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TRIP REPORT

SUBJECT: Trip to Yucca Mountain for Hydrology Field Work (20-5708-861)

DATE/PLACE: March 26–28, 1997
Yucca Mountain, NV

AUTHOR: Stuart A. Stothoff and James R. Winterle

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SUBJECT: Trip to Yucca Mountain for Hydrology Field Work (20-5708-861)

DATE/PLACE: March 26-28, 1997
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PERSONS PRESENT:

The trip to Yucca Mountain (YM), on March 26–28, 1997 was undertaken by S. Stothoff and J. Winterle (CNWRA), D. Groeneveld and J. Thompson (Natural Resources, Inc.), and D. Or (Utah State University).

BACKGROUND AND PURPOSE OF TRIP:

CNWRA is working with D. Groeneveld, D. Or, and J. Thompson to aid in characterizing the impact of vegetation upon shallow infiltration. Transpiration is a process included in DOE models but not considered in CNWRA modeling efforts to date. The intent of the CNWRA work is to incorporate vegetation into infiltration-modeling efforts in a plausible and defensible manner, with appropriate modeling of soil-moisture uptake by plants of particular interest. The trip was inspired by the need for field-checking hypothesized relationships between vegetation and bedrock type, soil cover, slope, and solar loading. In a parallel effort, watershed-scale modeling is being performed by D. Woolhiser. Soil permeability in the wash channels is one of the critical parameters in the watershed-scale model. J. Winterle accompanied the group to obtain soil permeabilities in Solitario Canyon channels, which will be used in the watershed-scale model.

SUMMARY OF ACTIVITIES:

The field work was split into three activities: (i) a spot-check vegetation survey verifying the more-detailed TRW vegetation work and examining factors governing the distribution of individual species (D. Groeneveld and J. Thompson); (ii) a spot-check of soil-permeability measurements to verify more-detailed United States Geological Survey (USGS) work, as well as examination of plant rooting distributions (D. Or and S. Stothoff); and (iii) channel permeability measurements in Solitario Canyon (J. Winterle). The vegetation survey was conducted over four days while the remaining work was performed over two days. Prior to the main trip, D. Groeneveld flew a photographic airborne survey of plant distributions, augmenting a collection of coarser-scale photographs taken previously by EG&G.

OVERALL IMPRESSIONS

The trip was extremely useful in orienting Or to the YM site and to identifying and refining hypotheses regarding the spatial distribution of plants and plant uptake patterns. Soil measurements taken during field activities will provide direct input into modeling activities. The trip was also useful in planning future activities with Groeneveld and Or.

INTERPRETATIONS BASED ON FIELD OBSERVATIONS

Prior to the field excursion, aerial photographs were examined and it was noticed that linear vegetation features could be identified, particularly along Yucca Crest. As a working hypothesis, it was felt that these linear features represent fissures in the bedrock that the plants were able to take advantage of for water uptake. To verify this hypothesis, several pits were dug adjacent to flourishing plants. Two pits were dug along an apparent linear feature in the Tiva Canyon caprock. Bedrock was reached at a depth of approximately 30 to 40 cm under the plants and in both pits a fissure of approximately 5 to 15 cm was identified, aligned with the vegetation feature, that was densely populated with roots. In one of the pits, a carbonate layer was identified within the fissure at a depth of roughly 5 cm below soil/bedrock contact; in the other, no distinct carbonate layer was identified to a depth of about 20 to 30 cm but there did appear to be increasing carbonate concentrations in the soil with depth.

Plant roots were exposed at three additional sites with shallower soil. At one site, in caprock, both plants exposed had roots predominantly within fissures or extending to fissures. At the second site, in caprock, the plant selected was in the center of a pocket of soil several meters across, with bedrock cropping out on three sides and a soil depth of at least 30 to 40 cm directly under the plant. Although a fissure existed, the plant did not appear to take special advantage of the fissure but appeared to take advantage of runoff from the surrounding bedrock. Nearby plants in fissures between bedrock outcrops appeared more verdant. At the third site, on a side slope in the upper lithophysal unit of the Tiva Canyon formation, the plants were rooted in rubble with 30 cm of cover. For these locations, typical of ridgetops and side slopes, the use of unrestricted rooting systems reported in the literature is precluded due to the strong influence of bedrock.

In all locations examined, the soil cover was sandy loam to loam with bedrock fragments, and was rather permeable. The fine portion of the soil appears to be eolian in nature wherever it was examined. Although permeabilities and soil depths were only determined at a few locations, soil samples were collected at scattered locations (including each vegetation transect). Roughly two dozen soil samples were obtained. The similarity of the samples suggests that it would be reasonable to assume that soils are reasonably similar over the entire mountainside (except perhaps in areas with sorting due to overland flow such as washes and wash channels), consistent with Flint et al. (1996).

Four ponded-head permeameter measurements were made at three sites with relatively shallow slopes along Yucca Crest and Highway Ridge. Measured saturated conductivity values ranged from 1.2×10^{-3} to 4.9×10^{-3} cm/s. The smallest reading occurred at a site where a large rock was subsequently found to lie directly under the disk; the next-largest reading was 2.9×10^{-3} cm/s. For comparison, Flint et al. (1996) reported soil conductivities in the YM area of 5.6×10^{-4} to 3.8×10^{-3} cm/s based on soil-texture analysis. Three tension-head measurements (two readings with different suctions at one site, one reading at another site) were also obtained, indicating consistent values. The measured values are remarkably similar.

Rock particles found in the soil ranged from small pebbles through cobble-sized blocks. In the pits and in trenches with bedrock exposed, the bedrock was considerably more irregular than the soil surface implying that vegetation may be preferentially located in locally deeper pockets of soil where water can be stored for longer periods after precipitation.

The welded Tiva Canyon units do not exhibit gullying along the side slopes of the washes over the proposed repository footprint, suggesting that erosional processes are not dominated by overland flow. The high permeability of the shallow soils and the dense carbonates existing in fractures exposed by trenches in the TCw units below the caprock further suggest that lateral flow is likely to be primarily along the soil/bedrock interface rather than as overland flow. The distribution of vegetation suggests that lateral flow may be significant; vegetation is relatively sparse at the top of slopes and relatively dense at points where slopes flatten. Note that the existence of subsurface lateral flow is also suggested by neutron-probe measurements.

Based on topography, soil depth, and bedrock materials, the ground surface over the repository footprint can be divided into four categories:

- Tiva Canyon caprock on ridgetops. Slopes are generally moderate (less than 10 degrees) with shallow soils (0 to 40 cm with pockets greater than 60 cm). The bedrock is generally massive with fissures spaced sufficiently far apart in places to provide significant organization to vegetation. The fissures are typically 5 to 15 cm in aperture, and appear to form by eolian soils filling between boulders. Bedrock is irregular in topography, with at least 40 cm variation possible within the space of 2 m. The bedrock is sufficiently permeable that moisture may interact significantly with it over periods of days to weeks. Soil fills the fissures to a depth of at least 5 to 30 cm, with carbonate fillings possible. Roots are common, almost ubiquitous, within fractures. Net infiltration may be quite significant due to shallow soils. Several vegetation transects were taken in this environment, 4 soil-permeability and 2 bedrock-permeability measurements were made, and 5 bedrock-exposure pits were dug.

- Tiva Canyon welded units (i.e., lithophysal units) below the caprock. Slopes are generally moderate to steep (10 to 45 degrees). Scree exists where slopes are greater than roughly 40 degrees. Bedrock is irregular in topography, although perhaps less so than for the caprock. There is some evidence of stairstepping in the bedrock surface that is not echoed in the soil profile, which may provide localized pockets for vegetation. Fractures are typically narrow in aperture (less than 1 cm) but closely spaced. The fractures appear to be filled with carbonates as a rule, and generally not penetrated by roots except for perhaps a few localized zones with wider apertures. Vegetation is predominantly Great Basin on the north-facing slopes and Mojavian on the south-facing slopes, with vegetation densities about twice as large on the north-facing slopes. Vegetation increases in density downslope. Net infiltration may be significant due to shallow soils. Lateral redistribution along the soil/bedrock interface may also be significant. Several vegetation transects were taken in this environment, a pair of soil-permeability measurements were taken, and several trenches and pavements were examined in detail.

- Alluvium-filled washes. Slopes are shallow and soils tend to be greater than 1 m in depth. Net infiltration may not be significant, due to the large storage capacity of the soils and the presence of vegetation. This environment was not examined in detail, aside from one or two vegetation transects.

- The west face of Yucca Crest. Slopes are quite steep, as much as 50 degrees. Numerous strata are exposed, ranging from densely welded to nonwelded. Soil pockets exist of as much as 50 cm even in the steepest slopes. Vegetation is dominated by crack-dwelling species. Overland flow should be significant, as evidenced by gully formation. Of the four environments this environment is by far the most complex to model however, relatively little of the repository footprint is overlain by this category. The environment was not examined in detail, aside from daily hikes up and down to Yucca Crest.

HYDRAULIC CONDUCTIVITY MEASUREMENTS IN SOLITARIO CANYON

J. Winterle obtained 13 hydraulic conductivity measurements for the stream beds in Solitario Canyon and its side canyons. These measurements were obtained using a Guelph Permeameter which is used by augering a hole 20 to 40 cm deep into the sediments and measuring infiltration of water out of the bottom of this hole while a constant water level is maintained in the hole. There were problems with this technique involving difficulty in augering holes due to the presence of large cobbles, and a tendency for the holes to collapse due to the lack of cohesiveness of the sediments. Nevertheless, 13 measurements were obtained with hydraulic conductivities on the order of 10^{-3} to 10^{-1} cm/s. These values are consistent with published values for silty sands and gravels. It should be noted that 10^{-2} cm/s is the upper limit of the range of hydraulic conductivities for which the Guelph permeameter is designed, thus the values outside of this range may not be as accurate as the lower values; however, they do represent a good order-of-magnitude estimate. Samples of sediments were obtained from the auger holes and their hydraulic conductivities are currently being measured in the laboratory. Locations of each of the conductivity measurements was recorded using a GPS unit. The GPS measurements are accurate to the nearest 100 m. The following table summarizes the data collected.

Sample #	GPS Loc. (UTM)	Hydraulic Conductivity (cm/s)	Notes
1	X: 546637 m Y: 4077467 m	0.04	silty coarse gravels with many large cobbles.
2	X: 546517 m Y: 4077632 m	0.02	coarse gravel with fine silty sand
3	X: 546794 m Y: 4077389 m	0.07	sandy coarse gravel
4	X: 546826 m Y: 4077651 m	0.05	well-sorted, pea-sized gravel
5	X: 546772 m Y: 4077250 m	0.002	silty, sandy gravel with large cobbles
6	X: 546667 m Y: 4077103	0.007	silty, sandy gravel with a few large cobbles

Sample #	GPS Loc. (UTM)	Hydraulic Conductivity (cm/s)	Notes
7	X: 546612 m Y: 4076972 m	0.002	silty coarse gravel
8	X: 546593 m Y: 4076710 m	0.012	sandy gravel with a few large cobbles
9	X: 546597 m Y: 4076410 m	0.02	sandy gravel
10	X: 547186 m Y: 4079275 m	0.1	coarse sand and gravel
11	X: 547135 m Y: 4078848 m	0.04	well-sorted pea-gravel with coarse sand
12	X: 547121 m Y: 4078681 m	0.01	well-sorted pea-gravel with coarse sand
13	X: 547021 m Y: 4078283 m	0.002	silty overbank sediments (stream channel is well sorted pea-gravel)

PROBLEMS ENCOUNTERED:

The real-time differential GPS did not function properly, almost certainly due to operator error. Reported measurements are therefore only accurate to within 100 m.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

None.

REFERENCES:

Flint, A., J. Hevesi, and L. Flint. 1996. *Conceptual and Numerical Model of Infiltration for the Yucca Mountain Area, Nevada*. USGS Water Resources Investigation Report. Denver, CO. Draft dated September 20, 1996.

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