QA: QA

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Test Plan for Alluvial Testing Complex – Single-well, Multi-well, and Laboratory Studies

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DISCLAIMER

Alluvial Testing Complex – Single-well, Multi-well, and Laboratory Studies

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CHANGE HISTORY

Revision Number	Interim Change No.	Effective Date	Description of Change
00	0		Initial issue
01	0	04/03/02	Revision 00 was approved and testing was authorized to begin on 12/11/01. That revision was not issued as a controlled document, because minor changes became evident from review of other test plans submitted in late December 2001 and early January 2002. This revision corrects editorial issues and adds further clarification for consistency with other test plans that will be submitted to NRC as KTI agreement products.
01	1		Removed a sentence in section 2 on a KTI agreement that is not directly related to this SITP.

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FIGURES

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ACRONYMS AND ABBREVIATIONS

ACC	Accession Number
ATC	Alluvial Testing Complex
AMR	Analysis and Modeling Report
AP	Administrative Procedure
BNSCL	Bechtel Nevada Standards and Calibration Laboratory
BSC	Bechtel SAIC Company, LLC
CRWMS	Civilian Radioactive Waste Management System
DOE	U.S. Department of Energy
DTN	Data Tracking Number
EBS	Engineered Barrier System
Eh	Reduction - oxidation potential
ERP	Electrical Resistivity Probe
ES&H	Environment, Safety and Health
EWDP	Early Warning Drilling Program (Nye Co.)
FWP	Field Work Package
HRC	Harry Reid Center (UNLV)
IPLV	Implementing procedure (UNLV)
Interval	For this plan, the terms interval, screen number and screened interval are synonymous
ISM	Integrated Safety Management
LA	License Application
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
M&TE	Measuring and Test Equipment
masl	meters above sea level
NBS	Natural Barrier System
NC	Nye County
NLP	Nevada Line Procedure
NRC	U.S. Nuclear Regulatory Commission
NWI	Nevada Work Instruction
NWRPO	Nye County Nuclear Waste Reporistory Project Office
OCRWM	Office of Civilian Radioactive Waste Management

ACRONYMS AND ABBREVIATIONS (Continued)

PA	Performance Assessment
PC	Performance Confirmation
pH	potential of hydrogen (measure of acidity/alkalinity)
PMR	Process Model Report
QA	Quality Assurance
QAP	Quality Assurance Program
QARD	Quality Assurance Requirements and Description
QIP	Quality Implementing Procedure
QMP	Quality Management Plan (UNLV)
RIS	Records Information System
RT	Radionuclide Transport
Screen Number	For this plan, the terms interval and screen number and screened interval are synonymous
SITP	Scientific Investigation Test Plan
SN	Scientific Notebook
SR	Site Recommendation
SZ	Saturated Zone
TCO	Test Coordination Office
TDMS	Technical Data Management System
TIP	Technical Implementing Procedures (LBNL)
TSPA	Total System Performance Assessment
TWP	Technical Work Plan
UCCSN	University & Community College System of Nevada
UNLV	University of Nevada, Las Vegas
UPS	Uninterrupted Power Supplies
USFIC	Unsaturated and Saturated Flow under Isothermal Conditions
USGS	U.S. Geological Survey
UZ	Unsaturated Zone
YAP	Administrative Procedure (YMP)
YMP	Yucca Mountain Site Characterization Project

1. PURPOSE

This test plan, SITP-02-SZ-003, addresses single-well and multiple-well hydraulic and tracer testing and associated laboratory investigations to be conducted at the Alluvial Testing Complex (ATC) south of Yucca Mountain. The test plan was developed per AP-SIII.7Q. The ATC activities will support Total-System Performance Assessment (TSPA) by evaluating alternative conceptual flow and radionuclide transport models in the saturated alluvium south of Yucca Mountain and providing flow and transport parameter estimates for these models. The ATC investigations will be a collaborative effort conducted by various entities within the United States Department of Energy (DOE), the Bechtel SAIC Company, LLC (BSC), the United States Geological Survey (USGS), the University of Nevada-Las Vegas, Harry Reid Center for Environmental Studies (UNLV/HRC), and Nye County and its employees, contractors and consultants.

The ATC test site is located to the south of Yucca Mountain, along a potential groundwater flow path parallel to Fortymile Wash, as illustrated in Figure 1. It consists of wells NC-EWDP-19D1, -19IM1, and -19IM2, as well as the shallow piezometer borehole, -19P (Figure 2). The field tests will be conducted by the DOE and its contractors with assistance from the Nye County Nuclear Waste Repository Project Office (NWRPO) under a Cooperative Agreement between Nye County and the DOE for the Nye County Early Warning Drilling Program (EWDP) and the ATC program. The Nye County EWDP has been implemented to collect data and develop a database for the saturated zone located hydrologically down gradient from Yucca Mountain. The EWDP is part of Nye County's mission of independent verification testing and oversight drilling with the requirement that any activities at Yucca Mountain will be performed in a manner to protect the integrity of the site.

Single-well hydraulic and tracer testing in NC-EWDP-19D1, the first of the ATC wells, was completed in April 2001, prior to the drilling of additional testing wells at the ATC location. The single-well testing included an open-hole hydraulic test, isolated interval #1, #2, #3, and #4 hydraulic tests (the four uppermost screened intervals in NC-EWDP-19D1, all of which are completed in the alluvium, see Figures 3 and 4), and three push/pull tracer tests in screened interval #1 (uppermost screen interval). The testing was performed under the original Field Work Package FWP-SBD-99-002. This current test plan focuses specifically on efforts that will be undertaken in Phase I of cross-hole testing at the Alluvial Testing Complex to evaluate hydraulic and transport properties of the saturated alluvium. Note that in the remainder of this test plan, interval numbers will refer to screened intervals in NC-EWDP-19D1, with interval #1 referring to the uppermost screen and interval #7 referring to the lowermost screen (see Figures 3 and 4). For the purposes of this test plan, the use of terms such as interval, screened interval, or screen number are identical.

2. PRODUCT SUPPORTED

This test plan is covered under Technical Work Plan for Saturated (SZ) Zone Flow and Transport Modeling and Testing, TWP-NBS-MD-000001, (Robinson, 2001), the Field Work Package for Alluvial Tracer Testing, FWP-SBD-99-002, (Wasson, 2001A), and the Field Work Package for Nye County Early Warning Drilling Program (EWDP) Phase II, III, and Alluvial Testing

Complex (ATC), FWP-SBD-99-001,(Wasson, 2001B). This plan supports the License Application (LA) Product and Performance Confirmation (PC).

This test plan fulfills the requirements of four Key Technical Issues (KTI) Agreements between NRC and DOE. Specifically, this test plan meets the needs of Radionuclide Transport (RT) agreement RT.203, and it includes a discussion of ATC pre-test predictions RT.2.04 (Section 6.2). It also fulfills Unsaturated and Saturated Flow under Isothermal Conditions agreement USFIC.5.03 which is identical in scope to RT.2.03.

3. QUALITY ASSURANCE AND INTEGRATED SAFETY MANAGEMENT SYSTEM PROGRAM

This test will be performed in full compliance with the Yucca Mountain Quality Assurance (QA) and Integrated Safety Management (ISM) requirements (PGM-CRW-AD-000001). Section 4 of FWP-SBD-99-002, "Alluvial Tracer Testing" describes various aspects of the Environment, Safety, and Health (ES&H) requirements and compliance. FWP-SBD-99-002 also contains a hazard analysis for testing activities. The Occupational Safety and Health Program requirements apply to effort under this test plan (AP-ESH-004).

The BSC organizations and the USGS will conduct the hydraulic and tracer testing activities in accordance with the YMP Quality Assurance Requirements Document (QARD). The QARD specifies that all work will be conducted according to project quality assurance procedures. All OCRWM procedures. Relevant QA procedures that are expected to be used during the test are listed in Section 3.1 below. Because of the broad scope, frequently changing nature, and long duration of the ATC field and laboratory tests, the use of additional QA procedures may become necessary. If this occurs, applicable procedures will be reported in data packages and reports (e.g., AMRs) that are generated as a result of this test plan. Some QA procedures that apply to detailed technical aspects of testing may have to be developed or modified as needs are identified during testing. Nye County and its contractors will conduct work under the Nye County Quality Assurance Program Plan (QAPP) and its subordinate Work Plans. All references to tasks performed by Nye County are non-quality affecting (non-Q) references and do not mandate the county to perform work to this test plan. The Alluvial Testing Complex (ATC) is an amendment to the Nye County EWDP program.

UNLV/HRC will perform all work to the University Community College Systems of Nevada (UCCSN) Quality Assurance Program (QAP), developed under the DOE/UCCSN Cooperative Agreement Task 3. The UNLV/HRC produced data are "quality-affecting (Q) data" as described under the DOE/UCCSN QAP cooperative agreement.

3.1 APPLICABLE QA PROCEDURES

3.1.1 Test Plan

AP-SIII.7Q	Scientific Investigation Laboratory and Field Testing

3.1.2 Test Controls

AP-3.12Q	Design Calculations and Analyses
AP-5.2Q	Testing Work Packages
AP-SI.1Q	Software Management
AP-SIII.1Q	Scientific Notebooks
AP-SIII.9Q	Scientific Analyses
AP-SIII.10Q	Models
NLP-2-0	Determination of Importance Evaluations
AP-SV.1Q	Control of the Electronic Management of Information

All activities in the field will be coordinated with the Test Coordination Office (TCO).

3.1.3 Sample Controls

LP-SMF-002Q-M&O	Field Logging, Handling, and Documenting Borehole Samples
NWI-DS-002Q	Field Drilling Support Activities
NWI-SMF-001Q	Removal of Whole and Other Specimens from Samples by the Sample Management Facility for Shipment and Remnant Return
NWI-SMF-002Q	Transport, Receipt, Admittance, and Processing of Borehole Samples for the Sample Management Facility
YAP-SII.2Q	Requesting Samples for Examination at the Yucca Mountain Site Characterization Project Sample Management Facility
YAP-SII.4Q	Collection, Submission, and Documentation of Non-Core and Non-Cuttings Samples to the Sample Management Facility for Site Characterization

3.1.4 Record Controls

AP-SIII.3Q	Submittal and Incorporation of Data to the Technical Data Management System
AP-17.1Q	Record Source Responsibilities for Inclusionary Records
AP-2.23Q	Work Request/Work Order Process
AP-3.11Q	Technical Reports
AP-2.14Q	Review of Technical Products and Data
AP-3.15Q	Managing Technical Product Inputs

All records will be submitted to the Record Processing Center in records packages.

3.1.5 Equipment/Instrument Calibration Records

AP-7.6Q	Procurement of Items and Services
AP-7.7Q	Acceptance of Items and Services
AP-12.1Q	Control of Measuring and Test Equipment and Calibration Standards

Calibration services will be procured through BSC from qualified vendors. Calibration records will be submitted with data submittals as part of the records package.

3.1.6 Nonconformance and Corrective Actions

AP-15.2Q	Control of Nonconformances
AP-16.1Q	Management of Conditions Adverse to Quality

3.1.7 Test Equipment

AP-12.1Q	Control of Measuring and Test Equipment and Calibration Standards

3.1.8 Permits, Environmental Compliance, and ISMS Compliance

AP-EM-002	Land Access and Environmental Compliance
AP-EM-004	Spill Management
AP-ESH-004	Occupational Safety and Health Program
AP-ESH-008	Hazard Analysis System
PGM-CRW-AD-000001	Integrated Safety Management Description Document

3.1.9 National Laboratory Procedures

LANL-EES-4-DP-801, Single and Multiple-Well Tracer Transport Experiments in the Field
LANL-EES-4-DP-802, R2 Preparation of Standards for Tracer Concentration Measurements
LANL-EES-4-DP-803, R1 Use of Flow Cytometer to Determine Particle Concentrations in Solution
LANL-EES-5-DP-705, R0, Determination of Metals in Aqueous Solutions By High Resolution ICPMS
LANL-YMP-QP-08.1Identification and Control of Samples
LANL-YMP-QP-08.3Transfer of Data

3.1.10 Analytical Laboratory Procedures

IPLV-003, Analytical and Top Loading Balance Use
IPLV-008, Measurement of Inorganic Anions in Water Samples by the Ion Chromatography System
IPLV-8.3, Groundwater Sample Collection and Control
IPLV-009, Measurement of Trace Elements in Water Samples by the Inductively Coupled Mass Spectrometry System
IPLV-004, High Performance Liquid Chromatograph Operation
IPLV-017, Pipettor Calibration Check
QAP-1.0, Organization
QAP-2.0, Quality Assurance Program- Preparation, Approval, and Revision of Procedures
QAP-2.1, Qualification, Indoctrination and Training of Personnel
QAP-3.0, Scientific Investigation Control
QAP-3.1, Control of Electronic Data
QAP-3.2, Software Management
QAP-3.6, Submittal of Data to the Technical Data Management System
QAP-6.0, Document Control
QAP-7.0, Control of Quality-Affecting Procurement and Receipt
QAP-8.0, Identification and Control of Items and Samples

QAP-8.2, Sample Transfer
QAP-12.0, Control of Measuring and Test Equipment
QAP-16.0, Nonconformances and Trending
QAP-16.1, Stop Work
QAP-17.0, Quality Assurance Records

3.1.11 USGS Procedures

SN-USGS-SCI-123-V1 [Initial volume of the USGS] Alluvial Testing Complex [ATC] Scientific Notebook: all work performed by the USGS at the ATC will be documented in this Scientific Notebook of several volumes.

Procedure to conduct single-hole and cross-hole hydraulic tests – To be developed.

4. PURPOSE AND OBJECTIVES

The ATC hydrologic and tracer testing will address the needs for additional saturated zone (SZ) data for the alluvium/valley fill material south of Yucca Mountain, and it will provide estimates of hydraulic and radionuclide transport parameter estimates for performance assessment (PA). The testing will also define and, to the validate conceptual models of flow and radionuclide transport in the alluvium/valley fill material. The testing will also support defining and validating conceptual models of flow and radionuclide transport in the alluvium / valley fill material.

The specific objectives of the ATC testing program are to:

- Support the development of a conceptual model of groundwater flow and radionuclide transport in saturated alluvium south of Yucca Mountain to the Amargosa Desert.

- Quantify flow parameters including saturated thickness, transmissivity, hydraulic conductivity, water flux/specific discharge, and possibly storativity.

- Quantify transport parameters including effective flow porosity, longitudinal dispersivity, sorption parameters, parameters describing diffusion between flowing and stagnant water, and colloid/colloid-facilitated transport parameters.

- Measure sorption coefficients in the laboratory using materials from the ATC borehole(s). The lab data will be compared to the field data.

- Conduct geophysical logging (bulk density, neutron porosity, resistivity, acoustic televiewer, caliper, and vertical deviation information) at two to four ATC wells. In addition, conduct gravity meter surveys at well EWDP-NC-19D/D1.

Additionally, there are other activities within the YMP Saturated Zone testing program that are not specific to the ATC, but which include investigations at the ATC as part of their overall objectives. These activities are SZ hydrochemistry (both isotopic and geochemical) and colloid sampling/characterization, and their objectives include:

- Determine the Eh-pH conditions at the ATC and EWDP wells.
- Determine natural colloid concentrations and characteristics in the alluvium at the ATC and EWDP wells.
- Analyze isotopic relationships and geochemistry of alluvium ground water samples to provide information on flow pathways and support conceptual flow and transport models in the alluvium ground water flow system.

5. WORK SCOPE

5.1 PRODUCT DESCRIPTION

The ATC hydraulic and tracer testing will support updating documentation of the SZ flow and transport model to support TSPA-LA. The Analyses Report will be produced, reviewed and approved according to AP-SIII.9Q. Calculations and data will be produced, reviewed and approved according to AP-3.12Q and AP-SIII.3Q, respectively.

5.2 RESPONSIBLITIES

The work will be performed by scientists and research associates from the Science and Engineering Testing Department and the SZ Department, Science and Analysis Project, Bechtel SAIC Company, LLC (BSC), the USGS, UNLV and Nye Co employees, contractors and consultants. The USGS, BSC (i.e., Los Alamos National Laboratory [LANL]) and Nye Co. will conduct hydraulic and tracer testing at the ATC. LANL and USGS will perform pre- and post-test modeling and interpretations. The Test Coordination Office (TCO) will provide the interface between Nye County and the YMP for ATC testing activities.

Nye County NWRPO will drill and complete the test wells, procure and install test equipment/instrumentation in the main pump borehole (19D1) and monitoring boreholes, set up surface equipment, install discharge piping, and provide generator power for conducting the multi-well tests. Nye County will provide fuel, maintenance, repair, or replacement to the test pumping system and surface equipment, generator power, and maintenance and access control to the ATC facility. Nye County is also responsible for obtaining and complying with the right-of-way permits for the ATC testing, and it is responsible for the water quality during the equipment installation into the borehole. These activities will be conducted in accordance with the “Cooperative Agreement” modification between the Nye County NWRPO and the U.S. Department of Energy (DOE).

The UNLV/HRC for Environmental Studies Laboratory will perform laboratory analytical services (i.e., tracer concentration analysis on ground water samples) under the “University Community College Systems of Nevada (UCCSN) Cooperative Agreement” with DOE/YMSCO.

The YMSCO, in conjunction with the BSC Environmental Controls Department, will obtain permits for water appropriations (water discharge) and underground injection control (tracer injections) associated with ATC testing. Information on water and tracer usage will be reported to the State of Nevada in accordance with the authorization letters for tracer injections and discharges issued to YMSCO. UNLV/HRC will provide laboratory analyses of pumped ground water samples tracer content to Principal Investigators (PIs) for preliminary determination of tracer breakthrough, peak concentration, and tracer reduction from peak concentration over time. PIs will provide the amount of water pumped and tracer usage to the TCO on a monthly basis.

The YMSCO is responsible for any adverse impacts to the ground water quality from tracer injections and/or discharge activities. The DOE/YMSCO has assumed all liability associated with the tracer testing as written in the Underground Injection Control (UIC), Water Appropriations, and the "Cooperative Agreement" between DOE and Nye County.

The Nye County NWRPO will retain ownership of the boreholes at the completion of ATC testing. Nye County will integrate the ATC boreholes into the EWDP long-monitoring network.

5.3 ACTIVITIES AND TASK DESCRIPTIONS

BSC activities and task descriptions associated with ATC testing are covered under work package P4D1224SF1(SZ Testing). Work activities and task descriptions for the USGS are covered under work packages 8191224SUA (SZ Investigations - FY02), 8191224SUB (SZ Isotope Hydrology - FY02), and 8191224SUD (USGS Liaison to SZ Studies - FY02). Applicable portions of these work packages are summarized in the following subsections.

5.3.1 P4D1224SF1- SZ Testing (BSC organizations)

With USGS, Nye County, and UNLV/HRC, BSC/LANL will conduct cross-hole hydraulic and tracer tests at the alluvial testing complex (EWDP-19D location) as well as supporting laboratory investigations. Specific activities include:

- Interactions with Nye Co., USGS, and UNLV to coordinate test planning, equipment selection and installation, environmental permitting, sorption testing on nonsorbing tracers used in field, tracer solution preparations, and other test preparation/planning activities.
- Conduct of cross-hole hydraulic testing.
- Conduct of cross-hole tracer testing, including preparation of tracer solutions, and analysis of microspheres and isotopic tracers.
- Interpretation of cross-hole tracer tests, including software QA associated with modeling.
- Minimal laboratory testing to verify sorption and transport behavior of tracers in field test interval.
- Laboratory developmental work on isotopic tracers sorbed onto inorganic colloids to be used in cross-hole field-testing.
- QA of lab and field data.

- Hydrostratigraphy investigations (mineralogy, stratigraphy) in support of ATC studies.

Colloid sampling and hydrochemistry investigations that fall under Work Package P4D1224SF1will also be integrated into ATC testing to satisfy objectives that are not specific to the ATC. These activities include:

- Continue to analyze for colloid concentrations and colloid size distributions in ATC wells as they are sampled. Correlate this information with groundwater chemistry. To the extent possible, collect colloid samples during cross-hole testing at ATC to analyze mineralogy.
- Collect and analyze water samples from ATC boreholes to determine the Eh-pH conditions in these wells, and incorporate these measurements into laboratory radionuclide transport testing plans.

5.3.2 Work Package 8191224SUA - SZ Investigations - FY02 (USGS)

With BSC and Nye Co., determine the hydraulic and transport properties of unconsolidated, valley-fill material (alluvium and colluvium) along a potential ground-water flow path from the proposed repository area south to the Amargosa Desert. Conduct cross-hole hydraulic and single-hole/cross-hole tracer testing at the ATC during FY02 utilizing existing borehole 19D1, and newly drilled boreholes IM1 and IM2. The concentrations of the solute tracers recovered during the pumping from 19D1 will be determined by analysis of samples, collected at known times, using high pressure liquid chromatography (HPLC). UNLV/HRC will perform the analyses. Other, as yet to be determined, boreholes in the vicinity of the ATC will be instrumented with pressure transducers to monitor for possible water-level responses.

5.3.3 Work Package 8191224SUB - SZ Isotope Hydrology - FY02 (USGS)

Ground water samples for hydrochemical and isotopic analyses will be collected as available from ATC wells to continue the three dimensional characterization of the flow system at the ATC, which will aid in the conceptual understanding of SZ flow through the alluvium. Time series samples will be collected during the ATC hydraulic and tracer testing from all pumped zones. If the monitoring wells are not pumped, samples from those wells may be collected using the USGS discrete zone sampler. The results of the hydrochemical and isotopic analyses will be incorporated into the USGS integrated hydrochemical database and the Projects technical database. These data will be used in the overall assessment of flow paths and in reaction path modeling.

5.3.4 Work Package 8191224SUD - USGS Liaison to SZ Studies - FY02 (USGS)

The USGS Liaison will serve as the primary point of contact at the USGS for the BSC Science and Analysis Saturated Zone Department for strategic planning, scientific content of work proposals, prioritization of tasks, and integration of scientific progress and results.

5.4 SCHEDULE

The general testing sequence and anticipated duration is presented in Table 1.

Table 1. General Schedule for Phase I Hydraulic and Tracer Testing at the ATC

General Testing Sequences	Duration [Month]
1) Multi-well Hydraulic Testing (Initial)	
Combined Intervals #5, 6, and 7 (19D1) Confirmatory Hydraulic Test	0.25
Isolated-Interval #5 (19D1) Confirmatory Hydraulic Test	0.25
Isolated Interval #4 (19D1) Confirmatory Hydraulic Test	0.25
Open-alluvium hydraulic test: pump intervals 1 through 4 in 19D1	0.25
Isolated Interval #4 (19D1) Test (not needed if interval (screen) #1 is selected for cross-hole tracer testing): combined hydraulic & push/pull tracer test.	0.5
Subtotal	1.5
2) Multi-well Tracer Testing	
First Tracer Injection (Reactive & Conservative – IM2)	
Second Tracer Injection (Conservative – IM2)	
Third Tracer Injection (Conservative – IM1)	
Subtotal	16
3) Multi-well Hydraulic Testing (Continuation)	
Isolated Interval Screen #3 (19D1)	0.5
Isolated Interval Screen #2 (19D1)	0.5
Isolated Interval Screen #1 (19D1)	0.5
Subtotal	1.5
Multi-well Hydraulic and Tracer Testing	**19 Total**

*Assumes interval #4 will be used for cross-hole testing.

The criteria for test completion during Phase I of investigations are:

- Sufficient information from the cross-hole hydraulic and tracer is obtained to update the SZ In-Situ Testing Analyses Report for License Application, and support a docketable LA.

- Expiration of the water discharge waiver.

6. SCIENTIFIC APPROACH/TECHNICAL METHODS

6.1 SUMMARY OF ATC FIELD TESTING CONDUCTED TO DATE

The ATC project has been underway since June 2000. Nye County drilled the wells NC-EWDP-19D and 19P as part of the Phase II Early Warning Drilling Program (EWDP) in the Spring of 2000. As Figure 1 shows, these wells are located along a potential flow pathway from the potential Yucca Mountain repository. The lower part of the 19D borehole was deviated and was partially grouted and then re-drilled at the same location, with the re-drilled borehole being designated “19D1.” A completion diagram for 19D1 is provided in Figure 3. The locations of the screened intervals were selected based on a combination of lithological logs, geophysical logs, and observations of water production during drilling. The 19P borehole is a 2-7/8" OD piezometer well located approximately 25 meters northeast of NC-EWDP-19D1. It is completed to only 469 feet below surface, with a single screened interval extending from 359 to 459 feet below surface. Other than being monitored for pressure responses, -19P will not be used in ATC cross-hole hydraulic or tracer testing, so it is not discussed further in this test plan. Figure 4 is a schematic depiction of the lithology at the 19D1 location. Depth to water in 19D1 under open-hole conditions is ~349 ft below surface.

Hydraulic testing by the YMP in 19D1 began in July 2000. One open-hole aquifer test (alluvium intervals only) and four isolated interval hydraulic tests were conducted between July and November 2000. Each hydraulic test involved approximately one week of pumping and one week of monitoring recovery. Three single-well injection-withdrawal tracer tests were then conducted in interval #1 of 19D1 (uppermost interval) from late November 2000 through April 2001.

The single-well hydraulic test pressure responses in each of the aquifer tests in 19D1 were best matched using a semi-analytical model that assumed an unconfined aquifer. A preliminary estimate of composite alluvium transmissivity of approximately 300 ft^2/day was obtained from this model, and the estimated hydraulic conductivity in three of the four isolated alluvium intervals was approximately 0.7 ft/day (interval #2 was the exception, with a much lower hydraulic conductivity).

In each of the three tracer tests in interval #1 of 19D1, two nonsorbing solute tracers with different diffusion coefficients were simultaneously injected (a halide and a fluorinated benzoate dissolved in the same solution). Polystyrene microspheres were also injected in one of the tests to obtain information on colloid filtration in the vicinity of the wellbore. The three tracer tests were conducted in essentially the same manner except for the time that was allowed to elapse between the cessation of tracer and chase water injection and the initiation of pumping; i.e., the so-called “rest” or “shut-in” period. The rest period was systematically varied from ~0.5 hr, to ~2 days, to ~30 days in the tests to vary the time allowed for tracers to diffuse into stagnant water in the flow system and for the tracers to migrate with the natural groundwater flow. The tracers and test conditions used in the three single-well tracer tests are summarized in Table 2.

Tracer test interpretations were based on comparing the responses of the different tracers in the same test as well as the responses of similar tracers in the different tests (“responses” refers to either actual tracer concentrations, tracer concentrations normalized to injection mass, or tracer concentration normalized by the maximum concentration, as a function of time or volume pumped). Differences in the responses of the two tracers injected in the same test provided information on diffusion into stagnant water in the system, while differences in the responses of tracers injected in different tests (after correcting for the effects of diffusion) provided information on tracer drift during the rest periods of the tests as well as dispersivity and porosity.

The preliminary conclusions from the single-well tracer tests are:

- In each test, the two solute tracers with different diffusion coefficients had nearly identical responses, suggesting minimal diffusive mass transfer between flowing and stagnant water in the alluvium flow system. That is, the tracer test results were consistent with a single-porosity flow/transport system.

- Analyses by LANL of different tracer peak times and different tail slopes as a function of different rest periods yielded estimates of ground water specific discharge that ranged from 1 to 10 m/yr.
- An alternate analysis by the USGS of the single-hole injection-pumpback tracer tests conducted at NC-EWDP-19D1 will be included in the SZ In-Situ Testing Analyses Report. The analysis uses a methodology which implements three different analytic solutions to the governing equation during a tracer test, namely the advection-dispersion equation. The three solutions describe the three phases of a single-hole injection-pumpback tracer test: injection of tracer and chase fluid, drift of the injected tracer plume with the natural ground-water movement, and finally pump back of the dispersed plume into and out of the well. This analysis gave preliminary, unreviewed values of 10% medium porosity, 5 meter (m) longitudinal dispersivity, 1 m transverse dispersivity, and 1.5 m/year specific discharge.
- A large fraction of microspheres were reversibly filtered near the 19D1 wellbore. Microsphere detachment was enhanced by flow transients. Analysis of microsphere tailing provided estimates of colloid detachment rate constants in the alluvium.

Additional details of the conduct, results, and interpretations of the single-well hydraulic and tracer tests conducted in NC-EWDP-19D1 between July 2000 and April 2001 will be provided in the SZ In-Situ Testing Analyses Report.

Table 2. Summary of the Three Injection-Withdrawal Tracer Tests in Interval 1 of NC-EWDP-19D1

Rest Period (Test)	**0.5 hrs**	**2 days**	**30 day**
Dates	1/5/01 – 1/12/01	12/1/00 – 12/18/00	1/27/01 – 4/25/01
Tracers (conc., g/L)	2,4-DFBA [(a)] (0.46 g/L) Cl^- (0.62 g/L NaCl) 640-nm Microspheres	2,6-DFBA[(a)] (0.46 g/L) I^- (0.64 g/L KI)	PFBA[(a)] (0.46 g/L) Br^- (0.64 g/L NaBr)
Injection Rate, gpm	15.0	15.0	15.0
Avg Pumping Rate, gpm	13.3	10.9	13.65
Pumping Duration, days	7	14	54
Total Gallons Pumped	134,900	220,000	1,063,000
Tracer Recovery (FBA)	0.864	0.928	0.913

[(a)] DFBA = difluorobenzoate, PFBA = pentafluorobenzoate

During single-well hydraulic and tracer testing in NC-EWDP-19D1, water samples were collected from each of the four isolated alluvium intervals as well as the four combined intervals. These samples were analyzed for major ion chemistry as well as for isotope geochemistry and redox conditions (Eh measurements, dissolved oxygen concentrations, iron concentrations). The major ion chemistry in each of the intervals is listed in Table 3.

Table 3. Major ion chemistry of NC-EWDP-19D1 water from the different isolated intervals in the alluvium and from all four alluvium intervals combined

Species	Interval 1	Interval 2	Interval 3	Interval 4	Composite
Units (except pH)	**Mg/L**	**Mg/L**	**Mg/L**	**Mg/L**	**Mg/L**
Ca^{++}	7.7	11.0	1.6	1.5	2.2
Na^{+}	73.2	59.2	114	121	118
K^{+}	3.9	3.7	3.1	3.1	5.2
Mg^{++}	0.7	1.0	0.11	0.12	1.1
Li^{+}	0.08	0.07	0.13	0.13	0.15
Si	27.3	27.6	27.2	31.2	52.5
$HCO_3^{-} + CO_3^{2-}$	162	150	222	237	237
SO_4^{2-}	23.8	22.1	27.6	20.0	25.9
Cl^{-}	6.5	5.5	6.4	5.7	5.7
F^{-}	2.0	1.7	1.9	2.5	2.1
pH	9.0	8.0	8.1	8.4	9.2

Low Eh measurements, low dissolved oxygen concentrations, and high iron concentrations evaluated collectively qualitatively indicated that the upper alluvium intervals (zones 1 and 2) have conditions that are somewhat more reducing than the lower intervals (zones 3 and 4). Isotope geochemical data were not available to include in this test plan.

In September 2001, Nye County drilled and completed wells NC-EWDP-19IM1 and EWDP-19IM2 in the immediate vicinity of EWDP-19D1 (Figure 2). Completion diagrams for these wells are provided in Figures 5 and 6. The locations of the screened intervals in these wells were selected to roughly coincide with the screened intervals in 19D1 so that the screens would be in the same lithologic layers in each well. These wells will be used for cross-hole hydraulic and tracer testing in the cross-hole phase of the ATC test program.

6.2 PRE-TEST CALCULATIONS/ANALYSIS/MODEL PREDICTIONS FOR CROSS-HOLE TESTING AT THE ATC

USGS and LANL principal investigators have completed pre-test predictions of cross-hole tracer responses based on the assumption that interval #4 will be used for tracer testing. Hydraulic test responses have also been predicted, but these are not presented in this test plan because they simply reflect the transmissivities that were measured in the single-well tests in NC-EWDP-19D1 (with storativity being an adjustable parameter, since it was not measured in the single-well tests). Probably the most important insight that will be gained from cross-hole hydraulic testing will be whether the alluvium behaves as a confined or an unconfined medium. Although the single-well hydraulic tests were interpreted assuming an unconfined medium, most of intervals above and below the isolated pumped intervals exhibited a small pressure response during pumping of the isolated interval, which is consistent with the intervals being confined. Cross-hole hydraulic testing of isolated intervals should shed light on this issue. It could be simply that the conditions near the well (where the transducers are) were confined and became more and more unconfined with increasing distance from the well. The transducer in the interval being pumped will, with time, reflect the pressure at increasing distances from the well; hence the eventual unconfined character of the pressure history in all pumped intervals.

Cross-hole tracer test predictions were conducted primarily to estimate how long a cross-hole test may take to conduct so that scheduling, budgeting, and environmental permitting issues could be addressed. Emphasis was placed on the sensitivity of the predictions to variables such as interwell separation, interval thickness, flow porosity, production rate, longitudinal dispersivity, confined or unconfined flow conditions, and most importantly, lithium sorption parameters. Many of these sensitivities can be effectively captured using a simple analytical expression for nonsorbing tracer travel times in radial convergent flow to a pumping well in a confined homogeneous, isotropic medium:

$$t = \frac{hp\mathrm{L}^2\mathrm{T}}{\mathrm{Q}} \qquad \text{(Eq. 1)}$$

where

t = mean travel time, hr
h = effective flow porosity
L = distance between injection and production wells, m
T = formation thickness, m
Q = production flow rate, m3/hr.

Of course, any real flow system will never be completely homogeneous or isotropic, but this equation serves as a useful starting point for estimating travel times. It is clear that, all other things being equal, mean travel times will vary linearly with effective flow porosity and formation thickness, with the square of the distance between wells, and inversely with the production flow rate. Equation 1 does not account for any delays associated with diffusion into stagnant water in the system, although these delays are not expected to significantly affect first arrival times and peak arrival times of tracers in the valley-fill deposits, which are of greater practical interest than the mean arrival time. Also, the results of single-well testing indicated that diffusion between flowing and stagnant water in the alluvium at NC-EWDP-19D1 was negligible.

Two approaches were used to provide pre-test predictions, one by LANL and the other by the USGS.

In the LANL analysis, the first arrival times and peak arrival times of tracers were estimated as a function of mean travel time and dispersivity using the RELAP code. The ratio of first arrival time to mean arrival time and the ratio of peak arrival time to mean arrival time were both found to have a relatively smooth dependence on the Peclet number of the system. By obtaining a polynomial fit to these ratios as a function of Peclet number, the first and peak arrival times could be estimated from the mean arrival time obtained from Equation 1 for any assumed value of dispersivity.

To obtain estimates of the mean, first, and peak arrival times for a sorbing tracer, the corresponding arrival times for a conservative tracer can be multiplied by the retardation factor, R, given by:

$$R = 1 + \frac{r_B}{f} k_D \qquad \text{(Eq. 2)}$$

where

k_D = linear partition coefficient, ml/g
ϕ = porosity

To obtain an estimate of travel times in an unconfined system, the 2WELLS_3D code was used (Reimus 1996). 2WELLS_3D is a particle tracking code that simulates tracer transport between two wells in a homogeneous, isotropic medium. It assumes that flow streamlines into the production well follow trajectories given by the prolate spheroidal coordinate system. This coordinate system reduces to spherical coordinates in the limit of a = 0 (i.e., a point source instead of a line source). A number of 2WELLS_3D simulations with zero dispersion were conducted to determine mean nonsorbing tracer residence times as a function of the ratio of well separation to interval length (i.e., length of screen or gravel pack). In the limit of a very large interval length relative to well separation, the residence times approach that given by Equation 1 for radial flow in cylindrical coordinates, and in the limit of a very small interval length relative to well separation, the residence times approach what would be expected for spherical flow:

$$t = \frac{4hpL^3}{3Q} \qquad \text{(Eq. 3)}$$

The ratio of mean residence time in unconfined flow to mean residence time in confined flow was found to have a relatively smooth dependence on the ratio of well separation to interval length. This dependence was captured with a piecewise fit to the simulated data. Using the piecewise fit, it was possible to "correct" the mean residence times obtained from Equation 1 to obtain corresponding residence times for unconfined flow. The same correction factors were assumed to apply to the first and peak arrival times in cases where the dispersivity was not zero. This assumption was verified (though not rigorously) by using 2WELLS_3D to simulate tracer responses with different longitudinal dispersivities.

A final "correction" applied to the calculations described above was to account for shifts in first and peak tracer arrival times due to recirculation of produced water. Recirculation establishes a dipole flow pattern that causes some of the tracer mass to arrive earlier and some later than in the case of no recirculation. A correction factor for various recirculation ratios (ratios of recirculation flow rate to production flow rate) was obtained by simulating a series of tracer responses with different recirculation ratios using the 2WELLS_2D code (Reimus 1996). This code is very similar to the 2WELLS_3D code except that it simulates cross-hole responses in 2-dimensional flow using a cylindrical coordinate system instead of 3-D flow. These simulations assumed no longitudinal dispersion, so the travel time shifts reflected only the changing flow patterns. The correction factor for both first arrival times and peak arrival times was taken to be the ratio of peak recirculation arrival time to the peak arrival time without recirculation.

The methods described above for estimating first and peak arrival times while accounting for dispersion, sorption, unconfined flow, and recirculation ratio in cross-hole tracer tests are amenable to simple spreadsheet calculations once adequate expressions/fits are obtained for the dependence of the correction factors on the appropriate input parameters. A Microsoft Excel spreadsheet was set up for this purpose. It should be noted that the spreadsheet calculations assume that the correction factors are linearly independent and commutative. That is, corrections are made by multiplying the mean residence time (given by Equation 1) by each of the appropriate correction factors for a given set of test conditions. The validity of assuming linear independence of the correction factors was spot-checked with some model simulations, and was generally found to be valid, although this result was not rigorously verified.

Predictions of cross-hole tracer responses in intervals 4 and 1 at the ATC using this simple spreadsheet model and assuming a confined aquifer are presented in Table 4 (DTN: LA0112PR 831231.001). The production rate assumed in all calculations was 80 gallons/min (gpm) for interval 4 and 15 gpm for interval 1, and the longitudinal dispersivity was assumed to be 2.8 m (Peclet number of 10) in all calculations. The predictions are expressed as first and peak tracer arrival times as a function of flow porosity, ϕ, percent recirculation, and K_d values for lithium. The range of lithium K_d values is consistent with laboratory measurements of lithium sorption onto alluvium material from NC-EWDP-19D1, with the lab data indicating that the K_d values ranged from ~1 ml/g to ~6 ml/g. Additional details of the pre-test predictions of cross-hole tracer responses at the ATC will be included in the SZ In-Situ Testing Analyses Report, when published.

Table 4. Predictions of ATC cross-hole response times for conservative solute tracers and lithium in zones 4 and 1 (injection into IM2 and production from 19D1)

Zone 4 Cross-Hole Response Times (80 gpm, 28.3 m well separation, 24 m interval thickness)		
Conservative tracers as function of flow porosity and percent recirculation.		
	First Arrival, days	Peak Arrival, days
ϕ = 0.05, Recirculation = 10%	1.0	3.5
ϕ = 0.1, Recirculation = 10%	1.9	7.0
ϕ = 0.2, Recirculation = 10%	3.9	14.0
ϕ = 0.2, Recirculation = 0%	5.3	18.8
Lithium ion as function of flow porosity, K_d value, and percent recirculation.		
	First Arrival, days	Peak Arrival, days
ϕ = 0.05, K_d = 1 ml/g, Recirc. = 10%	7.0	25.1
ϕ = 0.05, K_d = 6 ml/g, Recirc. = 10%	37.1	133.1
ϕ = 0.2, K_d = 1 ml/g, Recirc. = 10%	28.0	100.4
ϕ = 0.2, K_d = 6 ml/g, Recirc. = 10%	148.5	532.3
ϕ = 0.2, K_d = 6 ml/g, Recirc. = 0%	200.2	717.7

Table 4. Predictions of ATC cross-hole response times for conservative solute tracers and lithium in zones 4 and 1 (injection into IM2 and production from 19D1) (Continued)

Zone 1 Cross-Hole Response Times (15 gpm, 28.3 m well separation, 7.6 m int. thickness)		
Conservative tracers as function of flow porosity and percent recirculation.		
	First Arrival, days	Peak Arrival, days
$\phi = 0.05$, Recirculation = 10%	1.6	5.9
$\phi = 0.1$, Recirculation = 10%	3.3	11.8
$\phi = 0.2$, Recirculation = 10%	6.6	23.6
$\phi = 0.2$, Recirculation = 0%	8.9	31.8
Lithium ion as function of flow porosity, K_d value, and percent recirculation.		
	First Arrival, days	Peak Arrival, days
$\phi = 0.05$, $K_d = 1$ ml/g, Recirc. = 10%	11.8	42.4
$\phi = 0.05$, $K_d = 6$ ml/g, Recirc. = 10%	62.7	224.8
$\phi = 0.2$, $K_d = 1$ ml/g, Recirc. = 10%	47.3	169.5
$\phi = 0.2$, $K_d = 6$ ml/g, Recirc. = 10%	250.7	899.0
$\phi = 0.2$, $K_d = 6$ ml/g, Recirc. = 0%	338.1	1212.1

In the USGS analysis to provide pre-test predictions, the Moench (1989, 1995) semi-analytic solution to the governing advection-dispersion equation (Equation 4 below), obtained using Laplace transforms, was used.

The advection-dispersion equation in radial coordinates is:

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r D_L \frac{\partial C}{\partial r}\right) - v\frac{\partial C}{\partial r} = R\frac{\partial C}{\partial t} \qquad \text{(Eq. 4)}$$

where (r) is the radial coordinate with its origin at the center of the pumped well, D_L is the Longitudinal Dispersion Coefficient (length^2 / time), v is the velocity (length /time), (t) is the time from the start of the tracer test, (C) is the tracer concentration in the pumped well, and R is the solute retardation factor.

Moench (1989, 1995) give the solution for Equation 4 in terms of dimensionless concentration, C_D , versus dimensionless time, t_D. C_D and t_D are related to C and t through the "mean travel time," τ, of Equation 1, which Moench (1989, 1995) refer to as the "advective travel time," t_a.

The Moench (1989, 1995) semi-analytic solution of the advection-dispersion equation for radially-convergent tracer testing is implemented in the USGS software analysis package, MOENCH.vi, version 1.0 (Software Tracking Number: 10582-1.0-00, Software Activity

Number: USGS-2001-160), which is currently going through the Software QA process. MOENCH.vi is a PC-based user interface that implements the Moench (1989, 1995) solution.

Predictions were made using the MOENCH.vi package for the upcoming cross-hole testing to be conducted in the upper-most interval, screen #1, or in the bottom-most interval, screen #4, of the alluvium section at the ATC. These predictions are presented in the next two paragraphs and as DTN: GS 0112083112315.002 (Umari, 2001).

Figure 7 below presents the predicted breakthrough curve for a cross-hole conservative tracer test conducted in interval #1 (screen #1) (32 ft [9.75 m] thick), from IM1 or IM2 to 19D1. It assumes a 25% single-porosity medium (no matrix diffusion), longitudinal dispersivity of 15 ft (4.57 m), complete mixing in the injection and pumped wells, Q = 14 gpm, inter-borehole distance of 82 ft (25 m), borehole diameter of 7 Inches. The peak would occur around 38 days of pumping and it would take about 180 days to define the curve. (The 25-m inter-borehole distance was chosen as representative of the actual 20 and 28.3-m well separations.)

Porosity of 25% above was based on the results of the gravity meter survey at the 19D1 location. If, however, a porosity of 10% is used , then the time base of the breakthrough curve would be 10/25 of what is indicated in Figure 7. In that case, the peak would occur around 38 x (10/25) days, or 15.2 days of pumping, and it would take about 180 x (10/25) days, or 72 days to define the curve.

Figure 8 below presents the predicted breakthrough curve for a cross-hole conservative tracer test conducted in interval (screen) #4 (84 ft [25.6 m] thick), assuming a 25% single-porosity medium (no matrix diffusion), longitudinal dispersivity of 15 ft (4.57 m), complete mixing in the injection and pumped wells, Q = 80 gpm, inter-borehole distance of 82 ft (25 m), borehole diameter of 7 inches. The peak would occur around 18 days of pumping and it would take 85-90 days to define the curve. (As in Figure 7, the 25-m inter-borehole distance was chosen as representative of the actual 20 and 28.3-m well separations.)

Again, porosity of 25% above was based on the results of the gravity meter survey at the 19D1 location. If, however, a porosity of 10% is used, then the time base of the breakthrough curve would be 10/25 of what is indicated in Figure 8. In that case, the peak would occur around 18 x (10/25) days, or 7.2 days of pumping, and it would take around 85-90 x (10/25) days, or 34-36 days of pumping to define the curve.

6.3 TEST METHODOLOGY

6.3.1 Field Testing

Cross-hole hydraulic testing will be conducted in all intervals in the alluvial aquifer in NC-EWDP-19D1 as well as in the entire saturated thickness of the alluvium. During these cross-hole tests, 19D1 will be the pumped well and IM1 and IM2 will be the observation wells. Cross-hole tracer testing will be conducted in a selected isolated interval that corresponds to one of the four screened intervals in 19D1 (most likely interval #4, the fourth interval from the surface, which is the deepest interval completed in the alluvium). A list of the tracers that may be used in tracer testing, and the maximum tracer injection quantities and concentrations is provided in Table 5.

Table 5. Tracers that may be used at the ATC

Tracers	Maximum Quantity	Maximum Test Concentration
Sodium Iodide	20,000 g	20,000 mg/L
Lithium Chloride Lithium Bromide	200,000 g	20,000 mg/L
Samarium Chloride Hexahydrate	10 g	100 ug/L
2, 4-Difluorobenzoic Acid	5,000 g	5,000 mg/L
2,5-Difluorobenzoic Acid	15,000 g	15,000 mg/L
2,4,5-Trifluorobenzoic Acid	15,000 g	15,000 mg/L
2,3,4,5-Tetrafluorobenzoic Acid	15,000 g	15,000 mg/L
Fluorescent CML* Microspheres Polystyrene Microspheres	100 mL of a 2% solution of microspheres	100 mg/L

NOTE: Above is the list of planned tracers for use in the push/pull injection and multi-well tracer test. Refer to the approved UIC and DOE/YMSCO approval letter(s) for the approved tracer list.

*CML refers to carboxylate-modified latex.

In all hydraulic and tracer tests, pressures and temperatures will be recorded in multiple intervals/multiple wells using calibrated pressure/temperature transducers (Westbay in 19IM1, Paroscientific in 19D1 and 19IM2). Inflatable packers will be used to isolate screened intervals in the wells. Barometric pressure and ambient surface temperature will also be recorded. Flow rates will be recorded using calibrated flowmeters. Groundwater samples will be collected for tracer analyses using both a programmable automatic sampler and by manually sampling from faucets in the discharge piping. Water production from isolated intervals will be accomplished using a submersible electric pump. A small pump will be installed in the tracer injection interval to mix the interval during tracer and chase injection. A pool heater system will be used to adjust the temperature of the injected tracer solution and chase water to match, as closely as possible, downhole water temperatures in the test interval.

Prior to conducting tracer tests, intervals 5, 6, and 7 of 19D1 (the intervals completed below the alluvium) will be pumped while interval #4 in 19D1 is isolated by packers (Figure 3). Pressures will be monitored in 19D1 in combined intervals 5, 6, and 7, in interval 4, and above interval 4 during both pumping and recovery. Pressures will also be monitored in intervals 1 through 5 in well IM1 using a Westbay monitoring system installed by Nye County (Figure 5). Following this test, interval 5 in 19D1 will be isolated by inflating a packer between intervals 5 and 6. Isolated interval 5 will then be pumped, and pressures will be monitored in 19D1 in intervals 4 and 5, above interval 4, and below interval 5, as well as in all intervals of IM1 during both pumping and recovery. After this test, the three-packer assembly in 19D1 will be moved up so that intervals 3 and 4 can be isolated, with the pump located in interval 4. Isolated interval 4 will then be pumped for a short time while pressures are monitored in 19D1 above interval 3, in intervals 3 and 4, and below interval 4, and in all intervals of IM1 during both pumping and recovery. While pumping interval 4, the produced water will be collected in storage tanks for future use in tracer testing. The purpose of this hydraulic testing sequence is to determine (1) how much flow is occurring vertically between intervals 4 and 5, and (2) whether this flow appears to be occurring through a leaky well completion in 19D1 or in the aquifer.

If the hydraulic tests described above indicate that a substantial portion of the flow while pumping interval 4 is coming from interval 5 (and below), then cross-hole tracer testing will be conducted in one of the intervals above interval 4 (probably interval #1). However, if a significant amount of flow is attributed to interval 4, then cross-hole tracer testing will be conducted in interval 4, with corrections being applied as necessary to account for flow contributions from interval 5 when tests are interpreted.

A single-well injection-pumpback tracer test will be conducted in one selected interval, followed by cross-hole tracer testing in the same interval. Specifically, work will consist of installing the pump and associated instrument/monitoring string in borehole 19D1 in the selected interval. If interval #4 is selected, the pump and instrumentation string will already be in place for testing. Instrumentation for monitoring pressures in isolated intervals and for injecting tracers will be installed in well IM2 prior to the injection-pumpback test and the open-hole hydraulic test.

After instrumentation of IM2, an open-alluvium hydraulic test will be conducted by pumping intervals 1 through 4 in 19D1 and monitoring IM1 and IM2 (Figures 3, 5 and 6 respectively). This is followed by an injection-pumpback test in 19D1 in the selected tracer-testing interval.

The injection-pumpback test will involve the injection of a fluorinated benzoic acid into the selected interval in 19D1 followed by several thousand gallons of "chase" water. Immediately after the chase water is injected, pumping of the test interval will be initiated to recover the injected tracer as well as to begin a cross-hole hydraulic test of the selected interval. Pressures will be monitored in all intervals of IM1 and IM2 after pumping is started. The cross-hole hydraulic responses will be used to evaluate alternative conceptual flow models of the alluvium and to obtain estimates of hydraulic conductivity (both horizontal and vertical) and storativity in the alluvium. The single-well tracer responses will provide preliminary estimates of transport parameters in the interval as well as allow comparisons with parameter estimates obtained later by cross-hole tracer testing in the same interval.

After a pre-determined mass of a fluorinated benzoic acid (Table 5) is recovered from 19D1 (or concentrations decrease below some pre-determined value), recirculation of approximately 10% of the water produced from 19D1 will be initiated into the test interval in IM2. After flow rates and pressures are steady, the water being recirculated directly from 19D1 will be replaced with 19D1 water containing fluorescent polystyrene microspheres and natural colloids that have ^{152}Sm sorbed onto them. This colloid solution will be injected at exactly the same rate as the recirculation water and without flow interruptions so that there are no flow transients. The colloid tracer solution will be followed by chase water for up to 7 days. After injecting the chase water, a solute tracer solution containing a fluorinated benzoic acid, lithium bromide, and lithium chloride will be injected into IM2 (again without any flow transients). Recirculation will be continued after this injection until solute tracers are detected in the water being produced from 19D1 or until 2 months after injection of the solute tracers, whichever comes first. The microsphere and ^{152}Sm responses will provide estimates of colloid transport parameters and colloid-facilitated radionuclide transport parameters, respectively, in the saturated alluvium. Estimates of longitudinal dispersivity and diffusive mass transfer parameters will be obtained by analyzing each of, and comparing, the responses of the fluorinated benzoic acid and bromide, which are both nonsorbing anion tracers but have diffusion coefficients differing by a factor of about three. Sorption parameters for lithium will be determined by comparing the lithium response to the responses of the two nonsorbing solute tracers. Flow porosity estimates will be based on the mean residence times of the nonsorbing solute tracers, the known pump flow rates, the distance between the wells, and the test interval thickness using the following equation, which is a rearrangement of Equation 1 above (or some slight variation to account for partial recirculation and/or "leakage" between intervals):

$$\varphi = \frac{Q\,\tau}{\pi L^2 T} \qquad \text{(Eq. 5)}$$

where

φ = flow porosity
Q = production flow rate, m^3/hr
τ = mean residence time of a conservative tracer, hr
L = distance between wells, m, and
T = formation thickness (assumed to be well screen length), m.

Within two months, the partial recirculation into IM2 will be stopped and a purely-convergent conservative tracer test will be started by injecting a fluorinated benzoic acid, followed by a small amount of chase water, into IM2. This injection will be followed, within a few days to a few weeks, by the injection of a fluorinated benzoic acid and sodium iodide, followed by a small amount of chase water, into the test interval in IM1 using the Nye County Westbay system for injection. Pumping of 19D1 and monitoring of interval pressures in all test wells will be continued during and after these tracer injections. The purely-convergent tracer injection into IM2 will allow comparisons between the tracer responses between IM2 and 19D1 under both weak-dipole and convergent flow conditions, which will provide information on flow heterogeneity in the aquifer. The tracer responses between IM1 and 19D1 will provide information on flow porosity, longitudinal dispersivity, and diffusion into stagnant water in a different direction than the IM2-to-19D1 direction. The tracer responses will also provide additional information on flow heterogeneity in the aquifer.

After the breakthrough curves from the above tracer tests are well enough developed to ensure their successful analysis for transport properties (effective porosity, longitudinal dispersivity, sorption, extent of diffusion into stagnant water, and colloid and colloid-facilitated transport parameters), the injection intervals in IM1 and IM2 will be pumped or sampled to obtain information on the masses/concentrations of tracers remaining in the injection wells. This information will help in the interpretation of the tracer tests. Isolated-interval cross-hole hydraulic tests will then be conducted in the intervals that were not pumped during cross-hole tracer testing. 19D1 will be used as the pumping well in these hydraulic tests. The cross-hole hydraulic tests will provide estimates of hydraulic conductivity and storativity (and also confirm conceptual flow models) in the alluvium intervals.

When interpreting the hydraulic and tracer tests, alternative flow and transport conceptual models will be evaluated against each other both qualitatively and quantitatively to ensure that the conceptual model that is most consistent with the hydraulic and tracer data is used for subsequent analyses. Hydraulic parameters will then be estimated by adjusting parameters in an appropriate semi-analytical "type-curve" to match the observed cross-hole pressure responses.

Numerical models will be used as necessary to refine parameter estimates and test interpretations. Transport parameters will be estimated from tracer responses by adjusting transport model parameters in both semi-analytical and numerical models to match observed tracer responses. For several transport parameters, estimates will be based on differences in the responses of different tracers with different physical and chemical properties rather than on absolute tracer responses of individual tracers.

6.3.2 Laboratory Testing

A significant amount of laboratory testing was conducted in FY 2001 to characterize the sorption of lithium ion onto alluvium materials in the saturated zone in NC-EWDP-19D1. Lithium will be used as a reactive tracer in cross-hole tracer testing, and comparing its field transport behavior with its laboratory transport behavior is an important objective of ATC testing because a favorable comparison will lend credibility to the Project’s approach of using laboratory-derived radionuclide sorption parameters in field-scale predictions of radionuclide transport. A summary of the FY 2001 test results is provided here.

Laboratory tests that have been conducted to support the ATC testing program have included:

- Batch sorption measurements of lithium ion onto alluvium materials from several different intervals in NC-EWDP-19D1.
- Column transport experiments investigating the transport of lithium ion relative to bromide and pentafluorobenzoate in columns packed with alluvium material.
- Measurements of mineralogy, surface area, and cation exchange capacity of alluvium samples to assist in the interpretation of the batch and column experiments.

Figure 9 shows the experimental dependence of lithium K_d values determined from batch sorption experiments on different depth intervals in –19D1 and –19P. Other experimental results have indicated that lithium sorption depends strongly on the zeolite content of the alluvium samples, with less dependence on clay (e.g., smectite) content. The fact that the larger sieve size fraction tended to have lower K_d values in Figure 9 is consistent with the fact that zeolites and clays tend to be concentrated in smaller size fractions in the alluvium.

Laboratory testing in FY 2002 will focus on measuring rates and extents of sorption and desorption of samarium onto natural colloids collected from NC-EWDP-19D1, as field testing plans include the use of ^{152}Sm-tagged natural colloids in cross-hole tracer testing. An understanding of the rates and extents of sorption and desorption are critical to obtain a quantitative interpretation of the field test results that provides unambiguous colloid-facilitated transport parameters for TSPA. Additional lithium sorption tests may be conducted in FY 2002 primarily to compare lithium sorption with the sorption of radionuclides such as ^{237}Np so that field test results can be used to make more defensible predictions of radionuclide transport in the alluvium.

6.3.3. Analytical Laboratory Support

Analytical laboratory measurements of tracer concentrations in water samples will be conducted to support both field and laboratory tracer tests. Procedures that describe these analytical methods will include:

LANL-EES-4-DP-803, R1 Use of Flow Cytometer to Determine Particle Concentrations in Solution

LANL-EES-5-DP-705, R0, Determination of Metals in Aqueous Solutions By High Resolution ICPMS

LANL-CST-DP-107, R1, Use of ICP Atomic Emission Spectrometry to Determine Constituent Concentrations in Solution

IPLV-008, Measurement of Inorganic Anions in Water Samples by the Ion Chromatography System

IPLV-004, High Performance Liquid Chromatograph Operation

Tracer analyses using these instruments will be conducted in accordance with approved quality assurance procedures listed in Section 3.1.

6.3.4 Testing Modifications

Modifications to this testing methodology may be required in the future and will be captured in the scientific notebooks maintained by project staff. Future detailed execution of this plan must remain flexible to satisfy testing requirements based on:

- emerging PA requirements based on model updates and new regulatory requirements
- performance confirmation baseline needs
- technical community expectations
- oversight body concerns and comments
- priorities relative to competing programmatic needs (e.g., UZ, near-field environment, biosphere, facility design)
- budget allocations.

6.4 IDENTIFICATION OF COMPUTER SOFTWARE

The software codes and routines used to support the conduct and interpretation of ATC field and laboratory tests are listed below. Some of this software is currently in the process of being qualified, but all software will be qualified before it is used for ATC activities.

1. Software routine: rcv2amos.exe, V 2.0, Software Tracking Number (STN) (10583-2.0-00)

The software routine rcv2amos.exe, V2.0, is used to analyze cross-hole tracer tests. rcv2amos.exe is a FORTRAN program developed to solve the advection-dispersion equation using Laplace transforms. The software is identified by software activity number (SAN) U.S. Geological Survey (USGS)-2001-161, with the (STN: 10583-2.0-00). Currently, this code is being qualified under AP-SI.1Q, as Level 3 software.

2. Software routine: MOENCH.vi, V1.0, (STN: 10582-1.0-00)

In conjunction with use of rcv2amos.exe, the routine MOENCH.vi, version 1.0, was developed to serve as a user interface and to display the results from rcv2amos.exe, V2.0. The MOENCH.vi routine, V1.0, is identified by SAN: USG-2001-160, having the STN: 10582-1.0-00. Currently, this code is being qualified under AP-SI.1Q, as Level 3 software.

3. Software routines: THEIS, HANTUSH_LEAKY, NEUMAN_UNCONFINED, STRELTSOVA_ADAMS

User interfaces have been developed to facilitate the analysis of hydraulic tests using type-curve matching techniques. The interfaces THEIS.vi, STRELTSOVA_ADAMS.vi, NEUMAN.vi, and HANTUSH.vi, were developed and qualified under the USGS software QA program and given the following software identification assignment numbers:

THEIS.vi	ESP5.91
HANTUSH_LEAKY.vi	ESP5.94
NEUMAN_UNCONFINED.vi	ESP5.96
STRELTSOVA_ADAMS.vi	ESP5.92

Recently, these user interfaces, in addition to two new ones (COOPER-JACOB.vi and DERIVATIVE.vi), have been combined into one hydraulic analysis package, HYDRAULIC-ANALYSIS.vi's, version 1.0, with SAN: USGS-2001-254, and STN: 10676-1-00. Currently, this code is being qualified under AP-SI.1Q.

4. Software code: RELAP V2.0 Software Tracking Number (STN) 10551-2.0-00, Software Activity Number (SAN) LANL-2001-131

RELAP is a FORTRAN code that operates with an Excel Spreadsheet interface for input and output control. It is used to obtain transport parameter estimates from field or laboratory tracer data by fitting a single- or dual-porosity transport model to the data using a least-squares algorithm. RELAP solves the advection-dispersion equation for a single- or dual-porosity system using a Laplace transform inversion algorithm. It is capable of simulating sorbing or nonsorbing tracer behavior, full or partial recirculation, wellbore mixing, and delay times in pipes. This software is currently in the process of being qualified under AP-SI.1Q.

5. Software code: RETRAN, V2.0 Software Tracking Number (STN) 10552-2.0-00, Software Activity Number (SAN) LANL-2001-132

RETRAN is a FORTRAN code that operates with an Excel Spreadsheet interface for input and output control. It differs from RELAP in that it is a numerical model rather than a semi-analytical model. It offers the capability to model nonlinear sorption behavior and flow transients in tracer tests. This software is currently in the process of being qualified under AP-SI.1Q.

6. Software code: MULTRAN, V1.0, (STN: 10666-1.0-00, SAN: LANL-2001-244)

This software is used for analysis of laboratory crushed rock and alluvium column experiments. It is also used for the analysis of the first peak in the Bullfrog Tuff C-wells field tracer test. This software is currently in the process of being qualified. This software is currently in the process of being qualified under AP-SI.1Q.

7. Software code: DIFFCELL, V2.0 Software Tracking Number (STN) 10557-2.0-00, Software Activity Number (SAN) LANL-2001-130

This software is used in the analysis of laboratory diffusion cell experiments.

8. Software code: 2WELLS_2D, V1.0, (SAN: LANL-2001-243)

This software is used in the analysis of longitudinal dispersivity in the Prow Pass Tuff C-wells field tracer test. It is also used for pre-test predictions of cross-hole tracer tests in alluvium. This software is currently in the process of being qualified. This software is currently in the process of being qualified under AP-SI.1Q.

9. Software code: 2WELLS_3D, V1.0, (SAN: LANL-2001-245)

This software is used in pre-test predictions of cross-hole tracer tests in alluvium. This software is currently in the process of being qualified.

10. Software code: EQUIL_FIT, V1.0, (SAN: LANL-2001-246)

This software is used to obtain cation exchange coefficients given experimental data on cation sorption (both for sorbing and displaced cations) and also given independent cation exchange capacity measurements. This software is currently in the process of being qualified under AP-SI.1Q.

11. Software routine RECIRC.vi (STN: 10673-1.0-00; SAN: USGS-2001-251)

Program used for analyzing full-recirculation and partial-recirculation cross-hole tracer tests. This software is currently in the process of being qualified under AP-SI.1Q.

12. Software routine: INJECTION-PUMPBACK.vi, version 1 (STN: 10675-1-00; SAN: USGS-2001-253)

Used for analyzing single-well injection-pumpback tracer tests. Analysis considers tracer injection, drift, and pumpback phases. This software is currently in the process of being qualified under AP-SI.1Q.

13. Software routines: ATC_001.vi (STN: 10475-VI-00); ATC_003.vi (STN: 10480-VI-00); ATC_004.vi (STN: 10481-VI-00); ATC_005.vi (STN: 10482-VI-00); ATC_005B.VI (STN: 10483-VI-00); ATC_005D.vi (STN: 10484-VI-00)

These are data acquisition routines.

The commercial software Microsoft Excel will be used for statistical analysis of data and plotting graphs. Only built-in standard functions in this commercial software will be used. Microsoft Excel was also used to generate pre-test predictions of tracer responses in this test plan.

The commercial software LabView (Johnson 1995) is a platform that is used for generating the user interfaces for: MOENCH.vi, V1.0; RECIRC.vi; INJECTION-PUMPBACK.vi; {HYDRAULIC-ANALYSIS.vi's, V1.0: THEIS.vi, V1.0; HANTUSH_LEAKY.vi, V1.0; NEUMAN_UNCONFINED.vi, V1.0; STRELTSOVA_ADAMS.vi, V1.0; COOPER-JACOB.vi, V1.0; and DERIVATIVE.vi, V1.0}

Labview VI's (subroutines, or "virtual instruments") will also be used for data acquisition and control of the automatic sampler at the ATC field site.

6.5 DATA RECORDING AND DATA REDUCTION

Table 6 lists the data that will be recorded during the conduct of ATC field and laboratory testing. Table 6 is not necessarily an all-inclusive list, but it captures the principal data recording requirements that can be foreseen prior to the start of testing. Additional data recording requirements may be added as testing progresses. The data listed in Table 6 will be acquired/recorded by a combination of automated data acquisition systems (e.g., the downloading of data from pressure transducers and flow meters by the Labview system) and scientific notebook entries. The data acquired by automated data acquisition systems will be transferred to Excel spreadsheets prior to data submittal to the TDMS.

Table 6. ATC Data to be Recorded (not necessarily all-inclusive)

Test Data to be Recorded	
a) Flow rates (in or out of wells) and downhole pressures and temperatures as a function of time.	b) Background ground water chemistry (including all tracer concentrations)
c) Tracer injection masses, concentrations, and volumes	d) Injection durations
e) Chase volumes and durations	f) Shut-in durations
g) Times at which samples are collected	h) Packer inflation pressures
i) Ambient (barometric) pressures and temperatures.	j) Tracer concentrations (and isotopic composition of Sm) as a function of time in discharge from well(s)
k) Weights, volumes, times, concentrations and identities of materials associated with laboratory sorption and transport tests.	l) Compositions and other properties of alluvium materials as determined by X-ray diffraction, BET isotherm measurement, cation exchange capacities, and organic carbon analysis.

Data reduction will be performed by a combination of hand calculations, calculations performed within Labview subroutines, spreadsheet calculations, and developed software calculations. Data reduction will span a range of complexity from simple unit conversions or conversions of voltages (from transducers and flow meters) to pressures and flow rates to detailed simulations by developed software to obtain flow and transport parameter estimates. Parameters that represent the end product of data reduction activities are listed in Table 7.

Table 7. Parameters Obtained from Data Reduction (not necessarily all-inclusive)

Parameters	
a) Transmissivity	b) Storativity
c) Flow Velocity/Specific Discharge	d) Hydraulic Conductivity
e) Effective Flow Porosity	f) Longitudinal Dispersivity
g) Tracer Diffusion Parameters	h) Tracer Sorption Parameters
i) Colloid Transport Parameters	j) Colloid-Facilitated Transport Parameters

Reduced data will be submitted to the TDMS according to project procedures.

6.6 ANALYSIS AND MODELING DURING AND AFTER TEST

Excel spreadsheets will be used to reduce hydraulic and tracer data during testing and to plot the reduced data as drawdown curves, tracer breakthrough curves, or other types of curves (e.g., flow rates vs. time). These types of rudimentary analyses are necessary to make decisions about modifying test conditions or completing certain phases of testing. They are also necessary for environmental reporting purposes.

The developed software listed in Section 6.4 will be used during and after testing to determine conceptual model applicability and to obtain estimates of flow and transport parameters as testing progresses. These more detailed analyses will also help determine when tests have progressed long enough to satisfy test objectives.

6.7 METHODS TO RECORD DATA AND RESULTS

Data will be recorded in scientific notebooks and Excel spreadsheets (which will become attachments to scientific notebooks). Results (e.g., parameters deduced from test interpretations) will be recorded in scientific notebooks or in documentation that is generated as a result of following software quality assurance procedures. Results will also be recorded (in summary form) in the SZ In-Situ Testing Analyses Report.

6.8 ACCURACY AND PRECISION

6.8.1 Experimental/Sampling Artifacts

6.8.1.1 Control/Determination of Independent Conditional Variables

The independent conditional variables for ATC testing are listed in Table 6. Experimental or sampling artifacts will occasionally occur for variables such as pressures and flow rates (e.g., spurious data points). They could also occur for other test variables. Such artifacts will generally be apparent from detailed examination of the data.

Artifacts in tracer concentrations could occur as a result of tracers unexpectedly sorbing to test equipment, microbial degradation of tracers, or from background tracer concentrations (in the ground water) that vary during testing. Such artifacts will be difficult to identify during or after testing. The tracers selected for testing and/or the methods employed were selected in part because they should be minimally affected by such artifacts.

Suspected artifacts in any collected data will be noted in scientific notebooks.

6.8.1.2 Control/Determination of the Boundary Conditions

Boundary conditions will not be controlled in the field tests. Cross-hole pressure responses may provide some indication of flow boundaries (for instance vertical boundaries that confine an aquifer or recharge boundaries), which can be factored into hydraulic and tracer test interpretations. Tracer injections will be conducted under controlled conditions (e.g., mixing in injection interval, chase with known water volumes) so that the tracer source function in tracer tests is reasonably well understood.

Laboratory column transport tests will have well-defined geometrical boundaries that will be accounted for in test interpretations.

6.8.2 Instrument Calibration and Instrument Error

6.8.2.1 Instrument Calibration

To ensure that the collected data meet the project needs, all field instruments will be calibrated in accordance with AP-12.1Q, *Control of Measuring and Test Equipment and Calibration Standards*. The instruments will either be calibrated by the Bechtel Nevada Standards and Calibration Laboratory or by other vendors on the OCRWM Qualified Suppliers List. Where applicable, closing calibrations will be obtained to ensure that test data were obtained with instrumentation that remained calibrated throughout the test. Calibration information will be documented in scientific notebook SN-USGS-SCI-123-V1 [Initial volume of the USGS] Alluvial Testing Complex [ATC] Scientific Notebook or attachments to notebooks. Calibration information also will be submitted with data packages resulting from the testing. Calibration of laboratory and analytical instruments is governed by AP-12.1Q and by detailed procedures listed in Section 3.1. These calibrations will be documented in scientific notebooks, which are yet to be designated.

6.8.2.2 Instrument Error

For most instruments, errors associated with instrument malfunction will be immediately apparent from the readouts/plots generated on the computer monitor associated with the Labview data acquisition system (or from data files generated by the system). Malfunction will generally involve loss of signal or nonsensical readings. These occurrences will be noted in scientific notebooks. Errors could also occur if the conversion factors for electronic signals (voltage, amps, etc.) to pressures or flow rates are inaccurate or the conversion factors are input incorrectly. The instrument calibration and unit conversion factors will be checked manually for correctness.

For laboratory instruments, instrument malfunction will be immediately apparent from a lack of instrument response, from nonsensical output, or from significant errors in measurements of check standards.

Suspected instrument errors will be noted in scientific notebooks.

6.8.3 Handling Unexpected Results/Conditions

6.8.3.1 Unexpected Results

In the event that the collected data differ substantially from the pre-test calculations, the modeling assumptions and conditions may require re-evaluation. The differences in the results will be assessed to determine why the results are outside of the ranges as predicted in Section 6.2. Possible determinations are that the assumed conceptual model is incorrect, or that the model parameters are substantially different from expected. If necessary, the test may be modified.

6.8.3.2 Unexpected Conditions

Most likely unexpected conditions are:

- out of range readings from the data collection system
- extended power failure
- pump failure.

Unless such conditions persist, the test will be allowed to continue. Unexpected conditions will be evaluated to determine their potential impact on the test to acquire the needed data and to determine whether the test must be modified or terminated. All unexpected conditions will be noted in scientific notebooks so that their impact on test results and interpretations can be fully evaluated.

6.8.4 Approach for Test Results

Accuracy and precision of test results will be evaluated and documented in scientific notebooks. Methods of determining accuracy and precision of test results could include: propagation of error analysis (e.g., for measurement errors), analysis of data scatter, measurements of check standards, pre- and post-test calibration data, estimation of confidence intervals for model parameter estimates.

7. INTERFACE CONTROL

7.1 PERFORMANCE ASSESSMENT

Total System Performance Assessment models and associated process models at the site and regional scales will implicitly and explicitly use conceptual model validations and parameter estimates obtained from ATC testing. The processes of model prediction, calibration, and validation can improve the confidence and credibility of models used for performance assessments.

7.2 DESIGN

Repository design and construction are not direct customers for data from the SZ program except for water level rise estimates that could impact design requirements. (It is unlikely that relevant information will be collected at the ATC.

7.3 PROCESS MODELS

Data obtained from the test are to be evaluated and summarized in the AMRs as appropriate detailing in-situ field properties, flow and transport. Modeling of the ATC experiment is critical to the overall investigation as it will help in the interpretation of field observations and provide input for the SZ site-scale process models.

7.4 PARAMETERS

The flow and transport model parameters that will be obtained from ATC test interpretations will be reported to the TDMS. Uncertainty distributions for these parameters will be developed and used in process and performance assessment models.

8. MANDATORY HOLD POINTS

Hold points are hereby placed on hydraulic and tracer testing for the ATC single and multi-well testing. No pumping and/or tracer injection shall occur until the DOE/YMSCO approvals are issued and documented. To close the hold points, the issuance of approvals and documentation must be completed. The Pre-Work briefing forms will be included in the FWP records package.

Additional Pre-Work briefing may be held for communicating environmental stipulation changes or modifications from approval letters.

8.1 HYDRAULIC TESTING

1. DOE/YMSCO environmental approval letter (AP-EM-002) shall be issued.
2. The TCO must conduct a Pre-Work briefing (AP-2.23Q) to ensure environmental stipulations are presented and understood by the PIs/Designees performing the work.

8.2 PUSH/PULL AND MULTI-WELL TRACER TESTING

1. The applicable State of Nevada permits (UIC) and DOE/YMSCO environmental approval letter shall be issued.
2. The TCO must conduct a Pre-Work briefing to ensure environmental stipulations are presented and understood by the PIs/Designees performing the work.

8.3 MULTI-WELL TRACER TESTING WITH SAMARIUM

The applicable State of Nevada permits (UIC) and DOE/YMSCO environmental approval letter shall be issued.

8.4 STOP WORK

Affected organizations must inform the TCO if quality-related work elements cannot be conducted as described in this SITP and the FWP. The TCO, will, if applicable, stop work on those elements. If SITP or FWP revisions are required, work on affected elements will be stopped until the modifications have been completed and controlled by the Project. Any YMP employee who discovers a condition or practice that creates, or if allowed to persist would create, any imminent danger to workers, the public, or the environment has the authority to stop work. The YMP personnel rights relating to S&H imminent danger conditions are described in Workers' Rights and the Attachment on Workers' Rights of the Occupational Safety and Health Plan (AP-ESH-004).

9. SECURITY

9.1 BOREHOLE OWNERSHIP AND CONTROL ACCESS

The Nye County NWRPO will retain ownership of the boreholes through the ATC testing. The YMP assumes all liability associated with the tracer injections testing as written in the approval letters for Underground Injection Control, Water Appropriation, and the "Cooperative Agreement" between DOE and Nye County. Nye County will control access to the borehole and drill site (i.e., protection of the equipment and borehole) during the duration of testing. Nye County will be responsible for right-of-way for the ATC testing activities.

9.2 DESCRIPTION OF FACILITY SECURITY MEASURES

The ATC test facility is surrounded by a security fence with gates that are locked with padlocks with controlled keys issued by Nye Co. The instrumentation, data loggers, or sample collection equipment is either down-hole or secured in a locked temporary trailer. Nye Co. Sheriffs Department provides off-hours test facility security. Participants from Nye Co., BSC, or USGS during major activities man the facility. At those times, the persons on site who have been issued keys are tasked with maintaining test bed and data security.

DOE/NV Safeguard and Security Division (SSD) provide auxiliary supports (as necessary and requested), YMP/BSC Security Department, and Wackenhut Services (WSI). All work performed at the ATC test facility will be performed in compliance with Nye Co. DOE, YMP/BSC, and WSI security orders/directives.

10. OTHER INFORMATION

Other information related to this test is contained in scientific notebooks maintained by the project scientists and will be included as portions of a record package or in the final records packages documenting this activity during closeout.

11. REFERENCES

Johnson, G., 1995. *Labview: graphical programming and application development*: New York, N.Y., McGraw-Hill, p. 606.

Moench, A.F., 1989. *Convergent radial dispersion: a Laplace transform solution for aquifer tracer testing*, Water Resources Research, v. 25, no. 3, pp. 439-447.

Moench, A.F., 1995. *Convergent radial dispersion in a double-porosity aquifer with fracture skin: Analytical solution and application to a field experiment in fractured chalk*, Water Resources Research, v. 31, no. 8, pp. 1823-1835.

Reimus, P., 2001, Pre-test calculations/analysis/model predictions for Cross-Hole Testing at the ATC. DTN: LA 0112PR 831231.001.

Robinson, B. 2001. *Technical Work Plan for Saturated (SZ) Zone Flow and Transport Modeling and Testing*. OCRWM Plan: TWP-NBS-MD-000001. ACC: MOL.20010924.0269.

Umari, M.J. 2001. Predicted breakthrough curves for cross-hole conservative tracer tests at Nye County wells to be conducted starting early 2002 at the alluvial testing complex in southern Nevada. DTN: GS011208312315.002.

Wasson, E. 2001A. *Field Work Package for Alluvial Tracer Testing* OCRWM Plan: FWP-SBD-99-002.

Wasson, E. 2001B. Field Work Package for Nye County Early Warning Drilling Program (EWDP) Phase II, III, and Alluvial Testing Complex (ATC) Drilling OCRWM Plan: FWP-SBD-99-001, ACC: MOL.20010709.0367.

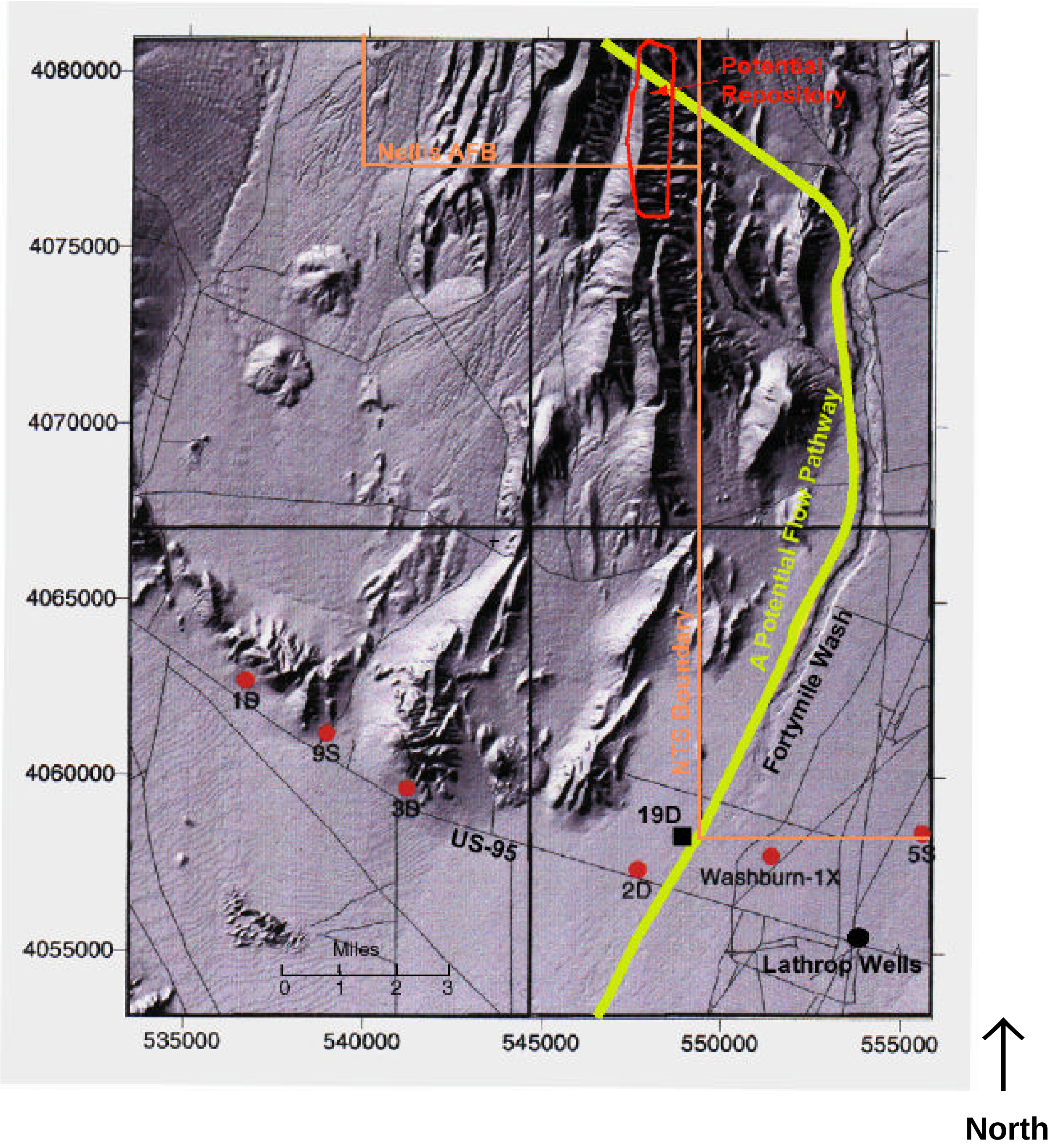


Figure 1. Location of ATC (19D on this map)

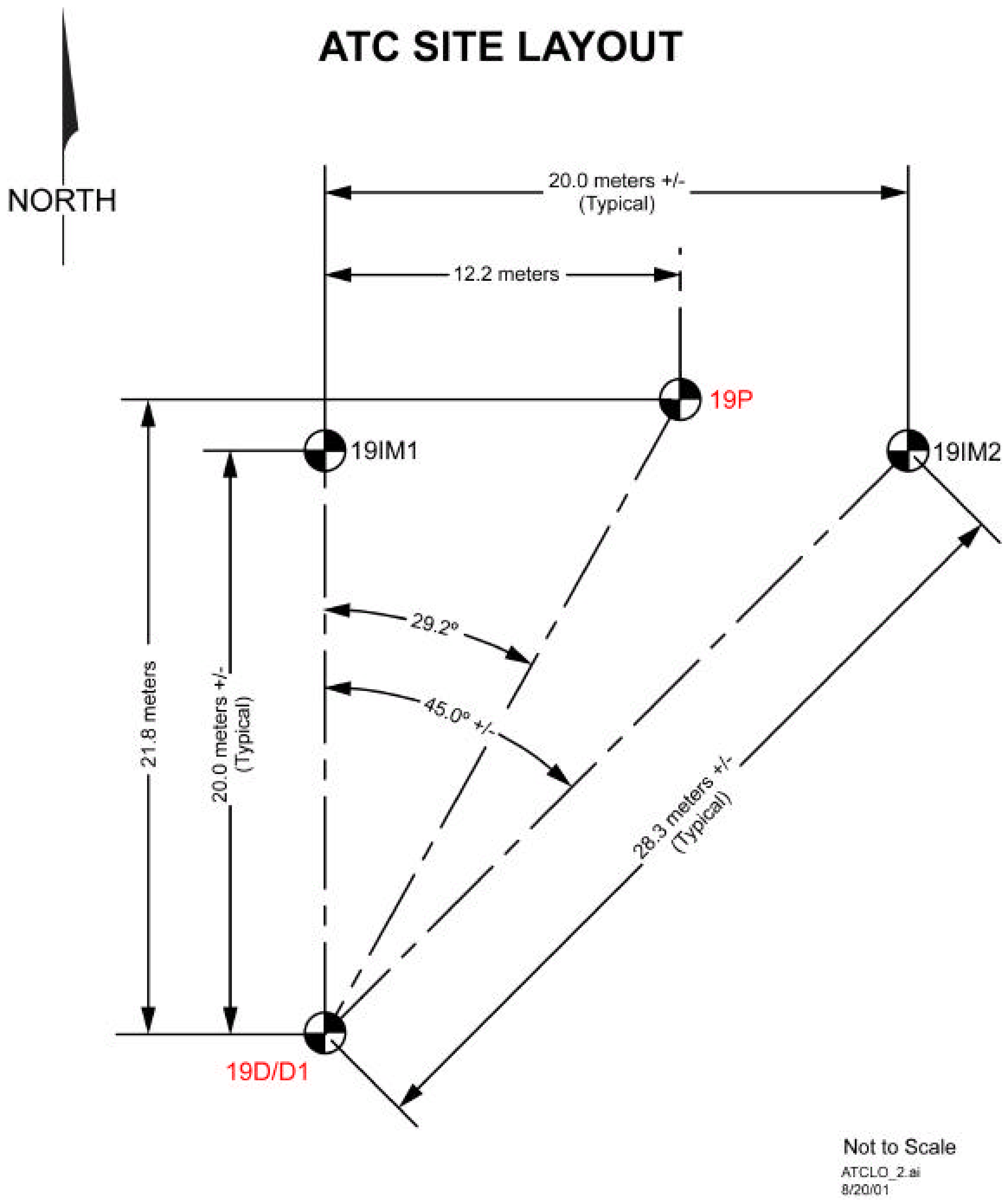
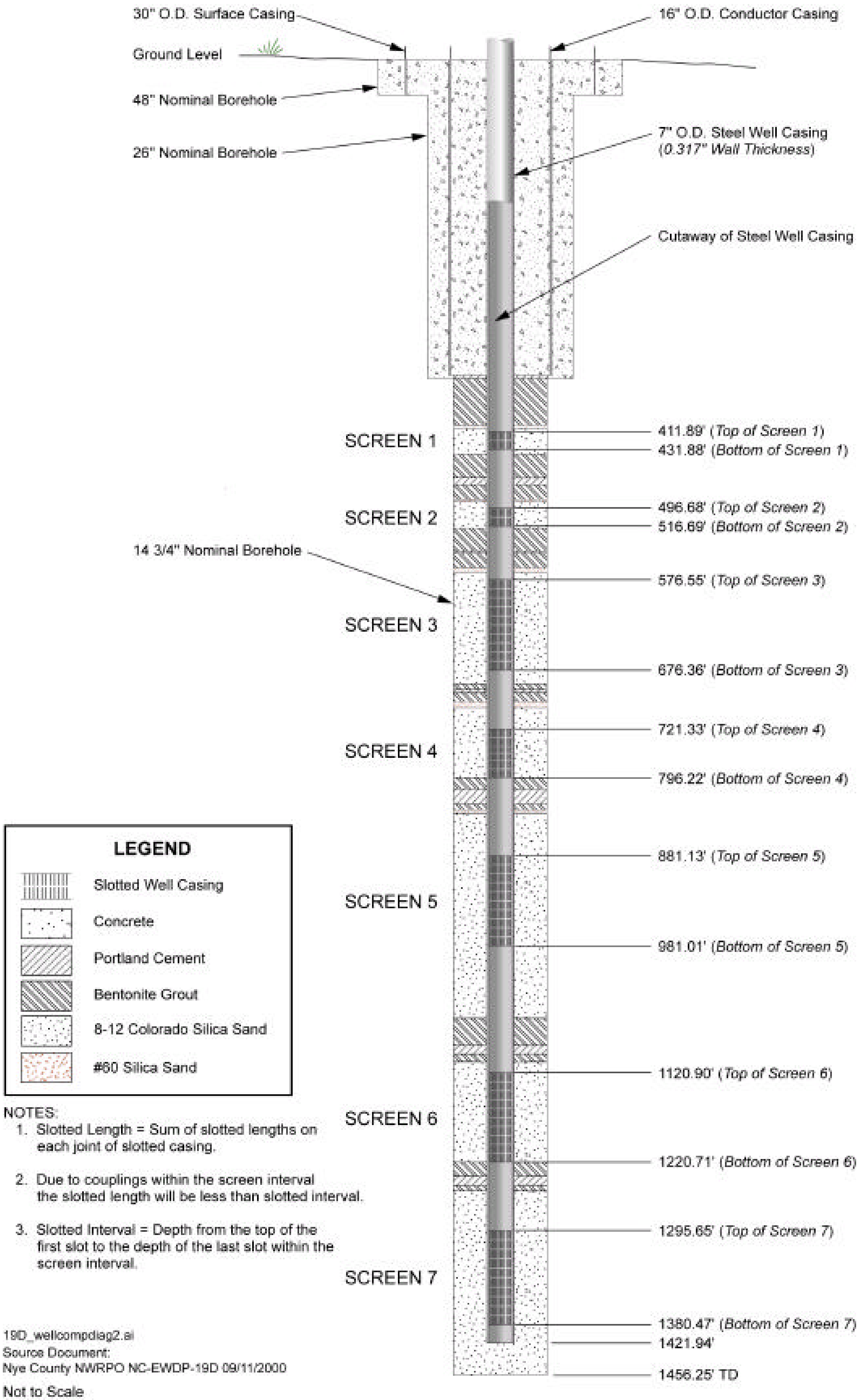


Figure 2. General Layout of the ATC Complex (includes Phase II wells EWDP-NC-19D/D1 and EWDP-NC-19P as well as Phase III wells EWDP-NC-19-IM1 and EWDP-NC-19-IM2)



NOTES:
1. Slotted Length = Sum of slotted lengths on each joint of slotted casing.
2. Due to couplings within the screen interval the slotted length will be less than slotted interval.
3. Slotted Interval = Depth from the top of the first slot to the depth of the last slot within the screen interval.

19D_wellcompdiag2.ai
Source Document:
Nye County NWRPO NC-EWDP-19D 09/11/2000

Not to Scale

Figure 3. Completion Diagram for NC-EWDP-19D1

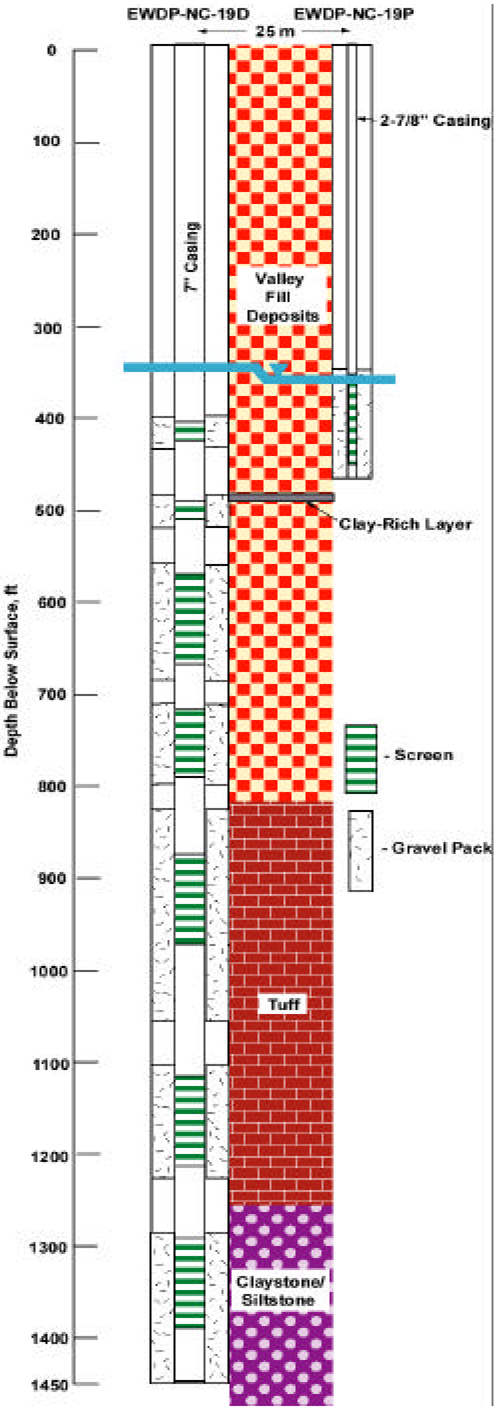


Figure 4. Generalized Schematic of Lithology at NC-EWDP-19D1 and NC-EWDP-19P

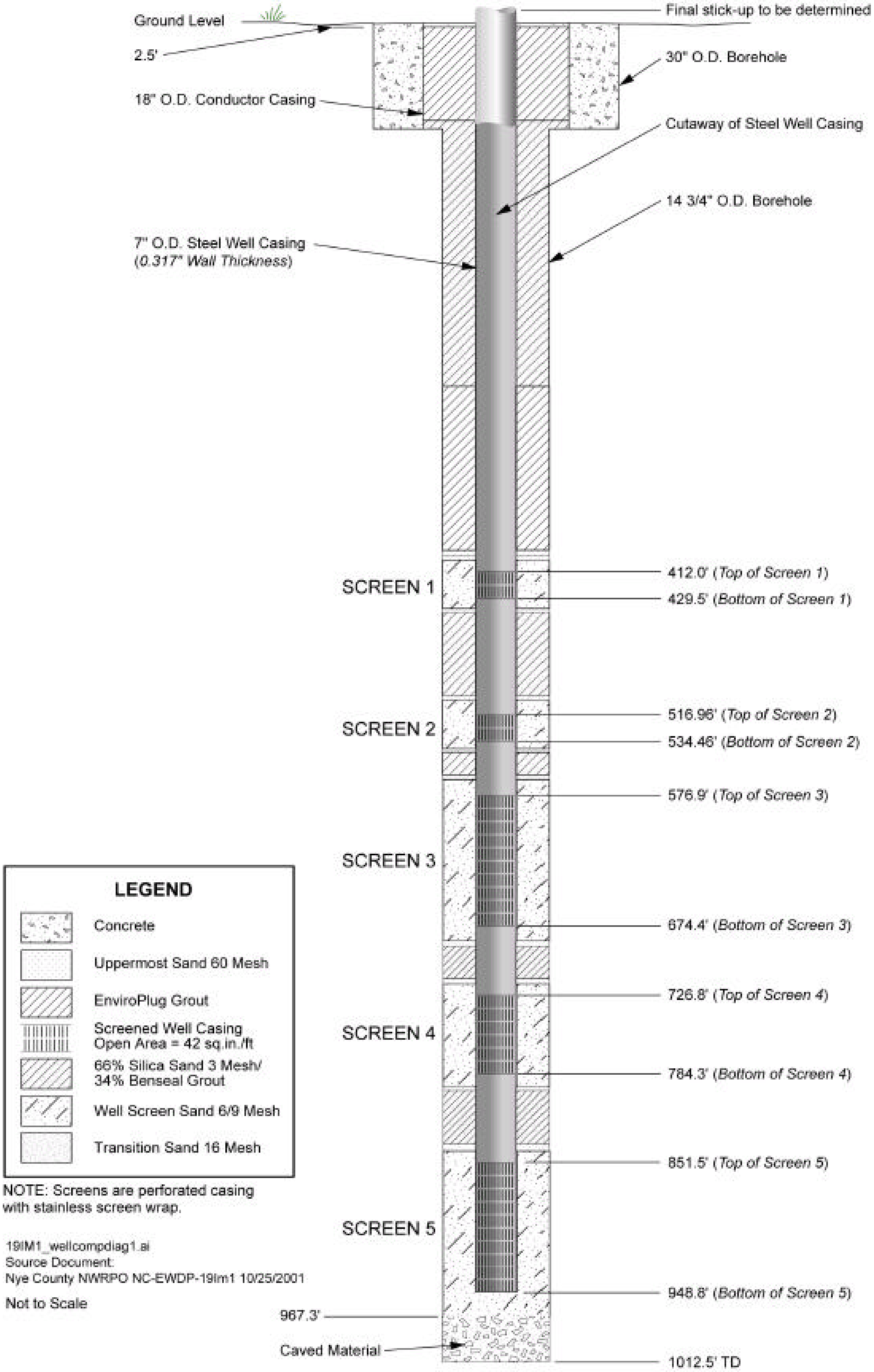
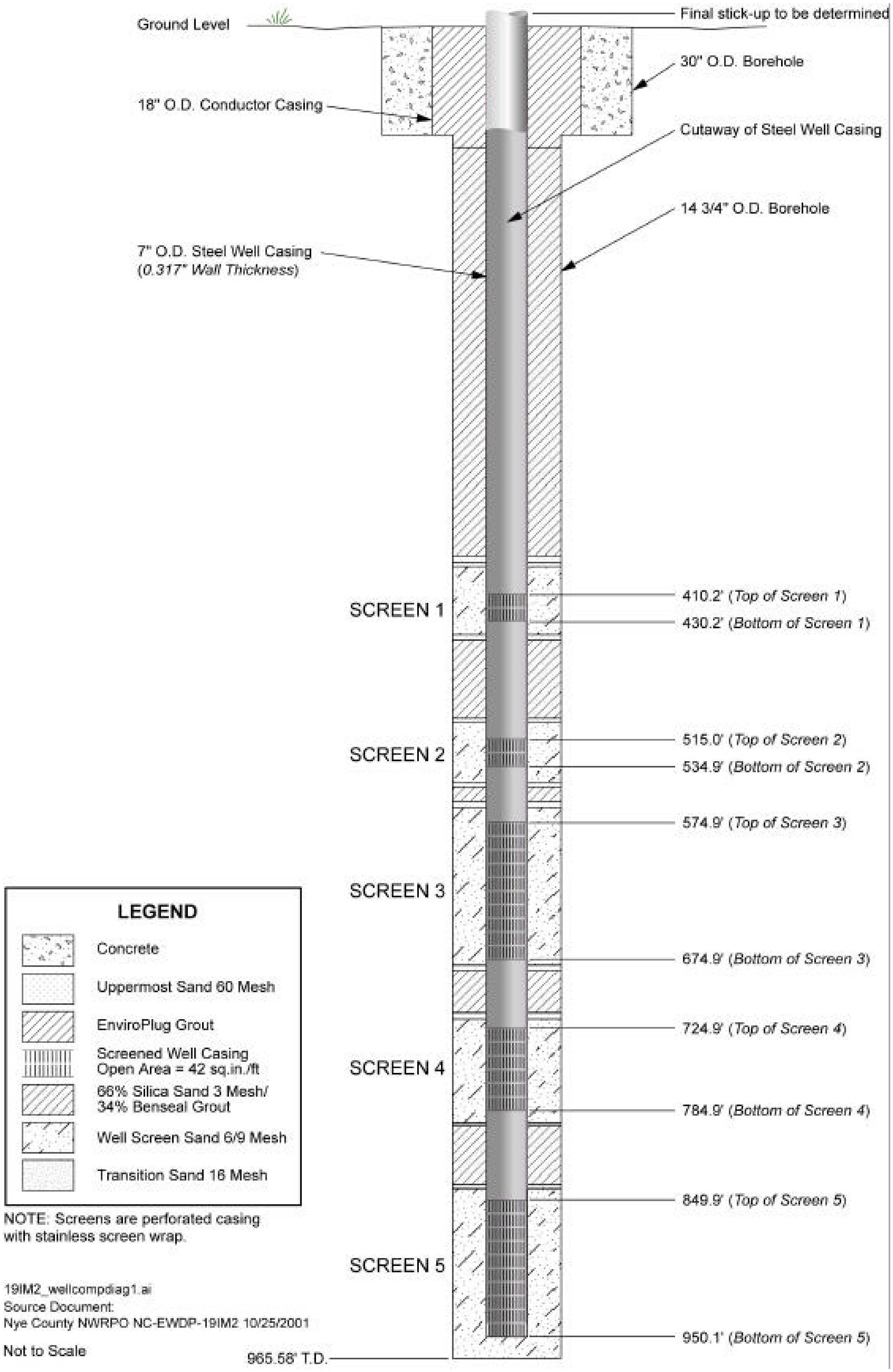


Figure 5. Well Completion Diagram of NC-EWDP-19IM1 (courtesy of Nye County)

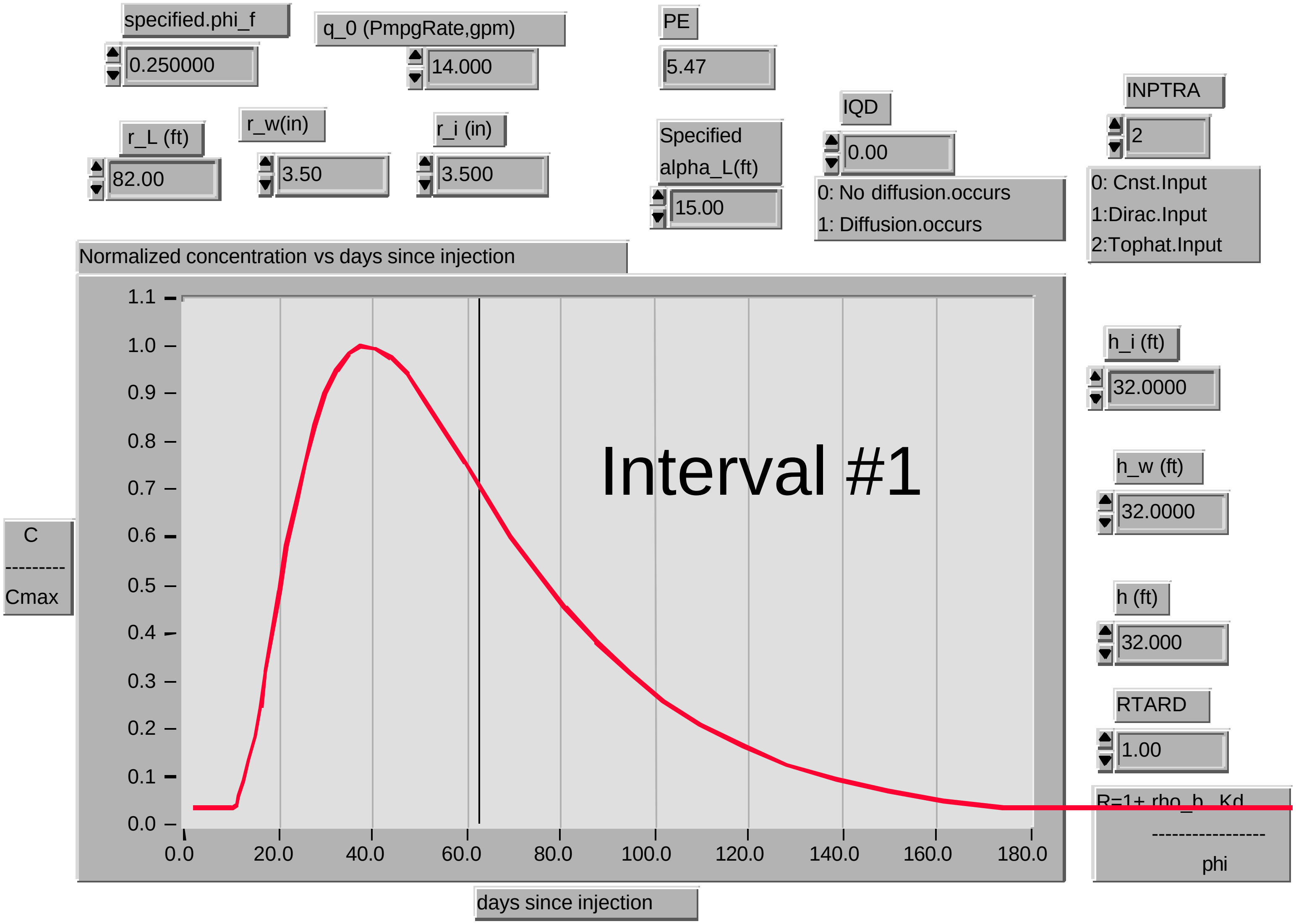


NOTE: Screens are perforated casing with stainless screen wrap.

19IM2_wellcompdiag1.ai
Source Document:
Nye County NWRPO NC-EWDP-19IM2 10/25/2001

Not to Scale

Figure 6. Well Completion Diagram of NC-EWDP-19IM2 (courtesy of Nye County)



specified.phi_f 0.250000

q_0 (PmpgRate,gpm) 14.000

PE 5.47

r_L (ft) 82.00

r_w(in) 3.50

r_i (in) 3.500

Specified alpha_L(ft) 15.00

IQD 0.00

0: No diffusion.occurs
1: Diffusion.occurs

INPTRA 2

0: Cnst.Input
1:Dirac.Input
2:Tophat.Input

h_i (ft) 32.0000

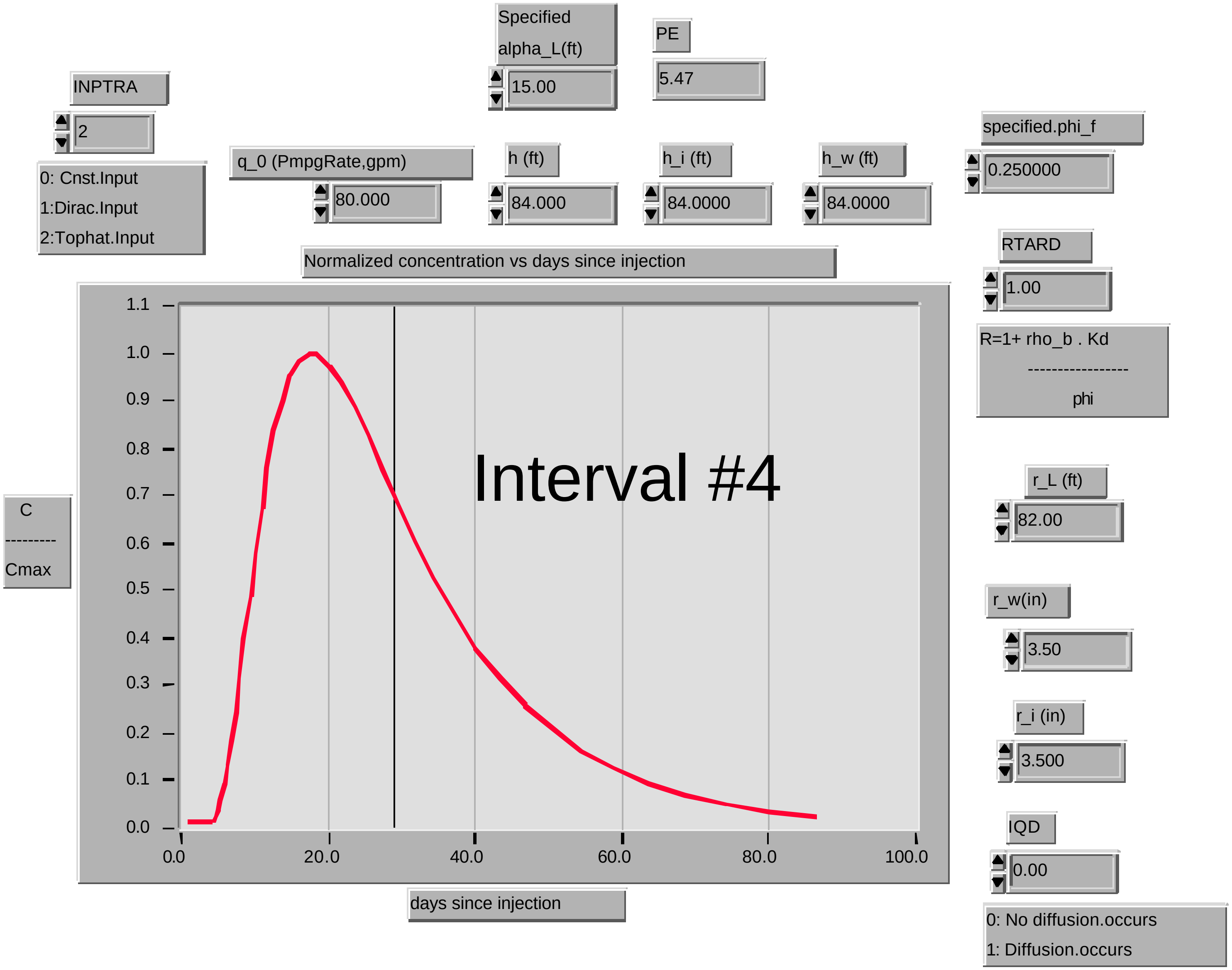
h_w (ft) 32.0000

h (ft) 32.000

RTARD 1.00

R=1+ rho_b_Kd
----
phi

Figure 7. Prediction of Cross-hole Conservative Tracer Testing in Screen #1 from IM1 or IM2 to 19D1



INPTRA: 2

0: Cnst.Input
1:Dirac.Input
2:Tophat.Input

Specified alpha_L(ft): 15.00

PE: 5.47

q_0 (PmpgRate,gpm): 80.000

h (ft): 84.000

h_i (ft): 84.0000

h_w (ft): 84.0000

specified.phi_f: 0.250000

RTARD: 1.00

R=1+ rho_b . Kd
----
phi

r_L (ft): 82.00

r_w(in): 3.50

r_i (in): 3.500

IQD: 0.00

0: No diffusion.occurs
1: Diffusion.occurs

Figure 8. Prediction of Cross-hole Conservative Tracer Testing in Screen #4 from IM1 or IM2 to 19D1

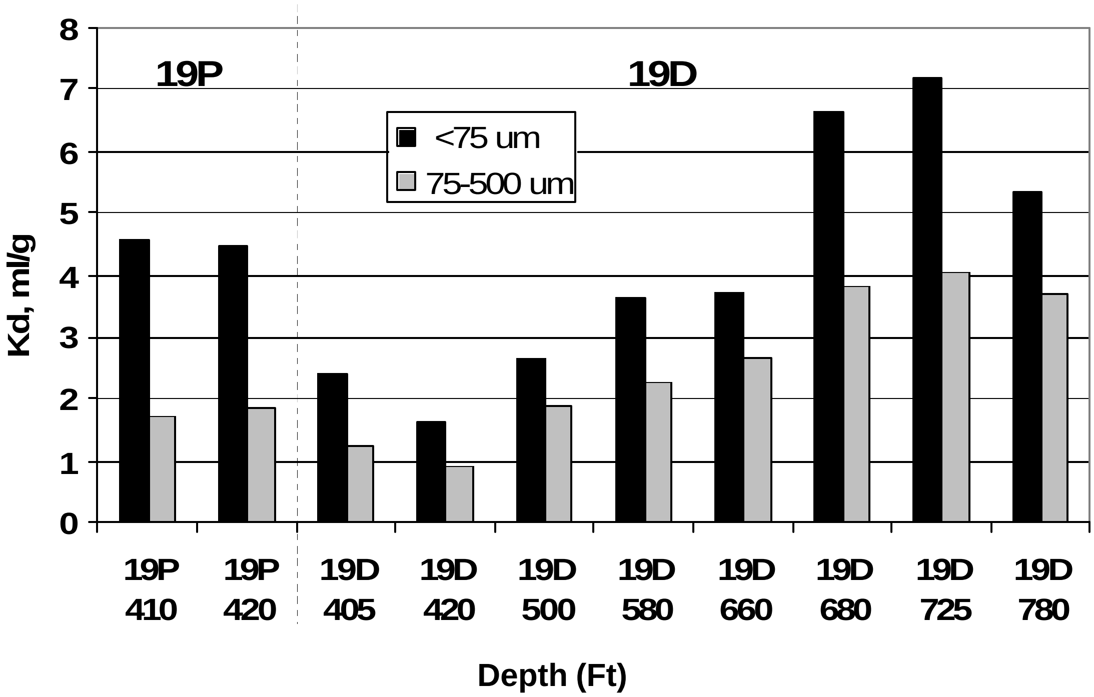


Figure 9. Lithium K_d Values (ml/g) as a Function of Depth and Sieve Size Fraction for Alluvium Material from NC-EWDP-19D1 and NC-EWDP-19P