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Water Quality and Hydrology Group (ESH-18)
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Date: March 29, 2002
Refer To: ESH-18/WQ&H:02-126

Mr. James Bearzi
Hazardous Waste Bureau Chief
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303

SUBJECT: LOS ALAMOS NATIONAL LABORATORY RESPONSE TO MARCH 1, 2002 NEW MEXICO ENVIRONMENT DEPARTMENT LETTER REGARDING HYDROGEOLOGIC WORKPLAN AND DRILLING SCHEDULE

Dear Mr. Bearzi:

Thank you for your March 1, 2002 letter describing New Mexico Environment Department's (NMED) concerns related to implementation of the Los Alamos National Laboratory (Laboratory) Hydrogeologic Workplan. We have carefully evaluated your comments, and a detailed response is included as Attachment 1 to this letter. Our detailed response indicates that the Laboratory believes that we are meeting the requirements of the Hydrogeologic Workplan and the associated hydrogeologic characterization elements of the RCRA/HSWA permit, particularly regarding the submittal of well fact sheets and completion reports. We have proposed a revised drilling schedule for FY-02 that meets NMED's desire for the installation of six (6) wells by December 30, 2002. Other technical requests outlined in your letter are specifically addressed in the attachment also.

Your letter highlights the importance of NMED's continuing involvement in the Laboratory's Hydrogeologic Characterization Program. We welcome NMED's constructive comments, as included in your letter, and trust that our response will be helpful to you, as well. Upon reflecting on the substance of your letter and our attached response, and discussing the documents with Laboratory staff, it appears that we not only have some differences of opinion regarding the technical implementation of the Hydrogeologic Workplan, but there appear to be communication issues as well. The Department of Energy (DOE) and the Laboratory are intent on resolving any differences and issues, and are committed to assuring a productive working relationship with NMED. It is our opinion that these differences and issues would be better resolved by means of face-to-face meeting(s) with key technical and management staff participation by all parties involved in order to expeditiously resolve them. Therefore, we recommend that a meeting be scheduled within the next

30 days to conduct a point-by-point review of your letter of March 1, 2002 and our attached response. The participants at this meeting(s) should at a minimum include: NMED; yourself, Greg Lewis, John Young, and Michael Dale; Laboratory; Jim Holt, Beverly Ramsey, Charlie Nylander, Julie Canepa, and John McCann; DOE/OLASO; Joe Vozella and Mat Johansen.

The goal of such a meeting(s) would be to make decisions and resolve the outstanding technical differences regarding the implementation of the Hydrogeologic Workplan, as included in the above-referenced documents, and ensure improved communication between the parties involved. Please contact Charlie Nylander, at 665-4681 to select the location, date and time for such a meeting.

On behalf of the Laboratory and DOE, we look forward to that meeting, as well as other opportunities to jointly ensure the successful implementation and completion of the Laboratory's Hydrogeologic Workplan.

Sincerely,

Corey Cruz, Acting Area Manager
Office of Los Alamos Site Operations

Sincerely,

John C. Browne, Director
Los Alamos National Laboratory

CN/tml

Attachments: a/s

Cy: G. Lewis, NMED/WWMD, Santa Fe, New Mexico, w/att.
D. Cobrain, NMED/HWB, Santa Fe, New Mexico, w/att.
C. Will, NMED/HWB, Santa Fe, New Mexico, w/att.
J. Parker, NMED/OB, Santa Fe, New Mexico, w/att.
M. Leavitt, NMED/GWQB, Santa Fe, New Mexico, w/att.
R. Mayer, EPA, 6PD-N, Dallas, Texas, w/att.
J. Vozella, OLASO, w/att., MS A316
M. Johansen, OLASO, w/att., MS A316
B. Ramsey, FWO-DO, w/att., MS K492
D. Stavert, ESH-DO, w/att., MS K491
S. Rae, ESH-18, w/att., MS K497
C. Nylander, ESH-18, w/att., MS K497
J. Canepa, E/ER, w/att., MS M992
D. McInroy, E/ER, w/att., MS M992
D. Woitte, LC/GL, w/att., MS A187
S. Yanicak, NMED/OB, w/att., MS J993
WQ&H File, w/att., MS K497
IM-5, w/enc., MS A150

Los Alamos National Laboratory Response to March 1, 2002 New Mexico Environment Department Letter Regarding Hydrogeologic Workplan and Drilling Schedule
Attachment 1

Drilling Methodologies

Page 1, paragraph 2 regarding drilling methodologies:

UC/DOE's approach to drilling regional wells has evolved over the past four years, in response to lessons learned, as well as input from NMED and other experts/stakeholders. We expect that these procedures will continue to evolve over the course of the drilling program. All of the evolutionary changes regarding the drilling methods have been previously negotiated with NMED, and have been dependent on UC/DOE's and NMED's desire for specific data quality objectives.

The original drilling configurations were laid out in Section 4 of the Hydrogeologic Workplan (5/22/98). This plan described three categories of regional wells:

- The first type would feature a single well screen, and would be drilled using casing advance and 10% core collection. Potential drilling methods might include hollow-stem auger, air-rotary/Odex™/Stratex™, air rotary/Barber rig, and mud-rotary drilling.
- The second type was identical to the first, except that it would provide for recovery of more than 10% of the core.
- The third type would be completed using a multiple completion (Westbay-type) system, and might reach a depth of up to 4,000 ft.

All three categories would feature characterization of perched zones during drilling, with decisions about installation of intermediate wells to be made based on analysis of water samples collected from the borehole during drilling.

In practice, the initial regional wells were R-9, with a single well screen, and R-12, a multiple completion well with three screens. Both were drilled using casing advance without fluid additives. Both were completed with wire-based screens. Experience in the field demonstrated a key disadvantage of dry drilling, namely that the drill casing frequently stuck due to the dry conditions, leading to schedule delays and additional expense.

A major drilling program change was prompted by an NMED letter (September 10, 1999) with two key points: (1) water samples taken from boreholes during the drilling operation would not be adequate for regulatory decisions; and (2) perched zones did not have to be sealed off during drilling, but could be left open until the well is constructed. As a result, while most of the subsequent boreholes were drilled faster than R-9 and R-12 because sealing of perched zones was not required, the wells have been constructed with multiple well screens designed to allow sampling of perched zones from the completed well, increasing construction complexity as well as drilling and analytical costs.

Drilling of the next set of wells (R-25, R-15, R-31, and R-19) was assisted by the use of additives such as EZ Mud, Quick Foam, and TORKease. All of these wells featured casing advance and collection of core. One of them (R-19) employed pipe-based rather than wire-based screens. The use of additives did result in lower costs, but the casing still stuck frequently, and a post-installation equilibrium period is required for the groundwater to become free of the drilling additives.

The next series of wells (R-22, R-7, CdV-15-3) featured open-hole drilling with limited casing advance, and the wells were completed with pipe-based screens. No core was collected during borehole advancement, because the open borehole allowed for the use of geophysical logging methods that could not be used with casing advance drilling methods. This configuration produced lower costs and fewer delays than with complete casing advance, but the problem of post-installation delay due to the impact of drilling fluids on water chemistry remained. These wells were also impacted by NMED's determination that filter packs can extend no more than 5 feet beyond the screen; this requirement increases well construction time and cost due to the need to let sand settle after each increment.

Finally, the most recent wells (R-9i, R-5,R-13 and R-8) have been additive-assisted open-hole wells with little casing advance and limited core collection. Problems with borehole stability in R-5 and R-8 created significant impacts to the drilling cost and schedule due to extensive fishing operations, re-drilling, and the resulting need to use casing advance drilling.

At present, in consideration of NMED's willingness to consider other drilling methods to achieve both the DQOs and borehole stability, UC/DOE will expand currently utilized drilling methodologies to include fluid drilling technologies and the use of permanent conductor casing in the vadose zone. Beginning with well R-14, which will start mid-May, 2002 and subsequent to our previous consideration of the DQOs, UC/DOE will drill the borehole using open-hole drilling techniques to a depth within approximately 100 feet of the top of the regional aquifer (approximately 700 feet). If borehole stability becomes an issue during drilling, a thin-walled steel casing will be installed to keep the borehole open. In either case, once the borehole reaches the 100 foot depth above the top of the regional aquifer, a thin-walled steel casing will be run from the surface to that depth, and will be pressure-sealed with cement from the bottom to the surface. At that point, a sealed conductor pipe will then exist throughout the vadose zone, static water level measured (if applicable), and the drilling technique will be changed to flooded-reverse drilling with mud. The borehole will reach its total depth using this drilling method; a stainless steel well string will be installed and backfilled; and the well will be rigorously developed to meet UC/DOE's well development specifications. Similar approaches will be used on subsequent wells according to the dictates of specific DQOs for those wells.

From the outset of the drilling program, UC/DOE has operated with a commitment to flexibility and mid-course improvement. As we continue to experiment with a number of variables, we are attempting the strike the right balance between cost-effectiveness and timeliness on the one hand, versus collection of complete information on the other. We agree with NMED that the ultimate goal is to achieve the DQOs for each well, and we will welcome NMED's continuing assistance in negotiating both the DQOs and a set of drilling methodologies that will achieve the goals of the HWP. This will be done according to the NMED-approved methodology specified in the Workplan, of using the Annual and Quarterly meetings as a process to allow negotiations leading to modifications of the Workplan in terms of scope and schedule.

Well Construction and Development

Page 1 and 2 regarding specific NMED comments:

Item 1 – Pipe-based versus wire-wrapped screen

The switch to pipe-based screens was a result of failure of standard wire screens to withstand the forces encountered during installation and construction of the deep regional wells. The pipe-based well screens were designed to provide maximum strength while maintaining reasonable open area for hydraulic performance. Johnson Well Screen fabricates UC/DOE pipe-based screens presently in use as per specifications recommended by the EAG. The base pipe used is the blank casing presently used for well completion. The perforated section of the base pipe is manufactured by drilling 84 half inch holes per linear foot. This design provides an open area of 8.75% of the pipe surface area. The screen jacket included in this pipe-based screen design is a continuous-slot V-shaped, non-clogging, wire wound design and conforms to industry standards. The slot size of the screen jacket is 0.010-inch and provides an open area of 14.29%.

The total area of holes (% open area) in the pipe is less than the area of the slot openings of the outer screen jacket. Therefore hydraulic performance of the screen is dependent on the % open area of the pipe base. The advantage of the screen lies in its increased strength allowing for safer installation and for more vigorous and sustained well development, thereby allowing for removal of EZ Mud and fines present in and adjacent to the filter pack. UC/DOE, in consultation with its Contractor (Washington Group International, Inc) and Johnson Well Screen, is presently evaluating whether the % open area of the base pipe can be increased withoutaffecting the overall screen strength. Any move to increase the open area of the base pipe will depend upon the manufacturing capabilities of Johnson Well Screen and the ability to maintain a reasonable margin of safety in column, tensile, and collapse strength of the resulting screen.

Review of all well development and quarterly sampling data indicates turbidity values of less than 5 NTUs, which would indicate that the fines are not being trapped in the screen, but are being developed and removed from the well.

Item 2 – Pressure grouting annular seal

Pressure grouting, or sealing is a commonly accepted technique that works in abandonment situations, particularly in-place abandonment of wells where the casing is generally perforated prior to sealing. In open borehole situations, pressure sealing requires a competent section of borehole to be effective. If the borehole is not competent, the use of pressure sealing significantly increases the risk for potential loss of sealing materials that could impact water quality and well integrity. The use of crushed bentonite and bentonite pellets provides an equally effective seal when installed according to industry standards and manufacturer's specifications. The use of a tremie pipe ensures proper emplacement of a continuous seal and serves primarily to prevent bridging of the seal material. The bentonite is delivered to the desired depth using a transport fluid, which effectively deposits the seal as the tremie pipe is retracted. The depth and complexity of the regional wells

makes pumping a liquid grout troublesome, resulting in a lower quality seal than methods currently used.

The Environmental Restoration Project Standard Operating Procedure 5.01, R3 for Well Construction, has been implemented to effectively place backfill materials. The methods in use ensure that materials are emplaced in an accurate and effective manner. In summary, all annular materials are emplaced through a tremie pipe. Tallies of tremie pipe are maintained by both the site geologist and driller to ensure that correct depths are known at all times. Potable water is used as a transport medium to carry materials to depth. A polymer may be added to the transport medium to delay hydration of bentonite pellets in deep applications. A record of quantities of materials, water, and additives is maintained in the field logbook. Drill casing is retracted as backfill materials are emplaced in order to minimize borehole collapse in unstable formations. The length retracted is determined in the field based on borehole stability, size of material batch to be poured and casing stickup. Volume calculations are made for all materials introduced into the borehole. Sounding depths to the top of fill materials are conducted after each batch introduced with a weighted tape or wire line sounding device. Measurements must be confirmed by repeating the measurement process three times with the same result before recording the measurement. Observations are recorded that include differences in measured and calculated fill levels, anomalous depth measurements, evaluation of any problems encountered with final resolution, and any other information that may be useful in assessing the quality of the installation. The experience gained over the course of continued well installation has resulted in more accurate placement of backfill materials in recent wells.

Transducer readings from multiple ports in Westbay installations from various wells indicate that the seals emplaced to isolate different screens zones have proven effective.

Item 3 – Sieve analysis

UC/DOE concurs with NMED that proper selection of filter pack and screen slot size is important for quality well construction. The size of material used in the filter pack limits the size of particles that reach the screen and the size of openings in the screen determines the size of particles that can enter the well. However, sieving is not necessary to properly match filter pack size and screen slot size. That is readily determined from tables in various standard references (e.g. Aller et al., 1991 and Anderson, 1993). Numerous discussions have been held with NMED regarding the deletion of sieving requirements from the HWP and the RCRA/HSWA permit since 1997. Proposed permit language regarding a flexible requirement for sieve analyses has been previously negotiated with NMED, and is anticipated in the upcoming draft permit reissuance.

UC/DOE uses mainly Johnson 10-slot screen (spaces between wire wraps are 0.0097 or 0.01 inches wide) because none of the filter pack sands will pass through the 10-slot screen. Appropriate filter pack relative to this screen size would be anything that would not pass through a 0.01-inch opening. Several sands have been used for filter pack in the R wells:

Designation	*Grain Diameter Range (inches)*
6/9	< 0.0787 - 0.132
9/12	0.0661 - <0.0937
20/40	0.0165 - 0.0331
30/70	0.0083 - 0.0234

The coarser sizes are used for primary filter pack (opposite screens) while the finer sizes are used as secondary filter pack (between bentonite and primary filter pack).

The purpose of sieving is to determine the texture of the saturated formation to be screened. More specifically, selection of the filter pack size is based on the finest formation materials present (Aller et al., 1991). Sieving is necessary only when the formation is poorly known and practical only when the formation has a fairly uniform texture. Neither of these conditions apply at the Laboratory. The materials encountered in the regional (R) wells have been penetrated by many previous wells and their texture is fairly well known. Furthermore, their texture is known to be variable at all scales. Although fractured basalts do not contribute fines to a well, the sedimentary materials commonly penetrated in the R wells can. However, proper well construction and adequate well development minimizes this in the R wells, as evidenced by the low turbidity values reported during quarterly sampling.

Sieving would not be productive for two reasons. First, texture of materials like the Puye Formation varies greatly (very fine to very coarse) over short vertical distances. In these situations it is not clear what grain size should be used. Second, the sieving of cuttings would miss this finer fraction, which is largely drained away with the water when samples are caught. Because the goal is to keep fines from entering the well, this can be assured by selecting sand and slot sizes accordingly.

Item 4 – Well screen lengths

The deep and intermediate well screens installed as part of the Hydrogeologic Workplan and ER groundwater investigations are generally less than 20 ft in length. A tabulation of screen lengths for each well is listed in the table below. In all wells installed pursuant to the Hydrogeologic Workplan, only those screens straddling the top of the regional aquifer exceed 20 feet in length. The lengths of screens straddling the top of regional aquifer are based on an expected well life of 30 to 40 years and on historic drawdown patterns recorded for nearby water-supply and test wells (e.g. Rogers et al., 1996). The EPA TEGD guidance on the selection of appropriate well screen and casing materials implicitly recognizes the long expected life of wells through their statement that "Long term structural integrity, i.e., 30 or more years, is essential to the collection of unbiased groundwater samples over the lifetime of the facility and post-closure period" (EPA, 1986, p.81).

Table Well Screens Installed to Date

Well Name	Screen #	Screen Length (ft)	Comment
R-5	1	5.1	Perched Zone.
	2	16	Perched Zone.

Well Name	Screen #	Screen Length (ft)	Comment
	3	43.4	Straddles top of regional saturation in area of drawdown near water supply wells PM-1, PM-3, and Otowi 1.
	4	5	Within regional saturation.
R-7	1	16	Perched Zone.
	2	16	Perched Zone.
	3	41.9	Straddles top of regional saturation in area of drawdown near water supply well Otowi 4.
R-8a	1	50.4	Straddles top of regional saturation in area of drawdown near water supply wells PM-3, Otowi 1, and Otowi 4.
	2	6.7	Within regional saturation.
R-9	1	65.5	Straddles top of regional saturation in area of drawdown near water supply wells PM-1, PM-3, and Otowi 1. Core area of maximum drawdown.
R-9I	1	10.4	Perched Zone.
	2	10.4	Perched Zone.
R-12	1	8.5	Perched Zone.
	2	3.5	Perched Zone.
	3	38	Straddles top of regional saturation in area of drawdown near water supply wells PM-1 and PM-3.
R-13	1	60.4	Within the regional saturation in area of drawdown near water supply wells PM-1, PM-2, PM-3, and PM-4. Core area of maximum drawdown.
R-15	1	61.7	Straddles top of regional saturation in area of drawdown near water supply wells PM-2, PM-3, PM-4, PM-5 and Otowi 4. Core area of maximum drawdown.
R-19	1	16.4	Perched Zone.
	2	16.3	Perched Zone.
	3	44	Straddles top of regional saturation in area of drawdown near water supply well PM-2 and PM-4.
	4	7.2	Within regional saturation.
	5	7.2	Within regional saturation.
	6	7.1	Within regional saturation.
	7	7.1	Within regional saturation.
R-22	1	41.9	Water level measurements indicated that the regional static water level was at one of two depths; screens 1 and 2 were designed to cover both possibilities.
	2	41.9	
	3	6.7	Within regional saturation.
	4	6.7	Within regional saturation.
	5	5	Within regional saturation.
R-25	1	20.8	Perched Zone.
	2	10.8	Perched Zone.
	3	10	Perched Zone.
	4	10	Alternating wet/dry zone
	5	10	Top of regional zone of saturation.
	6	10	Within regional saturation.
	7	10	Within regional saturation.

Well Name	Screen #	Screen Length (ft)	Comment
	8	10	Within regional saturation.
	9	3.5	Within regional saturation.
R-31	1	15.3	Perched Zone.
	2	30.7	Straddles top of regional saturation.
	3	10	Within regional saturation.
	4	10	Within regional saturation.
	5	10	Within regional saturation.
CDV-R-15-3*	1	6.8	Perched Zone.
	2	6.9	Perched Zone.
	3	16.1	Perched Zone.
	4	43.9	Straddles top of regional saturation.
	5	6.9	Within regional saturation.
	6	6.9	Within regional saturation.
MCOBT-4.4*	1	42	Perched zone of uncertain extent; longer than normal screen installed to capture saturated zone.

* ER Project Groundwater Investigation wells, not installed pursuant to the Hydrogeologic Workplan

Item 5 – Length of filter pack

UC/DOE agrees that the filter pack length normally should not exceed 10 feet beyond the screen interval, and based on conversations with NMED is striving to meet this goal. Review of as-built diagrams for 13 deep and intermediate wells indicates that in some instances the 10-foot target lengths have been exceeded above or below the screened interval (see Table Summary of Filter Pack Lengths below). Review of completion records indicates that in the majority of instances, unstable borehole conditions resulted in slough increasing the overall filter pack lengths. Every attempt is made, by prescribed methods and precautions, to install the filter packs such that they extend no more than 10 feet above or 5 feet below the screen length. Borehole irregularity may cause the calculated volume of filter sand to exceed the capacity of the calculated borehole volume in some instances. At other times borehole instability may contribute to sloughing, resulting in a longer filter pack than desired. Techniques such as creating additional hydrostatic head in the borehole to control sloughing is employed, but is not always successful. In any case, installing backfill at the depths required, in the unstable formations encountered, makes for challenging completions.

Table of Filter Pack Lengths

WELL No.	Filter Pack Above/Below Screen (feet)(7)							
	Screen #1	Screen #2	Screen #3	Screen #4	Screen #5	Screen #6	Screen #7	Screen #8
R-25	5.6/3.6	4.6/3.6	NA	3.6/3.6	4.7/2.3	6.7/.3	4.7/3.3	8.7/.3
R-31 (1)	6.3/6.2	18.7/5.6	7.3/0.7	46.1/5.4	133.4/55.5			
R-19 (2)	25/15	25/16.4	21.6/25.1	30.2/28.1	24.7/17	50.9/45.9	4.2/8.9	
R-9	7.5/0							
R-9I	3.6/1.2	3.2/1.8						
R-15	15.5/4.7							
R-12 (3)	6/13.5	9.5/14	8/17					
R-22 (4)	10.3/7.8	9.5/18.1	28.7/5.1	9.7/2.1	10.3/25.7			
R-7 (5)	7.6/4.4	5.4/7.6	15.5/9.4					
R-5	9.9/6.5	8.3/10.7	10.4/1.2	7.7/3.8				
MCOBT 4.4	5.3/3							
R-13	9.4/5.95							
R-8A (6)	11/41.1	9/4.4						

(1) Screens #2 and #3 - problems included annular materials (sands and bentonites) washing into the formation matrix and therefore annular-material instability due to sloughing. Filter packs at screens #4 and #5 were designed to be a combination of coarse sand and natural sand, gravel, and cobble formation material, suspected to cave into the borehole upon casing withdrawal, which indeed happened.
(2) Screens #1 and # 2 were installed at depths of suspected perched groundwater and sand filter packs were extended to maximize potential for capturing groundwater. Screen #3 straddled the regional water table. Screens #4, #5, and #6 were all within the regional zone of saturation. Separate and sporadic problems at each of these screened intervals included cavernous borehole annular spaces due to wash out during drilling; annular material sloughing due to wash-out into the formation (like R-31); the formation at times sloughing into the annular space, bentonite bridging on centralizers below and above the filter packs at screens, and erratic soundings of annular fill material depths due to false measurements on well-casing centralizers and borehole drift from vertical during drilling. Screen filter packs of sufficient length were placed to ensure that screens would not become engulfed by sloughing bentonite.
(3) Screen #1 – the perching horizon at the base of the uppermost perched zone was adequately sealed to isolate the screened interval; the bentonite was stopped 3 feet short as a precaution to avoid impacting the screen. For screens #2 and 3 the lower bentonite seals were stopped short as a precaution to avoid impacting the screen. No stratigraphic boundaries were identified in these intervals.
(4) Screen #2 – bentonite below the screen settled after the first lift of filter pack sand was emplaced. Screen #3 – formation caving and flowing sand intrusion displaced filter pack during emplacement. Screen #5 – bottom of borehole caved severely; bentonite was omitted below bottom of filter pack to prevent potential displacement of bentonite upwards into the screened interval from continued caving.
(5) Screen #3 – formation caving and flowing sand intrusion displaced filter pack during emplacement.
(6) Screen #1 – severe formation caving and flowing sand intrusion displaced filter pack during emplacement.
(7) Note accuracy of depth measurement devices +/- 1 ft.

Item 6 – Well development

As most of the R wells are constructed with multiple screens, development methods focus on each screened interval. Development is vigorous and follows a multi-step protocol:

Primary Development

1. Wirebrushing for a coarse cleaning of screen openings
2. Bailing to remove material loosened by wirebrushing (including the sump)[a]
3. Surging, jetting, or swabbing to further clean screen openings[b]
4. Bailing to remove fines produced by these activities

Secondary Development

1. Pumping to extract fines loosened in primary development[c]

[a] Field parameters are measured for water from the first bail as a reference.
[b] Surging involves moving a snuggly-fitting block up and down past each screen. Jetting includes spraying municipal water into the openings of each screen. Swabbing involves surging while injecting water across each screen.
[c] When a turbidity of <5 NTU is achieved, the pump is shut of for 15-30 minutes and then turned back on to see oif turbidity is still <5 NTU. This is repeated two more times (thus, final turbidity is checked four times).

Effectiveness of the development is evaluated by measuring various field parameters for samples of water produced by bailing or pumping. Parameters include pH, temperature, specific conductance and turbidity. The goal of development is a reproducible turbidity of <5 NTU. Development is halted when turbidity reaches this goal or cannot be improved.

The development approach described is in line with industry standards and EPA guidelines (Aller et al., 1991). Furthermore, it has successfully cleaned the screens and reduced turbidity in R wells at the Laboratory. It should be noted that the development methods described are entirely mechanical and address the physical suitability of the water in the well. Chemical development methods would be required to more completely mitigate the impact of drilling fluids on water chemistry. However, no attempt is made to chemically clean the R wells as that would result in other undesirable changes in water chemistry. The revised Standard Operating Procedure for Well Development is included with this attachment in response to the NMED request for such a document within forty-five days of receipt of NMED's March 1st letter. In addition, Robert Powell and David Schafer, both members of the External Advisory Group are in the process of finalizing a document on the subject of well development, which will be transmitted to you in April 2002.

Item 7 – Borehole completion

The NMED March 1, 2002 letter suggests that not all boreholes need to be completed as wells. LANL appreciates the flexibility to make these decisions after consultation with NMED, based on the anticipated future uses of the borehole.

Data Collection and Reporting

Page 3,paragraph 1, regarding NMED required submittal of fact sheets:

The referenced NMED letter of January 24, 2001 referred to the "NMED requirement for submittal of a "completion report" within 30 days of well completion". In that letter, the NMED reference to a "completion report" was synonymous with a then new document, originally offered by UC/DOE subsequent to the installation of well R-22 in January, 2001, which was a 2-page Fact Sheet or Well Completion Summary describing the pertinent construction details of a characterization well installed pursuant to the Hydrogeologic Workplan. UC/DOE had attempted to be responsive to a request by NMED for timely, summary information regarding well construction by volunteering to prepare such a summary-level document. There is no requirement for a Fact Sheet in the NMED-approved Hydrogeologic Workplan, nor in UC/DOE's RCRA/HSWA permit. However, UC/DOE

has already committed to provide the Well Completion Summary document or Fact Sheet for each new well installed pursuant to the Hydrogeologic Workplan in a letter to NMED dated September 20, 2001, which was written to include a response to the NMED January 24, 2001 letter. Therefore, UC/DOE will continue to voluntarily provide a Well Completion Summary document or Fact Sheet to NMED for new wells installed pursuant to the Hydrogeologic Workplan within 30 days of well completion, as previously promised.

The NMED-approved Hydrogeologic Workplan does not contain a requirement to provide well completion reports. Moreover, UC/DOE's RCRA/HSWA permit has never been specifically modified to include implementation of the Workplan as a permit requirement. The current language in the HSWA module of the permit requires completion reports for specific permit-required wells, and does not include the wells being installed pursuant to the Workplan. Nonetheless, UC/DOE has historically, through Quarterly/Annual meetings with NMED and correspondence, agreed to prepare well completion reports, and has submitted such reports during the implementation of the Workplan. To date, eight (8) well completion reports have been submitted to NMED for wells R-9, R-9i, R-12, R-15, R-19, R-22, R-25, and R-31. Well completion reports are presently being prepared for the most recent wells R-5, R-7, R-8, and R-13.

UC/DOE will continue to voluntarily prepare well completion reports for the wells installed pursuant to the Hydrogeologic Workplan, but will require one hundred and eight days (180) to submit the reports following well construction. At present, the information required to complete the comprehensive report in the current format is derived from various sources including, but not limited to, commercial analytical laboratories, HydroGeological Technologies (a Schlumberger subsidiary), Washington Group International, Ltd., and the Laboratory itself. The anticipated turn-around time for receiving data and information pertinent to the completion report; time necessary to digest said information and write the draft completion report; the mandatory peer review, security classification, and DOE review of the draft reports requires a minimum of one hundred and eighty days.

Page 3, paragraph 2 regarding 10 percent coring:

The Hydrogeologic Workplan commitment to provide at least 10 percent coring for each regional aquifer well was modified following the installation of wells R-9, R-12, and R-25. Through the NMED-approved methodology specified in the Workplan, of using the Annual and Quarterly meetings as a process to allow negotiations and result in modifications of the Workplan in terms of scope and schedule, we have jointly learned through early experiences in attempting to collect significant amounts of core, that experience proved that the activity was not cost-effective in most cases. The minutes from numerous Quarterly meetings since 1997 reflect that there was agreement between NMED and LANL that as drilling methods evolved towards faster drilling techniques, and that data quality objectives associated with core collection were largely satisfied by employing geophysical logging of the boreholes and using drill cuttings. Moreover, each regional aquifer wells drilled to date, have been drilled pursuant to a Field Implementation Plan, which has been reviewed by NMED with respect to the planned data quality objectives and drilling methods. Thus, the role of coring in meeting data quality objectives is and has been mutually decided through negotiations and finalization of individual Field Implementation Plans.

Page 3, paragraph 3 regarding the top of the saturated zone:

Pinpointing the top of saturated zones, regardless of whether perched or regional, is always difficult. First water is readily detected when drilling with air: cuttings are suddenly wet. However, in the case of deeper saturation, when there may already be water in the borehole, it is less obvious. Drillers are the onesin the best position to determine this. They rely mainly on the volume of water returned to the surface. However, if yield of the saturated material is low, drilling may continue below the top of saturation before any "excess" water is recognized at the surface. A water level measured at that time is admittedly a composite value. It should be noted that an increase in return flow, may also indicate that drilling has entered a tight zone. In such intervals, more water returns because less is lost to the formation. Usually there are enough observations that screens are placed across the regional water table. In only one case (R-13) has the uppermost screen targeting the regional zone of saturation failed to straddle the water table, and that was by design due hydrologic conditions.

Page 3, paragraph 4 regarding NMED-required submittal of fact sheets and completion reports

As previously addressed above, the fact sheets are not a specifically required document in either the Hydrogeologic Workplan, nor UC/DOE's RCRA/HSWA permit, but rather have been voluntarily provided by UC/DOE since the installation of well R-22. UC/DOE is in the process of retro-actively preparing fact sheets for those wells installed prior to well R-22, as well as those wells installed since well R-13 (i.e. the latest fact sheet submitted to NMED). It is anticipated that a complete set of fact sheets for all of the regional aquifer wells will be available at the Annual Meeting scheduled for April 10, 2002.

UC/DOE does not agree with NMEDs' assertion that failure to submit the fact sheets and completion reports on the NMED schedule constitutes a violation of the RCRA/HSWA permit. UC/DOE also does not agree with NMEDs' assertion that fact sheets and well completion report submissions is not restricted to wells installed under the HWP, and that any well, piezometer, or borehole shall also follow these reporting requirements.

<u>Drilling Schedule and Cost</u>

The NMED-approved Hydrogeologic Workplan contains the following statements regarding the negotiation of Workplan scope and schedule on pages I-2, I-3, I-8, and 4-15.

Pages I-2 and I-3:

"The implementation of this Workplan is intended to remain flexible, such that the scope and schedule of activities can be based on annual re-evaluation of the conceptual site model and reiteration of the DQOs. A critical factor in maintaining flexibility in the Workplan is communication with the regulatory decision-makers. Although decisions about Workplan activities will be on an annual basis, DOE and the Laboratory are committed to keeping NMED consistently informed as described in this section."

"An annual meeting will be held in March to perform a review and reassessment of DQOs and to negotiate the Workplan scope and schedule for the next year's well installation and other activities. Although the installation schedules contained in this Workplan (see Figure 1-1) are intended to be comprehensive and to indicate prospective long-term order of activity performance, it is technically prudent to perform activities using a year-by-year interative process of data collection, review and re-assessment. By doing so, full advantage will be taken of all new information and data prior to locating and installing subsequent wells. This approach will ensure that characterization activities and well installation are optimized; the need for subsequent wells (alluvial, intermediate perched zone, or regional aquifer wells) will always depend on data and information gained from previously installed wells and on interpretation of data from those wells."

"An annual report, the "Groundwater Annual Status Summary Report", will be prepared to summarize the activities over the previous fiscal year and to make recommendations for the current fiscal year's activities...Both the annual report and the annual meeting minutes describing modifications to the Hydrogeologic Workplan scope and schedule will be distributed based on a formal distribution list to be developed and maintained by the Laboratory."

"In addition to the annual meeting, there will be regularly scheduled quarterly meetings to present progress on active workplan tasks and to discuss the available data....The minutes from these meetings will also be distributed based on the formal distribution list."

Page I-8:

"Three of the regional aquifer wells (see below) are committed to in FY-98. All wells proposed to be installed subsequent to the first year are contingent on data obtained from previously-advanced boreholes and on the annual regulatory renegotiation of the Workplan scope and schedule. This annual Laboratory/DOE/NMED review, reassessment, and renegotiation is proposed to occur in March of each calendar year that the Workplan is in force."

Page 4-15:

"Installation of these wells will be subject to negotiation with the NMED as described in the following paragraphs, and there is no commitment implied by the identification of prospective numbers and locations."

"Commitments for future well installation beyond the three well scheduled in FY-98 (See Section 1.5) will be negotiated annually. Thus, this annual meeting will result in renegotiation of all Workplan activities and the schedule for their performance."

Page 4, paragraph 2 regarding the drilling schedule:

Throughout the entire discussion of the drilling scope and schedule topic, the above-mentioned language in the NMED-approved Workplan should be considered. Changes in scope and schedule have occurred at virtually every Annual and Quarterly meeting, and have been documented in the formal meeting minutes. Although the use of formal meeting minutes to modify the Workplan was approved by NMED, correspondence received from NMED includes refusal to provide written

concurrence of those minutes. However, as a result of management discussions at the 2001 Annual Meeting, NMED did agree to approve an annual workplan. Specific to the NMED statements in the March 1, 2002 letter, UC/DOE completed well R-8a in February 2002. UC/DOE's letter dated September 20, 2001 stated that well R-27 had been pushed out in the baseline schedule.

Page 4, paragraph 3 regarding the drilling schedule

UC/DOE has consistently listed well R-11 on the schedules for a FY-04 start. Well R-27 was pushed out to FY-03 in the Groundwater Annual Status Report for FY-00 (published in March 2001). The R-27 well is currently scheduled for start in FY-04 according to the latest Groundwater Annual Status Report for FY 01. As the NMED has participated in all of the Quarterly meetings since 1997, as well as the last four Annual meetings, it should be apparent that specific well priorities have been changed over time (either accelerated or delayed) since the very first well R-9, based on mutual negotiations. There have also been numerous letters sent by UC/DOE referencing the drilling schedule and the ultimate goal of satisfying the Workplan commitments by FY-05, regardless of a specific number of wells in a given fiscal year. Of course, the proposed DQO re-iteration document, referred to on page 4 of the NMED March 1, 2001 letter is integral to meeting the FY-05 Workplan completion.

At this date, UC/DOE will complete the following wells during FY-02: wells R-8, R-13, R-14, and R-21. In addition, UC/DOE intends to also complete wells R-20, R-23, and R-16 (moved to the northern side of Technical Area 54) during FY-02, contingent on the approval of additional funding requested for these wells by Laboratory and DOE management during April 2002. All other wells listed in the out-years, beginning with FY-03, are to be negotiated with NMED pursuant to the NMED-approved process delineated in the HWP, i.e. via the Annual meetings held in March of each year.

Modeling

Page 5, paragraphs 1-4:

In correspondence dated March 16, 2001, the NMED discussed concerns pertaining to the data quality used in groundwater modeling. In particular, the NMED did not take issue with the computer code selected for groundwater modeling (FEHM), but rather that the data available were insufficient to support the model. Further, in the correspondence dated March 1, 2002, NMED questioned whether the modeling can be used for making regulatory compliance, corrective action, and groundwater protection decisions at this time.

In UC/DOE's response to the NMED letter dated March 16, 2001, there was a commitment to provide meetings with NMED technical staff to update them on details of model input parameters, assumptions, and sensitivity analyses. Despite having held a number of these modeling update meetings in the intervening year, the March 1, 2002 letter contains a request for the same information on the modeling. It is apparent that the meeting format for exchange of modeling information is ineffective. To remedy this failure to communicate, the following are provided with this letter:

- A matrix that lists the data needs from Attachment B of NMED's May 10, 2001 and March 1, 2002 letters; a brief description of the existing data; and a reference to the section of the annual modeling report where more detail can be found (Table Attachment 1-1), and
- Two annual regional aquifer modeling reports (1999 and 2000). The most recent report, dated December 2001, is still in review and will be submitted to NMED by July 2002.

In our reports, you will find detailed descriptions of modeling assumptions, methodology, and hydrologic data. In addition to providing these details, a comment regarding our general modeling approach and the adequacy of the underlying hydrologic dataset is appropriate here. Our opinion is that the amount of data required for modeling is *not* dictated by factors such as the choice of code or the degree of hydrogeologic complexity of the site. Rather, it is dictated by 1) the particular question the model is addressing, 2) the modeling approach used to answer the question (which could either be very simple or very complex), and 3) the level of uncertainty that can be tolerated in the model result. If, for example, a high level of certainty is required, then a large amount of data must be used to inform the model. The amount of data required, therefore, may vary considerably depending on the particular modeling application. Our modeling approach is designed so that the adequacy (or lack thereof) of the dataset is directly reflected in the bounds of uncertainty that accompany model results.

Based on discussion of modeling at the Quarterly Hydrogeologic Characterization Program meeting held on January 30, 2002, LANL is preparing a "transparent modeling" description that is written for a lay audience. It is hoped that this modeling description will make the process of model development and refinement accessible and understandable to the public. The transparent modeling description is expected to be complete by the July 1, 2002 deadline in the March 1, 2002 letter.

Similar information on the vadose zone modeling conducted for the Environmental Restoration Project is not included because to this point, groundwater decisions have been based on the assumption that contaminants are directly introduced to the regional aquifer and transport of contaminants in the regional aquifer alone. As pointed out in the March 1, 2002 letter from NMED, starting in FY02, the vadose zone and regional aquifer models willbe linked and used to assess the adequacy of the monitoring network. Annual reports on this linked modeling will be issued, beginning in FY03, similar to the annual regional aquifer modeling reports that accompany this letter. Please refer to the Summary of Data and Modeling Approach included with this attachment.

The reference information for the two regional aquifer modeling reports included here is as follows:

Keating, E.H., Kwicklis, E., Witkowski, M. and Ballantine, T., 1999. A Regional Flow Model for the Regional Aquifer beneath the Pajarito Plateau. Los Alamos National Laboratory Report .LA-UR-00-1029.

Keating, E., Kwicklis, E., Vesselinov, V., Idar, A., Lu, Z., Zyvoloski, G. and Witkowski, M., 2000a. A Regional Flow and Transport Model for Groundwater at Los Alamos National Laboratory. Los Alamos National Laboratory Report, LA-UR-01-2199, http://lib-www.lanl.gov/la-pubs/00818241.pdf.

A third report, which is the most recent, is still in the review process. It will be provided to NMED by July 2002.

> Keating E, Vesselinov, V., Lu, Z. and Kwicklis, E. (2001) Annual Report on regional aquifer modeling and data analysis. Los Alamos National Laboratory

Finally, while UC/DOE will continue to provide the information requested, the characterization by NMED that the March 1, 2002 letter would "impose" such deliverables as described in Attachment C is inconsistent with more formal processes typically required to establish such conditions. UC/DOE welcome NMED's ongoing involvement with the implementation of the Hydrogeologic Workplan and hope that through our open exchange of issues and concerns, the goals of the Hydrogeologic Workplan will be reached.

References

Aller, L., T. W. Bennett, G. Hackett, R.J. Petty, J.H., Lehr, H. Sedoris, and J.E. Denne, 1991, Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells: U.S. Environmental Protection Agency Report, 600/4-89/034, 221 p.

Anderson, K.E., 1993, Ground Water Handbook: National Ground Water Association, Dublin, Ohio, 401 p.

EPA, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD), OSWER-9950.1.

Nylander, C.L., Ball, T.T., Bitner, K.A., Henning, K., Keating, E.H., Longmire, P., Robinson, B., Rogers, D.B., Stone, W.J., and Vaniman, D., 2002. Groundwater Annual Status Report for Fiscal Year 2001. Los Alamos National Laboratory Status report, Number pending, Los Alamos, New Mexico

Rogers, D.B., Stoker, A.K., McLin, S.G., and Gallaher, B.M., 1996, Recharge to the Pajarito Plateau regional aquifer system, New Mexico Geological Society Guidebook, Jemez Mountains Region, 47th Annual Field Conference, pp. 407-412.

Stone, W.J., Cole, G., Carey, W., and Jones, M., 2001. Los Alamos National Laboratory Expanded Hydrogeologic Atlas. Los Alamos National Laboratory Report LA-UR-01-70, Los Alamos, New Mexico

Los Alamos National Laboratory Response to March 1, 2002 New Mexico Environment Department Letter Regarding Hydrogeologic Workplan and Drilling Schedule
Table Attachment 1-1

NMED March 1, 2002 Attachment B Data Needs	Summary Description of Data and Modeling Approach	Reference for Detailed Information
Aquifer boundaries	The regional aquifer is assumed to be a single aquifer, bounded by the water table (on the top) and the bottom of the Santa Fe group. Although the aquifer is very heterogeneous and strongly anisotropic, in some rocks, there is no physical or hydrologic evidence that multiple, separate aquifers exist within the regional zone of saturation. The lateral boundaries are the hydrologic divides that define the Española Basin	Keating et al (2000), Section 4; Keating et al. (1999), Figure 1
Extent of saturation	We assume that the regional aquifer extends to natural hydrologic boundaries of the Espanola Basin. Simulating the details of flow far from LANL by including the entire hydrologic basin in our model provides critical information on total flux through the system. The hydrologic connection between groundwater beneath LANL and the Valles Caldera is unclear; in order to test alternative conceptual models concerning this connection we include the caldera in the model domain.	Keating et al. (1999), Figure 1; Keating et al (2000), Section 4
Thickness of saturation	The vertical extent is defined by the distance between the water table and the bottom of the Santa Fe Group (below 0 MSL). As such, the aquifer is assumed to be several thousand meters thick.	Nylander et al (2002), Figure 4.3.1-1
Water levels/water table and potentiometric surface map-head distributions	The current water table map for the Pajarito Plateau shows the potentiometric surface sloping from west to east. In the Española Basin, the potentiometric surface slopes from the high areas along the western and eastern boundaries towards the Rio Grande.	Nylander et al (2002), Figure 4.3.1-1 (water table map), 4.3.1-2 (vertical cross-section of head data), and Table A-1 (tabular compilation of water level data); Keating et al (1999) Figures 17 and 18.
Groundwater flow directions and velocities	Groundwater flow directions and velocities are the subject of quantitative analyses and are described in detail in the 2001 Regional Aquifer Data Analysis and Modeling Report, available by July 2002.	Nylander et al (2002), Figure 4.3.2-1 and Section 3.4

Los Alamos National Laboratory Response to March 1, 2002 New Mexico Environment Department Letter Regarding Hydrogeologic Workplan and Drilling Schedule
Table Attachment 1-1

NMED March 1, 2002 Attachment B Data Needs	Summary Description of Data and Modeling Approach	Reference for Detailed Information
Transmission or movement of ground water across hydrostratigraphic boundaries	The regional aquifer is considered a single aquifer composed of over 20 connected hydrostratigraphic units. The degree of movement of water across hydrostratigraphic unit boundaries in the regional aquifer is largely controlled by permeability contrasts between juxtaposed hydrostratigraphic units. The permeability of hydrostratigraphic units in the regional aquifer has been estimated for some units by aquifer testing and estimated for other units by calibration of the regional aquifer model.	Keating et al (1999), Table 11, Chapter 3; Keating et al (2000), Table 5-3, Section 5
Geologic maps	A map of the geology of the Pajarito Plateau was provided in the Hydrogeologic Workplan. The understanding of the geology is continually being refined as new wells are drilled and is reflected in the site –wide 3-D geologic model. The current geologic model is shown in the Sitewide Atlas.	Stone et al (2001)
Topographic maps	Several maps of the topography of the Pajarito Plateau were provided in the Hydrogeologic Workplan. The topographic control has been improved since the Hydrogeologic Workplan was issued. The current topographic is shown in the Sitewide Atlas.	Stone et al (2001)
Saturated hydraulic conductivity, porosity, effective porosity, transmissivity, storage coefficients and estimated fracture/secondary porosity for the important hydrostratigraphic units	The saturated hydraulic conductivity and porosity values used in the model are based on aquifer tests in wells throughout the Española Basin. For units where no data exist, initial assumptions were based on the geologic character of the unit and were adjusted based on model calibration and sensitivity. We do not use transmissivity values for the models because they are fully 3-D. Unsaturated hydraulic conductivities and porosities are not used in the regional aquifer model. Fracture properties are very poorly known, but regional aquifer model model calibration and sensitivity analyses suggest that fracture and secondary porosity are not necessary to simulate flow conditions that reasonably match observed data.	Nylander et al (2001), Section 4.3.4; Keating et al (2000), Chapters 3 and 4.2
Sorption coefficients.	In the regional aquifer modeling, transport of sorbing species has not been simulated. In future work, we anticipate modeling sorption and at that time we will provide detail justification of our selection of parameters.	

Los Alamos National Laboratory Response to March 1, 2002 New Mexico Environment Department Letter Regarding Hydrogeologic Workplan and Drilling Schedule
Table Attachment 1-1

NMED March 1, 2002 Attachment B Modeling Issues	Summary Description of Data and Modeling Approach	Reference for Detailed Information
1) Compile a listing of all model input parameters, with discussion/rationale of the methodologies used to determine appropriate values for those parameters	The input parameters and rationale are described in detail in the reports that accompany this letter.	See Chapter 5 in Keating et al. (2000); more current information will be available when 2001 Regional Modeling report is released (by July 2002).
2) Provide information regarding the quality of the input parameters and discussions as to the procedures used to assess the quality of the data used.	Uncertainty estimation is provided in the 2001 Regional Modeling report. We believe that for both the regional aquifer there is more than enough data available to make the models meaningful. This is not to say that the models are certain, but that they are a useful platform for performing sensitivity analyses to address basic characterization and contaminant transport questions.	Keating et al.(2000), Chapters 4 and 5
3) Identify the most critical (sensitive) input parameters for each model and discussion of the uncertainties associated with the available data	Uncertainty estimation is provided in the 2001 Regional Modeling report. We believe that for both the regional aquifer there is more than enough data available to make the models meaningful. This is not to say that the models are certain, but that they are a useful platform for performing sensitivity analyses to address basic characterization and contaminant transport questions.	Keating et al.(2000), Chapters 4 and 5
4) Identify current data needs and show how those data needs will be satisfied for each component of the hydrogeologic system	This is a primary goal of the Groundwater Pathways Assessment Project; results should be available by Fall 2002.	

Los Alamos National Laboratory Response to March 1, 2002 New Mexico Environment Department Letter Regarding Hydrogeologic Workplan and Drilling Schedule
Table Attachment 1-1

NMED March 1, 2002 Attachment B Modeling Issues	Summary Description of Data and Modeling Approach	Reference for Detailed Information
5) Indicate the expected and acceptable confidence and/or uncertainty level of the modeled results	Uncertainty estimation is provided in the annual regional aquifer progress reports that accompany this letter. The most current uncertainty estimation will be in the 2001 Regional Modeling report.	See Chapters 4 and 5 in Keating et al. (2000); more current information will be available when 2001 Regional Modeling report is released (by July 2002).
6) Provide a discussion of whether existing data are sufficient for a meaningful model, model calibration and how the process will be implemented.	We believe that for both the regional aquifer there is more than enough data available to make the models meaningful. This is not to say that the models are certain, but that they are a useful platform for performing sensitivity analyses to address basic characterization and contaminant transport questions.	Keating et al. (2000), Chapters 4 and 5; Keating et al (1999) Chapters 3 and 4.

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environmental restoration project

A Department of Energy Environmental Cleanup Program

Environmental Restoration Project
Standard Operating Procedure

for:

Well Development

Los Alamos
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0	6/1/92	Sandra Wagner	New Procedure	All
1	06/01/99	J. Skalski & B. Gilkeson	NA	NA
2	4/27/01	William Stone, Steve Pearson, Joe Skalski	Update procedures; new SOP format	all

Well Development

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Well Development

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes procedures for the development of monitor wells subsequent to drilling and installation at the Los Alamos National Laboratory (Laboratory) ER Project.

2.0 SCOPE

This SOP is a mandatory document and shall be implemented by all ER Project participants when performing well development procedures for the ER Project.

3.0 TRAINING

3.1 All users of this SOP are trained by reading the procedure, and the training is documented in accordance with the most recent version of QP-2.2.

3.2 The Field Team Leader (FTL) shall ensure the proper implementation of this procedure and that relevant team members have completed all applicable training assignments in accordance with the most recent version QP-2.2.

4.0 DEFINITIONS

Note: A glossary of definitions can be located on the ER Project internal homepage *http://erinternal.lanl.gov.*

4.1 *Development* — Procedures performed to (1) repair damage to the formation caused by drilling activities and (2) increase the porosity permeability of the materials surrounding the well screen. Development procedures serve to remove foreign materials from the groundwater, well annulus, or well screen during and/or after well installation, and to facilitate hydraulic communication between the formation and the well screen.

4.2 *Filter pack* — Sand or gravel that is emplaced in the well annulus surrounding a screen to prevent formational material from entering the well.

4.3 *Intermediate monitor well* — A monitor well that is screened across a perched-water zone other than that occuring in the shallow alluvium.

4.4 *Multiple completion* — A single well completed with more than one screen. Each well screen accesses a descrete perched-water zone or interval within the regional water table.

4.5 *pH* — The hydrogen ion concentration in water. A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with alkalinity and decreasing with acidity.

4.6 *Regional water table monitor well* — A monitor well that is screened below the water table in the regional aquifer.

4.7 *Site-Specific Health and Safety Plan (SSHASP)*—A health and safety plan that is specific to a site or ER-related field activity that has been approved by an ER health and safety representative. This document contains information specific to the project including scope of work, relevant history, descriptions of hazards by activity associated with the project site(s), and techniques for exposure mitigation (e.g., personal protective equipment [PPE]) and hazard mitigation.

4.8 *Specific (electrical) conductance* — A measure of the ease with which a conduction current flows through a substance under the influence of an applied electric field. It is dependant upon the presence of ions (total and relative concentrations, valence, and mobility) and temperature. It is the reciprocal of resistivity and is measured in either siemens(S) or micro-ohms per centimeter (μohm/cm) at 25°C.

4.9 *Turbidity* — Refers to inorganic solids and organic matter suspended in water. Turbity, in nephelometric turbidity units (NTU), is measured as the intensity of light scattered by the suspended particulates in a water sample relative to a standard reference suspension. The goal of well development is to improve water quality until turbidity readings have stabilized at levels of less than 5 NTU.

4.10 *Well casing volume* — volume of water standing in a well. One casing volume, in gallons, is computed as the measured length of the water column (ft) times the cross-sectional area of the well casing (ft^2) times 7.48 gal/ft^3.

5.0 BACKGROUND AND PRECAUTIONS

This SOP shall be used in conjunction with an approved SSHASP. Also, consult the SSHASP for information on and use of all PPE.

5.1 Regulatory guidance for well completion may be found in the RCRA Ground Water Monitoring Technical Enforcement Guidance Document (EPA, 1986), and the EPA Handbook (EPA, 1991).

5.2 All well drilling and installation procedures create a skin, or filter cake, on the borehole wall. During well development, the fine particulate matter is removed from the well or saturated formation near the screen. A secondary function of development is to settle the annular fill to a stable position.

5.3 The following factors influence the success of well development:

- the drilling method employed in the well construction
- the design and completion of the well
- the type and gradation of geologic material surrounding the screen

Because of the small size of weathering products from the volcanic tuff, in some of the alluvial canyon aquifers in the region, it is virtually impossible to eliminate turbidity while developing the well.

5.4 Well Development Methods

There are various techniques that may be effective in developing wells depending on the hydrogeologic conditions encountered in the aquifer, drilling method used, and well design. Since hydrogeologic conditions may be complex and unpredictable, a single SOP can not be developed that will apply to all possible situations. Rather, the methods discussed briefly below are intended to be used as alternatives or as a series of steps to achieve acceptable well development results. Refer to the site-specific work plan for more information on the scope of work activities for determining the most appropriate method to be used for existing conditions.

5.4.1 *Wire-brush method* — Running a tight-fitting wire brush up and down the interior of the well casing, screen, and sump serves to remove sediment and debris particles and clears the screen openings. Use of the wire-brush method followed by bailing is an effective primary development scheme preliminary to surging or pumping.

5.4.2 *Bailing method* — Bailing involves inserting and withdrawing of a bailer or length of pipe with an end cap on the bottom. Bailing serves to remove turbid water and exerts a surging action as the bailer passes the screen. After wire brushing of the well interior has been peformed, the well is bailed to remove sediment and debris. The bailing method is also used as an alternative when the formation or water-producing zone fails to supply water at sufficient rates to sustain development by pumping.

5.4.3 *Mechanical surging* — Surging involves raising and lowering a surge block inside the well to force water to flow into and out of a screen and through the filter pack. The seals on the surge block are the same diameter as the inside of the well casing or ½ in. smaller if surging is conducted inside the screened interval. Turbid water must frequently be bailed from the well so that fines are not forced into the formating and to prevent sand from locking up the surge block.

5.4.4 *Swabbing method* — A swab is a mechanical surging device that is pulled upward through the water column in a well. Swabbing may be done with single- or double-swab flanges and with or without water-bypass vents. Water may be injected into the well to the formation

through the swabbing tool. In this method, water flows into one part of the screen, through the filter pack and adjacent formation, and out in another part of the screen. Swabbing is an aggressive development method that may be suitable if the introduction of water is acceptable. Swabbing is not recommended for wells with plastic casing or screens.

5.4.5 *High-velocity jetting* — Jetting, or forcing water through the screen from nozzles on a pipe assembly, can clear screen openings. The jetting method is not always adviseable as it forces the fines back into the filter pack and formation, and adds large volumes of water to the system.

5.4.6 *Overpumping* — A simple method of removing fines from a water-bearing formation is by overpumping. This method involves alternately pumping the well at a rate that will force it to become dry and allowing it to recover. The overpumping method is not always effective, particularly in unconsolidated formations, and may result in a formation that is partially developed.

5.4.7 *Pump development* — Pump development is commonly used as the final phase of well development for ER Project monitor wells after wire brushing and bailing methods have been performed. A submersible pump and packer assembly, if applicable, is installed and pumping at a sustainable rate is conducted until the water attains acceptable criteria to complete well development.

6.0 RESPONSIBLE PERSONNEL

The following personnel are responsible for activities identified in this procedure:

6.1 Focus Area Leader

6.2 Team Leader

6.3 Quality Program Project Leader

6.4 Author

6.5 ER Project personnel

7.0 EQUIPMENT

A checklist of suggested equipment and supplies needed to implement this SOP is provided in Attachment A. Additional equipment are listed in Attachment A of ER-SOP 4.01 and Attachment B of ER-SOP 5.01.

8.0 PROCEDURE

Note: Subcontractors performing work under the ER Project's quality program may follow this standard operating procedure (SOP) for well development. Subcontractors may substitute their own procedure(s) provided the substitute meets the requirements prescribed by the ER Project Quality Management Plan, and have been approved by the ER Project's Quality Program Project Leader (QPPL) before starting designated activities.

Note: ER Project personnel may produce paper copies of this procedure printed from the controlled-document electronic file located at website http://erinternal.lanl.gov/home_links/Library_proc.htm. However, it is their responsibility to ensure that they are properly trained and are utilizing the current version of this procedure. The author may be contacted if text is unclear.

Note: Deviations from SOPs are made in accordance with QP-4.2, Standard Operating Procedure Development and documented in accordance with QP-5.7, Notebook Documentation for Environmental Restoration Techncial Activities.

8.1 Preoperation Activities

8.1.1 Coordinate efforts for on-site staging of water that is produced during development. Assemble containers for temporary water storage. The containers must be structurally sound, decontaminated, compatible with anticipated contaminants, and field manageable. All development water must be containerized until water can be discharged in accordance with an NMED approved Notice of Intent (NOI) or other appropriate disposal method. Clearly label each container with the location ID, date, and time. Labels should be placed on the side of the containers and covered with clear tape to ensure their permanence.

8.1.2 Decontaminate all equipment that will enter the well or come into contact with the development water before developing each well according to ER-SOP-1.08.

8.1.3 Assemble equipment on a plastic sheet in an area that is beyond the range of splashing development water activities.

8.1.4 Well development may begin as soon as is practical after the well is installed, but no sooner than 48 hrs after grouting is completed. Do not use any dispersing agents, acids, or disinfectants to enhance the development of the well unless specifically instructed in writing by the Focus Area Leader. If problems or unusual conditions arise that

require the addition of water to aide development, the site geologist should coordinate with the Focus Area Leader as soon as possible.

Note: In the installation of some monitoring wells in perched alluvial aquifers at Los Alamos, partial development is desirable before emplacing the bentonite seal and cement grout because of settling that commonly occurs.

8.2 Well Development Activities

8.2.1 Open the surface protective casing and remove the well cap (if applicable). Monitor air quality at the top of the casing and in the breathing zone using a PID or other suitable monitoring instrument.

8.2.2 Measure and record depth to water and the total depth of the well according to ER-SOP-7.02.

8.2.3 Perform wire-brush procedures throughout the interior length of the well casing, screen(s), and sump.

8.2.4 Begin bailing to remove turbid water from the well and sediment from the sump. Measure and record initial field chemical parameters (pH, electrical conductivity, and temperature) and turbidity. Periodically measure field paramters as specified in the site-specific Field Implementation Plan (FIP). Note and record volumes of water produced as bailing procedes. Continue bailing as prescribed by the FIP or as otherwise directed by the Focus Area Leader.

8.2.5 Begin pump-development procedures. For wells with multiple completions, each water-bearing zone is isolated using inflatable packers above and below the screen. The following general steps are taken to develop each screen individually and in succession:

8.2.5.1 The drilling contractor installs a submersible pump-and-packer assembly across the first screen to to be developed. Pumping is initiated at a sustainable rate that will not induce excessive drawdown.

8.2.5.2 A transducer and/or a bubble piezometer may be installed in the well to measure water levels during the pump-development phase.

8.2.5.3 When the pump has been turned on, collect a sample of the development water to measure and record initial field chemical parameters and turbidity. Note the initial color, clarity, and any obvious odor of the water. Periodically monitor water quality parameters throughout the pump-development phase as prescribed in the FIP. Likewise, note and record flow measurements (flow rate and volume

produced) as indicated by an in-line flow meter. Continue to record measurements until the screen interval has been fully developed.

8.2.6 In general, well development procedures will continue for each screen interval until (1) the development water becomes free of suspended sediment, (2) an appropriate volume of water has been purged, and (3) field parameters have stabilized. Criteria for completing well development are described as follows:

8.2.6.1 Turbidity citeria — The Hazardous and Solid Waste Amendments Permit (May, 1990) requires that well development shall continue until the turbidity readings stabilize at levels of less than NTU <u>or</u> cannot be improved. Be sure to document all turbidity measurements in the Daily Activity Log (Attachment A in ER-SOP-1.04). If the well is not free of sediment after the required volume of water has been removed, continue pumping until twice that volume has been purged <u>or</u> approval to cease development activities is authorized by the Focus Area Leader.

8.2.6.2 Purge volume criteria — For wells where borehole drilling was conducted without the use of drilling fluid (water, mud, or additives), purge a minimum of five casing volumes of water before stopping well development. In situations where the groundwater flow from the screen interval is exceeded by the development pumping rate, the well may temporarily dry up. Contact the Focus Area Leader when it is determined that five casing volumes can not be purged within a 24-hour period.

8.2.6.3 Field parameter criteria — This criterion for well development has been met when field chemical parameters have stabilized over a series of monitoring measurements.

8.2.6.4 Development criteria deviations — If it is determined that one or more of the above criteria for well development can not be met regardless of the amount of pumping, the site geologist will coordinate with the Focus Area Leader to select an alternate procedure for verifying that the well is adequately developed.

8.3 Documentation

8.3.1 All manually measured data and procedural descriptions should be recorded in a field notebook as required by QP-5.7.

8.3.2 Complete the appropriate data entry requirements on the Borehole/Well Completion Information form to document well development. A copy of the form and instructions for completing it are given in Attachment B of ER-SOP-5.01.

8.3.3 All deviations from the FIP should be documented in accordance with QP-4.2.

8.4 Postoperation Activities

8.4.1 Groundwater samples may be collected from the well in accordance with ER-SOP-1.03 as early as 30 days after well development is complete or as otherwise specified in project documents.

8.4.2 Insure that all equipment is accounted for and decontaminated (refer to ER-SOP-1.08).

8.5 Lessons Learned

During the performance of work, ER Project personnel shall identify, document and submit lessons learned in accordance with QP-3.2, Lessons Learned. This QP can be located at website: http://erinternal.lanl.gov/home_links/Library_proc.htm.

9.0 REFERENCES

ER Project personnel may locate the ER Project Quality Management Plan/ER Project QP requirements crosswalk at website http://erinternal.lanl.gov/home_links/Library_proc.htm.

The following documents are cited within this procedure:

QP-2.2, Personnel Orientation and Training

QP-3.2, Lessons Learned

QP-4.2, Standard Operating Procedure Development

QP-4.3, Records Management

QP-5.7, Notebook Documentation for Environmental Restoration Technical Activities

ER-SOP-1.03, Handling, Packaging, and Shipping of Samples

ER-SOP-1.04, Sample Control and Field Documentation

ER-SOP-1.08, Field Decontamination of Drilling and Sampling Equipment

ER-SOP-4.01, Drilling Methods and Drill Site Management

ER-SOP-5.01, Monitoring Well and RFI Borehole Construction

ER-SOP-7.02, Fluid Level Measurements

EPA, "RCRA Ground Water Monitoring Technical Enforcement Guidance Document," (OSWER, Washington D.C., 1986) (EPA-530SW86055).

EPA, "Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells," (Environmental Monitoring Systems Laboratory, Office of Research and Development, 1991).

10.0 RECORDS

The FTL is responsible for submitting the following records (processed in accordance with QP-4.3) to the Records Processing Facility.

10.1 Completed Borehole/Well Construction Field Data Log (Attachment B in ER-SOP 5.01)

10.2 Completed Daily Drilling Summary Log (Attachment C in ER-SOP 4.01), which will include calibration data, deviations, and any additional comments.

10.3 Completed Summary of Well Development Procedures (Attachment B)

11.0 ATTACHMENTS

The document user may employ documentation formats different from those attached to/named in this procedure—as long as the substituted formats in use provide, as a minimum, the information required in the official forms developed by the procedure.

Attachment A: Well Development Equipment and Supplies Checklist (1 page)

Attachment B: Summary of Well Development Procedures

Well Development Equipment and Supplies Checklist

____ Water level meter

____ Specific Conductance/Temperature/pH meter

____ Distilled water

____ Stopwatch

____ Plastic sheet

____ wire brush assembly

____ Bailer

____ Pump

____ Surge block

_____ Equipment and supplies listed in Attachment A of ER-SOP-4.01

_____ Borehole/Well Completion Information form (Attachment A in ER-SOP-5.01)

____ Any PPE listed or required in the SSHASP

____ Any additional supplies listed in associated procedures, as needed

_____ Turbidity meter with range of 0 – 400 NTU

_____ Photo-ionization detector (PID)

_____

_____

Other method-specific equipment (add below)

_____

_____

_____

_____

_____

_____

_____

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Summary of Well Development Procedures/Plan

Well I.D. _____ Date development began _____ Date development ended _____

Screen No._____	Screen Interval (Perforations) _____ to _____
Formation:	
Development Method	**Final Development Criteria**

Screen No._____	Screen Interval (Perforations) _____ to _____
Formation:	
Development Method	**Final Development Criteria**

Screen No._____	Screen Interval (Perforations) _____ to _____
Formation:	
Development Method	**Final Development Criteria**
This form is available online via a link from the form title in Section 11.	

Screen No._____	Screen Interval (Perforations) _____ to _____
Formation:	
Development Method	**Final Development Criteria**

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Example Only