fetter, C.W., 1993. Contaminant Hydrogeology. Macmillan Publishing, New York, NY, pp. 11 - 14.

New Mexico Quality Control Commission, December, 1995. State of New Mexico Ground and Surface Water Quality Protection Regulations (20 NMAC 6.2) and Utility Operator Certification Regulations (20 NMAC 7.4). pp. 23 - 25.

One Hundred Fourth Congress, United States of America, 1996. Safe Drinking Water Act Amendments of 1996, Section 109.

U.S. Environmental Protection Agency Region 6 Drinking Water Section, May 1997. Current and Proposed National Primary and Secondary Drinking Water Regulations & Health Advisories for Other Contaminants.