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MEMORANDUM FOR: Malcolm R. Knapp, Chief, WMGT
Division of Waste Management

Myron H. Fliegel, WMGT
Division of Waste Management

FROM: Michael F. Weber, WMGT
Division of Waste Management

SUBJECT: REPORT ON TRIP TO GRANTS MINERAL BELT, NEW MEXICO, MAY 5-8, 1985

On Sunday, May 5, 1985, I travelled to Albuquerque, New Mexico to visit the Ambrosia Lake (Phillips/United Nuclear) UMTRAP site, to discuss DOE's proposed Statement of Work (SOW) for hydrogeologic characterization of the Ambrosia Lake site, and to visit Homestake's uranium mill in Milan, New Mexico. The enclosed trip report documents my observations of the two mill sites (Ambrosia Lake and Homestake) and my discussions with DOE's Technical Assistance Contractor (TAC) and representatives of the Environmental Improvement Division of the State of New Mexico. The following discussion summarizes my principal observations and recommendations based on the trip.

Ambrosia Lake Site Visit

The Ambrosia Lake (Phillips/United Nuclear) UMTRAP site is located in McKinnley County in northwestern New Mexico approximately 25 miles north of Grants. The environment surrounding the Ambrosia Lake site has been significantly impacted by uranium mining and milling, and ancillary activities, which represent hundreds of potential sources of groundwater and surface water contamination in the Ambrosia Lake Valley. Besides the mill tailings pile at the site, other potential sources of contamination include chemical storage areas in the mill yard, mine water treatment and settling ponds, ore storage areas, windblown contamination of undetermined origin, several open dumps, and injection wells. In addition, exploratory boreholes and pits, mine shafts, ventilation shafts, as well as potential fracture zones, faults, and joints may provide hundreds to thousands of preferential pathways for downward migration of contaminated groundwater near the site. Furthermore, the hydrogeologic system near the site has been impacted by mine dewatering and mine water discharge at the surface. Collectively, these activities and features impart significant complexity to the hydrogeologic system at the site. Consequently, characterization of the site and decisions about appropriate remedial actions for groundwater contamination at the site may be extremely complex.

TAC/NRC/New Mexico Meeting

On May 7, I met with representatives of the TAC and Environment Improvement Division (EID) of the New Mexico Department of Health and Environment to discuss DOE's proposed Statement of Work (SOW) for installation of monitoring wells at the Ambrosia Lake site. Specifically, the TAC hydrogeologists proposed to discuss the need for the installation and monitoring of deeper wells in the Tres Hermanos A Sandstone, Dakota Sandstone, and Morrison Formation beneath the site. The group at the meeting concluded that drilling deep (G.T. 300 feet) monitoring wells is not warranted at this time because of (1) potential impracticalities of characterizing discontinuities (fracture zones, exploratory drill holes, ventilation shafts) that may provide downward pathways for contamination, (2) impracticalities of characterizing the extent of groundwater contamination in aquifers beneath 300 feet of overburden, in which the hydraulic gradient has been significantly perturbed by mine dewatering, and (3) the complexity of distinguishing groundwater contamination caused by the Ambrosia Lake milling operations from that caused by mining, injection, mine dewatering, mine water treatment, ore storage, and migration along discontinuities.

During the group's discussion of the Ambrosia Lake site, EID representatives indicated that they were uncertain about how the state will regulate DOE's performance of remedial actions at the site. They requested a formal review of the proposed SOW for hydrogeologic characterization and mentioned that they were considering the applicability of RCRA regulations for the remedial action project. TAC representatives stated that they could not commit to complying with EID's request without DOE's involvement. Subsequent to the meeting on May 20, 1985, the EID formally requested DOE to submit a discharge plan for the proposed uranium tailings remedial action project at the Ambrosia Lake site. Because the state's regulation of remedial actions at Ambrosia Lake may significantly influence the scope and detail of hydrogeologic characterization activities at the site, I encouraged the EID representatives to clarify the state's relationship with DOE on the remedial action project as soon as practical to establish the regulatory framework for the remedial actions within the state.

Milan Mill Site Visit

On Tuesday afternoon, I visited Homestake's uranium mill located in Milan, New Mexico. The purpose of my visit was to observe the groundwater restoration system operated by the Homestake mill and to discuss with Edward Kennedy, Director of Environmental Affairs, practical and technical aspects of the restoration system. In contrast to concerns expressed by other operators of uranium mills, Homestake considers their groundwater restoration project at the Milan mill to be successful. The environmental staff at Homestake is proud of their accomplishments to date, although Mr. Kennedy stressed that the

success of the particular system implemented by Homestake is strongly dependent upon site-specific conditions. As a follow-up activity to my visit to the Homestake mill, I recommend that WMGT continue to track the progress of groundwater restoration activities at the mill in support of the Division of Waste Management's rulemaking, implementation, and national program responsibilities.

The slides I took while visiting the Ambrosia Lake and Homestake mills provide the basis for constructive and educational presentations about the Ambrosia Lake UMTRAP site and groundwater restoration activities at the Homestake Mill. Please contact me if you would like me to arrange presentations on either of these topics or if you have questions about my trip.

Enclosure:
Trip Report

Enclosures available in DCC.

OFC	:WMGT MW	:	:	:	:	:	:
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JUN 1 2 1985

REPORT ON TRIP TO GRANTS MINERAL BELT, NEW MEXICO
MICHAEL WEBER, DIVISION OF WASTE MANAGEMENT
MAY 5-8, 1985

Ambrosia Lake Site Visit

On Monday, May 6, I visited the Ambrosia Lake UMTRAP site near Ambrosia Lake, New Mexico in the Grants Mineral Belt. I was guided during the visit by Kimberely Ries, who is the TAC's hydrogeologist working on Ambrosia Lake. Later in the day, we were joined by the larger group of NRC, DOE, TAC, and New Mexico State representatives at the site. Documentation of the site visit is divided into two parts: a general description of the site based on the engineering assessment prepared by Ford, Bacon, Davis Utah (FBDU, 1981, DOE/UMT-0113), and a summary list of my observations relevant to WMGT's evaluation of the site. The general description below aids readers in relating my observations of the site to DOE's proposed site characterization activities and ultimately to decisions by the NRC about the appropriateness of DOE's proposed remedial actions at the site.

General Description

The Ambrosia Lake (Phillips/United Nuclear) UMTRAP site is located in McKinnley County in northwestern New Mexico approximately 25 miles north of Grants, New Mexico. At an elevation of 6980 feet (AMSL), the site is located in the Ambrosia Lake Valley, which trends NW-SE and is bordered by San Mateo Mesa (elevation 7400 feet) to the north and Mesa Montanosa (elevation 7300 feet) to the southwest. The climate is semi-arid to arid with a mean annual precipitation of approximately 10 inches.

Constituting a principal mining district in the Grants Mineral Belt, the Ambrosia Lake Valley has been extensively mined for uranium recovery. The mines extract uranium ore from the Westwater Canyon Member of the Morrison Formation and from the Todilto Limestone. In addition to numerous ventilation shafts and exploratory boreholes, several mineshafts close to the Ambrosia Lake site penetrate bedrock from the land surface down several hundred feet to the ore-bearing formations. The Anne Lee mine shaft is located approximately 500 feet NE of the NE corner of the Ambrosia Lake tailings pile. Accompanying the extensive mining in the valley, several large conventional uranium mills have also disturbed the environment since their construction and operation in the late-1950's. The largest pile of uranium mill tailings in the United States is located about 1.5 miles west of the site at the Quivera (Kerr-McGee) mill.

The Ambrosia Lake mill was constructed and operated by the Phillips Petroleum Company in 1958 as a carbonate-leach mill to process uranium ores of the district. In 1963, the United Nuclear Corporation invested in the mill shortly before the mill closed in April of the same year. Unlike conventional uranium mills which utilize acid-leaching, alkaline-leach mills do not use solvent extraction circuits to concentrate uranium in leach solutions. Instead the uranium ore is leached by sodium carbonate and bicarbonate solutions; the uranium is generally precipitated directly from clarified leach solutions. During its five years of operation, the Ambrosia Lake mill generated approximately 3 million tons of tailings, most of which were disposed of in a shallow, above-grade, engineered impoundment west of the mill area. The pile covers 105 acres to an average depth of 12 feet. About 400,000 tons of tailings were removed from the pile for use as backfill materials in local mines.

The tailings pile and mill area rests on unconsolidated, fine alluvium of variable thickness. The alluvium mantles the Mancos Shale and interbedded lenses of the waterbearing Tres Hermanos Sandstone. Other potential aquifers beneath the site include the Dakota Sandstone, Westwater Canyon Member of the Morrison Formation (principal ore horizon), Bluff Sandstone, Todilto Limestone, Entrada Sandstone, and the San Andres Limestone in descending order. Groundwater flow in the alluvium and shallow bedrock units is expected to be toward Arroyo del Puerto, an intermittent stream SW of the site between the site and the Quivera mill. In contrast, groundwater flow in the deeper bedrock aquifers (e.g., Tres Hermanos Sandstone A, Dakota Sandstone, Westwater Canyon Member) is expected to be down stratigraphic dip to the northeast toward the center of the San Juan structural basin. Regional and local information indicates that groundwater flow and quality within the deeper units have been perturbed by artificial influences such as mine dewatering and well injection.

Surface water runoff from the upslope area N of the mill site drains toward the tailings pile and mine area NE of the tailings. Several runoff diversion and containment ditches have been excavated to control the runoff. North of the mill area, mine water sedimentation and treatment ponds were constructed to prevent discharge of contaminated water from the Anne Lee Mine. On the north side of the tailings pile, a small square impoundment was excavated to collect and retain runoff from the mine area. An impoundment of similar dimensions was also constructed along the east edge of the tailings to contain sewage effluent from the mine/mill complex. In spite of attempts to prevent significant erosion of the tailings by surface water, surface water and wind have transported tailings to significant distances on all sides of the tailings pile.

Site Observations

The environment surrounding the Ambrosia Lake site has been significantly impacted by uranium mining and milling, and ancillary activities, which represent hundreds of potential sources of groundwater and surface water contamination in the Ambrosia Lake Valley. Besides the mill tailings pile at the site, other potential sources of contamination include chemical storage areas in the mill yard (Observation 6), mine water treatment and settling ponds (Observation 4), ore storage areas (Observation 5), chemical storage areas near the Anne Lee Shaft, windblown contamination of undetermined origin, several open dumps (Observations 6 and 3), and injection wells (Observation 2). In addition, exploratory boreholes and pits, mine shafts, ventilation shafts, as well as potential fracture zones, faults, and joints may provide hundreds to thousands of preferential pathways for downward migration of contaminated groundwater near the site. Furthermore, the hydrogeologic system near the site has been impacted by mine dewatering and mine water discharge at the surface. Collectively, these factors impart significant complexity to the hydrogeologic system at the site. Consequently, characterization of the site and decisions about appropriate remedial actions for groundwater contamination at the site may be extremely complex.

The general observations listed below are numbered in accordance with the annotated topographic map in Figure 1.

1. Cattle graze in the mill area. As evidenced by hair snagged on the fence, the cattle access the mill area by squeezing through two small openings in the chain-link fence north of the mill. The origin of the openings could not be determined (i.e., did the cattle create the openings or did they merely enlarge openings created by man). The ability of the cattle to penetrate through the fence into the restricted mill area may have significant ramifications on decisions to fence and protect the stabilized tailings embankments.

2. Several injection wells are located on hill slopes north of the mill. The wells are not serviced with electricity; pumps were not observed in the wells. The wells were connected with 3-inch, black PVC(?) pipe. The purpose(s) of the wells is unknown, but they may have been used to inject mine water to leach ore pillars remaining in the mines north of the site. Similar wells are also located in the flat area to the west of the tailings pile.

3. Two construction/industrial waste dumps are located on the hillslopes north of the mill area. Both dumps are uncovered and located in parallel, excavated trenches approximately 20 feet wide and 15 feet deep. Wastes include scrap steel and wood, air filters, 55-gallon drums, sample vials, domestic garbage, and tires. The wastes may be mining or milling wastes, or a

combination of wastes from both activities. The trenches are excavated in alluvial sediments similar to those that the tailings pile rests on. The alluvium is fine to medium grained, buff colored, and contains numerous shale (Mancos Shale?) fragments, as well as coarser granules of quartzite.

4. Two mine-water treatment ponds are located northwest of the mill area and southeast of the Anne Lee headframe. The western pond contains a thick layer of sludge at the base, whereas the eastern pond is relatively free from settling sludge. Although both ponds were dry, water had recently ponded in both ponds as evidenced by saturated clay deposits on the surface of small depressions.

5. Ore stored in the flat area east of the Anne Lee shaft is coarse to medium grained, buff to reddish brown, friable, arkosic sandstone with local pods of black mineralization (uraninite?) and brightly colored secondary mineral crusts characteristic of uranium mineralization (e.g., carnotite, meta-carnotite). In and near the mineralized pods, the sandstone contained fine to medium grains of pyrite.

6. The drainage ditch east of the mill buildings contains 55-gallon drums. Black and dark brown stains on soils along the ditch appear to have been caused by oil and grease spills, which are confirmed by strong hydrocarbon odors. Another small trench near the ditch contains scrap steel and 55-gallon drums. This trench is approximately 10 feet wide, 5 feet deep, and 35 feet long. Other drums located nearby on wooden platforms contain oils and greases, which were apparently used in milling and/or mining activities.

7. The upper surface of the tailings pile is relatively flat with a large pond in the south central portion of the pile. The tailings are very fine to fine grained, pink to buff colored, and well-indurated at the surface. White precipitates on the surface and along the shores of the pond may be calcite, as the precipitates effervesced strongly in weak (0.1N) HCl. The surface has been eroded to form meandering channels, where meander wavelengths appear to be proportional to the width and depth of the channels, and inversely proportional to the order of the channels. The pile is barren of vegetation. Although the southern border of the pile appears to have been stabilized by a thin covering of silt and coarse alluvium, the tailings have been severely eroded by wind creating large blow-outs and moonscape topography.

8. In the southcentral portion of the pile near the southern shore of the pond, a large mound of tailings contains fire bricks and 55-gallon drums containing bright orange, yellow, and green powder and granules (yellowcake?). The drums have been severely corroded, so their contents are being dispersed across the surface of the tailings into the pond.

9. Three large (1.5-foot diameter) air vents are located within several hundred yards west of the tailings pile in the flat area undermined by the Kerr-McGee mines. The surface of this area was slightly depressed, which Kim Ries attributed to mine subsidence.

10. In outcrops south of the site along State Highway 509, the Westwater Canyon Member of the Morrison Formation is a orange to buff colored, thickly bedded (G.T. 1 m), friable, trough cross-bedded, calcite cemented, arkosic sandstone. Fractures in the sandstone are primarily cemented with calcite, although open joints and bedding planes are abundant. As observed in these outcrops, the Westwater Canyon member may be a high-yielding aquifer down stratigraphic dip in the vicinity of the Ambrosia Lake site.

TAC/NRC/New Mexico Meeting

On Tuesday morning, May 7, I met with representatives of the TAC and Environment Improvement Division (EID) of the New Mexico Department of Health and Environment to discuss DOE's proposed Statement of Work (SOW) for installation of monitoring wells at the Ambrosia Lake site. The SOW directs a portion of field work in support of hydrogeologic site characterization that supports DOE's selection of appropriate remedial actions. DOE was not represented at the meeting. Table I lists the individuals who attended the meeting, which was held in the offices of the Jacobs Engineering Group in Albuquerque, New Mexico.

The TAC representatives proposed the meeting to provide NRC and EID an opportunity to review planned hydrogeologic activites prior to their implementation. Although they did not request official approval of the SOW, the TAC representatives sought indications from myself and EID whether the planned characterization activities represented a reasonable approach at the present time. Specifically, the TAC hydrogeologists proposed to discuss the need for installation and monitoring of deeper wells in the Tres Hermanos A Sandstone, Dakota Sandstone, and Morrison Formation beneath the site. Monitoring these deeper units may not be necessary depending on the results of shallower monitoring or may be futile because of the expected complexity of the hydrogeologic system or the presence of deeper contamination in these units associated with uranium mining in the Ambrosia Lake Valley.

Kim Ries opened the meeting with a brief discussion of the meeting's objectives and a detailed explanation of the proposed SOW for installation of monitoring wells within the alluvium and Tres Hermanos Units B and C beneath and near the Ambrosia Lake site. The objectives of this phase of the hydrogeologic characterization program include the following:

1. To characterize the vertical extent of groundwater contamination;

2. To characterize the lateral extent of saturated and contaminated alluvial groundwater system;

3. To distinguish groundwater contamination caused by seepage from the Ambrosia Lake tailings from that caused by mine dewatering discharges, mine water treatment, injection wells, ore stockpiles, and other potential sources of contamination near the site; and

4. To characterize the hydraulic properties and attenuative capacities of the alluvium, Tres Hermanos Sandstones, and Mancos shale.

The group discussed each of the objectives along with the proposed characterization activities proposed to achieve them, which include the installation of 28 to 33 monitoring wells to maximum depths of approximately 300 feet with optional installation of up to 16 more wells to greater depths contingent upon the monitoring results from the shallow wells.

The TAC is primarily concerned about potential groundwater contamination in the Tres Hermanos Sandstones within the Mancos Shale. The TAC and EID agreed that the alluvium beneath the site was probably not saturated prior to commencement of milling and mining activities within the valley during the mid- to late-1950's. This implies that the uranium recovery activities have created an "aquifer" by saturating portions of the alluvial sediments that mantle the valley floor and flanks. Unlike the alluvium, it is unclear whether deeper hydrogeologic units above the Morrison Formation were also unsaturated prior to commencement of mining and milling. Based on local and reconnaissance investigations of the area, the TAC and EID agreed that the Tres Hermanos Sandstones and the Dakota Formation were probably at least partially saturated prior to the mid-1950's, and thus should be considered as aquifers. In addition, these units could be especially vulnerable to groundwater contamination from the Ambrosia Lake tailings because of their shallow depths beneath the site and abundant natural and artificial discontinuities (e.g., drill holes, mine shafts, fracture zones) that could promote downward contamination.

Discontinuities may also connect the shallow groundwater system with the deeper Morrison Formation. Until recently, the Westwater Canyon Member of the Morrison Formation was the principal aquifer at Ambrosia Lake because it yielded abundant quantities of high quality groundwater. Since the mid- to late-1950's, deep mining of uranium ores required extraction of large volumes of groundwater, which created extensive cones of depression around the deep mines. Mine dewatering also locally decreased saturation of the shallow aquifers above the Morrison Formation. Following the cessation of mining and milling in the valley, potentiometric heads in the Morrison Formation and shallow aquifers are expected to gradually revert to pre-mining conditions.

EID hydrogeologists indicated that the pre-mining hydraulic gradient between the Tres Hermanos, Dakota, and Morrison sandstones was probably vertically downward.

Groundwater quality in the Westwater Canyon Member has been degraded by the influx of oxidizing groundwater near mine drifts and shafts. Oxidizing groundwater mobilizes many of the redox-sensitive metals, such as uranium and selenium, originally present in ore deposits and adjacent country rock. In addition, several mines near Ambrosia Lake were leached after closure by injecting raw or treated water that would leach uranium and other metals from the ore remaining in mine pillars. The combination of injected leach solutions, influx of oxidizing groundwater, and potential migration through discontinuities from shallow contaminated aquifers may have caused widespread degradation of groundwater quality within the Morrison Formation beneath the Ambrosia Lake site.

At the meeting, the group recognized the potential impracticalities of characterizing the discontinuities (fracture zones, exploratory drill holes, ventilation shafts) and the extent of groundwater contamination in aquifers beneath 300 feet of overburden, in which the hydraulic gradient has been significantly perturbed by mine dewatering. Further, the group recognized the larger problem of distinguishing groundwater contamination caused by the Ambrosia Lake milling operations from that caused by mining, injection, mine dewatering, mine water treatment, ore storage, and migration along discontinuities. Based on these considerations, the group agreed that the TAC's approach of first characterizing shallow aquifers, especially the Tres Hermanos Sandstones, constituted a reasonable approach for hydrogeologic characterization of the site. The TAC recognized that additional characterization may be necessary depending on the results and analysis of the initial characterization program.

During the group's discussion of Ambrosia Lake, EID representatives indicated that they were uncertain about how the state will regulate DOE's performance of remedial actions at the site. The state mentioned that they may request DOE to submit a "discharge plan" as required in New Mexico's Water Quality Control Commission Regulations, Sections 3-104 and 3-106. Such discharge plans are required for anthropic activities that discharge contaminants into the waters of the state. EID representatives also mentioned that they were evaluating the applicability of RCRA regulations for remedial actions at Ambrosia Lake. In response to my question about what portions of the RCRA regulations they felt were applicable to the project, (e.g., liner requirements, groundwater monitoring and response requirements), the EID representatives stated that they had not completed their evaluation. EID requested formal review of the SOW, which would require DOE's submission of the SOW to EID followed by an official EID response approving or rejecting the proposed activities. TAC representatives stated that they could not commit to

EID's request without DOE's approval. Subsequent to the meeting on May 20, 1985, the EID formally requested DOE to submit a discharge plan for the proposed uranium tailings remedial action project at the Ambrosia Lake site [cf. letter from Denise Fort to Frank Bosiljevac dated May 20, 1985].

The state's regulation of remedial actions at Ambrosia Lake could significantly affect the scope and detail of hydrogeologic characterization at the site. For example, based on the group's discussion of the New Mexico water regulations, background concentrations of constituents in groundwater in the alluvium may be determined based on the present configuration of contaminant plumes, if they exist downgradient of the site. Migration of the contaminants downgradient may cause state contaminant limits to be exceeded, thus requiring control or restorative actions (e.g., slurry walls, aquifer restoration) to protect the shallow aquifer from further contamination. This consideration and others stipulated by the New Mexico regulations could require DOE to characterize any existing contamination in the shallow groundwater system in more detail than currently proposed in the SOW. Consequently, I encouraged the EID representatives to clarify the state's relationship with DOE on the remedial action project as soon as practical to establish the regulatory framework for the remedial actions within the state.

Milan Mill Site Visit

On Tuesday afternoon, I visited Homestake's uranium mill located in Milan, New Mexico, which is several miles west of Grants. The purpose of my visit was to observe the groundwater restoration system operated by the Homestake mill and to discuss with Edward Kennedy, Director of Environmental Affairs, practical and technical aspects of the restoration system.

Operating since 1958, the Homestake mill has produced more than 22 million tons of tailings using alkaline leach milling circuits similar to those operated at the Ambrosia Lake (Phillips/United Nuclear) UMTRAP site. Disposal of the tailings in unlined, above-grade impoundments has contaminated a shallow aquifer downgradient of the site, where local investigations identified several contaminated domestic wells in 1976. Despite significant uncertainties about the source of the contamination and liabilities of the mill, Homestake installed an extensive groundwater injection system upgradient from the Broadview Acres subdivision, where the contaminated wells were located. Subsequent upgrades to the system have included the installation and operation of a line of collection wells near the downgradient edge of the active tailings pile (1978), a small nest of three collection wells near another subdivision (Murray Acres - 1980), and another line of injection wells immediately upgradient from Murray Acres (1983). In addition, Homestake recently completed

installing an extension of a municipal water supply main from Milan to the residents of the subdivisions. Kennedy and Hoffman (1985) summarize the characteristics of the remedial measures taken to contain and restore contaminated groundwater at the Homestake mill. The current configuration of the restoration system is illustrated in Figure 2.

The cumulative pumping rate of the collection wells at the base of the active tailings pile is approximately 300 gallons per minute (gpm), whereas the cumulative injection rate in the Broadview Acres (300 gpm) and Murray Acres (300 gpm) injection wells is about twice the collection rate. The collection wells near Murray Acres were installed to contain a narrow extension of the contaminant plume and are pumped at an average rate of 70 gpm. The collected water is pumped to an open sump along the downgradient edge of the active tailings pile, where it is pumped into the mill's ion exchange (IX) circuit. Concentrations of uranium in the groundwater collected downgradient of the tailings and pumped into the IX circuit range from 35 to 45 mg/l. Mr. Kennedy estimated that the IX removal efficiency for uranium was about 60 to 70%. After passing through the IX circuit, the treated water is discharged along with tailings slurry to the active tailings ponds.

High concentrations of selenium in domestic wells in the Broadview Acres subdivision precipitated the remedial actions in 1976 to control and restore groundwater quality in the alluvial aquifer. These concentrations were as high as 1.2 to 1.5 mg/l, which is more than two orders of magnitude above the drinking water standard of 0.01 mg/l (NIPDWR - 40 CFR 141). Accompanying the high concentrations of selenium, sulfate concentrations were also elevated as high as 1000 mg/l in the domestic drinking water.

Injection of water upgradient from the two subdivisions has significantly improved the quality of groundwater in the shallow alluvium. The injection water is withdrawn from the San Andres aquifer, which is separated from the contaminated alluvium by the relatively impermeable Chinle Shale. In addition to diluting the contaminated groundwater in the vicinity of the subdivisions, the injected water has also reversed the hydraulic gradient back toward the tailings pile and the collection wells. Thus the well system controls groundwater contamination by reversing the hydraulic gradient and capturing seepage from beneath the active tailings pile, as well as restores groundwater quality by sweeping (flushing) the contaminated aquifer. By monitoring the quality of shallow groundwater within the alluvial aquifer, Homestake has demonstrated significant reductions in the concentrations of selenium and sulfate as shown in Figure 3.

According to Mr. Kennedy, significant groundwater contamination by other constituents typically observed at alkaline-leach uranium mills (e.g., molybdenum) has not been observed at the Homestake mill. In the vicinity of

the subdivisions, uranium concentrations are below the state groundwater standard of 5 mg/l. Molybdenum concentrations in groundwater affected by seepage from the tailings remain low because molybdenum is extracted in the milling process to prevent fouling of circuits and to sell as a byproduct of the mill. Significant radium migration has not been observed at the Homestake mill. In groundwater withdrawn from immediately downgradient of the active tailings piles, the concentrations of radium-226 do not exceed 1.2 pCi/l, which is well below the 5 pCi/l drinking water limit for combined radium-226 and -228.

In contrast to concerns expressed by other operators of uranium mills, Homestake considers their groundwater restoration project at the Milan mill to be successful. The environmental staff at Homestake is proud of their accomplishments to date, although Mr. Kennedy stressed that the success of the particular system implemented by Homestake is strongly dependent upon site-specific conditions. Groundwater restoration systems would have to be modified at other mill sites to account for site-specific conditions and to optimize the effectiveness and efficiency of the systems.

Reference

Kennedy, E. E., and Hoffman, G. L. 1985. Remedial measures to contain seepage from Homestake's uranium tailings at Milan, New Mexico. Proceedings of the Seventh Symposium on Management of Uranium Mill Tailings, Low-Level Waste and Hazardous waste, February 6-8, 1985. pp. 513-522.

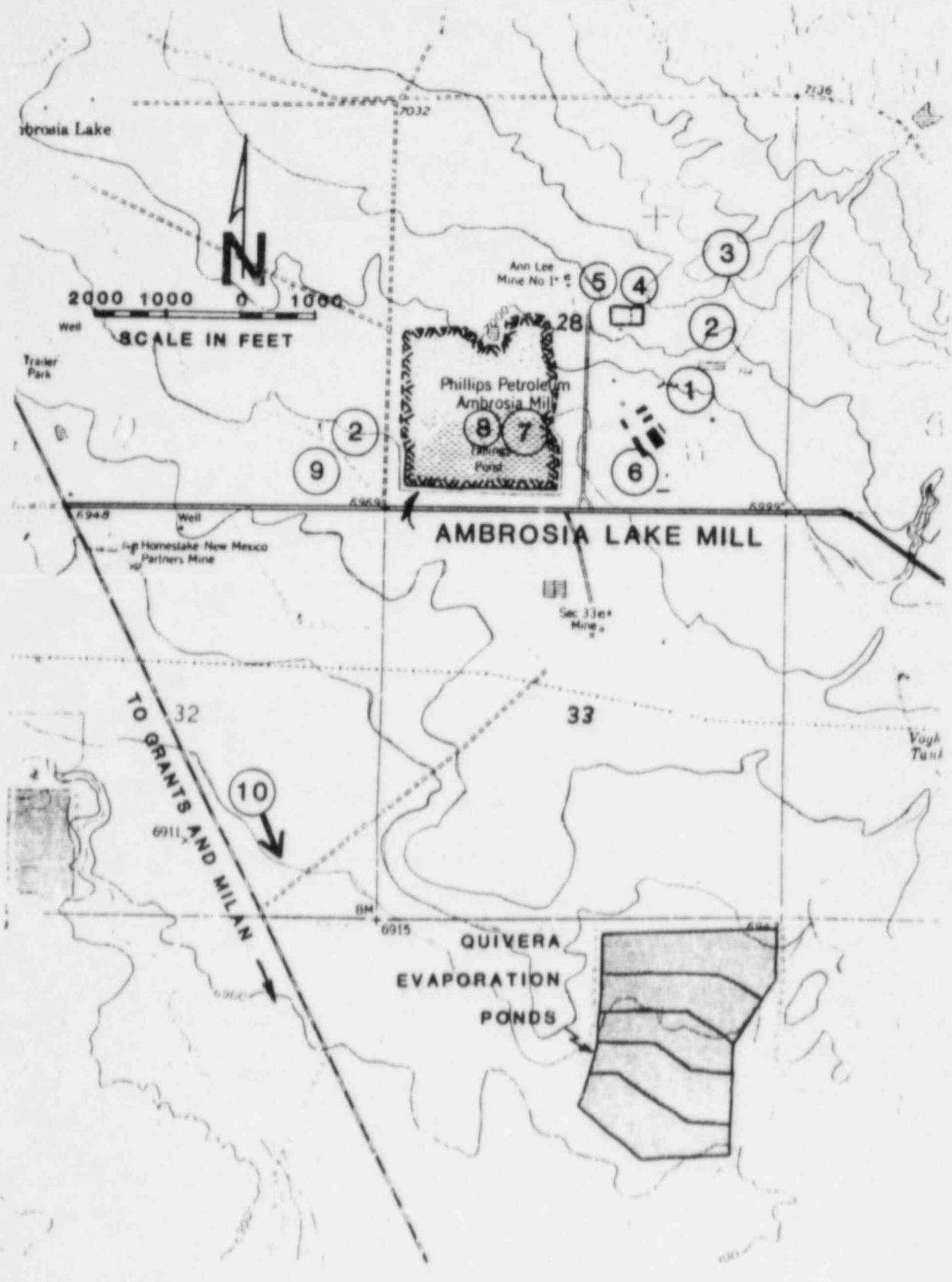

Figure 1. Annotated topographic map of the Ambrosia Lake UMTRAP site. Numbers correspond to observations described in text.

JUN 1 2 1985

TABLE I
ATTENDEES OF THE AMBROSIA LAKE CHARACTERIZATION MEETING - MAY 7, 1985

NAME	ORGANIZATION	TELEPHONE NUMBER
Michael Weber	NRC/WMGT	FTS or (301) 427-4746
John Thackston	Jacobs Engineering/TAC	FTS or (505) 846-1250
Greg Lewis	New Mexico/EID/GWHWB	(505) 984-0020
Kent Bostick	New Mexico/EID/GWHWB	(505) 984-0020 ext. 286
Michael Taylor	New Mexico/EID/RPB	(505) 984-0020 ext 275
Terry Morgan	New Mexico/EID/RPB	(505) 984-0020 ext 275
Kim Ries	Jacobs/TAC	FTS 846-1250
Gary Parker	Jacobs/TAC	FTS 846-1250
Bruce Kennedy	Jacobs/TAC	FTS 846-1250

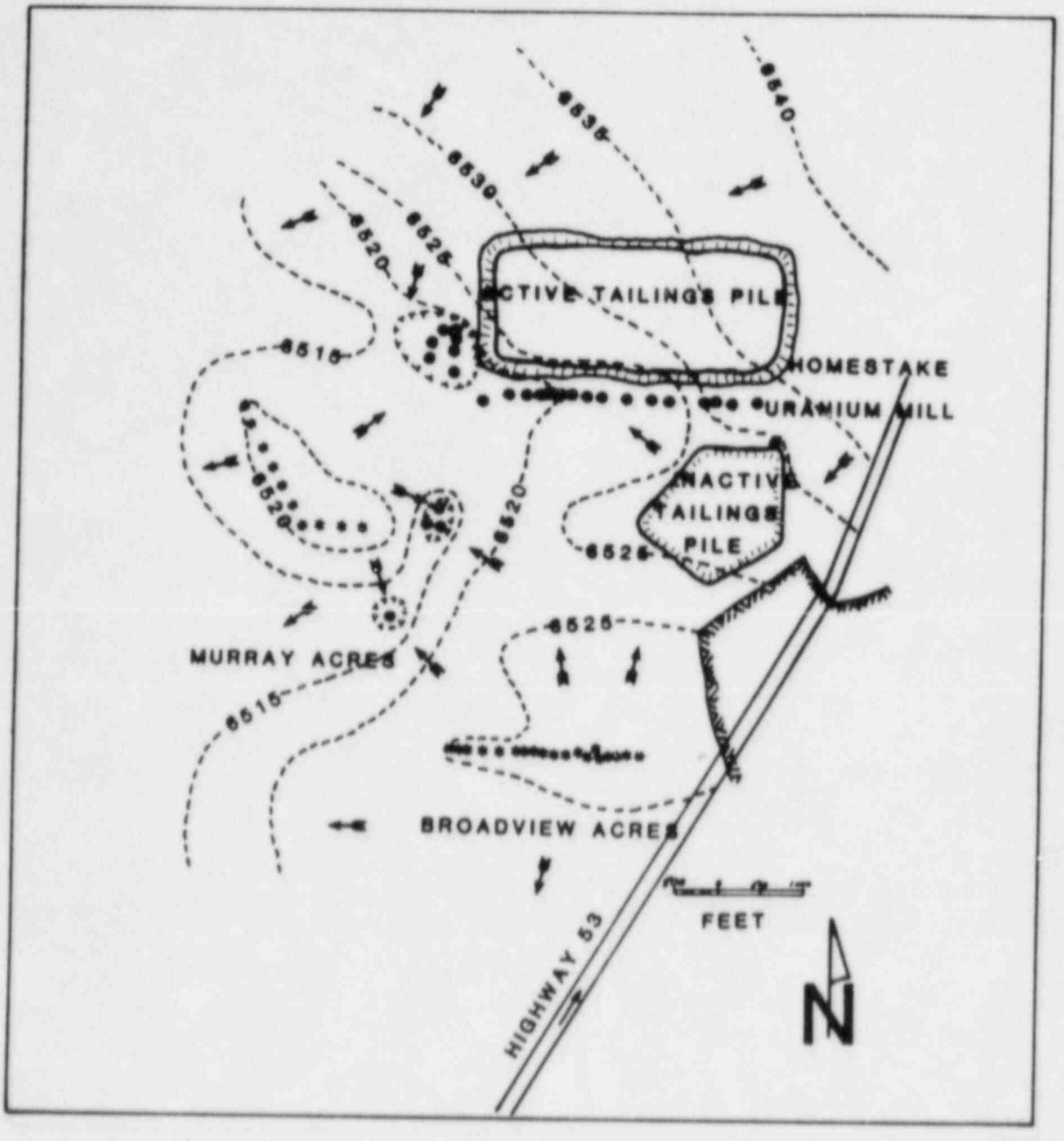

Figure 2. Groundwater control and restoration system at Homestake's Milan mill. Dots represent collection or withdrawal wells, asterisks represent injection or recharge wells, and arrows represent the directions of shallow groundwater flow. Dashed contours depict the configuration of the water table in June, 1984, and are expressed in feet above mean sea level (Kennedy and Hoffman, 1985).

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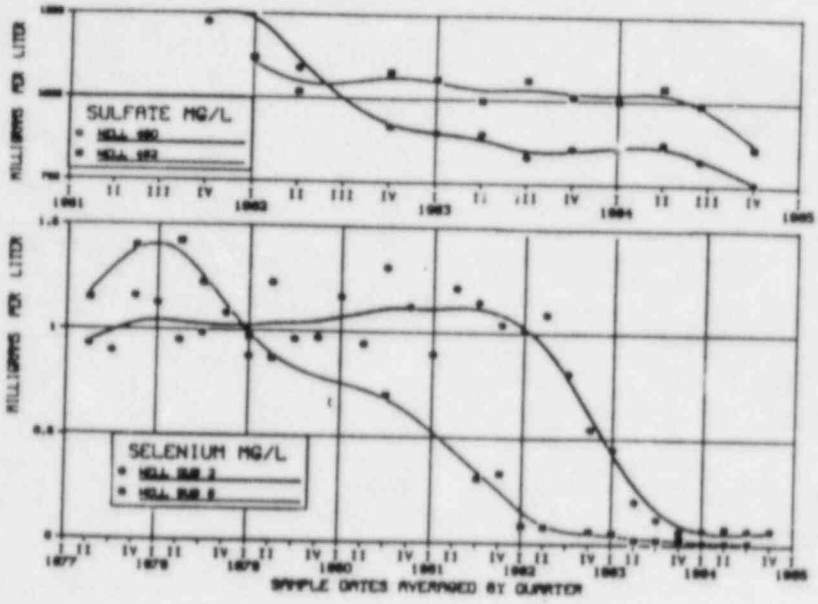

FIGURE 3. SELENIUM CONCENTRATIONS FOR WELLS SUB 2 AND SUB 6 AND SULFATE CONCENTRATIONS FOR WELLS 490 and 492.

REF: Kennedy and Hoffman, 1985