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Los Alamos
NATIONAL LABORATORY
EST 1943

Environmental Protection Division
Environmental Compliance Programs (ENV-CP)
PO Box 1663, K490
Los Alamos, New Mexico 87545
(505) 667-0666

National Nuclear Security Administration
Los Alamos Field Office, A316
3747 West Jemez Road
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(505) 667-5794/Fax (505) 667-5948

Date: AUG 0 6 2015
Symbol: ENV-DO-15-0225
LA-UR: 15-25882
Locates Action No.: NA

Ms. Michelle Hunter, Acting Chief
Ground Water Quality Bureau
New Mexico Environment Department
Harold Runnels Building, Room N2250
1190 St. Francis Drive
P.O. Box 26110
Santa Fe, NM 87502

Mr. James Hogan, Bureau Chief
Surface Water Quality Bureau
New Mexico Environment Department
Harold Runnels Building, Room N2050
P.O. Box 5469
Santa Fe, NM 87502

Dear Ms. Hunter and Mr. Hogan:

Subject: Notice of Intent to Conduct a Tracer Test in the Cañon de Valle Surface Water/Alluvial System at Los Alamos National Laboratory, Technical Area 16

In accordance with Subsection A of 20.6.2.1201 New Mexico Administrative Code, the U.S. Department of Energy and Los Alamos National Security, LLC (DOE/LANS) are filing this notice of intent (NOI) to conduct a tracer test in the Cañon de Valle surface water/alluvial system at Los Alamos National Laboratory. The tracer test is being conducted to test connectivity of various parts of the Technical Area (TA)-16 hydrological system and to support the future assessment of potential remedial alternatives for groundwater contaminated with high explosives (HE). Enclosure 1 contains a completed NMED NOI form. Enclosures 2, 3, and 4 provide information to support this notice.

37237

Please contact Robert S. Beers by telephone at (505) 667-7969 or by email at bbeers@lanl.gov if you have questions regarding this NOI.

Sincerely,

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

Sincerely,

Gene E. Turner
Environmental Permitting Manager
National Security Missions
Los Alamos Field Office
U.S. Department of Energy

AMD:GET:MTS:RSB/lm

Enclosures:
(1) Completed NMED GWQB Notice of Intent to Discharge Form
(2) *Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16, Revision 1*
(3) Supplemental information on salt dilution flow gauging (Moore, 2004)
(4) Safety Data Sheet (SDS) for the proposed tracers

Cy: Gladys Gooden-Jackson, USEPA/Region VI, Dallas TX, (E-File)
John E. Kieling, NMED/HWB, Santa Fe, NM, (E-File)
Stephen M. Yanicak, NMED/DOE/OB, (E-File)
Cheryl L. Rodriguez, EM-SG, (E-File)
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GROUND WATER
AUG 06 2015
BUREAU

Date: AUG 06 2015
Symbol: ENV-DO-15-0225
LA-UR: 15-25882
Locates Action No.: NA

Ms. Michelle Hunter, Acting Chief
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New Mexico Environment Department
Harold Runnels Building, Room N2250
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Santa Fe, NM 87502

Mr. James Hogan, Bureau Chief
Surface Water Quality Bureau
New Mexico Environment Department
Harold Runnels Building, Room N2050
P.O. Box 5469
Santa Fe, NM 87502

Dear Ms. Hunter and Mr. Hogan:

Subject: Notice of Intent to Conduct a Tracer Test in the Cañon de Valle Surface Water/Alluvial System at Los Alamos National Laboratory, Technical Area 16

In accordance with Subsection A of 20.6.2.1201 New Mexico Administrative Code, the U.S. Department of Energy and Los Alamos National Security, LLC (DOE/LANS) are filing this notice of intent (NOI) to conduct a tracer test in the Cañon de Valle surface water/alluvial system at Los Alamos National Laboratory. The tracer test is being conducted to test connectivity of various parts of the Technical Area (TA)-16 hydrological system and to support the future assessment of potential remedial alternatives for groundwater contaminated with high explosives (HE). Enclosure 1 contains a completed NMED NOI form. Enclosures 2, 3, and 4 provide information to support this notice.

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AUG 06 2015
SURFACE WATER
QUALITY BUREAU

Environmental Protection Division
Environmental Compliance Programs (ENV-CP)
PO Box 1663, K490
Los Alamos, New Mexico 87545
(505) 667-0666

National Nuclear Security Administration
Los Alamos Field Office, A316
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Date: AUG 06 2015
Symbol: ENV-DO-15-0225
LA-UR: 15-25882
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Mr. James Hogan, Bureau Chief
Surface Water Quality Bureau
New Mexico Environment Department
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P.O. Box 5469
Santa Fe, NM 87502

Dear Ms. Hunter and Mr. Hogan:

Subject: Notice of Intent to Conduct a Tracer Test in the Cañon de Valle Surface Water/Alluvial System at Los Alamos National Laboratory, Technical Area 16

In accordance with Subsection A of 20.6.2.1201 New Mexico Administrative Code, the U.S. Department of Energy and Los Alamos National Security, LLC (DOE/LANS) are filing this notice of intent (NOI) to conduct a tracer test in the Cañon de Valle surface water/alluvial system at Los Alamos National Laboratory. The tracer test is being conducted to test connectivity of various parts of the Technical Area (TA)-16 hydrological system and to support the future assessment of potential remedial alternatives for groundwater contaminated with high explosives (HE). Enclosure 1 contains a completed NMED NOI form. Enclosures 2, 3, and 4 provide information to support this notice.

ENCLOSURE 1

Completed NMED GWQB Notice of Intent
to Discharge Form

ENV-DO-15-0225

LA-UR-15-25882

Date: AUG 0 6 2015

1. **Name and mailing address of person proposing to discharge:**

Stephani F. Swickley
Los Alamos National Security, LLC
P.O. Box 1663, Mail Stop M992
Los Alamos, NM 87544

Work Phone: 505-606-1628
Email: sfuller@lanl.gov

Point of Contact: Robert S. Beers, 505-667-7969, bbeers@lanl.gov

2. **Name of facility:** Los Alamos National Laboratory (LANL).

3. **Physical location of discharge (if applicable, give street address, township, range, section, distance from closest town or landmark, directions to facility, location map):**

Cañon de Valle near the Burning Ground Spring. LANL Technical Area (TA)-16 in Township 19N, Range 6E, Sections 29 and 30. **Enclosure 2** contains a location map of the project site.

4. **Type of operation generating the discharge (e.g., truck wash, food processing plant, restaurant, etc.):**

A naphthalene disulfonate (NDS) tracer will be deployed within the surface water/alluvial system near the area of Burning Ground Spring. This near-surface tracer may provide information on recharge rates from the alluvial aquifer to the deep perched-intermediate zone. 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. See **Enclosure 2,** *Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16, Revision 1.*

As part of the tracer monitoring, surface water discharge will also be measured along the TA-16 flowing reach using the salt dilution technique (See **Enclosure 3**) to provide additional measurements beyond the E256 station). Salt (NaCl, common Kosher salt) will be used to quantify discharge during the tracer test on a quarterly basis. It is expected that measurements will be made for up to six quarters at two or three locations along the flowing reach each quarter.

5. **Source(s) of the discharge. Describe how the wastewater, sludge, or other discharges processed and/or disposed at your facility are generated. Identify all sources. Attach additional pages if needed:**

A nonreactive tracer will be deployed to the surface water/alluvial system. See Table 1 below.

Table 1. Summary of the proposed tracers, locations, and quantities.

Locale	Unit	Tracer(s)	Quantity Injected	Volume of Tracer Solution Applied[a]	Notes
Cañon de Valle near Burning Ground Spring	Alluvial	Na-2,7-NDS[b]	50 kg	12,000 gal. Flush with 1000-2000 gal. of clean water after tracer deployment.	Alluvial aquifer transport and long-term/large-scale natural-gradient test. Anticipated recovery: <2%
Cañon de Valle near Burning Ground Spring	Alluvial	Sodium Chloride	100 g	≤1 L	Common Kosher salt, quarterly applications to measure stream discharge during above tracer test

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

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

[b] NDS = Naphthalene disulfonate.

6. **Expected contaminants in the discharge (e.g., nitrate-nitrogen, metals, organic compounds, salts, etc.) include estimated concentration if known, and copies of results of laboratory analyses, if available:**

Naphthalene disulfonate will be introduced at the quantities listed in Table 1. Sodium chloride will be introduced in quantities listed in Table 1 for each location (up to 300 g total for three locations in a given quarter).

Enclosure 3 provides supplemental information on salt dilution flow gauging (Moore, 2004).

Enclosure 4 provides the Safety Data Sheets (SDS) for the proposed tracers.

7. **Describe all components of wastewater processing, treatment, storage, and disposal system (e.g., grease interceptor, lagoon, septic tank/leachfield, etc.) Include sizes, site layout map, plans and specifications, etc. if available:**

   See **Enclosure 2**, *Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16, Revision 1.*

8. **Estimated maximum daily discharge volume in gallons per day (or other units):**

   Total discharge is approximately 12,000 gallons. Daily maximum discharge is approximately 12,000 gallons.

9. **Estimated depth to ground water (ft):** Depth to alluvial groundwater is ~1 ft.

Signature: Stephani Smickley **Date:** 7/30/15

Printed name: Stephani Smickley **Title:** Program Manager

Please return this form to:
NMED Ground Water Quality Bureau
P.O. Box 5469
Santa Fe, New Mexico 87502-5469

Telephone: 505-827-2900
Fax: 505-827-2965

ENCLOSURE 2

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

ENV-DO-15-0225

LA-UR-15-25882

Date: AUG 0 6 2015

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

Los Alamos National Laboratory, operated by Los Alamos National Security, LLC, for the U.S. Department of Energy under Contract No. DE-AC52-06NA25396, has prepared this document pursuant to the Compliance Order on Consent, signed March 1, 2005. The Compliance Order on Consent contains requirements for the investigation and cleanup, including corrective action, of contamination at Los Alamos National Laboratory. The U.S. government has rights to use, reproduce, and distribute this document. The public may copy and use this document without charge, provided that this notice and any statement of authorship are reproduced on all copies.

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		Project Manager	Environmental Remediation Program	6/24/15

Responsible LANS representative:

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

Responsible DOE representative:

Printed Name	Signature	Title	Organization	Date
Christine Gelles		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)

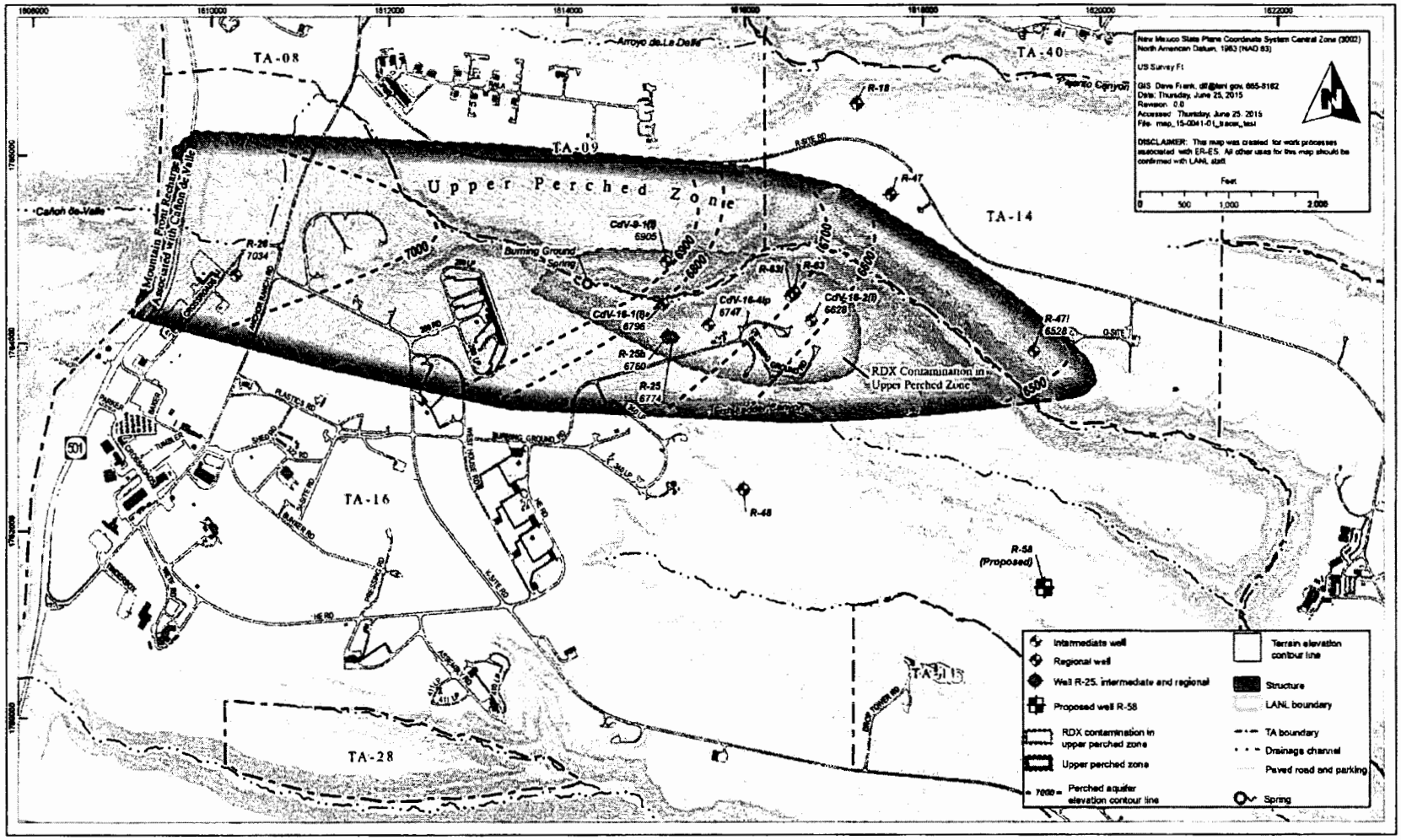

Figure 1.0-1 **Location of wells and other hydrologic features within the Cañon de Valle watershed. The extent of the upper perched zone (with water-elevation contour lines) and the extent of RDX contamination in this zone are shown as an example of the subsurface conditions at TA-16.**

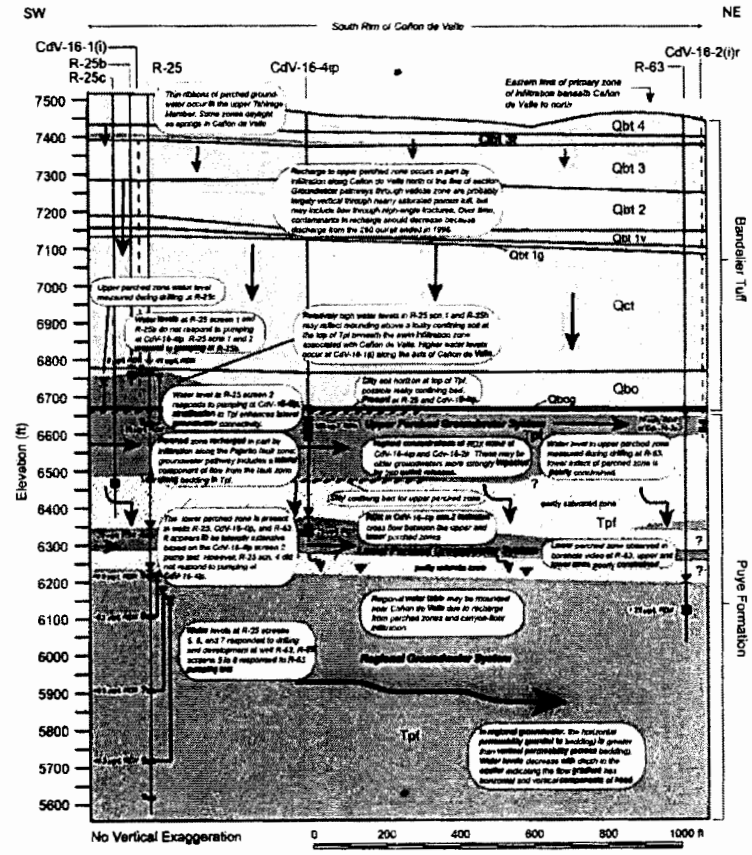

Figure 1.0-2 **Annotated cross-section illustrating the hydrologic conceptual model for the deep-perched aquifer at TA-16 (after LANL 2011, 207069)**

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.

ENCLOSURE 3

Supplemental information on salt dilution flow gauging
(Moore, 2004)

ENV-DO-15-0225

LA-UR-15-25882

Date: AUG 0 6 2015

Introduction to Salt Dilution Gauging for Streamflow Measurement: Part 1

R.D. (Dan) Moore

Editor's note: This is the first in a series of planned articles that will explore the topic of salt dilution gauging for streamflow. The other articles will discuss constant rate injection, slug injection (solution), and dry salt injection.

Introduction

Discharge is an important variable that governs many aspects of stream function, such as habitat diversity and rates of nutrient export. It is also a direct measure of the amount of water available to meet instream and extractive water uses. The most common approach to measuring discharge is the velocity-area method, which involves measuring water depth and velocity at points across a stream section with a current meter. Hydrometric agencies including Water Survey of Canada and U.S. Geological Survey favour this method, which is endorsed by the provincial Resource Inventory Standards Committee.

Measuring discharge using a current meter can be difficult, if not impossible, in small streams, especially steep streams with a step-pool or boulder-cascade morphology (Figure 1). These channel morphologies are common in small and intermediate-sized catchments (drainage areas up to about 100 km^2), especially in mountainous areas. In these streams, the irregular, bouldery cross-section and strong turbulence decrease the accuracy with which depth and velocity can be measured. In addition, flow depths and velocities in small streams during low-flow conditions may be too small for reliable measurement. An alternative method of stream gauging involves injecting a chemical tracer and determining its dilution following complete mixing into the flow. Dilution gauging can be effective where current metering would not be accurate, and vice versa, so the techniques are complementary. An additional advantage is that dilution can be measured without wading across the stream, which can be hazardous in steep streams at higher flows. Under good conditions, salt dilution gauging can be precise to within 5% (Day 1977; Johnstone 1988), equivalent to the accuracy of current metering at a suitable cross-section.

There are two variations on dilution gauging, depending on whether the tracer is injected into the stream at a constant rate or as a near-instantaneous "slug." In both cases, the tracer is injected at some point along the stream, and the tracer concentration in streamwater is measured at a downstream point, where the tracer has become uniformly mixed with the streamwater. For a given volume or rate of injection, greater stream discharges will result in greater tracer dilution and lower concentrations measured at the downstream site. Equations based on the mass balance principle are applied to compute the stream discharge.

This note introduces the general principles and applicability of streamflow measurement by salt dilution. Articles in future issues of *Streamline* will give more detailed information on dilution gauging procedures.

D. Whyte

Figure 1. A steep stream unsuitable for gauging with a current meter. Because of the significant approach velocity, a standard weir equation may not be accurate, and the weir should be rated using discharge measurements.

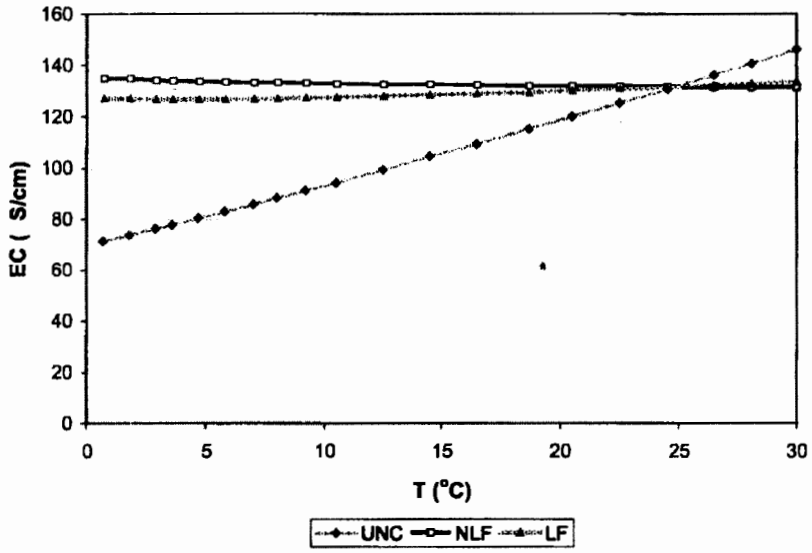

Figure 2. Dependence of electrical conductivity on temperature for a moderate strength solution. UNC = uncorrected; NLF = corrected to 25°C using a non-linear function; LF = corrected to 25°C using a linear correction (2%/°C). Measurements were made with a WTW LF-340 probe and meter.

Advantages of Salt as a Tracer

A range of tracers has been used for dilution gauging. Fluorometric dyes such as Rhodamine WT can be measured at very low concentrations, and thus can be used for higher flows and greater dilutions than tracers such as salts. However, dyes require specialized, expensive equipment for measuring their concentrations, and are more expensive and not as readily available as salts.

Common table salt (sodium chloride, NaCl) is popular for dilution gauging for three reasons. First, table salt is inexpensive and readily available, even in rural areas. Second, it can be accurately measured in the field using an electrical conductivity meter. Third, it is non-toxic for the concentrations and exposure times typically associated with discharge measurements. For example, in the author's experience, peak concentrations of NaCl at the lower end of the mixing reach are usually well under 100 mg/L, far lower than any of the toxicity thresholds shown in Table 1. This value is also substantially lower than the U.S. water quality standard for chloride concentration for protection of aquatic life (230 mg Cl/L, equivalent to a concentration of 373 mg NaCl/L) and the recommended ambient water quality guidelines specified by the B.C. Ministry of Water, Land and Air Protection (Table 2). In addition, the high concentrations usually persist for a few minutes at most, compared with the 48-hour exposures typically used in toxicity trials. While high concentrations may occur at the point of injection, these will decrease rapidly as the tracer disperses into the downstream flow.

Electrical Conductivity as a Measure of Salt Concentration

Electrical conductivity is a measure of the ease with which an electrical current can travel through water. For low solute concentrations, the conductivity will vary linearly with the salt concentration; inversely, there should be a linear relation between the concentration of salt and the electrical conductivity of the solution. This relation can be expressed as follows for application to dilution gauging:

$$C = k(EC - EC_{bg})$$

where C is the concentration of the salt in stream water, EC is the electrical conductivity of the streamwater-injection solution mixture, EC_{bg} is the background or natural electrical conductivity of the streamwater, and k is a proportionality constant, to be determined by calibration. In general, the relation depends on the natural streamwater chemistry (i.e., background conductivity) (e.g., Hongve 1987). For the greatest accuracy, therefore, calibrations should be conducted for each measurement.

The electrical conductivity of a solution varies with temperature. Therefore, it is important to use an EC probe that is capable of adjusting measured EC to a standard temperature, typically 25°C. These adjustments can be based on a linear correction, typically about 2%/°C, or a non-linear function. Both types of adjustments appear satisfactory if temperatures vary by up to a few degrees Celsius (Figure 2), but the author has found that the non-linear function performs slightly better, especially for more dilute solutions.

Constant-Rate versus Slug Injection

Constant-rate injection allows for greater accuracy, especially for low flows, but requires a pump or other device for injecting the tracer. The author and his co-workers have successfully measured flows as low as 1 L/s and up to 100 L/s using a 10-L Mariotte bottle for injection, but lower and higher flows could be measured at suitable sites with appropriate equipment. Johnstone (1988) measured flows up to 100 m^3/s in a New Zealand stream using a siphon-based system to inject tracer at about 1 L/s. However, use of constant-rate injection will not

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Continued from page 21

Table 1. Aquatic toxicity of table salt (NaCl)

Species	Parameter	Threshold concentration (mg/L)
[illegible]	NOEC	[illegible]
Daphnia pulex	48-h LC50 or EC50	1 470
[illegible]	[illegible]	[illegible]
Myriophyllum spicatum (water milfoil)	Phytotoxicity (EC50 for growth)	5 962
[illegible]	[illegible]	[illegible]
Lepomis macrochirus (bluegill)	LC50 or EC50	7 846
[illegible]	[illegible]	[illegible]

Source: U.S. EPA, Ambient Water Quality Criteria for Chloride, 1988, cited by the Salt Institute: http://www.saltinstitute.org
Notes:
NOEC = no observed effect concentration.
EC50 = concentration at which 50% of individuals show a toxic effect.
LC50 = concentration at which 50% of individuals perish.

Table 2. Recommended ambient water quality guidelines for chloride

Water use	Guideline (mg Cl/L)
Drinking water	250
[illegible]	[illegible]
Freshwater aquatic life (30-day average concentration)	150
[illegible]	[illegible]
Wildlife	600

Source: http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/chloride.html

normally be feasible for such high flows, especially for remote sites, due to the large volumes of tracer solution and the bulky equipment required to maintain a high rate of injection. Slug injection, on the other hand, can be readily used for higher flows at remote sites, but requires that the tracer concentrations at the downstream monitoring point be recorded through time, either manually or by using an electronic data logger. Table 3 summarizes the relative advantages of the two approaches.

The traditional approach to salt dilution gauging by slug injection is to use a salt solution as the tracer. However, for flows greater than about 15 m^3/s, the volumes of tracer solution required may become unworkable (Kite 1993). To overcome this problem, a number of workers have used dry salt as a tracer (Elder *et al.* 1990; Hudson and Fraser 2002). While injection of dry salt can allow higher flows to be gauged, one potential disadvantage is the need for a longer mixing length to ensure complete dissolution of salt within the streamwater.

Salt dilution techniques can often be used to measure streamflow where conventional current metering may be inaccurate.

Table 3. Relative advantages of constant-rate versus slug injection

Injection method	Advantages	Disadvantages
Constant-rate	• can easily verify complete mixing • only requires measurement of background and steady-state EC values • at steady-state, losses to transient storage zones such as pools and the streambed do not affect discharge measurement	• requires equipment for constant-rate injection • maximum flow that can be gauged is limited by the rate of tracer injection; therefore is best suited to lower range of flows
Slug	[illegible]	[illegible]

Choice of Measurement Reach

The success of both constant-rate and slug injection methods requires a reach that provides complete lateral mixing in as short a distance as possible. The reach should also have minimal pool volume. An ideal situation occurs where the tracer is injected just upstream of a flow constriction (e.g., where the flow narrows around a boulder) and the reach below contains no pools or backwater areas.

A rough guideline for the required length of the mixing reach is 25 times the stream width (Day 1977). However, the actual mixing length can vary significantly from this value depending on channel morphology, and should be verified for each site and flow condition. For constant-rate injection, lateral mixing can be checked once "steady state" conditions have been achieved (i.e., EC has reached a "plateau" and has stopped increasing) by measuring EC at different points across the stream cross-section. For slug injection, complete mixing can be verified by using two probes, located either on each side of the stream, or at two different distances downstream of the injection point. If only one probe is available, consecutive measurements during a steady discharge can be made using different reach lengths, or by measuring EC on each side of the stream. If mixing is complete, consistent discharge values should be determined.

Streams with significant in-stream vegetation are not suitable candidates for salt-dilution gauging. The vegetation will suppress mixing, and may adsorb or absorb salt (L. Tolland, pers. comm., 2003; J. Fraser, pers. comm., 2003).

Summary

Salt dilution techniques can often be used to measure streamflow where conventional current metering may be inaccurate. Salt is a useful tracer because it is (1) inexpensive and readily available, (2) easily measured in the field as electrical conductivity, and (3) non-toxic at the concentrations that occur during dilution gauging. Future articles in *Streamline* will provide more detail on field procedures and computations.

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References and Useful Sources:

Church, M. and R. Kellerhals. 1970. Stream gauging techniques for remote areas using portable equipment. Department of Energy, Mines and Resources, Inland Waters Branch, Ottawa, Ont. Technical Bulletin No. 25.

Day, T.J. 1977. Field procedures and evaluation of a slug dilution gauging method in mountain streams. Journal of Hydrology (New Zealand) 16:113–133.

Elder, K., R. Kattelmann, and R. Ferguson. 1990. Refinements in dilution gauging for mountain streams. In Hydrology in mountainous regions. I - Hydrological measurements; the water cycle, IAHS Publication No. 193, International Association for Hydrological Science, Proceedings of two Lausanne Symposia, August 1990, pp. 247–254.

Herschy, R.W. 1995. Streamflow measurement. E & FN Spon, London.

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Hudson, R. and J. Fraser. 2002. Alternative methods of flow rating in small coastal streams. B.C. Ministry of Forests, Vancouver Forest Region, Nanaimo, B.C. Extension Note EN-014. 11 p.

Johnstone, D.E. 1988. Some recent developments of constant-injection salt dilution gauging in rivers. Journal of Hydrology (New Zealand) 27:12B–153.

Kite, G. 1993. Computerized streamflow measurement using slug injection. Hydrological Processes 7:227–233.

Resource Inventory Standards Committee (RISC). 1998. Manual of standard operating procedures for hydrometric surveys in B.C. Version 2.1. Available from: srmwww.gov.bc.ca/risc/pubs/aquatic/hydro/index.htm.

UPDATE

Workshops, Events, and News

May 1–5, 2004

BC Water & Waste Association 2004 AGM. Whistler, BC

http://www.bcwwa.org/agm2004/index.php

May 2–6, 2004

Fourth World Fisheries Congress. Vancouver, BC

http://www.worldfisheries2004.org/

May 12–14, 2004

BC Land Summit 2004 Conference. University of British Columbia, Vancouver, BC

http://www.bclandsummit.com/program.html

June 6–10, 2004

North American Benthological Society, 52nd Annual Meeting. University of British Columbia, Vancouver, BC

http://faculty.forestry.ubc.ca/richardson/NABS2004.htm

June 11–15, 2004

BCLSS Annual Conference. 108 Mile Resort, 108 Mile House, BC

http://www.nalms.org/bclss/

June 13–16, 2004

2004 International Mountain Logging Conference - Forest Operations under Mountainous Conditions. Vancouver, BC

http://www.feric.ca/en/wd/home/events/mountainlogging/MountainLogging.htm

June 16–18, 2004

57th Annual Water Resources Conference: Water and Climate Change, Knowledge for Better Adaptation. CWRA. Montreal, PQ

http://www.ouranos.ca/acrh/

June 22–25, 2004

International Instrumented Watershed Symposium 2004. University of Alberta, Edmonton, AB

http://www.rr.ualberta.ca/oilsands/IIWS.htm

June 27–30, 2004

International Conference on Sediment and Geochemical Budgets in Geomorphology to Honour Professor Olav Slaymaker. University of British Columbia, Vancouver, BC

http://www.geog.ubc.ca/department/activities/

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ENCLOSURE 4

Safety Data Sheet (SDS) for proposed tracers

ENV-DO-15-0225

LA-UR-15-25882

Date: AUG 0 6 2015

SIGMA-ALDRICH

sigma-aldrich.com

Material Safety Data Sheet

Version 4.1
Revision Date 12/01/2011
Print Date 03/20/2012

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Sodium 2-naphthalenesulfonate
Product Number	:	N6885
Brand	:	Aldrich
Supplier	:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone	:	+1 800-325-5832
Fax	:	+1 800-325-5052
Emergency Phone # (For both supplier and manufacturer)	:	(314) 776-6555
Preparation Information	:	Sigma-Aldrich Corporation Product Safety - Americas Region 1-800-521-8956

2. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
Irritant

GHS Classification
Skin irritation (Category 2)
Eye irritation (Category 2A)
Specific target organ toxicity - single exposure (Category 3)

GHS Label elements, including precautionary statements

Pictogram

Signal word Warning

Hazard statement(s)

H315	Causes skin irritation.
H319	Causes serious eye irritation.
H335	May cause respiratory irritation.

Precautionary statement(s)

P261	Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P264	Wash skin thoroughly after handling.
P271	Use only outdoors or in a well-ventilated area.
P280	Wear protective gloves/ eye protection/ face protection.
P302 + P352	IF ON SKIN: Wash with plenty of soap and water.
P304 + P340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P312	Call a POISON CENTER or doctor/ physician if you feel unwell.
P321	Specific treatment (see supplemental first aid instructions on this label).
P332 + P313	If skin irritation occurs: Get medical advice/ attention.
P337 + P313	If eye irritation persists: Get medical advice/ attention.

P362	Take off contaminated clothing and wash before reuse.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

HMIS Classification

Health hazard:	2
Flammability:	0
Physical hazards:	0

NFPA Rating

Health hazard:	2
Fire:	0
Reactivity Hazard:	0

Potential Health Effects

Inhalation	May be harmful if inhaled. Causes respiratory tract irritation.
Skin	May be harmful if absorbed through skin. Causes skin irritation.
Eyes	Causes eye irritation.
Ingestion	May be harmful if swallowed.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Synonyms	:	2-Naphthalenesulfonic acidsodium salt
Formula	:	$C_{10}H_7NaO_3S$
Molecular Weight	:	230.22 g/mol

Component		Concentration
Sodium naphthalene-2-sulphonate		
CAS-No.	532-02-5	-
EC-No.	208-523-8	

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIREFIGHTING MEASURES

Conditions of flammability
Not flammable or combustible.

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

Hazardous combustion products
Hazardous decomposition products formed under fire conditions. - Carbon oxides, Sulphur oxides, Sodium oxides

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protective equipment. Avoid dust formation. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.

Environmental precautions
Do not let product enter drains.

Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.

Conditions for safe storage
Keep container tightly closed in a dry and well-ventilated place.

hygroscopic Keep in a dry place.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Contains no substances with occupational exposure limit values.

Personal protective equipment

Respiratory protection
For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator.For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Eye protection
Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	powder
Colour	white

Safety data

pH	no data available
Melting point/freezing point	no data available
Boiling point	no data available
Flash point	no data available
Ignition temperature	no data available

Autoignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Vapour pressure	no data available
Density	no data available
Water solubility	no data available
Partition coefficient: n-octanol/water	no data available
Relative vapour density	no data available
Odour	no data available
Odour Threshold	no data available
Evaporation rate	no data available

10. STABILITY AND REACTIVITY

Chemical stability
Stable under recommended storage conditions.

Possibility of hazardous reactions
no data available

Conditions to avoid
no data available

Materials to avoid
Strong oxidizing agents

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Carbon oxides, Sulphur oxides, Sodium oxides
Other decomposition products - no data available

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Oral LD50
LD50 Oral - rat - 13,900 mg/kg

Inhalation LC50
Dermal LD50
no data available

Other information on acute toxicity
no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitization
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable,

possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity

no data available

Teratogenicity

no data available

Specific target organ toxicity - single exposure (Globally Harmonized System)
Inhalation - May cause respiratory irritation.

Specific target organ toxicity - repeated exposure (Globally Harmonized System)
no data available

Aspiration hazard
no data available

Potential health effects

Inhalation	May be harmful if inhaled. Causes respiratory tract irritation.
Ingestion	May be harmful if swallowed.
Skin	May be harmful if absorbed through skin. Causes skin irritation.
Eyes	Causes eye irritation.

Signs and Symptoms of Exposure
To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

Synergistic effects
no data available

Additional Information
RTECS: QK3678000

12. ECOLOGICAL INFORMATION

Toxicity

Toxicity to daphnia and other aquatic invertebrates.	LC50 - Daphnia magna (Water flea) - 135 mg/l - 4.2 d

Persistence and degradability
no data available

Bioaccumulative potential
no data available

Mobility in soil
no data available

PBT and vPvB assessment
no data available

Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

OSHA Hazards
Irritant

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Acute Health Hazard

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Sodium naphthalene-2-sulphonate	532-02-5	

New Jersey Right To Know Components

	CAS-No.	Revision Date
Sodium naphthalene-2-sulphonate	532-02-5	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Further information
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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Co., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

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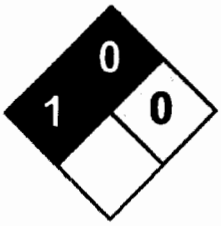

Health	1
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Sodium chloride MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium chloride

Catalog Codes: SLS3262, SLS1045, SLS3889, SLS1669, SLS3091

CAS#: 7647-14-5

RTECS: VZ4725000

TSCA: TSCA 8(b) inventory: Sodium chloride

CI#: Not applicable.

Synonym: Salt; Sea Salt

Chemical Name: Sodium chloride

Chemical Formula: NaCl

Contact Information:

Sciencelab.com, Inc.
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Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

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International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium chloride	7647-14-5	100

Toxicological Data on Ingredients: Sodium chloride: ORAL (LD50): Acute: 3000 mg/kg [Rat.]. 4000 mg/kg [Mouse]. DERMAL (LD50): Acute: >10000 mg/kg [Rabbit]. DUST (LC50): Acute: >42000 mg/m 1 hours [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention.

Skin Contact:
Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if symptoms appear.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: When heated to decomposition it emits toxic fumes.

Special Remarks on Explosion Hazards:
Electrolysis of sodium chloride in presence of nitrogenous compounds to produce chlorine may lead to formation of explosive nitrogen trichloride. Potentially explosive reaction with dichloromaleic anhydride + urea.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Do not ingest. Do not breathe dust. Avoid contact with eyes. Wear suitable protective clothing. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents, acids.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Hygroscopic

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Solid crystalline powder.)

Odor: Slight.

Taste: Saline.

Molecular Weight: 58.44 g/mole

Color: White.

pH (1% soln/water): 7 [Neutral.]

Boiling Point: 1413°C (2575.4°F)

Melting Point: 801°C (1473.8°F)

Critical Temperature: Not available.

Specific Gravity: 2.165 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Easily soluble in cold water, hot water. Soluble in glycerol, and ammonia. Very slightly soluble in alcohol. Insoluble in Hydrochloric Acid.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, high temperatures.

Incompatibility with various substances: Reactive with oxidizing agents, metals, acids.

Corrosivity: Not considered to be corrosive for metals and glass.

Special Remarks on Reactivity:
Hygroscopic. Reacts with most nonnoble metals such as iron or steel, building materials (such as cement) Sodium chloride is rapidly attacked by bromine trifluoride. Violent reaction with lithium.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals:
WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 3000 mg/kg [Rat.]. Acute dermal toxicity (LD50): >10000 mg/kg [Rabbit]. Acute toxicity of the dust (LC50): >42000 mg/m3 1 hours [Rat].

Chronic Effects on Humans: MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/ or yeast.

Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Lowest Published Lethal Dose (LDL) [Man] - Route: Oral; Dose: 1000 mg/kg

Special Remarks on Chronic Effects on Humans:
Causes adverse reproductive effects in humans (fetotoxicity, abortion,) by intraplacental route. High intake of sodium chloride, whether from occupational exposure or in the diet, may increase risk of TOXEMIA OF PREGNANCY in susceptible women (Bishop, 1978). Hypertonic sodium chloride solutions have been used to induce abortion in late pregnancy by direct infusion into the uterus (Brown et al, 1972), but this route of administration is not relevant to occupational exposures. May cause adverse reproductive effects and birth defects in animals, particularly rats and mice (fetotoxicity, abortion, musculoskeletal abnormalities, and maternal effects (effects on ovaries, fallopian tubes) by oral, intraperitoneal, intraplacental, intrauterine, parenteral, and subcutaneous routes. While sodium chloride has been used as a negative control n some reproductive studies, it has also been used as an example that almost any chemical can cause birth defects in experimental animals if studied under the right conditions (Nishimura & Miyamoto, 1969). In experimental animals, sodium chloride has caused delayed effects on newborns, has been fetotoxic, and has caused birth defects and abortions in rats and mice (RTECS, 1997). May affect genetic material (mutagenic)

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause skin irritation. Eyes: Causes eye irritation. Ingestion: Ingestion of large quantities can irritate the stomach (as in overuse of salt tablets) with nausea and vomiting. May affect behavior (muscle spasicity/contraction, somnolence), sense organs, metabolism, and cardiovascular system. Continued exposure may produce dehydration, internal organ congestion, and coma. Inhalation: Material is irritating to mucous membranes and upper respiratory tract.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Sodium chloride

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R40- Possible risks of irreversible effects. S24/25- Avoid contact with skin and eyes.

HMIS (U.S.A.):

Health Hazard: 1

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References:
-Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. -SAX, N.I. Dangerous Properties of Indutrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II.

Other Special Considerations: Not available.

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