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# Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16

Los Alamos
NATIONAL LABORATORY
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Prepared by the Environmental Programs Directorate

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January 2012

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## 1.0 BACKGROUND

Consolidated Unit 16-021(c)-99 (the 260 Outfall) at Technical Area 16 (TA-16) is currently subject to corrective action for high explosives– (HE-) contaminated groundwater under the Compliance Order on Consent (the Consent Order) (LANL 2007, 098734). Details concerning the site and its groundwater are provided in a series of regulatory documents (LANL 1998, 059891; LANL 2003, 077965; LANL 2007, 098734; LANL 2011, 203711; LANL 2011, 207069, and references therein).

Both deep perched-intermediate groundwater (700–1200 ft below ground surface [bgs]) and regional groundwater (>1200 ft bgs) are contaminated with HE, particularly RDX (hexahydro-1,3,5-trinitro-1,3,5 triazine), and other related constituents (LANL 2011, 207069). RDX levels are consistently above the risk-based screening level of 6.11 μg/L in deep perched-intermediate groundwater in multiple groundwater wells (R-25, R-25b, CdV-16-1i, CdV-16-2ir, CdV-16-4ip) (Figure 1.0-1), with the highest values (>200 μg/L) in recently drilled well CdV-16-4ip (screen 1). Currently, regional groundwater wells show RDX at levels below the screening level.

The hydrogeologic framework for the contaminated deep perched-intermediate zone and regional aquifer is complex (LANL 2011, 207069). A wide range of hydrologic, geochemical, and geophysical data suggest these groundwater zones are quite heterogeneous. In a broad sense, the deep perched-intermediate zone is divided into an upper zone and a lower zone, with the upper zone consistently more contaminated than the lower zone; this is expected conceptually because the contaminant source is located at the ground surface. Conservative geochemical signatures vary both spatially and, to a lesser degree, temporally (LANL 2011, 207069). Hydrologic data, including water levels, pump-test results, and drilling observations demonstrate the deep perched-intermediate zone is hydrogeologically complex, with localized hydrogeologic regimes (LANL 2011, 207069). Hydraulic connectivity appears to be weaker vertically than horizontally. A recent version of the hydrologic conceptual model for the TA-16 area deep perched-intermediate aquifer is shown in Figure 1.0-2.

## 2.0 RATIONALE FOR TRACER TEST

This tracer test is being conducted to support a future assessment of potential remedial alternatives for contaminated groundwater associated with the 260 Outfall. A remedial alternatives analysis would likely benefit from an improved understanding of (1) local hydrogeologic gradients and groundwater velocities/fluxes within the deep perched-intermediate zone; (2) lateral contaminant travel times and associated hydrologic parameters within hydrogeologic subunits of the Otowi Formation and Puye Formation; and (3) vertical contaminant travel times, particularly between the upper-perched zone and lower-perched zone and between the lower-perched zone and the regional aquifer. Pathways, groundwater velocities/fluxes, and travel times from near-surface alluvial aquifers to the deep-perched zone are also poorly constrained. All these questions may potentially be addressed through a multiple-constituent tracer test.

## 3.0 IMPLEMENTATION PLAN

To address the uncertainties delineated in section 2.0, Los Alamos National Laboratory (LANL or the Laboratory) proposes the following actions.

1. Passive deployment of multiple nonreactive tracers in wells CdV-16-1(i) and R-25b, the two deep-perched zone wells located farthest upgradient within the contaminated deep-perched zone. The

principal tracer types selected are fluorinated benzoates (FBAs) (Reimus et al. 2003, 209697; Reimus et al. 2003, 210315; Duke et al. 2007, 210313) and naphthalene sulfonates (NSs) (Nimmo et al. 2002, 210314; Wright and Hull 2004, 209698), although sodium iodide would be used at one location for comparative purposes. Different, chemically distinct tracer species will be deployed at each location. These tracers can be easily measured using in-house Laboratory methods (high performance liquid chromatography) with low-sensitivity (detection limits of ~5 ppb for FBA, 10–50 ppt for NS, and low ppb for iodide). These tracers are also nontoxic, should not interfere with sampling of regulated constituents in the aquifer, are inexpensive, and have been successfully used in other tracer tests in which Laboratory personnel have participated (Reimus et al. 2003, 209697; Reimus et al. 2003, 210315; Duke et al. 2007, 210313). NSs alone are not proposed because they are somewhat experimental and may not be conservative within TA-16 media (Wright and Hull 2004, 209698); however, they offer superior detection limits and thus increase the probability of tracer detection if very low breakthrough concentrations are observed. Before specific FBAs and NSs are selected, simple laboratory column tests will be performed using site waters to ensure no analytical interferences occur between specific tracer compounds and site constituents, such as HE, and to ensure conservative tracer behavior in TA-16 media. Details of proposed tracer types, tracer masses, and water volumes for each deployment locality are provided in Table 3.0-1. Pressures in all well screens in the vicinity of the tracer deployments will be monitored during the tracer test. Each deployment screen will be instrumented with an in situ real-time multiprobe, which includes a conductivity probe, so dispersal of the tracers from each screen into the deep-perched zone can be monitored. The dispersal measurements will be used to estimate local flow velocities at the deployment locations. Surface water fluxes will be monitored in the gauging stations within Cañon de Valle.

2. Deployment of a nonreactive tracer in the Peter Seep area (Figure 1.0-1), an upgradient location within the alluvial aquifer. This tracer test is not as important as those described in item 1 above; however, since tracers are being sampled in the deep-perched aquifer, this near-surface tracer can opportunistically be deployed at little added cost and may provide information on recharge rates from the alluvial aquifer to the deep perched-intermediate zone. A single NS (different from any deployed in the deeper zones) is proposed here because of anticipated longer travel times and lower breakthrough concentrations, thus requiring ultra-low detection limits.

3. Periodic sampling for these tracers in wells R-25 (screens 1, 2, and 4), R-25b, CdV-16-1(i), CdV-16-2ir, and CdV-16-4ip (Figure 1.0-1). Based on the known hydrologic properties of the lithologies sited next to the deployment screens, initial breakthroughs in nearby wells would be anticipated within 2 yr. Calculations suggest a sampling interval 2 wk, 6 wk, and 12 wk after deployment, followed by continued quarterly sampling, will likely capture the initial breakthrough of the tracers, if breakthrough can be detected. The necessity for continued sampling will be evaluated periodically based on the ongoing observations. If the proposed sampling frequency does not adequately capture the breakthrough because of rapid travel times, a subsidiary tracer deployment would be considered in consultation with New Mexico Environment Department (NMED) personnel. Sampling would be coordinated with existing ongoing sampling of these wells through the Laboratory's site-wide groundwater monitoring program.

4. Frequency and locations of tracer monitoring. If tracer breakthrough is observed in any of these well screens, tracer monitoring will be extended to additional deep-perched and regional wells including R-25 (screens 5–8; note that screen 9 cannot be sampled), R-18, R-47i, and R-63. The sampling frequency will be increased in the screen in which breakthrough was observed until tracer breakthrough can be defined adequately to support hydrogeologic analysis. Following observation of breakthrough in any screen, hydrogeologic analyses will be completed to

determine the optimum sampling frequency to define the tracer breakthrough profile; NMED personnel will be included in these discussions. Any sample showing tracer breakthrough will be archived and potentially analyzed for RDX and RDX-degradation products; such analyses can provide information on RDX degradation rate constants.

5. Analysis of data. If tracer breakthrough is observed, data will be interpreted using methods outlined in the literature (e.g., Duke et al. 2007, 210313).

## 4.0 SCHEDULE AND REPORTING

Deployment of the tracer test is anticipated to begin after October 1, 2012 (fiscal year 2013), with preparatory activities such as permitting being initiated in fiscal year 2012.

Information on tracer breakthroughs will be formally reported in the biannual corrective measures evaluation (CME) progress reports. These reports will describe any tracer breakthroughs observed and propose any changes to sampling frequencies or other details associated with the tests. Informal notification of tracer breakthrough to NMED will be provided by email or phone.

## 5.0 REFERENCES

*The following list includes all documents cited in this plan. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.*

*Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.*

Duke, C.L., R.C. Roback, P.W. Reimus, R.S. Bowman, T.L. McLing, K.E. Baker, and L.C. Hull, November 2007. "Elucidation of Flow and Transport Processes in a Variably Saturated System of Interlayered Sediment and Fractured Rock Using Tracer Tests," *Vadose Zone Journal,* Vol. 6, No. 4, pp. 855–867. (Duke et al. 2007, 210313)

LANL (Los Alamos National Laboratory), September 1998. "RFI Report for Potential Release Site 16-021(c)," Los Alamos National Laboratory document LA-UR-98-4101, Los Alamos, New Mexico. (LANL 1998, 059891)

LANL (Los Alamos National Laboratory), September 2003. "Phase III RFI Report for Solid Waste Management Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-03-5248, Los Alamos, New Mexico. (LANL 2003, 077965)

LANL (Los Alamos National Laboratory), August 2007. "Corrective Measures Evaluation Report, Intermediate and Regional Groundwater, Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-07-5426, Los Alamos, New Mexico. (LANL 2007, 098734)

LANL (Los Alamos National Laboratory), June 2011. “Hydrologic Testing Report for Consolidated Unit 16-021(c)-99,” Los Alamos National Laboratory document LA-UR-11-3072, Los Alamos, New Mexico. (LANL 2011, 203711)

LANL (Los Alamos National Laboratory), September 2011. “Investigation Report for Water Canyon/Cañon de Valle,” Los Alamos National Laboratory document LA-UR-11-5478, Los Alamos, New Mexico. (LANL 2011, 207069)

Nimmo, J.R., K.S. Perkins, P.E. Rose, J.P. Rousseau, B.R. Orr, B.V. Twining, and S.R. Anderson, August 2002. “Kilometer-Scale Rapid Transport of Naphthalene Sulfonate Tracer in the Unsaturated Zone at the Idaho National Engineering and Environmental Laboratory,” *Vadose Zone Journal,* Vol. 1, No. 1, pp. 89–101. (Nimmo et al. 2002, 210314)

Reimus, P., G. Pohll, T. Miheve, J. Chapman, M. Haga, B. Lyles, S. Kosinski, R. Niswonger, and P. Sanders, December 2003. “Testing and Parameterizing a Conceptual Model for Solute Transport in a Fractured Granite Using Multiple Tracers in a Forced-Gradient Test,” *Water Resources Research,* Vol. 39, No. 12, pp. SBH 14-1 to SBH 14-15. (Reimus et al. 2003, 209697)

Reimus, P.W., M.J. Haga, A.I. Adams, T.J. Callahan, H.J. Turin, and D.A. Counce, April–May 2003. “Testing and Parameterizing a Conceptual Solute Transport Model in Saturated Fractured Tuff Using Sorbing and Nonsorbing Tracers in Cross-Hole Tracer Tests,” *Journal of Contaminant Hydrology,* Vol. 62–63, pp. 613–636. (Reimus et al. 2003, 210315)

Wright, K.E., and L.C. Hull, July 2004. “An Evaluation of Tracers for Use in Vadose Zone Investigations at the Idaho National Engineering and Environmental Laboratory,” report no. ICP/EXT-04-00334, prepared for the U.S. Department of Energy Idaho Operations Office, Idaho Completion Project, Idaho Falls, Idaho. (Wright and Hull 2004, 209698)

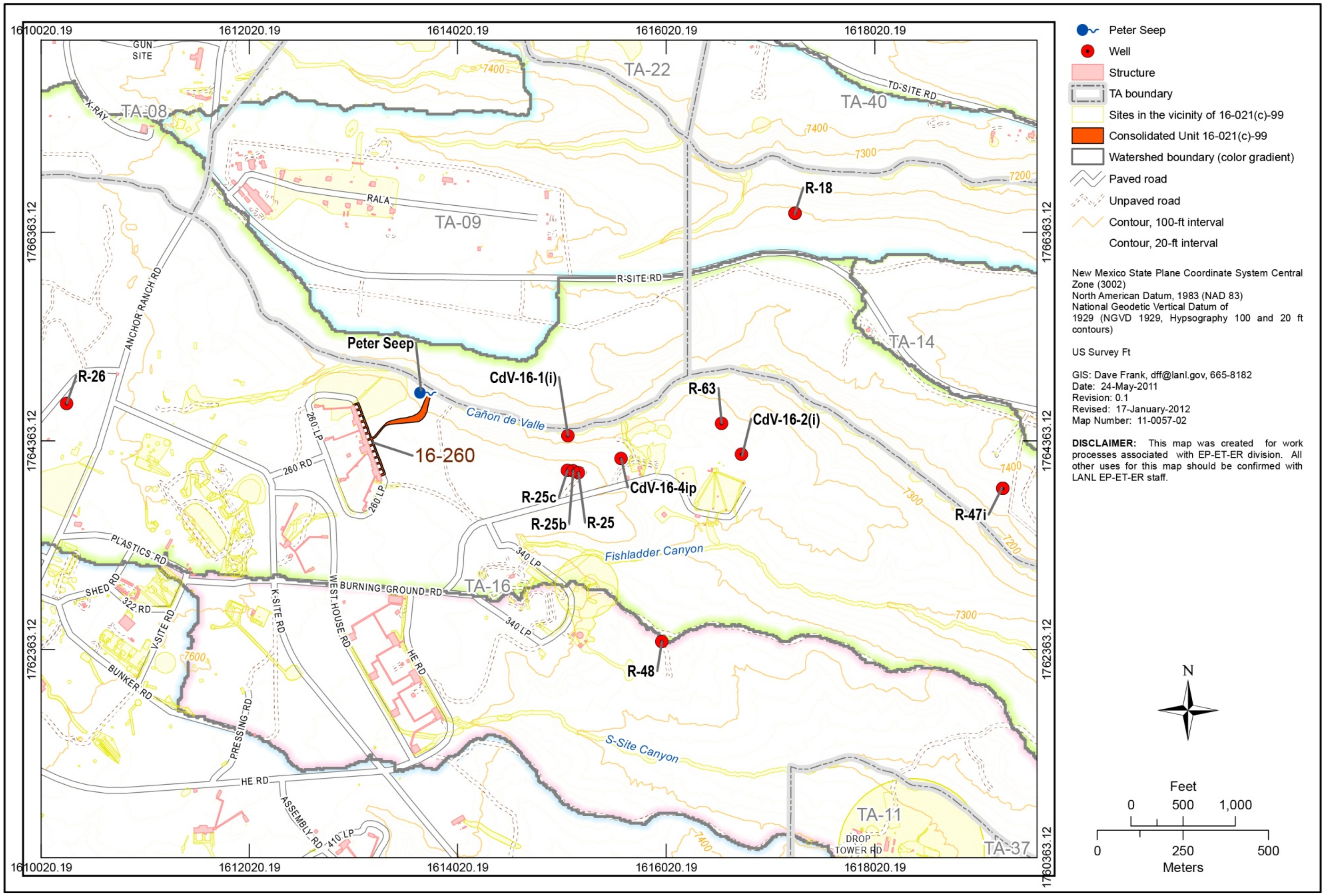
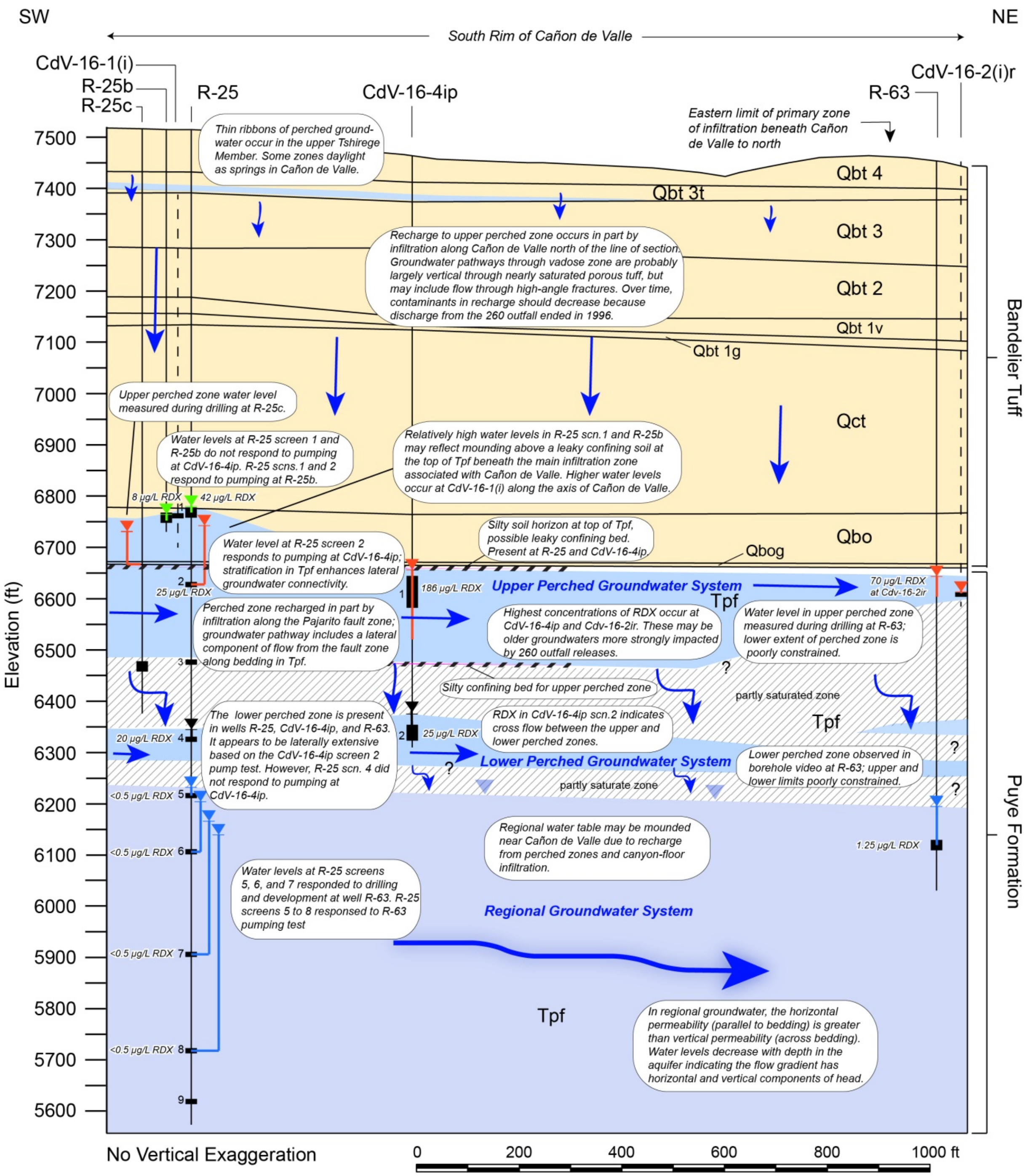


**Figure 1.0-1 Location map showing wells and other hydrologic features within the Cañon de Valle watershed**



Eastern limit of primary zone of infiltration beneath Cañon de Valle to north

Thin ribbons of perched groundwater occur in the upper Tshirege Member. Some zones daylight as springs in Cañon de Valle.

Recharge to upper perched zone occurs in part by infiltration along Cañon de Valle north of the line of section. Groundwater pathways through vadose zone are probably largely vertical through nearly saturated porous tuff, but may include flow through high-angle fractures. Over time, contaminants in recharge should decrease because discharge from the 260 outfall ended in 1996.

Upper perched zone water level measured during drilling at R-25c.

Water levels at R-25 screen 1 and R-25b do not respond to pumping at CdV-16-4ip. R-25 scns.1 and 2 respond to pumping at R-25b.

Relatively high water levels in R-25 scn.1 and R-25b may reflect mounding above a leaky confining soil at the top of Tpf beneath the main infiltration zone associated with Cañon de Valle. Higher water levels occur at CdV-16-1(i) along the axis of Cañon de Valle.

Silty soil horizon at top of Tpf, possible leaky confining bed. Present at R-25 and CdV-16-4ip.

Water level at R-25 screen 2 responds to pumping at CdV-16-4ip; stratification in Tpf enhances lateral groundwater connectivity.

Perched zone recharged in part by infiltration along the Pajarito fault zone; groundwater pathway includes a lateral component of flow from the fault zone along bedding in Tpf.

Highest concentrations of RDX occur at CdV-16-4ip and Cdv-16-2ir. These may be older groundwaters more strongly impacted by 260 outfall releases.

Water level in upper perched zone measured during drilling at R-63; lower extent of perched zone is poorly constrained.

Silty confining bed for upper perched zone

The lower perched zone is present in wells R-25, CdV-16-4ip, and R-63. It appears to be laterally extensive based on the CdV-16-4ip screen 2 pump test. However, R-25 scn. 4 did not respond to pumping at CdV-16-4ip.

RDX in CdV-16-4ip scn.2 indicates cross flow between the upper and lower perched zones.

Lower perched zone observed in borehole video at R-63; upper and lower limits poorly constrained.

Regional water table may be mounded near Cañon de Valle due to recharge from perched zones and canyon-floor infiltration.

Water levels at R-25 screens 5, 6, and 7 responded to drilling and development at well R-63. R-25 screens 5 to 8 responsed to R-63 pumping test

In regional groundwater, the horizontal permeability (parallel to bedding) is greater than vertical permeability (across bedding). Water levels decrease with depth in the aquifer indicating the flow gradient has horizontal and vertical components of head.

**Figure 1.0-2 Annotated cross-section illustrating the hydrologic conceptual model for the deep-perched aquifer at TA-16 (after LANL 2011, 207069)**

### Table 3.0-1
### Tracer Deployment Parameters

| Location | Tracers | Tracer Masses | Water Volume* | Notes |
|---|---|---|---|---|
| R-25b | FBA-1<br>NaI | FBA-1 – 25 kg<br>NaI – 25 kg | 12,000 gal. | Flush with a small amount of water (wellbore volume or less) after tracer deployment. |
| CdV-16-1(i) | FBA-2<br>NS-1 | FBA-2 – 40 kg<br>NS-1 – 10 kg | 12,000 gal. | Flush with a small amount of water (wellbore volume or less) after tracer deployment. |
| Peter Seep/Cañon de Valle alluvial well 2656 | NS-2 | NS-2 – 100 kg | 12,000 gal. | Flush with 1000–2000 gal. clean water after tracer deployment. |

*Tracer masses and water volumes are selected to minimize density driven tracer flow.