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Date: JUL 13 2015
Refer To: ADESH-15-092
LAUR: 15-24089
Locates Action No.: N/A

John Kieling, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Submittal of the Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16, Revision 1

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16, Revision 1. The revised work plan incorporates a new well, CdV-9-1(i), as an additional location to introduce tracers into multiple depths within the perched-intermediate zone. The plan also incorporates the use of alternative tracers (napthalene sulfonates) that have substantially lower analytical detection limits than the previously proposed fluorinated benzoates.

If you have any questions, please contact Kent Rich at (505) 665-4272 (krich@lanl.gov) or Cheryl Rodriguez at (505) 665-5330 (cheryl.rodriguez@em.doe.gov).

Sincerely,

Alison M. Dorries, Division Leader
Environmental Protection Division
Los Alamos National Laboratory

Sincerely,

Christine Gelles, Acting Manager
Environmental Management
Los Alamos Field Office

AD/CG/BR/KR:sm

Enclosures: Two hard copies with electronic files – Work Plan Tracer Test Consolidated Unit 16-021(c)-99 at Technical Area 16, Revision 1 (EP2015-0105)

Cy: (w/enc.)
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LA-UR-15-24089
July 2015
EP2015-0105

Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16, Revision 1

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

EP2015-0105

Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16, Revision 1

July 2015

Responsible project manager:

Printed Name	Signature	Title	Organization	Date
Kent Rich	[signature]	Project Manager	Environmental Remediation Program	6/24/15

Responsible LANS representative:

Printed Name	Signature	Title	Organization	Date
Randall Erickson	[signature] for R. Erickson	Acting Associate Director	Environmental Programs	6/26/15

Responsible DOE representative:

Printed Name	Signature	Title	Organization	Date
Christine Gelles	[signature] for	Acting Manager	DOE-~~LASO~~ EM-LA	7-10-2015

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1.0 BACKGROUND

Consolidated Unit 16-021(c)-99 (the 260 Outfall) at Technical Area 16 (TA-16) at Los Alamos National Laboratory (LANL or the Laboratory) 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 7 µg/L in deep perched-intermediate groundwater in multiple groundwater wells [R-25, R-25b, CdV-16-1(i), CdV-16-2ir, CdV-16-4ip, CdV-16-9(i)]. (Figure 1.0-1). Currently, regional groundwater wells show RDX at levels below the screening level. The extent of the upper perched zone and of RDX contamination within this zone is also shown in Figure 1.0-1, and the curved water-level contours in the vicinity of Cañon de Valle suggest groundwater mounding below the canyon axis.

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 zones are 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 is shown in Figure 1.0-2.

This plan is a revision of a previously approved tracer test plan for TA-16 (LANL 2012, 210352). Key reasons for the revision include (1) availability of a new well, CdV-9-1(i), which is at a good location to introduce the tracer into both the upper and lower perched-intermediate zone; (2) availability of alternative tracers (napthlalene sulfonates) that have substantially lower analytical detection limits and per weight costs than the previously proposed fluorinated benzoates (FBAs); and (3) changes in the surface water distribution in Cañon de Valle (see section 3.0).

2.0 RATIONALE FOR TRACER TEST

The rationale for the tracer test has not changed since the original plan was approved by the New Mexico Environment Department (NMED) (LANL 2012, 210352; NMED 2012, 210098). This tracer study is being conducted to test connectivity of various parts of the TA-16 hydrological system and to support the future assessment of potential remedial alternatives for contaminated groundwater associated with the 260 Outfall. A remedial alternatives analysis would benefit from an improved understanding of (1) local hydraulic gradients and groundwater velocities/fluxes within the perched-intermediate zone; (2) lateral advective travel times and associated hydrologic parameters within the Otowi Member of the Bandelier Tuff Formation and the Puye Formation; and (3) vertical advective 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, the Laboratory proposes the following actions (a pframework for the tracer deployments is provided in Table 3.0-1).

1. *Single Dilution Tracer Test.* For the initial investigation phase, a single-dilution tracer test will be conducted in each of the following wells: CdV-16-1(i), CdV-9-1(i), and R-25b. A small quantity of tracer will be introduced at the well screen and allowed to disperse into the groundwater under natural flow conditions (i.e., no pumping). The reduction in tracer concentration over the following week or two will be monitored. The dilution time series results will be used to quantify local flow velocities around the borehole screens. These tests will also serve to identify the best well to deploy sodium bromide (see item 2).

2. *Deployment of Multiple Nonreactive Tracers.* For the longer term, natural gradient phase of the plan, passive deployment of multiple nonreactive tracers in wells CdV-16-1(i), CdV-9-1(i), and R-25b will be made. These wells are within the perched-intermediate zone, are located farthest upgradient within the contaminated perched zone, and form a transect across Cañon de Valle. Different, chemically distinct tracers will be deployed at each location. The principal tracer types belong to a group of naphthalene sulfonates (NSs) (Nimmo et al. 2002, 210314; Wright and Hull 2004, 209698). Sodium bromide will be deployed along with an NS at one location to examine the effects of dual porosity/dual permeability. To examine the connection between the upper and lower perched-intermediate zone, two other NSs will be deployed in the shallow piezometers in CdV-9-1(i). The NSs can be easily measured using in-house laboratory methods (fluorescence detection) with detection limits <1 ppb. These tracers are nontoxic, should not interfere with sampling of regulated constituents in the aquifer, and are inexpensive. In the original plan, NSs alone were not proposed because at that time they were considered experimental and no testing of their conservative behavior for local TA-16 conditions had been done. Subsequently, a series of laboratory tests were conducted using water and Otowi and Puye material from TA-16 and NSs (LANL 2012, 232277). The results indicated that NSs are suitable to deploy at TA-16. They offer superior detection limits (approximately 0.5 ppb) compared with FBAs (10–30 ppb) and thus increase the probability of tracer detection if low breakthrough concentrations are detected. Details of proposed tracer types, tracer masses, and water volumes for each deployment locality are provided in Table 3.0-1. Masses (and other values) in the table are approximate and are based on estimates of the amount of dilution that may occur between release points and sampling points and the NS detection level. Actual deployment amounts will be subject to permitting by the NMED Ground Water Quality Bureau (GWQB). Pressures in all well screens in the vicinity of the tracer deployments will be monitored during the tracer test. An in-situ real-time conductivity probe will be used to monitor dispersal of the tracers into the perched zone.

3. *Initial and Pre-Breakthrough Monitoring*. Periodic sampling for the tracers will be conducted in intermediate wells R-25b, CdV-16-1(i), CdV-16-2(i)r, and CdV-16-4ip, CdV-9-1(i), and R-47i (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 sampling intervals of 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 NMED personnel. Sampling will be coordinated with existing ongoing sampling of these wells through the Laboratory's sitewide groundwater monitoring program. The following regional wells will also be sampled in concert with the Laboratory's sitewide groundwater monitoring program following the monitoring program schedule: R-18, R-47, R-48, R-58 (planned for installation in late fiscal year 2015), and R-63. The implied gradients from the water-level contours shown in Figure 1.0-1 illustrate how tracers introduced in the CdV-9-1(i), CdV-16-1(i), and R-25b transect might migrate to the monitoring locations listed above.

4. *Post-Breakthrough Monitoring*. If tracer breakthrough is observed in any of the above wells, tracer monitoring can be modified to a higher sampling frequency if there is concern about properly capturing the breakthrough curve. 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. Note that expectations of tracer mass recovery are low (Table 3.0-1) because of (1) uncertainties in flowpath directions, (2) the relatively long-length scales to many of the monitoring wells, and (3) natural gradient conditions.

5. *Deployment of an NS in Cañon de Valle*. An NS tracer will also be deployed within the surface water/alluvial system near the area of Burning Ground Spring (Figure 1.0-1). The original plan indicated deployment in Peter Seep. However, a recent field visit noted the lack of flowing surface water within the canyon above the Burning Ground Spring confluence (which includes the Peter Seep area). Therefore, it is prudent to move the location downcanyon to the head of the continuously flowing reach. 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) with a greater input mass than the well deployments is proposed because of anticipated longer travel times and lower breakthrough concentrations at deep-perched zone monitoring locations. Canyon alluvial wells and surface water sampling (e.g., near the E256 gage station) will be used to monitor tracer movement. Any new alluvial well installations may be used to supplement the existing sampling locations. Actual sampling locations will be determined after a site visit and before tracer deployment, so sampling can be optimized for current hydrological conditions in the canyon.

6. *Analysis of Data*. When 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

Dilution tests are anticipated to begin in August 2015, and the long-term tracers will be deployed by September 30, 2015. Applicable permits will be obtained from NMED before the tracers are deployed.

Information on tracer breakthroughs will be formally reported in the biannual corrective measures evaluation progress reports. These reports will describe any tracer breakthroughs observed and will propose any changes to sampling frequencies or other details associated with the tests. All tracer-monitoring data will also be included in the periodic monitoring reports for the TA-16 260 monitoring group. The NMED will be notified at least fifteen (15) calendar days before the tracer is deployed and will also be notified informally of tracer breakthrough by email or phone.

5.0 SUMMARY OF MODIFICATIONS FROM THE ORIGINAL TRACER PLAN

The following modifications were made to the original tracer test work plan:

- Addition of three dilution tests for characterization of local flow conditions in CdV-16-1(i), CdV-9-1(i), and R-25b using NSs.
- Addition of three new NS tracer deployments in well CdV-9-1(i) for larger-scale perched-zone investigations [CdV-9-1(i) had not been drilled at the time the original plan was submitted].
- Replacement of all previously suggested FBA long-term/natural-gradient deployments with NSs (lower detection limits and lower cost).
- Elimination of R-25 ports for monitoring the tracer from R-25b (R-25 is planned to be plugged and abandoned).
- Deployment of the Cañon de Valle tracer near the Burning Ground Spring confluence instead of Peter Seep (because of reduced continuous flow in the stream in Cañon de Valle).

6.0 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Investigation-derived waste will be managed in accordance with EP-DIR-SOP-10021, Characterization and Management of Environmental Programs Waste. This standard operating procedure incorporates the requirements of applicable U.S. Environmental Protection Agency and NMED regulations, U.S. Department of Energy orders, and Laboratory requirements.

7.0 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 or ESH ID. This information is also included in text citations. ER IDs were assigned by the Environmental Programs Directorate's Records Processing Facility (IDs through 599999), and ESH IDs are assigned by the Environment, Safety, and Health (ESH) Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the ESH 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)

LANL (Los Alamos National Laboratory), January 2012. "Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16," Los Alamos National Laboratory document LA-UR-12-0440, Los Alamos, New Mexico. (LANL 2012, 210352)

LANL (Los Alamos National Laboratory), November 2012. "Report on the Results of Laboratory Tests of Tracer Compounds at Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-12-26448, Los Alamos, New Mexico. (LANL 2012, 232277)

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)

NMED (New Mexico Environment Department), February 7, 2012. "Approval with Modification, Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2012, 210098)

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)

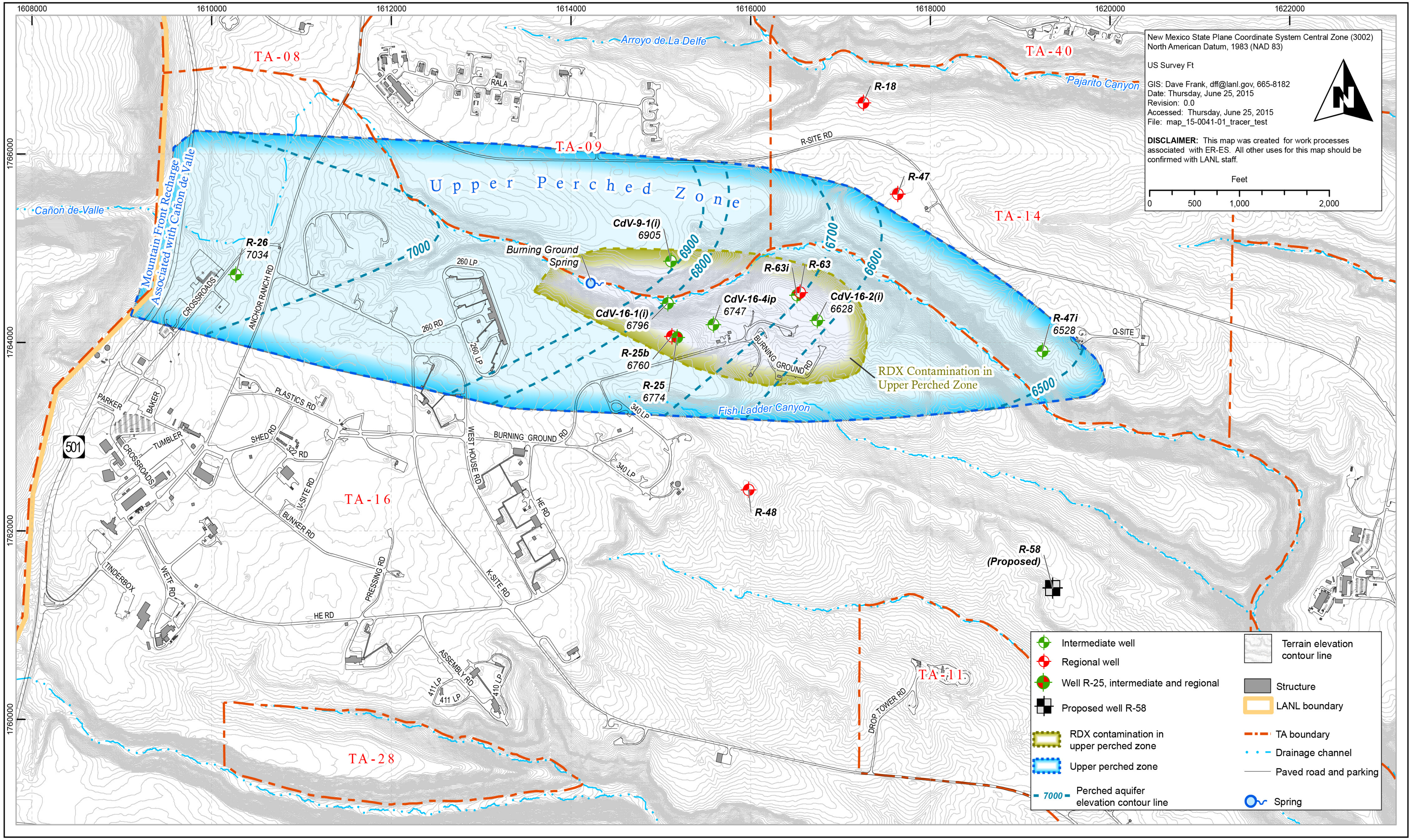

Figure 1.0-1 **Location of wells and other hydrologic features within the Cañon de Valle watershed. The extent of the upper perched zone (with water-elevation contour lines) and the extent of RDX contamination in this zone are shown as an example of the subsurface conditions at TA-16.**

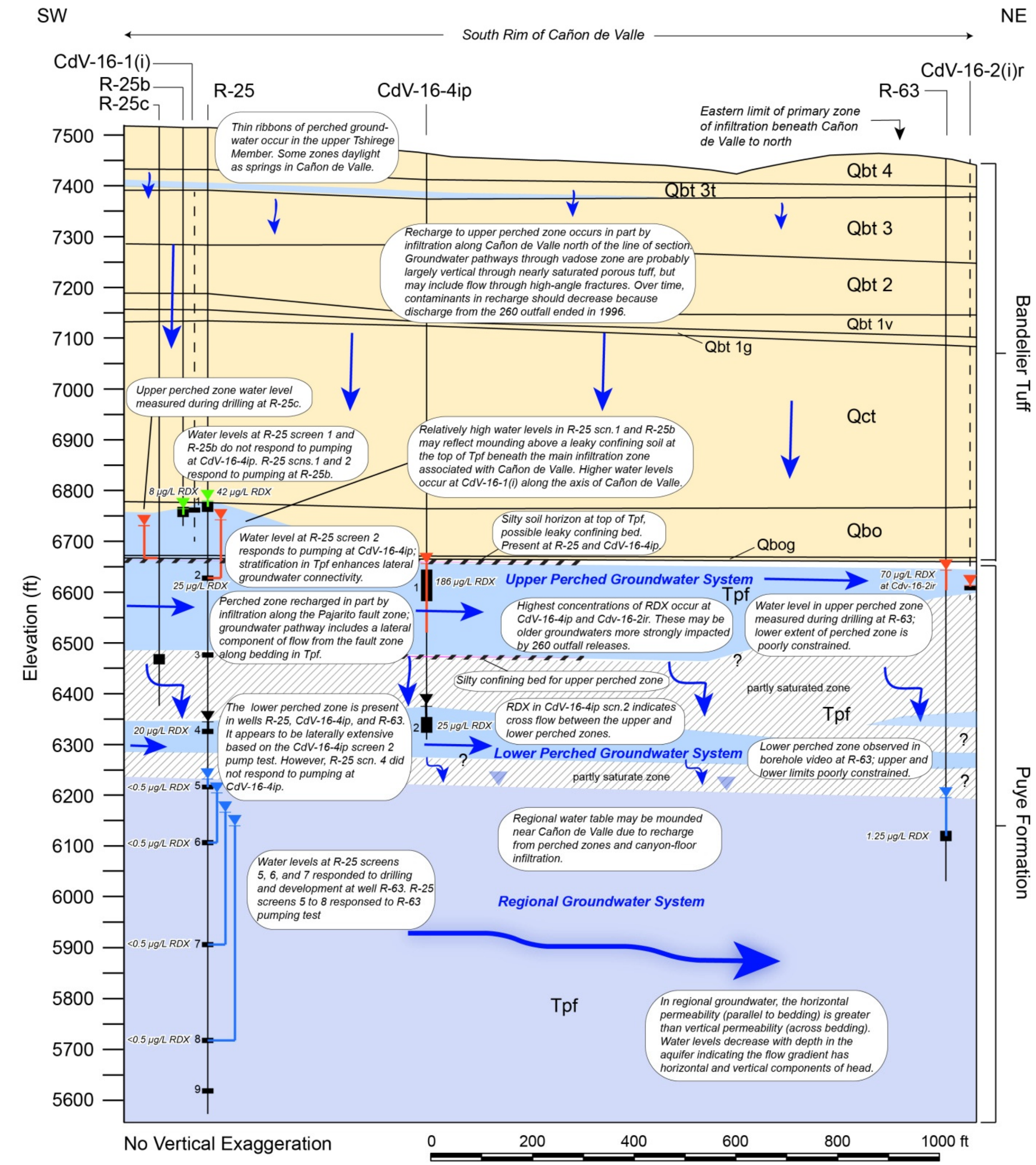

Figure 1.0-2 **Annotated cross-section illustrating the hydrologic conceptual model for the deep-perched aquifer at TA-16 (after LANL 2011, 207069)**

Table 3.0-1
Tracer Deployment Parameters

Locale	Unit	Tracer(s)	Quantity Injected	Volume of Tracer Solution Injected[a]	Notes
R-25b	Perched	Na-1 NS	2 g	<300 gal. (1 casing volume [CV])	Dilution test. Anticipated recovery: <2%
CdV-9-1(i) Screen 2	Perched	Na-1 NS	2 g	<300 gal. (1 CV)	Dilution test. Anticipated recovery: <2%
CdV-16-1(i)	Perched	Na-2 NS	2 g	<300 gal. (1 CV)	Dilution test. Anticipated recovery: <2%
R-25b	Perched	Na-1,6-NDS[b] NaBr[c]	40 kg 150 kg	12,000 gal. Flush with a small amount of water (wellbore volume or less) after tracer deployment.	Long-term/large-scale natural-gradient test. Anticipated recovery: <2%. Primary candidate location for paired tracer (NDS+Br).
CdV-16-1(i)	Perched	Na-1,5-NDS[d]	40 kg	12,000 gal. Flush with a small amount of water (wellbore volume or less) after tracer deployment.	Long-term/large-scale natural gradient test. Anticipated recovery: <2%. Alternative location for paired tracer (NDS+Br).
CdV-9-1(i) Piezometer 1 (662.9–672.4 ft)	Perched	Na-1,3,6-NTS	25 kg	6000 gal. Flush with a small amount of water (wellbore volume or less) after tracer deployment.	Primary objective: determine connectivity of upper and lower perched in CdV-9-1(i). Secondary objective: conduct long-term/large-scale natural gradient test. Anticipated recovery: <2%.
CdV-9-1(i) Piezometer 2 (852.9–862.4 ft)	Perched	Na-1,3,5-NTS	25 kg	6000 gal. Flush with a small amount of water (wellbore volume or less) after tracer deployment.	Primary objective: determine connectivity of upper and lower perched zones in CdV-9-1(i). Secondary objective conduct long-term/large-scale natural gradient test. Anticipated recovery: <2%.
CdV-9-1(i) Screen 1 (937.4–992.4 ft)	Perched	Na-2,6-NDS	40 kg	12,000 gal. Flush with a small amount of water (wellbore volume or less) after tracer deployment.	Long-term/large-scale natural-gradient test. Anticipated recovery: <2%. Alternative location for paired tracer (NDS+Br).
CdV near Burning Ground Spring	Alluvial	Na-2,7-NDS	50 kg	12,000 gal. Flush with 1000–2000 gal. clean water after tracer deployment.	Alluvial aquifer transport and long-term/large-scale natural-gradient test. Anticipated recovery: <2%

Note: This table presents an approximation of the types and masses of tracers that may be utilized. Final details are subject to NMED-GWQB approval.

[a] Tracer masses and water volumes are selected to minimize density-driven tracer flow.

[b] NDS = Naphthalene disulfonate.

[c] NaBr may be deployed in CdV-16-1(i), CdV-9-1(i), or R-25b, depending on dilution test results.

[d] NTS = Naphthalene trisulfonate.