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THE SHIPROCK URANIUM-MILL TAILINGS REMEDIAL ACTION (UMTRA) SITE, NEW MEXICO

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Abstract—A uranium mill tailings site on a high terrace adjacent to the San Juan River in Shiprock has been the focus for a Department of Energy remediation program. The mill tailings have been encased within a disposal cell. However, on the lower floodplain a contaminant plume has been identified. Remediation of this plume requires an understanding of the hydrological characteristics of the floodplain and the interaction of flows in the San Juan River and the shallow aquifer. The floodplain consists of alluvial gravels overlying coarser glacial outwash gravels that are sitting on fractured Mancos Shale. Spatial variation of the stratigraphy was determined by analyzing drillers' well logs, and from geophysical surveys. The extent of the contaminant plume has been determined by analysis of groundwater collected from monitoring wells and from electromagnetic (EM) surveys.

INTRODUCTION

Following cessation of milling operations at the Shiprock site in 1968, the uranium-mill tailings were left open to the environment until remediation, mandated by the Uranium Mill Tailings Radiation Control Act, began in 1985 and concluded in Fall 1986. Approximately 1,200,000 m^3 of material, which included both tailings and masonry from local buildings that had been constructed using tailings, were encapsulated in a pentagonal 29 hectare disposal cell (DOE, 1996). Within the disposal cell, contaminated material is covered by a 1–2 m thick layer of clay, which acts as a barrier. The clay is in turn covered by 15 cm of filter sand for drainage, and 30 cm of cobbles as protection against erosion (DOE, 1991). The base of the cell is unlined and lies on fluvial gravels and Mancos shale; a swale was excavated around the base of the cell for surface drainage. When completed, the cover was completely free of vegetation, but small shrubs and grasses have now taken root on its northeast and northwest flanks.

The disposal cell rests on an alluvial fill terrace that lies on a strath terrace cut into the Mancos Shale, approximately 20 m above the level of the San Juan River. The site is bounded on the west and north by Bob Lee Wash, a formerly ephemeral stream that now carries the continuous discharge (200–300 L/min) from an artesian well in the Morrison Formation (M. J. Johnson, personal commun., 1995) near the Shiprock fairgrounds. Bob Lee Wash descends from the terrace into the river floodplain, where it has created wetlands. The floodplain also receives groundwater from seeps at the base of the terrace, which are fed through fractures in the weathered Mancos Shale (DOE, 1996).

Groundwater beneath the disposal cell and in the floodplain has been contaminated by milling activities, leakage from the tailings pile, or both. Water samples taken from an array of about 30 monitoring wells in the vicinity of the site exceed maximum concentration limits for Cd, Se, U, ^{226}Ra, ^{228}Ra, and NO_3^- (DOE, 1993, 1996) and also contain significant quantities of SO_4^{2-}. A contaminant plume has been identified

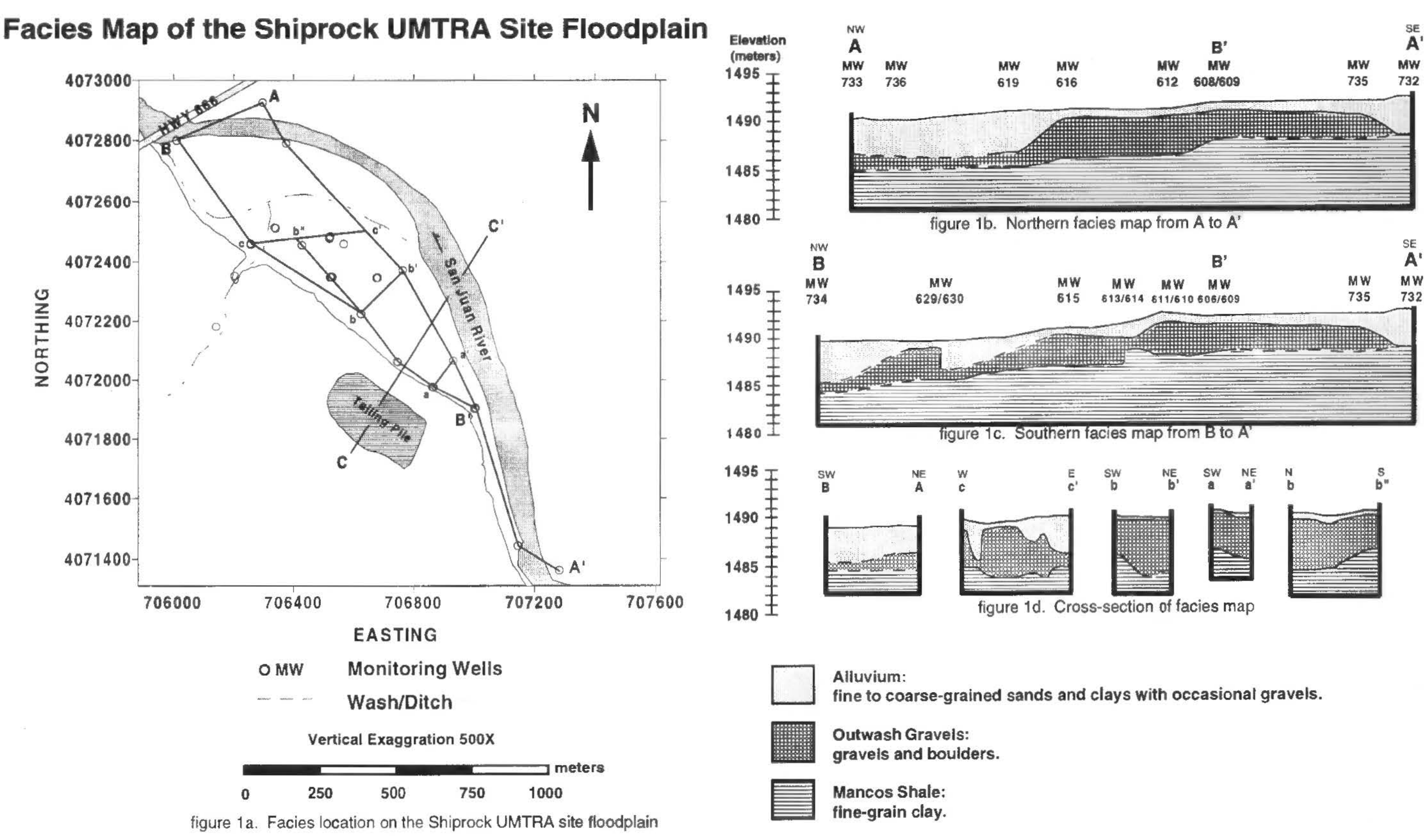

FIGURE 1. Facies maps and cross sections of the Shiprock UMTRA site floodplain.

in the floodplain aquifer by EM techniques and by water quality data from monitoring wells.

SITE CHARACTERIZATION

A research partnership between New Mexico Tech, the University of New Mexico, Navajo Community College, the Navajo Nation UMTRA Program, and the U.S. Department of Energy is currently characterizing groundwater contamination and evaluating potential remediation technologies for the Shiprock site (Brown et al., 1996; Thombre et al., 1996; Thomson et al., 1996). Our research focuses on characterizing floodplain hydrogeology below the UMTRA disposal cell, in order to determine the behavior of the unconfined aquifer within the floodplain and how this behavior influences movement of the contaminant plume. Undergraduate and graduate students from Navajo Community College and New Mexico Tech participated in the data collection for this study.

STRATIGRAPHY

Data from logs of abandoned and existing monitoring wells were used to create a facies map (Fig. 1a–d). Three different lithologies were identified in the floodplain; the Mancos Shale, glacial outwash gravels and fluvial gravels. Significant variation was observed in the thickness of gravel units and also in the depth to the Mancos Shale. For example cross section A–A' (Fig. 1b) shows that the surface of the Mancos Shale has not been affected by erosional scouring in the northeastern part of the floodplain. Outwash gravels and alluvium have consistent thickness in the center of the floodplain but increase in thickness near the San Juan River. The cross section B–A' (Fig. 1c) shows that gravel and alluvium thicknesses vary by as much as 3 m. The Mancos Shale surface shows few erosional channels, except for a resistant knob near monitoring wells 613 and 614, where gravel and alluvium also become thinner. The C–C' cross section (Fig. 1d) also shows ancestral alluvial channeling within the floodplain.

Shallow seismic reflection was used to better identify stratigraphic boundaries and fractures at the southeastern end of the floodplain. East of monitoring wells 608 and 609 an offset in the gravels was identified (J. Schlue, personal commun., 1995) that coincides with higher levels of soil contamination (as determined by electrical conductivity; see below). Groundwater and contaminant-flow paths may be locally affected by such fractures or by major changes in lithology, which has significant implications for remediation technologies, such as in-situ reactive barriers (Thomson et al., 1996), that may eventually be proposed for the site.

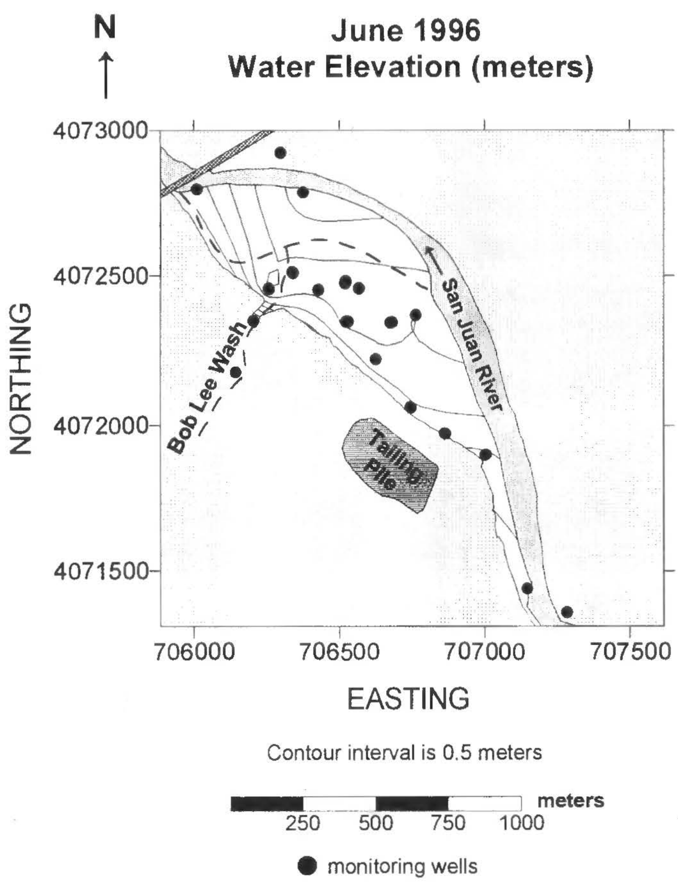

FIGURE 2. Average water elevation for June, 1996. Minimum elevation is 1487.5 m and maximum elevation is 1498 m.

FLOODPLAIN HYDROLOGY

Water levels were measured in 30 monitoring wells at or near the UMTRA site (Fig. 2), so that seasonal interactions between the San Juan River, Bob Lee Wash, and the floodplain aquifer could be determined. Ground-water flow in the floodplain is approximately perpendicular to the course of the San Juan River, suggesting that the San Juan River is a losing stream (Larking and Sharp, 1992). Water-table maps indicate that during low-flow periods in the San Juan River, groundwater levels in the floodplain near Bob Lee Wash do not vary with river levels. The wash, now flowing year-round, may be causing a freshwater divide on the floodplain separating the floodplain aquifer into two systems, upstream and downstream.

CONDUCTIVITY

We used conductivity meters (models EM-38 and EM-31) to measure the subsurface electrical conductivity of the regolith and shallow groundwater on the floodplain. These instruments generate an electromagnetic field that induces a small current into the ground. Magnetic field strength is determined by terrain conductivity (McNeil, 1992). Conductivity increases with salinity; thus the EM measurements provide a semiquantitative map of floodplain contamination. Four surveys were conducted on the floodplain in 1995 and 1996. The two probes afford different levels of vertical and horizontal resolution. The EM-38 has a maximum depth of signal penetration of 0.75 m horizontally and 1.5 m vertically, whereas the EM-31 signal penetrates to 3 m horizontally and 6 m vertically. An estimate of the vertical variation of the contaminant plume can be made by comparing the vertical measurements from the two instruments. Conductivity measurements indicate that the contaminant plume is concentrated in the lower portion of the aquifer (Fig. 3a–b). The best resolution of the contaminant plume by conductivity measurements is obtained when river levels are high.

RELATIONSHIPS BETWEEN HYDROLOGY AND CONDUCTIVITY

At the mouth of Bob Lee Wash (Fig. 3), conductivity contours are similar to water-level contours. Toward the outlet, local alluvial gravels maybe inhibiting the movement of contaminants into the river itself. Eastward (upstream) along the floodplain, decreased conductivity near the river is attributed to dilution by the losing stream. West of the arroyo, several homes are situated atop the terrace. Locally high conductivity in the floodplain below may be a result of contamination from domestic septic tanks situated within 3–6 m of the terrace escarpment, where surface encrustation of salts can be observed. Fractures in the Mancos Shale escarpment may thus be groundwater conduits contributing to contamination of the floodplain by tailings upstream of Bob Lee Wash, and by septic tanks downstream.

SUMMARY

This study has highlighted the complex nature of groundwater/surface water interactions and some of the difficulties of characterizing the behavior of shallow aquifers. The aquifer on the floodplain is influenced by the bedrock, the types and thicknesses of the alluvial gravels and interaction with the San Juan River. This scenario is similar to that found in many shallow aquifers in the southwest region. Determining the behavior of a contaminant plume in such aquifers requires detailed sampling of the groundwater as well as a careful analysis of the factors influencing groundwater flows.

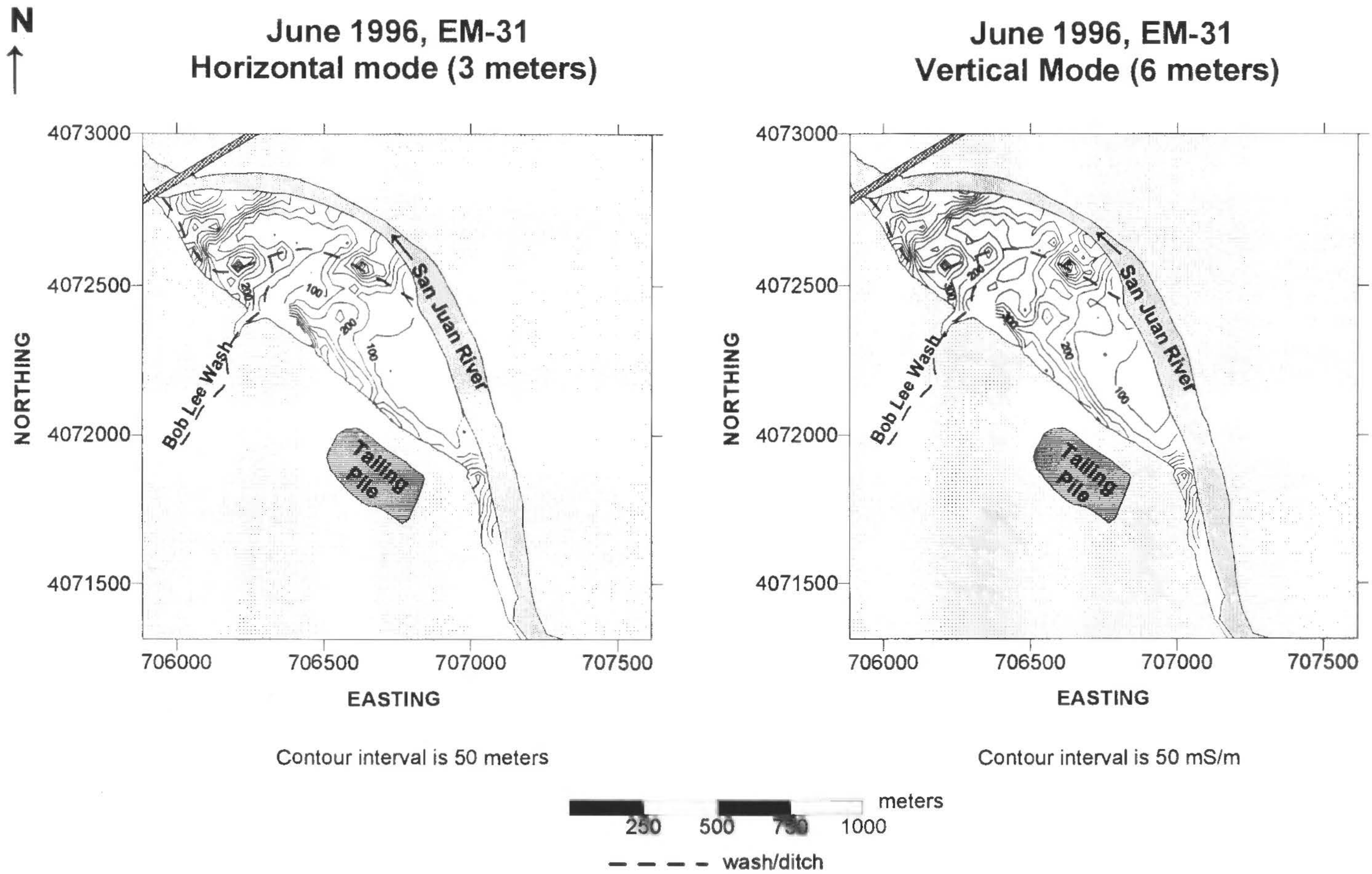

FIGURE 3. EM-31 horizontal (left) and vertical (right) mode points sampling every 50 m. Electrical conductivity low in horizontal mode is 39 mS/m and high is 634 mS/m; in vertical mode, low is 38 mS/m and high is 709 mS/m.

REFERENCES

Brown, C., Mitchell, M., Pierce, W., Tsosie, B. and Semken, S. C., 1996, Navajo students monitor a local uranium-mill tailings site: Abstracts, HSRC/WERC Joint Conference on the Environment, Albuquerque, p. 99.

DOE (U.S. Department of Energy), 1991, Report UMTRA-DOE/AL-400667.0000, UMTRA Project Office, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1993, Data collection objectives in support of the baseline risk assessment of ground water contamination at the Shiprock uranium mill tailings site: Report UMTRA-DOE/AL-050304.0000, UMTRA Project Office, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1996, Final programmatic environmental impact statement for the uranium-mill tailings remedial action ground water project: Report DOE/EIS-0198, UMTRA Project Office, Grand Junction, Colorado, p. 3.23–3.24.

Larkin, R. G. and Sharp, J. M., Jr., 1992, On the relationship between river-basin geomorphology, aquifer hydraulics, and ground-water flow direction in alluvial aquifers: Geological Society of America Bulletin, v. 104, p. 1608–1620.

McNeil, J. D., 1992, Rapid accurate mapping of soil salinity using electromagnetic ground conductivity meters; *in* Topp, G. C., Reynolds, W. D. and Green, R. E., eds., Advances in measurement of soil physical properties: Soil Science Society of America, Special Publication 30.

Thombre, M., Thomson, B. M. and Barton, L. L., 1996, Microbial reduction of uranium using cellulosic substrates: Abstracts, HSRC/WERC Joint Conference on the Environment, Albuquerque, p. 5–6.

Thomson, B. M., Henry, E. J. and Thomson, M., 1996, Applications of permeable barrier technology to ground water contamination at the Shiprock, NM, UMTRA site: Abstracts, HSRC/WERC Joint Conference on the Environment, Albuquerque, p. 9.