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OCTOBER 1999

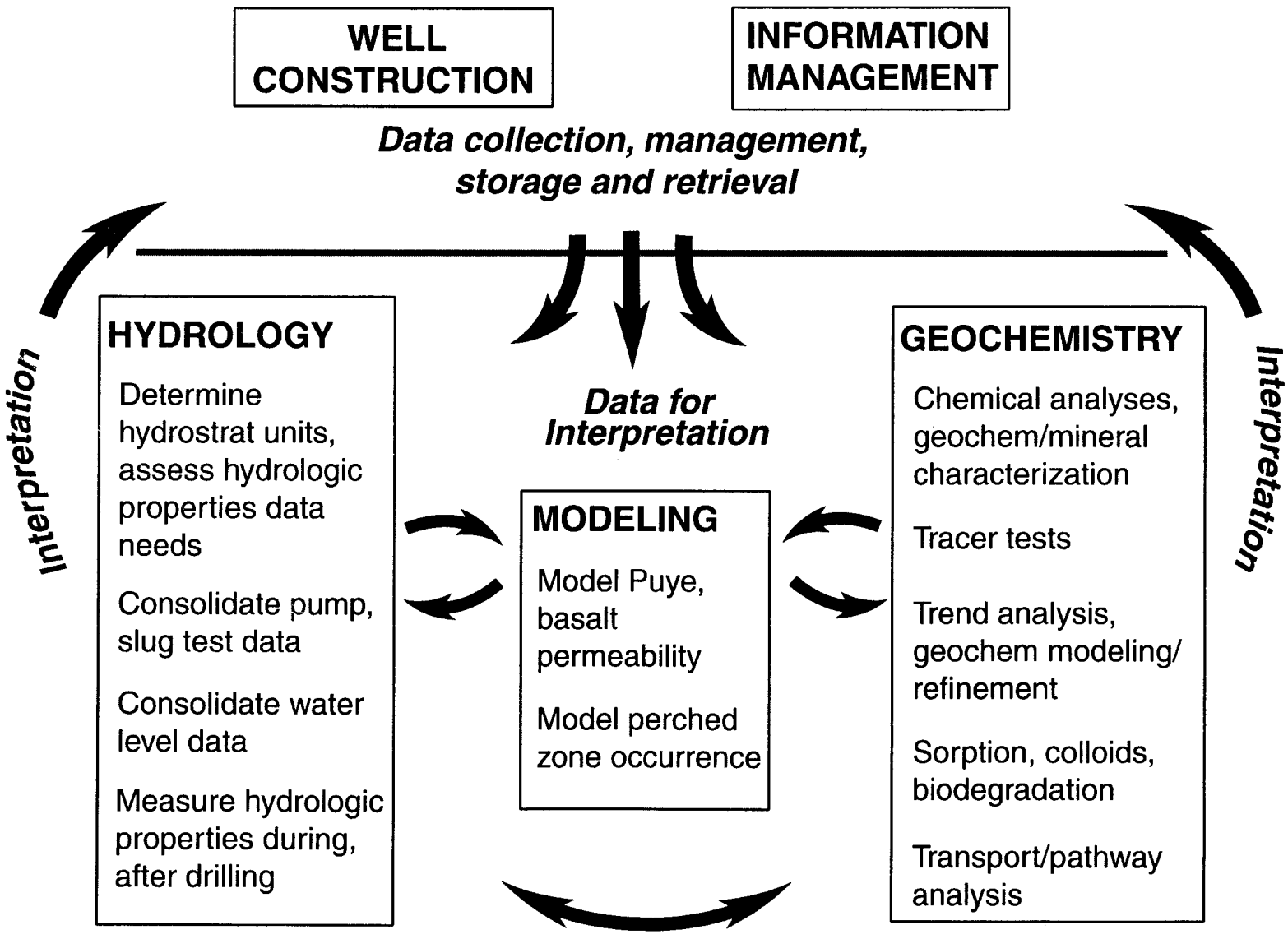
Groundwater Database Project

Information Management Subcommittee Status Report

13307

GIT Quarterly Meeting
October 14, 1999

GIT SUBCOMMITTEE INTERPRETIVE TASKS



Recent Activities

- System requirements definition meetings w/data experts
- Database Design
- Interface Prototyping
- Requirements document & project plan/schedule near completion
- Meeting with ERDB design team with goal of maintaining compatibility between databases
- Proposal for ESH Division funding to support web development using ESRI GIS software

Design Decisions

- Include groundwater data in a larger, more comprehensive database

- Refer to this database as the *"Water Quality Database"*

Development Tools

- **Oracle8 RDBMS**
- **Oracle Designer/Developer**
  - For developing web or client/server data management tool user interfaces
- **Oracle Discoverer**
  - For ad-hoc queries
- **HTML/Java**
  - For web pages on LANL Green partition

Water Quality Database
Phase I Data

- Chemistry
- Field Data (physical & screening data)
- Water Levels
- Hydraulic Properties
- Well Construction
- Geophysical Logs
- Geologic Units/ Contacts

Development Tasks

- **Create the Oracle Database**
- **Create Reference Table Management Tools**
- **Migrate Existing Data**
  - Electronic & Hardcopy
- **Develop Data Management Tools**
  - Data Entry/Import of Future Data Collected
- **Develop Web Interface**
  - End-user data queries
- **Report Generation Tools**
  - Environmental Surveillance Report
  - Discharge Monitoring Reports

Development Task Matrix

	MIGRATE EXISTING DATA	WEB INTERFACE	DATA MANAGEMENT TOOLS	REPORT GENERATION TOOLS
Chemistry	X	X	X	ESR DMR Well Completion
Field Data	X		X	
Water Levels	X	X	X	
Hydraulic Properties	X	X	X	
Well Construction	X	X	X	
Geophysical Logs	X	X	X	
Geologic Units/ Contacts	Utilize Existing Data			

Implementation Terminology

PHASE:
collection of all development tasks related to one product development lifecycle.

	MIGRATE EXISTING DATA	WEB INTERFACE	DATA MANAGEMENT TOOLS	REPORT GENERATION TOOLS
Chemistry	X	X	X	ESR DMR
Field Data	X		X	
Water Levels	X	X	X	
Hydraulic Properties	X	X	X	
Well Construction	X	X	X	
Geophysical Logs	X	X	X	
Geologic Units/ Contacts	Utilize Existing Data			

MODULE:
collection of all development tasks related to one functional area.

Setting Priorities

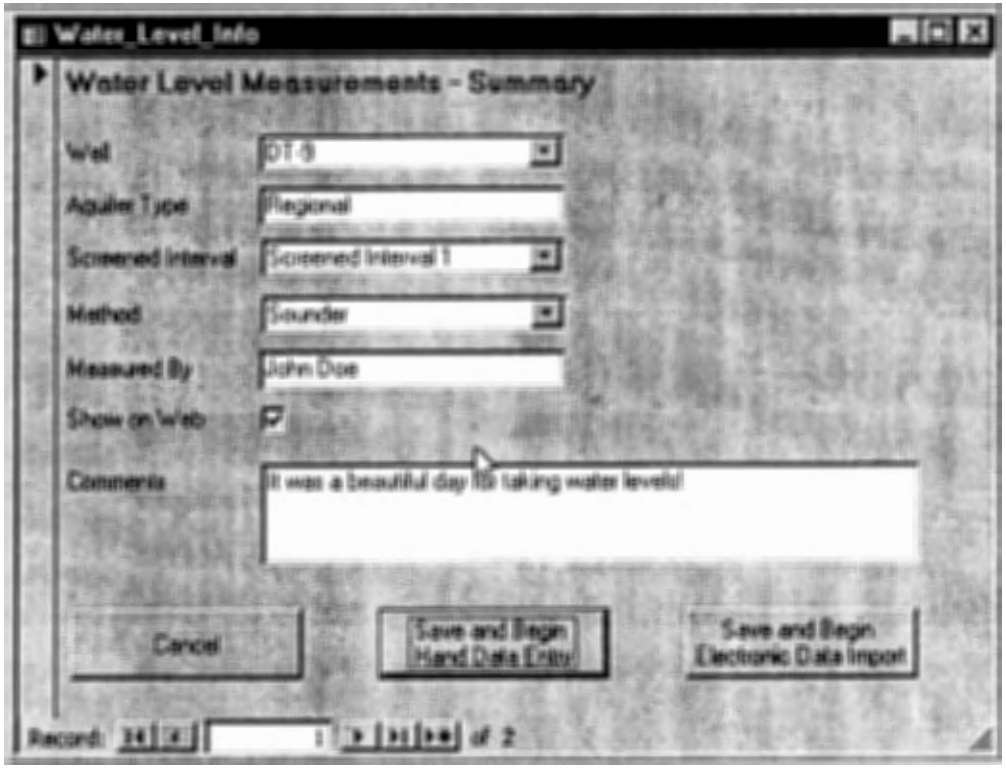
- Architectural Necessity
- User Demand for Data
- Data Migration Considerations
- Effort Required to Implement

Proposed Order of Module Implementation

1. Field Data (physical & screening data)
2. Chemistry
3. Water Levels
4. Hydraulic Properties
5. Well Construction
6. Geophysical Logs
7. Geologic Units/ Contacts

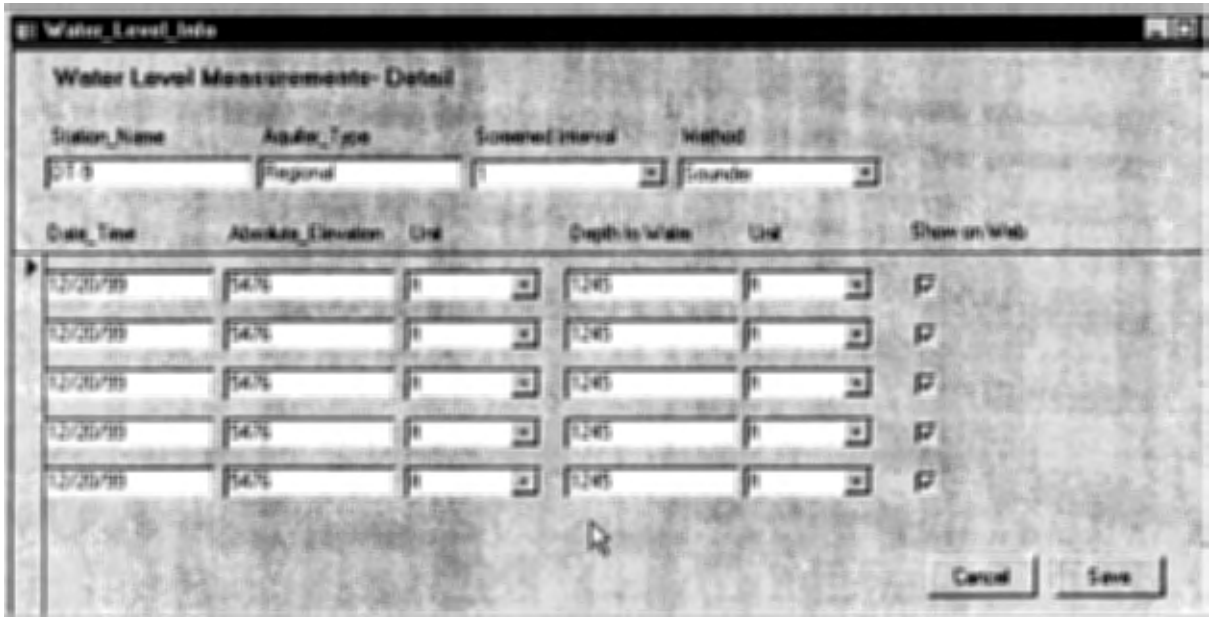
Prototype - Water Levels

- **Begin new data entry or import here:**



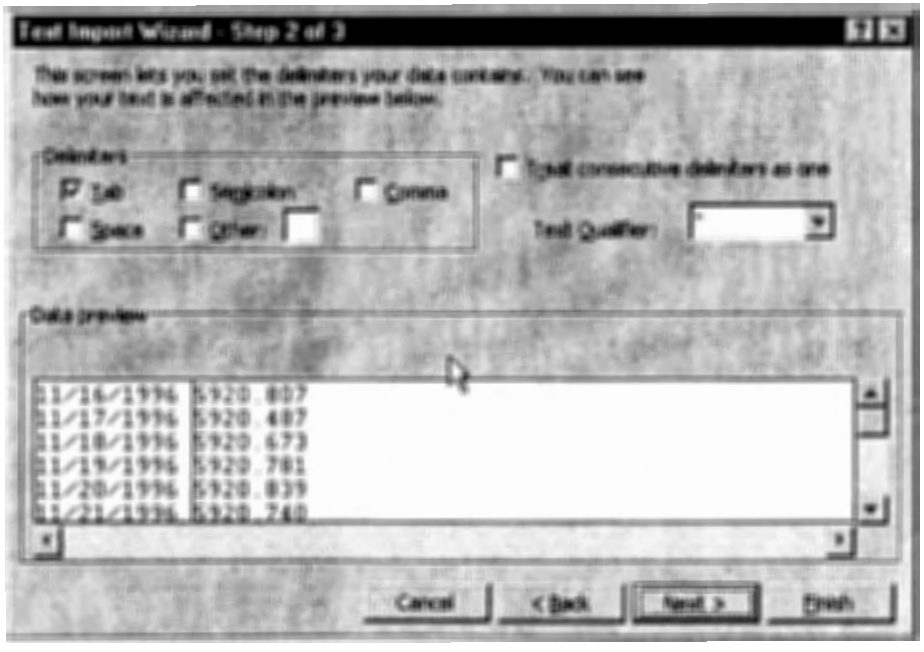
Prototype - Water Levels

- **Continue if new data ENTRY:**



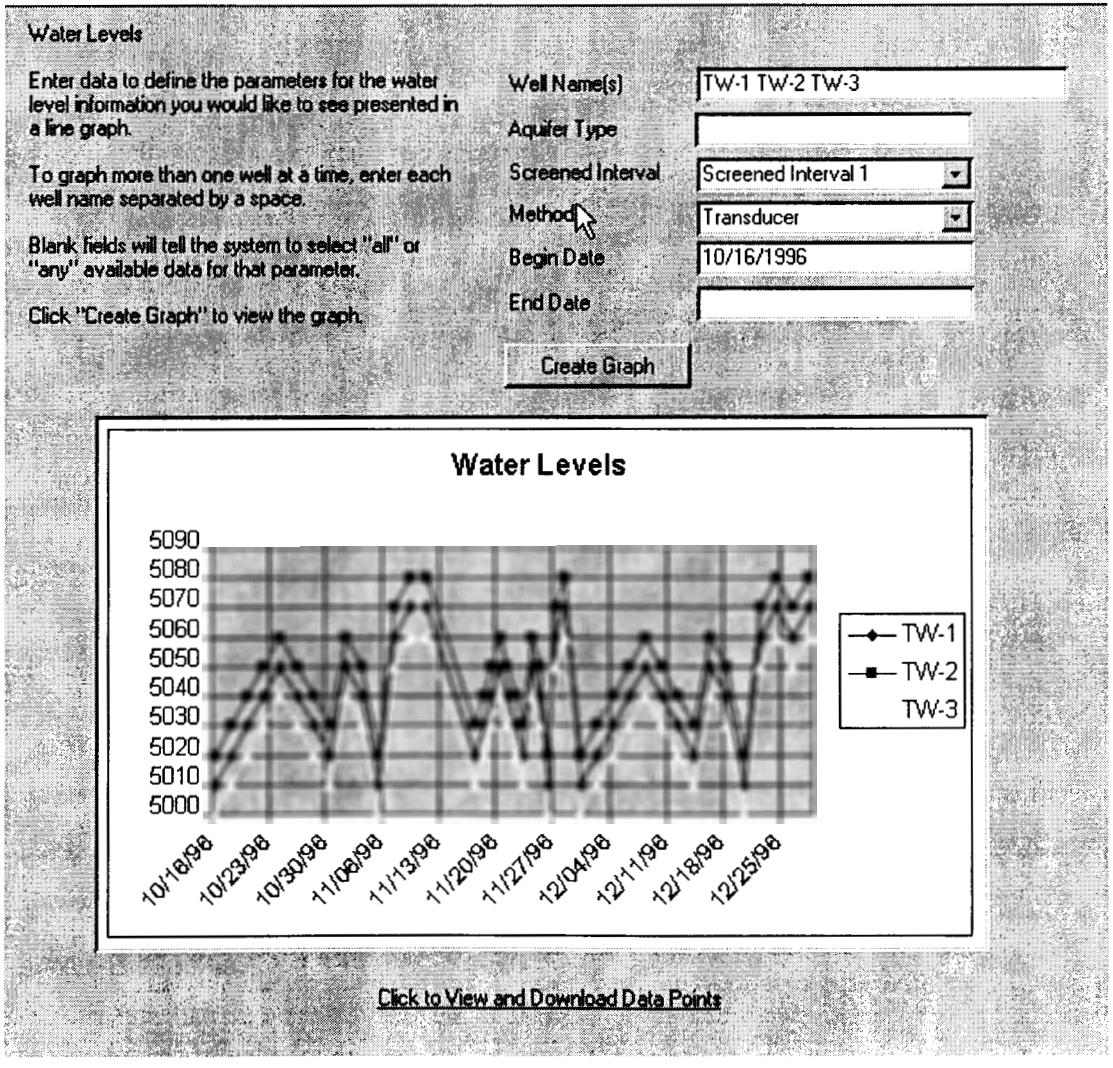
Prototype - Water Levels

- **Continue if new data IMPORT:**



Prototype - Water Levels

- **Web Interface - graphing**



Prototype - Water Levels

- **Web Interface - tabular data**

Water Levels - Tabular Data

Click to Download Tabular Data File

Well Name(s)	TW-1 TW-2 TW-3
Aquifer Type	
Screened Interval	Screened Interval 1
Method	Transducer
Begin Date	10/16/1996
End Date	

Date	TW-1	TW-2	TW-3
10/16/96	5010	5020	5000
10/18/96	5020	5030	5010
10/20/96	5030	5040	5020
10/22/96	5040	5050	5030
10/24/96	5050	5060	5040
10/26/96	5040	5050	5030
10/28/96	5030	5040	5020
10/30/96	5020	5030	5010
11/01/96	5050	5060	5040
11/03/96	5040	5050	5030
11/05/96	5010	5020	5000
11/07/96	5060	5070	5050
11/09/96	5070	5080	5060
11/11/96	5070	5080	5060
11/17/96	5020	5030	5010
11/18/96	5030	5040	5020
11/19/96	5040	5050	5030
11/20/96	5050	5060	5040
11/21/96	5040	5050	5030
11/22/96	5030	5040	5020

Challenges

- Programming Resources
- Migration of Historic Data

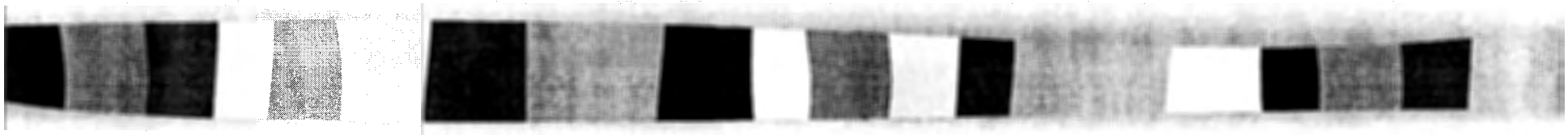
Estimated Cost and Schedule

- 2.5 FTE's
- 1 year total development time
- Estimated cost = $400,000

Moving Forward in Q4 1999

- Continued Communication with ERDB Team
- Complete Database Design
- Obtain Signoff on System Requirements
- Present Detailed Cost & Schedule Info
- Begin Development

Question & Answer



GIT Hydrology Subcommittee

Obtain hydrologic properties during drilling:

Core and cuttings:

- moisture content
- matric suction

Water levels

Slug tests:

- when water encountered, use opportunity after sampling to carry out slug test
- sampling = a slug; measure recovery

Single packer tests:

- packer at end of drill casing
- inject water

David Rogers

GIT Hydrology Subcommittee

Obtain hydrologic properties after drilling:

Core:

- core perching layers, zones of lithologic or hydrologic interest
- laboratory measurement of hydrologic properties
- have sent 8 cores from R-25, 4 from R-12, and 1 from R-9

Water levels

Slug or pump tests

David Rogers

GIT Hydrology & Modeling Subcommittees

Interpretive tasks:

1) Determination of hydrostratigraphic units and assessment of hydrologic properties data needs.

2) Permeability models for the Puye and basalt.

3) Consolidation of pump and slug test data.

4) Consolidation of water level data.

5) Conceptual model of perched zone occurrence.

6) Hydrologic property measurement during and after drilling.

7) Water budget.

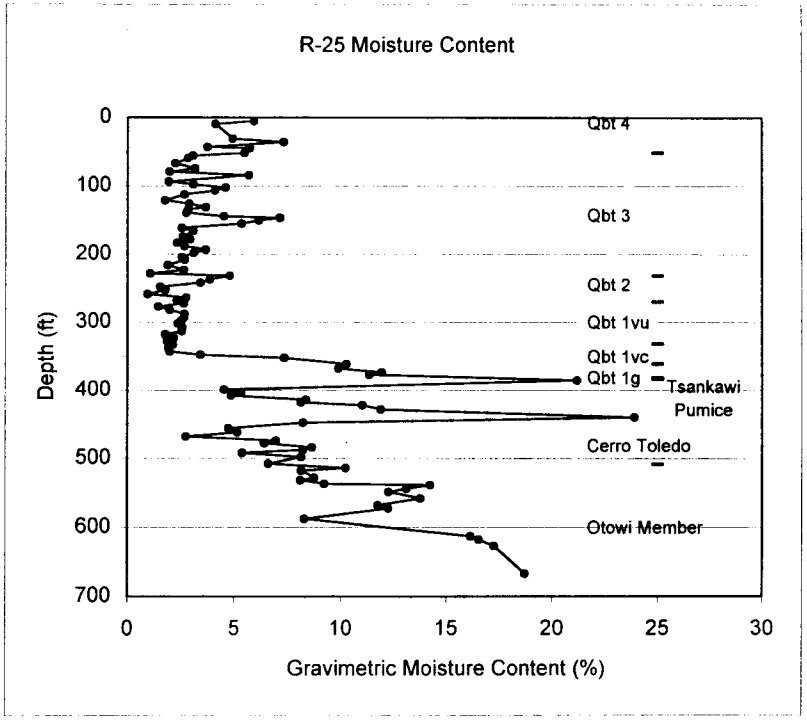
David Rogers

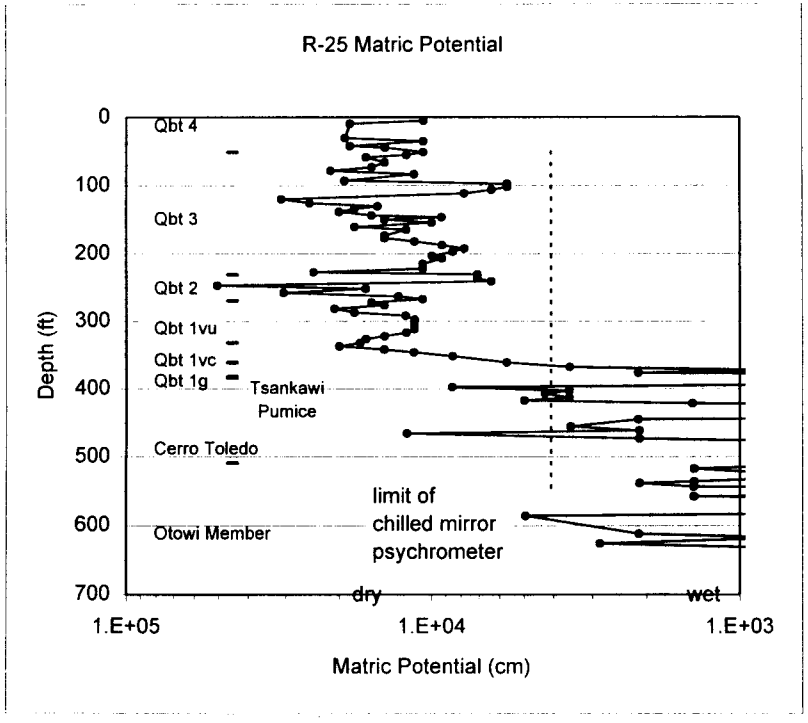
GIT Hydrology Subcommittee

Geophysical logs:

- Collected natural gamma and resistivity logs in R-9, R-12, R-25, and R-15
- Gamma logs through casing or in open hole-good stratigraphic correlation tool
- Resistivity logs in open hole
- Also borehole video and caliper logs

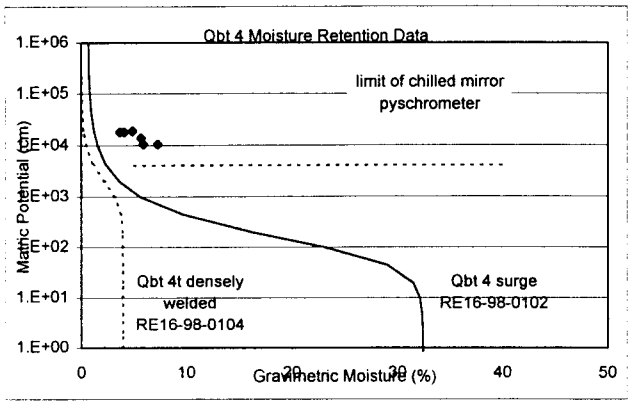
David Rogers

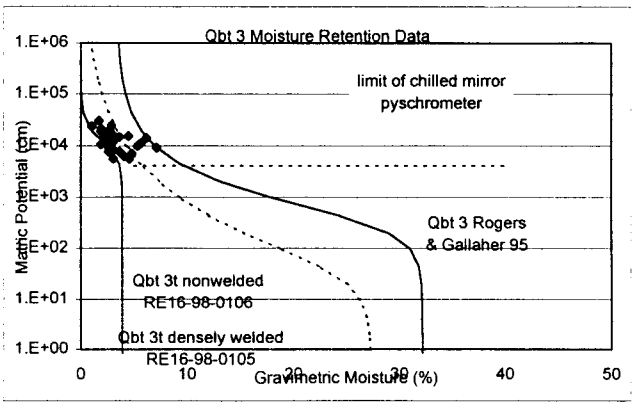


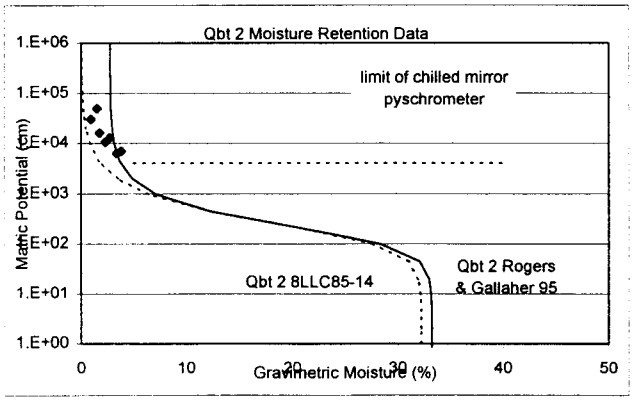


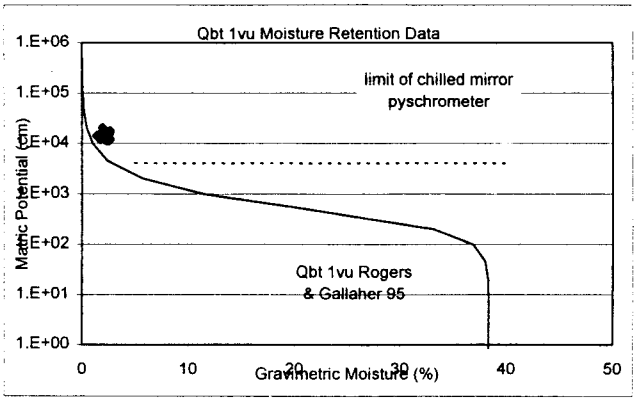
David Rogers

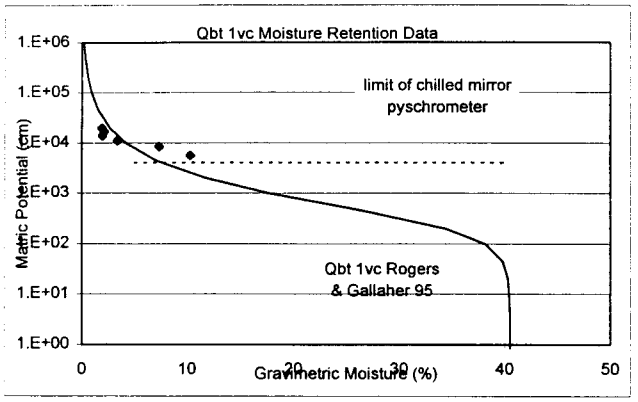
R-25 moisture retention data from cuttings

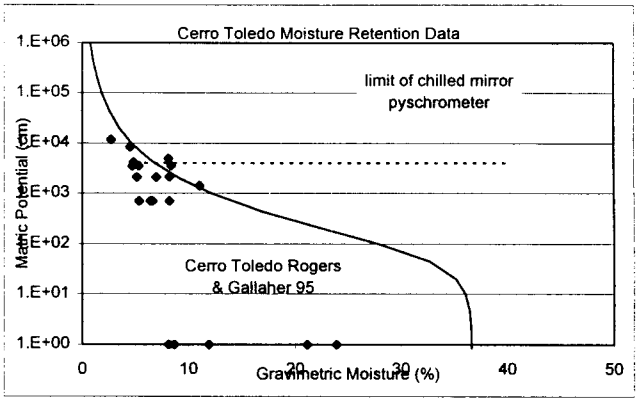




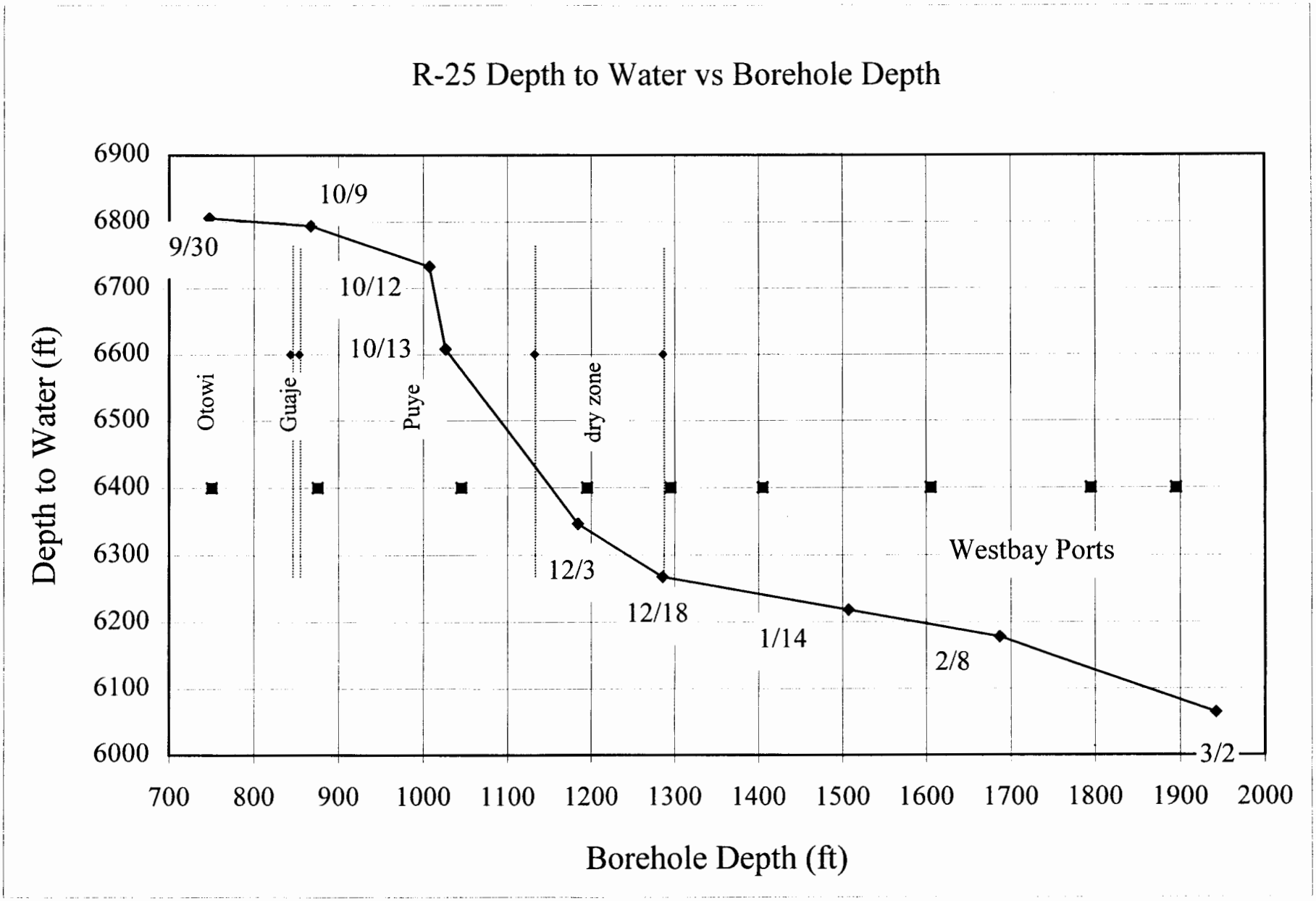








David Rogers



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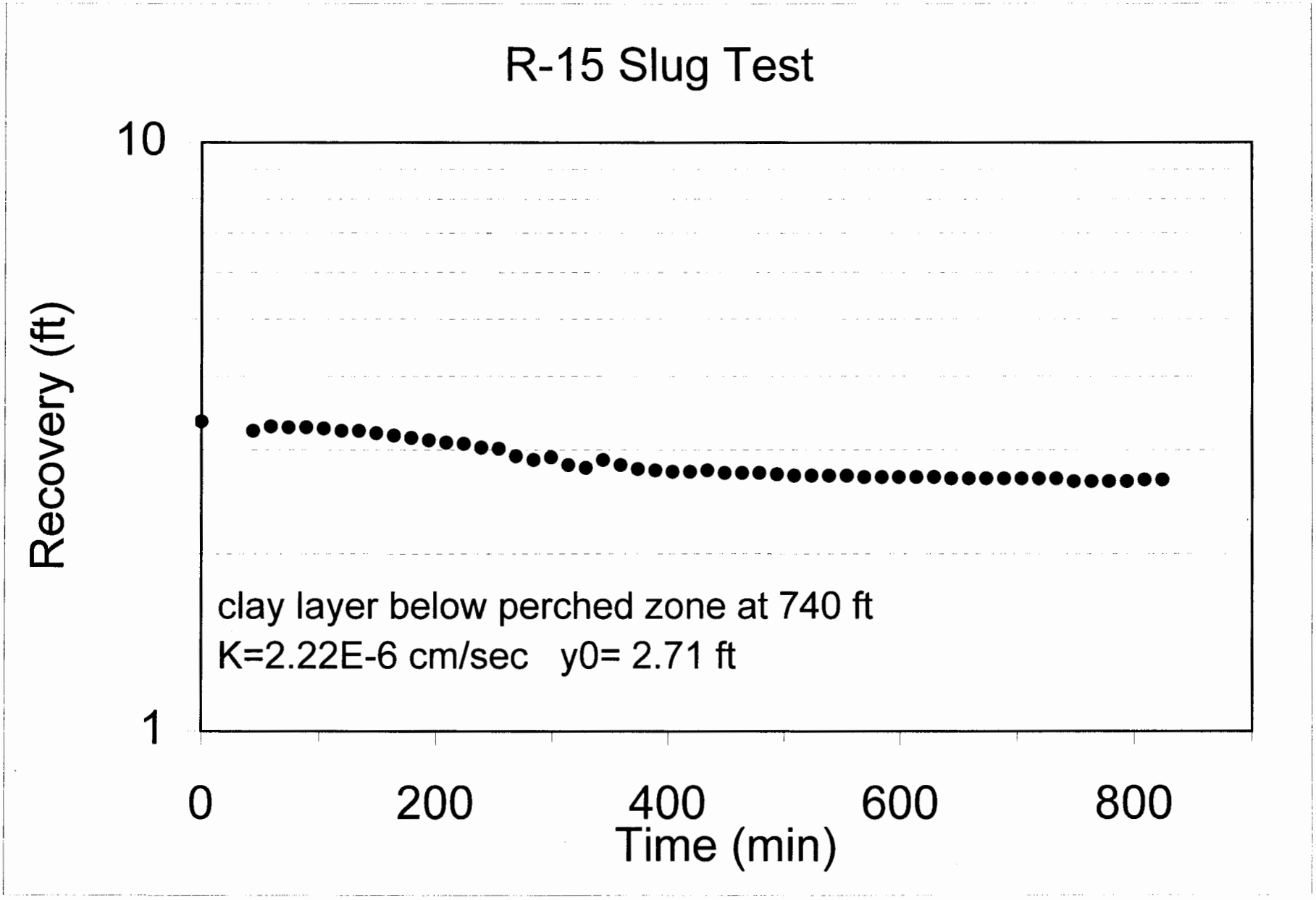

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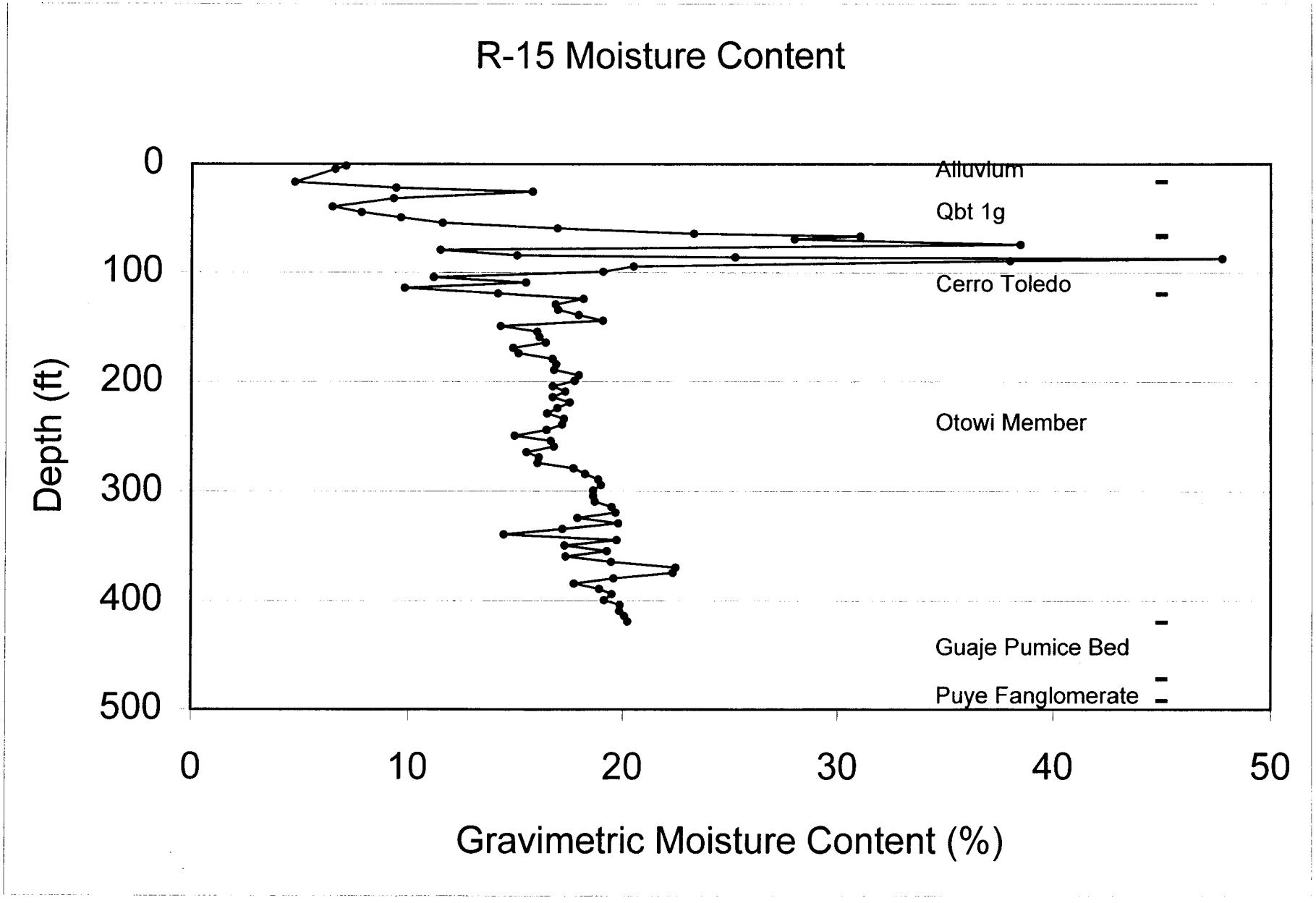

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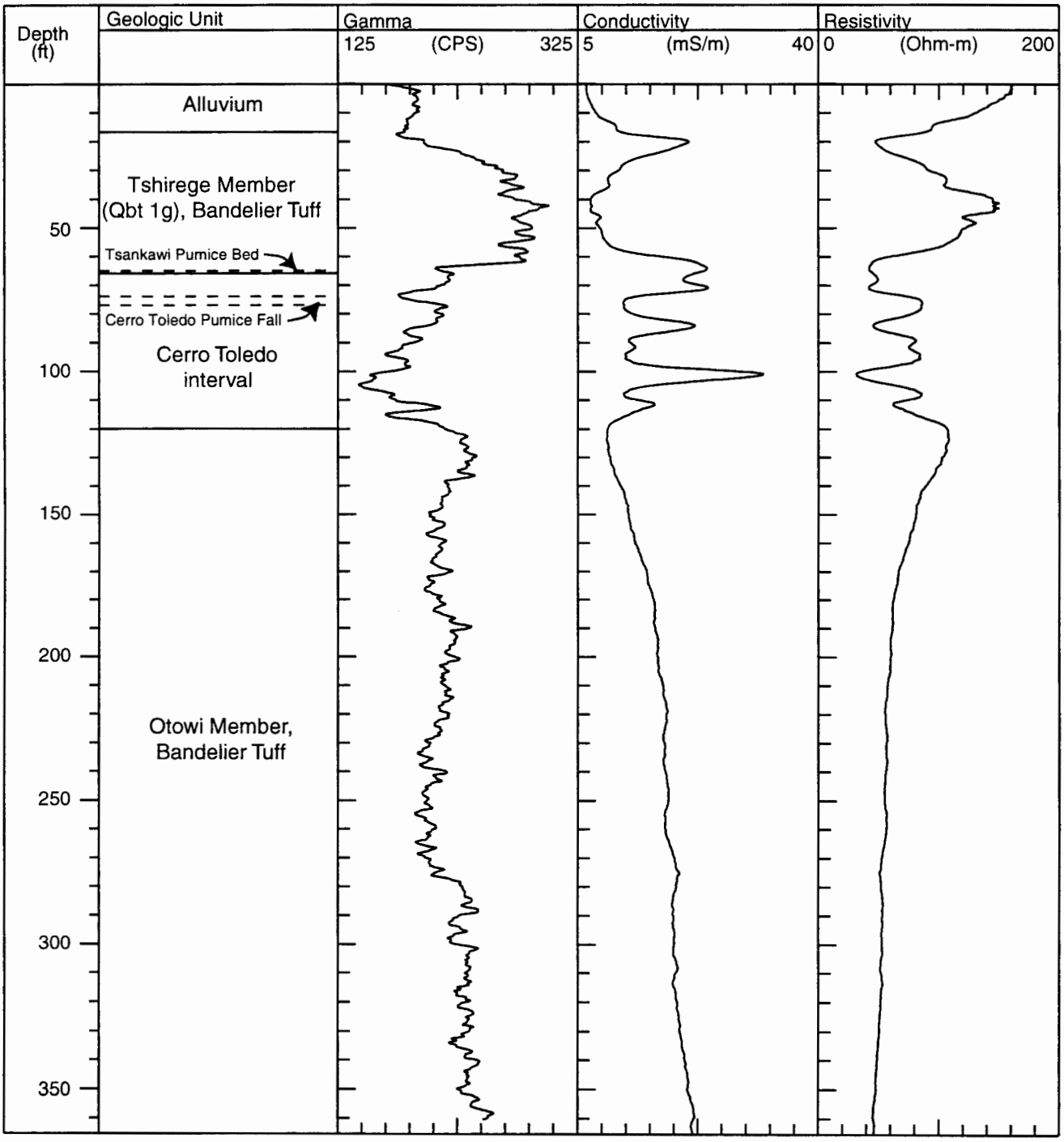


Open borehole natural gamma, conductivity, and resistivity measurements in R-15.

David Rogers

STATUS REPORT FOR GEOCHEMISTRY SUBCOMMITTEE (10/14/99)

Chair Person:

Patrick Longmire, EES-1

Co-Chair Person:

Brent Newman, EES-15

Subcommittee Members:

Steve Bolivar, Dale Counce, Fraser Goff, Stephanie Hagelberg, Bob Hull, Sue Johnson, Elizabeth Keating, Ed Kwicklis, Ken Mullen, Bruce Robinson, David Rogers, Everett Springer, Bill Stone, Gene Turner, and Bart Vanden Plas.

Reports: **R-15 Interim Completion Report, R-25 Interim Completion Report, R-25 Hydrochemistry Report, LANL Background Groundwater Report (data validation), and Geochemistry of Regional Aquifer (Modeling Subcommittee).**

Sampling: **MCO-7.5, R-15, TA-50, TA-16: intermediate wells (4), precipitation, and springs.**

Geochemical Modeling: **LANL background springs and wells, supply wells, domestic wells, TA-50 treated discharge, R-25, and R-15 (PHREEQC and MINTEQA2).**

Presentations: **GSA (11/99) and AGU (12/99)**

Task: Revision of ^{14}C Ages for the Regional Aquifer

Background:

A review of the published ^{14}C ages for the regional aquifer (Spangler, 1994) has found that some of the assumptions made for the calculated ages are incorrect. Problems occur with the correction of raw ^{14}C ages due to addition of dead carbon to the aquifer as a result of calcite dissolution. In addition, problems occur with the assumption that calcite dissolution is taking place within the entire aquifer. Modeling data suggest that calcite precipitation is occurring in some regional aquifer groundwaters. Because of the importance of these data in current laboratory modeling activities and in future monitoring activities, the ages should be revised. In addition, new ^{14}C samples will be collected as part of Hydrogeologic Workplan activities and the proposed work will provide a basis for correcting these new ^{14}C ages. A preliminary set of calculations shows that using more appropriate calcite $\delta^{13}C$ values will make a significant change in the ^{14}C ages.

Scope:

1. Collect a series of calcite samples from Cerros del Rio basalt, Puye Formation, and Santa Fe Group cores (preferably from the R-holes).
2. Supplement the core samples with samples collected from Puye Formation and Santa Fe Group outcrops (twenty core and outcrop samples will be collected).
3. Submit samples for $\delta^{13}C$ and quadrapole analysis at New Mexico Tech. The $\delta^{13}C$ data will be used directly in the ^{14}C age calculations. The quadrapole data will provide information on whether calcite is a carbon source or sink in the various parts of the regional aquifer.
4. Prepare a short report that contains a revised set of ages based upon the raw ^{14}C values in Spangler (1994) and include a table of $\delta^{13}C$ data for use in future ^{14}C age determinations.

Cost:

Analytical: 6K (New Mexico Tech)
FTE Charges: Brent Newman-22k for sampling, analysis, and report writing
David Broxton-2k for outcrop sampling

Total Cost: 30K

Reference:

Spangler, R. R., 1994. Effect of Carbonate Dissolution on Carbon-14 Groundwater Ages.

Task: Geochemical Data and Information

Background:
Geochemical data and information are needed to support policy and technical decisions, field, laboratory, and modeling investigations dealing with natural solute and contaminant distributions in groundwater. Mineralogical characterization is useful in performing model simulations, which quantify mineral-solution equilibria and adsorption processes. Mineralogical characterization is also useful in validating geochemical modeling results. Preparation of position papers regarding analytical methods, data validation, monitoring parameters, monitored natural attenuation, colloids, and low-flow sampling are required to establish technical consistency within the ER Project and Laboratory surveillance programs. These position papers shall be prepared on a case-by-case basis. Geochemistry short courses and seminars may also be included under this task scope.

Scope:
1. Prepare technical position papers on low-flow sampling, analytical methods, for example ICPMS, for selected trace elements (antimony, beryllium, cadmium, lead, thallium, and uranium), appropriate monitoring parameters, colloid transport, and monitored natural attenuation.
2. Perform mineralogical characterization on selected core samples collected from R wells. These results shall be used in sorption experiments, modeling simulations, and position papers dealing with monitored natural attenuation.
3. Perform geochemical modeling to quantify solute speciation, mineral-solution equilibria, sorption processes, mixing reactions, evaporation reactions, and reaction path modeling. Geochemical computer programs including PHREEQC and MINTEQA2 are appropriate codes for quantifying water-rock reactions.
4. Prepare reports detailing modeling simulations and mineralogical characterization investigations.

Cost:
Analytical: 25K (EES-1) (mineralogical characterization)
FTE Charges: 100K for Patrick Longmire, Brent Newman, Elizabeth Keating, Fraser Goff, and other geochemistry subcommittee members

Total Cost: 125K

Task: Measurement of Degradation Parameters and Constants for RDX and TNT at R-25

Background:
RDX and TNT have been detected at R-25 in the upper perched zone and regional aquifer (LANL, 1999) at concentrations exceeding EPA health advisory limits of 2 μg/L. Maximum groundwater concentrations of RDX and TNT observed at R-25 are 84 and 19 μg/L, respectively. These compounds are poorly sorbing onto aquifer material at R-25. Consequently, dilution, advection, and degradation are the dominant processes contributing to decreasing concentrations of RDX and TNT along the groundwater flow path. Degradation products of TNT, including 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene, are observed at R-25 (LANL, 1999) at concentrations less than 10 μg/L. Degradation products of RDX, however, have not been identified at R-25 using high pressure liquid chromatography (HPLC) (EPA method 8330). RDX is more recalcitrant than TNT in aqueous systems. Computer modeling is proposed at R-25 and site-specific input data will provide the most meaningful results to quantify groundwater flow and contaminant transport. A review of available literature suggests a lack of data and information regarding RDX degradation in groundwater. Most of the research has been conducted on RDX degradation in soil systems and TNT degradation in shallow groundwater systems. Site-specific data are recommended for quantifying degradation rates of RDX and TNT because the rates are dependent on site-specific water chemistry, groundwater temperature, microbial populations, nutrient availability, organic carbon, and mineral content. Site-specific degradation data and information for RDX and TNT should provide the most meaningful computer modeling results for groundwater flow, contaminant transport, and risk analysis at R-25.

Scope:
1. Collect a series of groundwater and core-cutting samples from the upper perched zone and regional aquifer at R-25.
2. Perform experiments using R-25 groundwater and core-cutting samples and organic carbon (nutrient) to determine rates of degradation for RDX and TNT over several months at ambient temperature.
3. Submit groundwater samples for high explosive and degradation product analysis, using EPA method 8330, at Paragon Analytics, Inc in Fort Collins, Colorado. The analytical results will be used directly for computer modeling simulations.
4. Prepare a short report that contains experimental results, including degradation constants for RDX and TNT.

Cost:
Analytical: 100K (Paragon Analytics, Inc.)
FTE Charges: Betty Strietelmeier-125k for conducting experiments and report writing.
Technician-50k for assisting in experiments.
Patrick Longmire-30k for supervision and report writing.

Total Cost: 305K

Reference:
LANL, 1999, Interim Completion Report for R-25.

Task: Measurement of Sorption Parameters and Constants for Radionuclides

Background:
Radionuclides, mainly including strontium-90, cesium-137, uranium isotopes, plutonium isotopes, and americium-241, are present in alluvial groundwater within Los Alamos Canyon and Mortandad Canyon since the past three decades (LANL annual surveillance reports). These contaminants adsorb onto aquifer material to varying degrees depending on contaminant concentration, water chemistry, contaminant speciation, pH, redox, and types of adsorbents (glass, clay minerals, solid organic carbon, calcium carbonate, and hydrous ferric oxides). Most of the mass distributions of cesium-137, plutonium isotopes, and americium-241 probably occur within the alluvium due to irreversible adsorption. Strontium-90 and uranium isotopes, however, adsorb onto aquifer material to a lesser extent and their mass distributions may be beneath the alluvium in Los Alamos Canyon and Mortandad Canyon. Contaminated perched groundwater zones within basalt, ranging from several feet to tens of feet, have been encountered at R-9, R-12, and R-15. Dissolved uranium (48.4 μg/L) is detected at R-9 within the lower perched zone of the Cerros del Rio basalt at concentrations exceeding local background (1 μg/L). The proposed EPA maximum contaminant limit (MCL) for uranium is 20 μg/L. At R-9, dissolved uranium is predicted to dominantly occur as the uranyl tricarbonato complex ($UO_2(CO_3)_3^{4-}$) based on computer modeling using MINTEQA2. Adsorption processes do not completely remove this dissolved complex from R-9 groundwater characterized by alkaline pH (8.8) and bicarbonate plus carbonate concentrations of 112 mg/L (Broxton et al., 1998). Both porous and fracture flow occurs within the basalt, which may decrease the amount of sorption of contaminants migrating through unlined fractures and air-fall deposits. Quantifying the mobility of uranium and other weakly sorbing contaminants found at Los Alamos National Laboratory is of importance in geochemical and solute transport modeling and risk analysis.

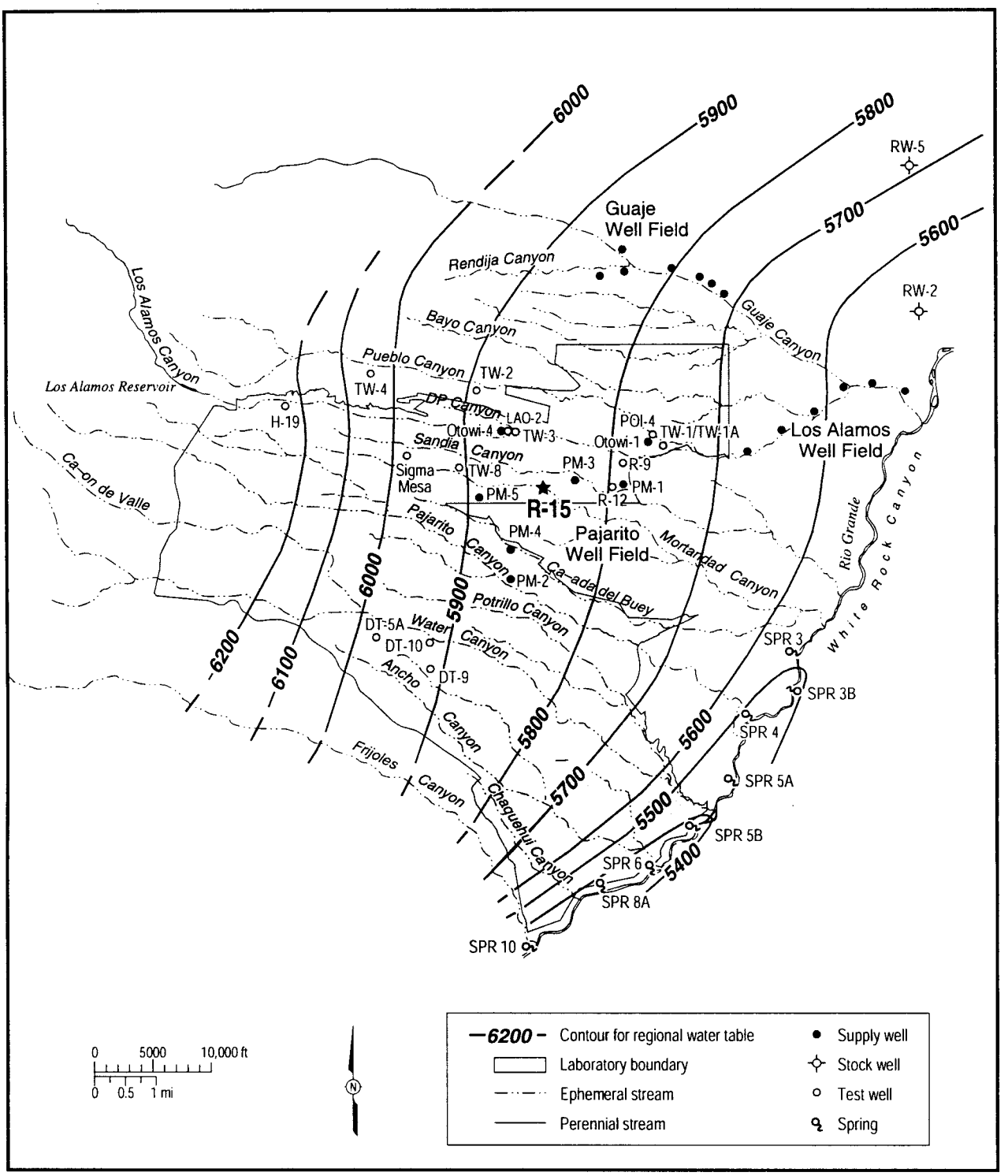
Scope:
1. Collect a series of groundwater and core-cutting samples from the lower basalt perched groundwater zone at R-9.
2. Perform sorption experiments on uranium, strontium, plutonium, and americium using R-9 groundwater and core-cutting samples to determine adsorption constants (distribution coefficients and surface complexation parameters).
3. Submit groundwater samples for uranium, strontium, plutonium, americium, and other solute analyses, using EPA and LANL methods, at CST-9 (DOE-approved analytical laboratory). The analytical results will be used directly for computer modeling simulations.
4. Prepare a report that contains experimental results, including adsorption constants for strontium-90, uranium, plutonium, and americium.

Task: Measurement of Sorption Parameters and Constants for Radionuclides

Cost:
Analytical: 75K (CST-9)
FTE Charges: Ningping Lu-150k for conducting sorption experiments and report writing.
Technician-50k for assisting in sorption experiments.
Patrick Longmire-50k for supervision and report writing.

Total Cost: 325K

Reference:
Broxton et al., 1998, Interim Completion Report for R-9.



Source: Purtymun 1984, 6513

F1-1 / R-15 WELL COMPLETION RPT / 081399

Figure 1-1. Location of R-15, existing water supply wells and test wells, and generalized water-level contours for the regional water table.

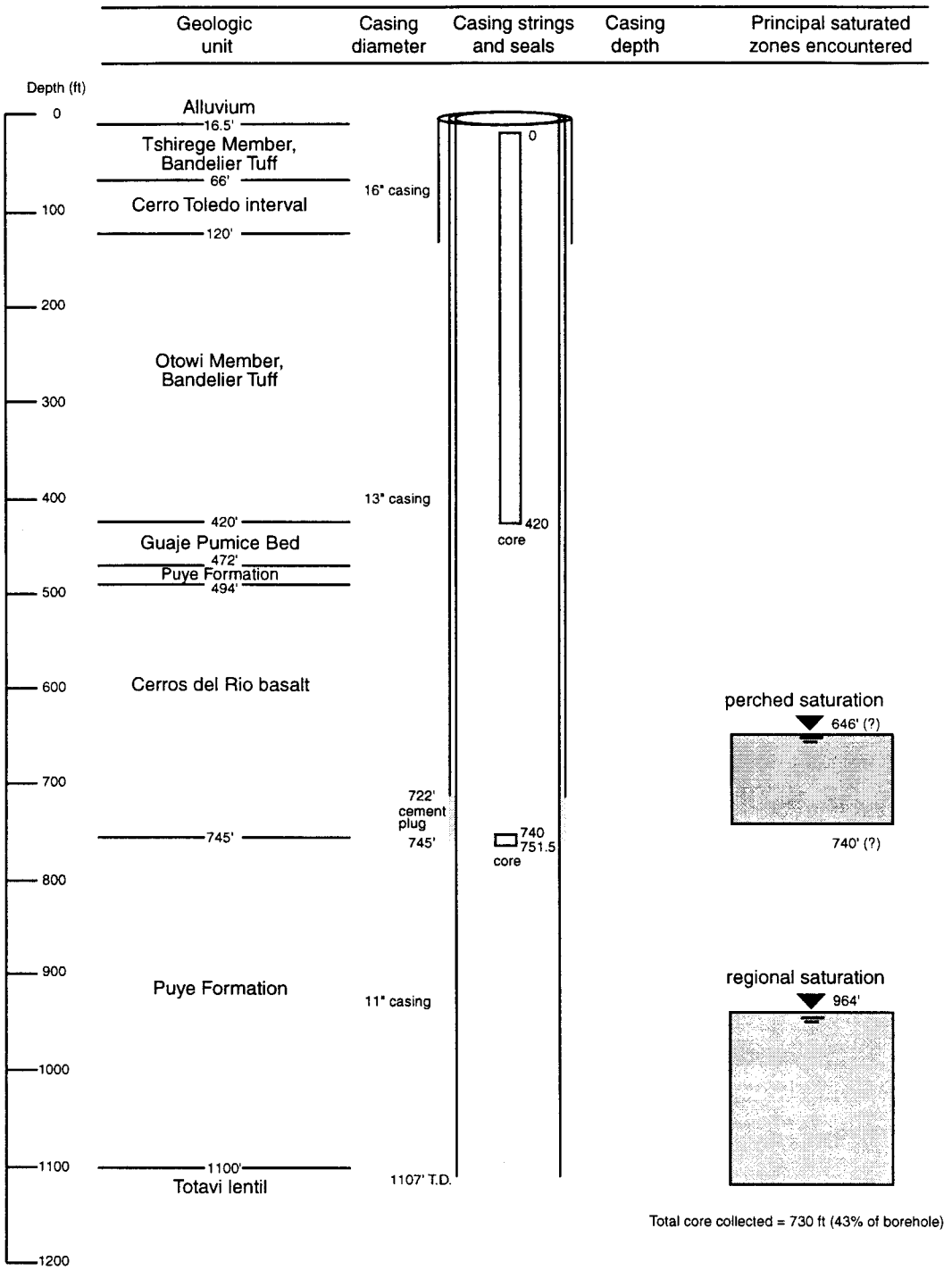
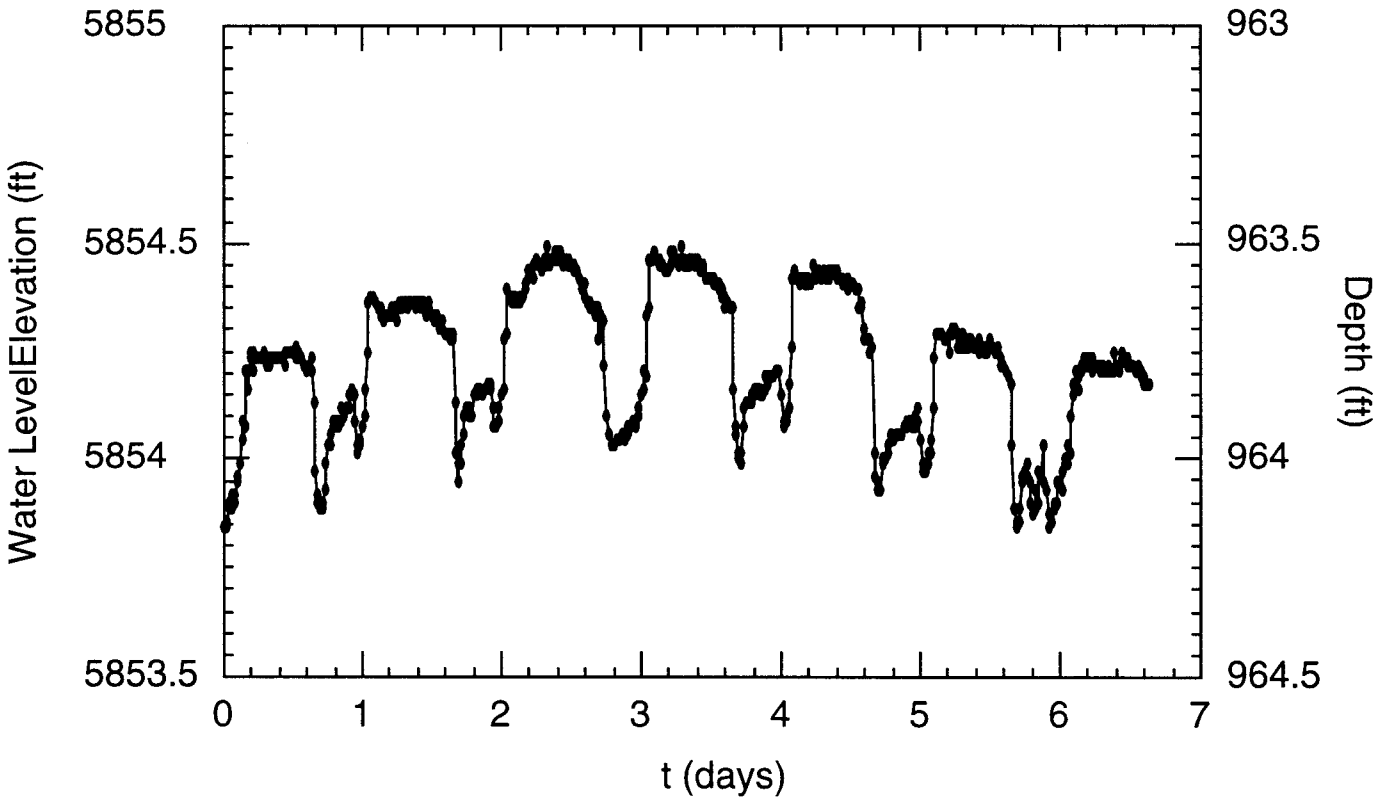


Figure 2.3-1. R-15 borehole configuration at total depth.



Water level based on surface elevation of 6818 ft.

Figure . Water levels measured in the regional aquifer prior to well completion at R-15 from August 31 to September 7, 1999.

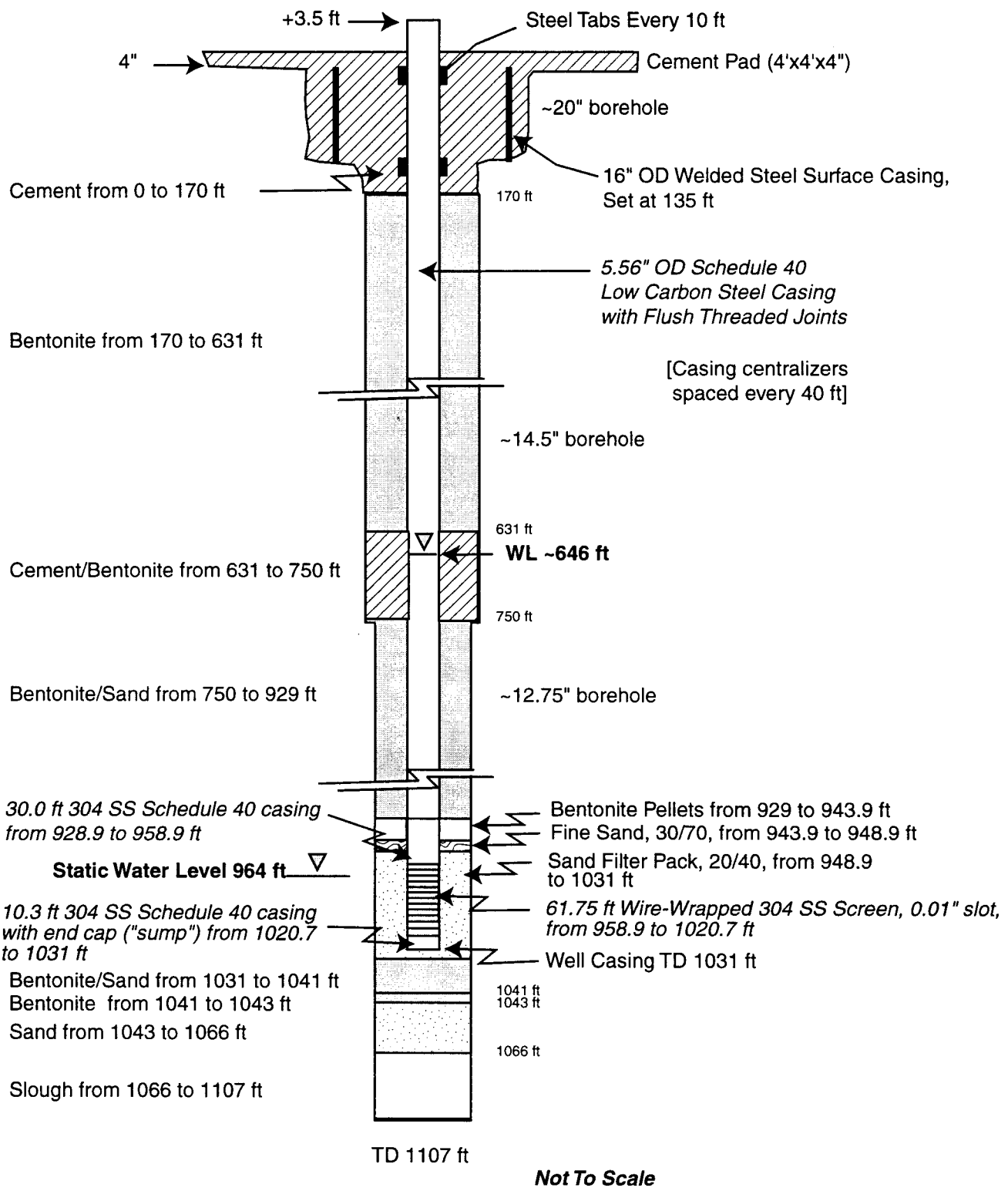


Figure 8.0-1. As-built well completion diagram of well R-15.

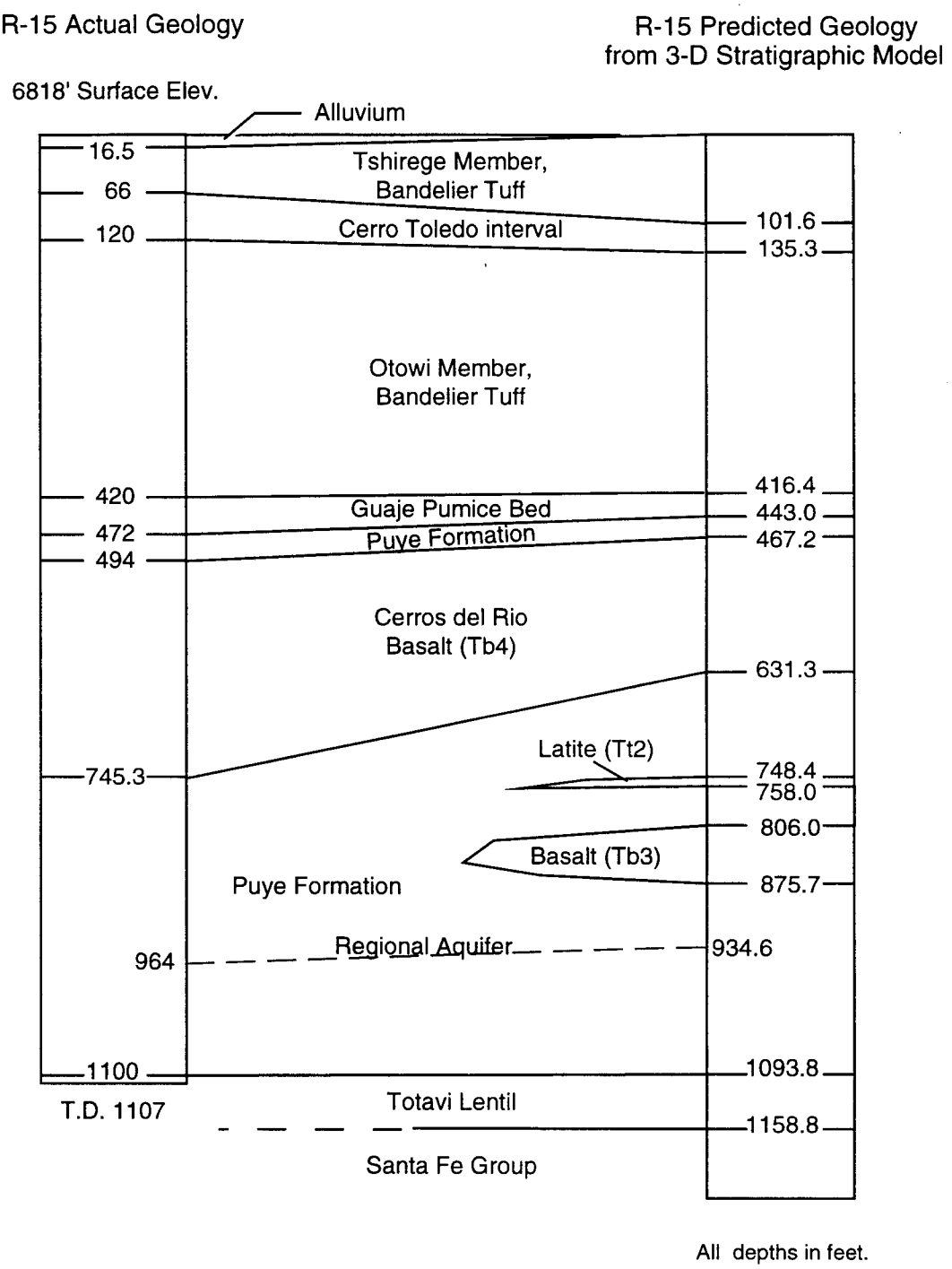
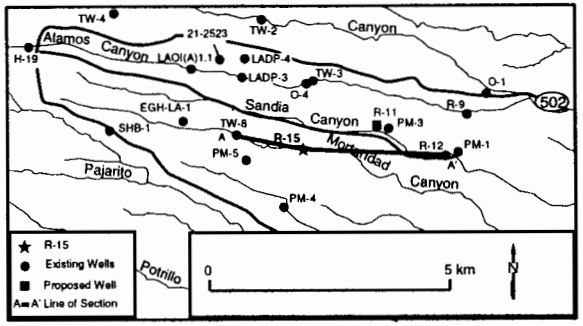
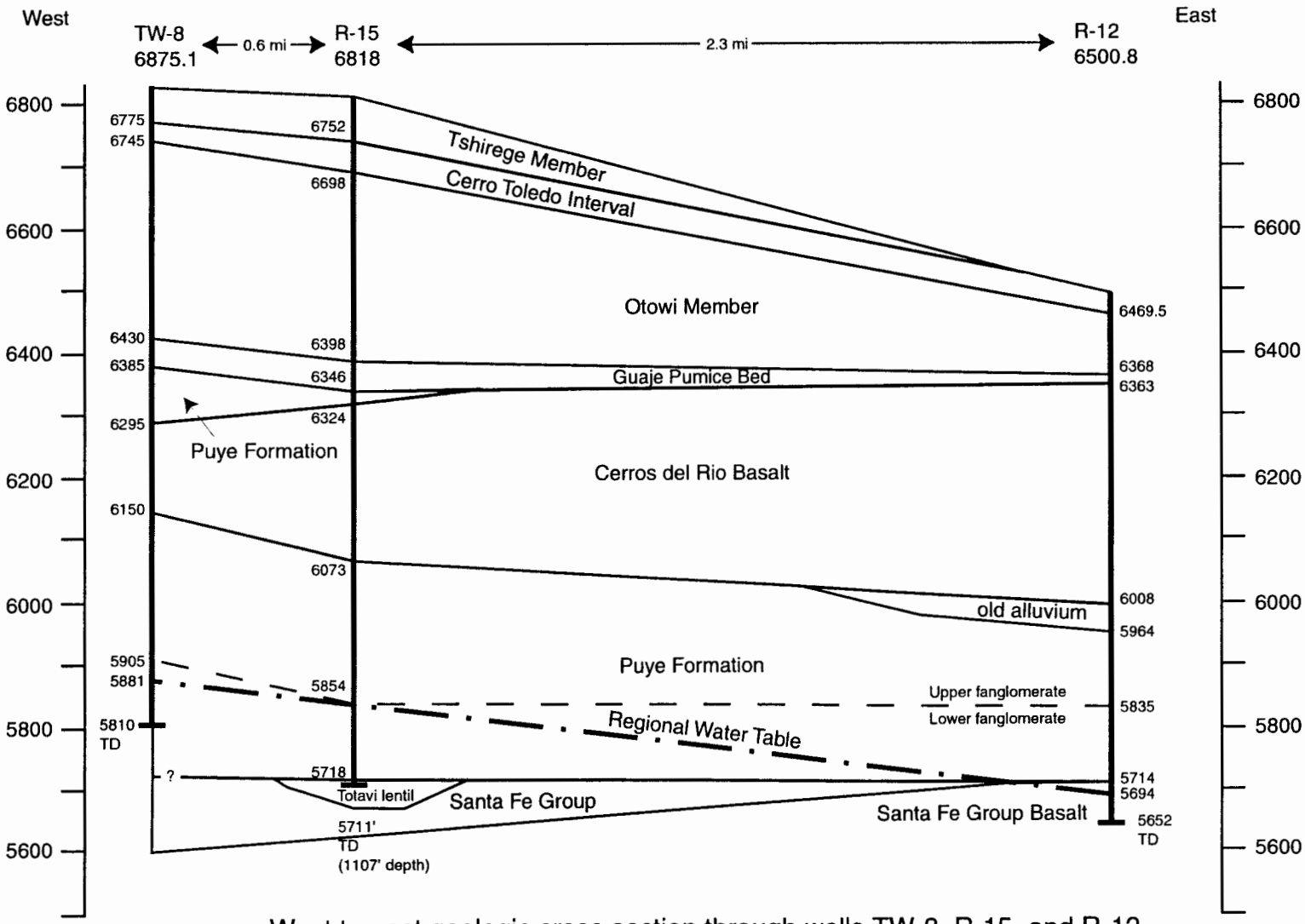


Figure . Comparison of actual vs. predicted geologic contacts in R-15.





West to east geologic cross section through wells TW-8, R-15, and R-12.

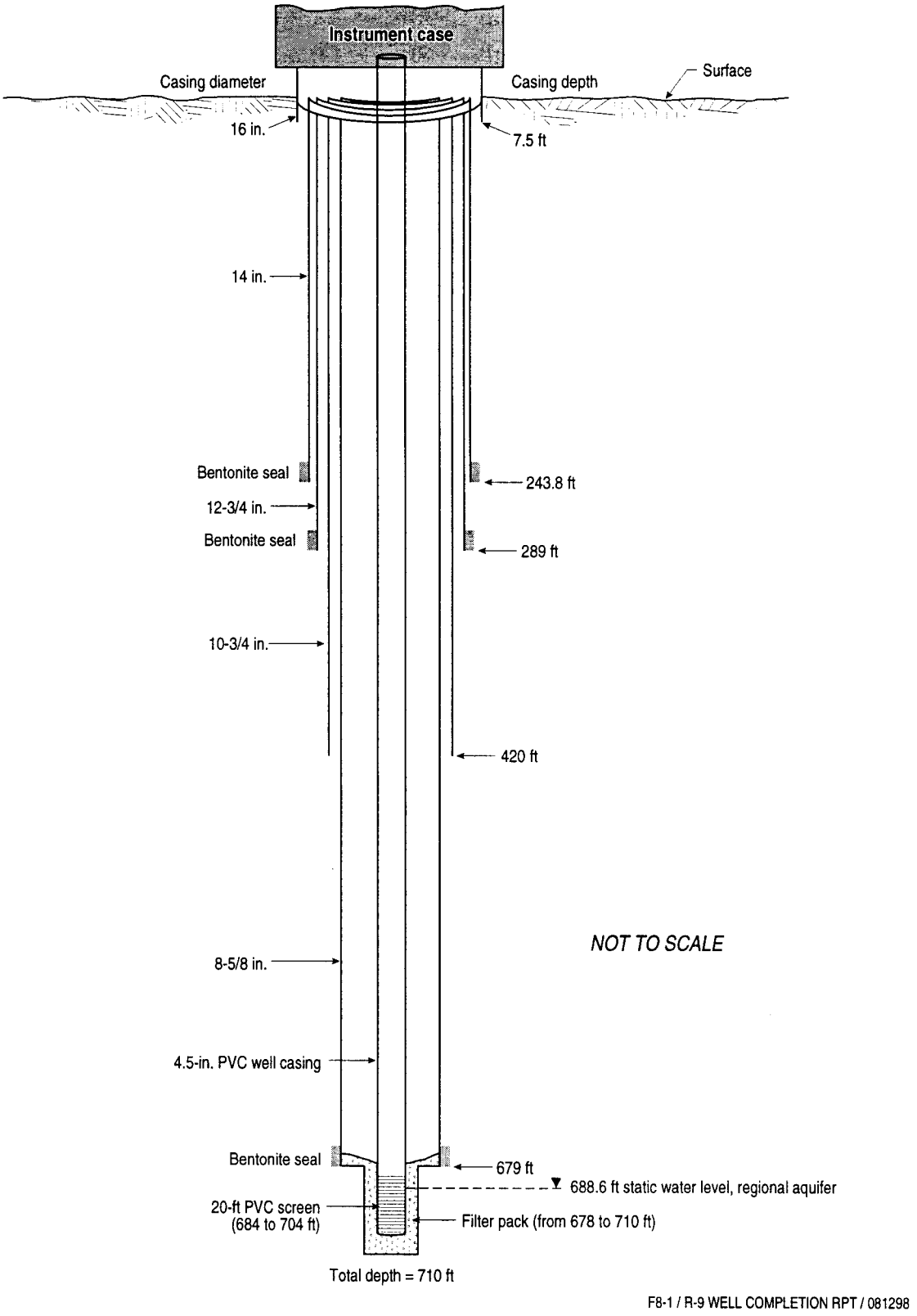
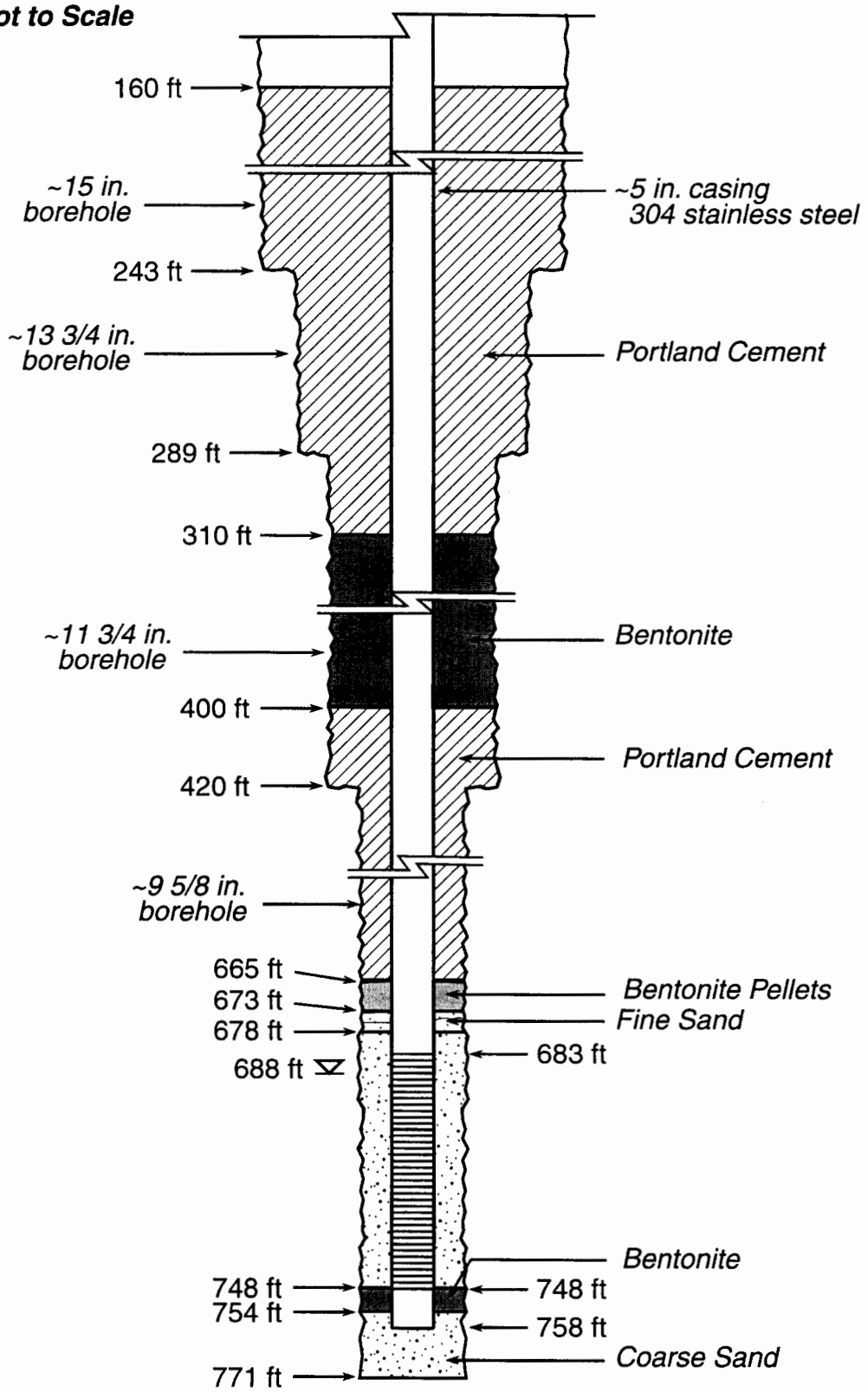


Figure 8-1. Configuration of the temporary well for R-9.

Well R-9 Completion
(Draft 10-13-99)

Drawing Not to Scale



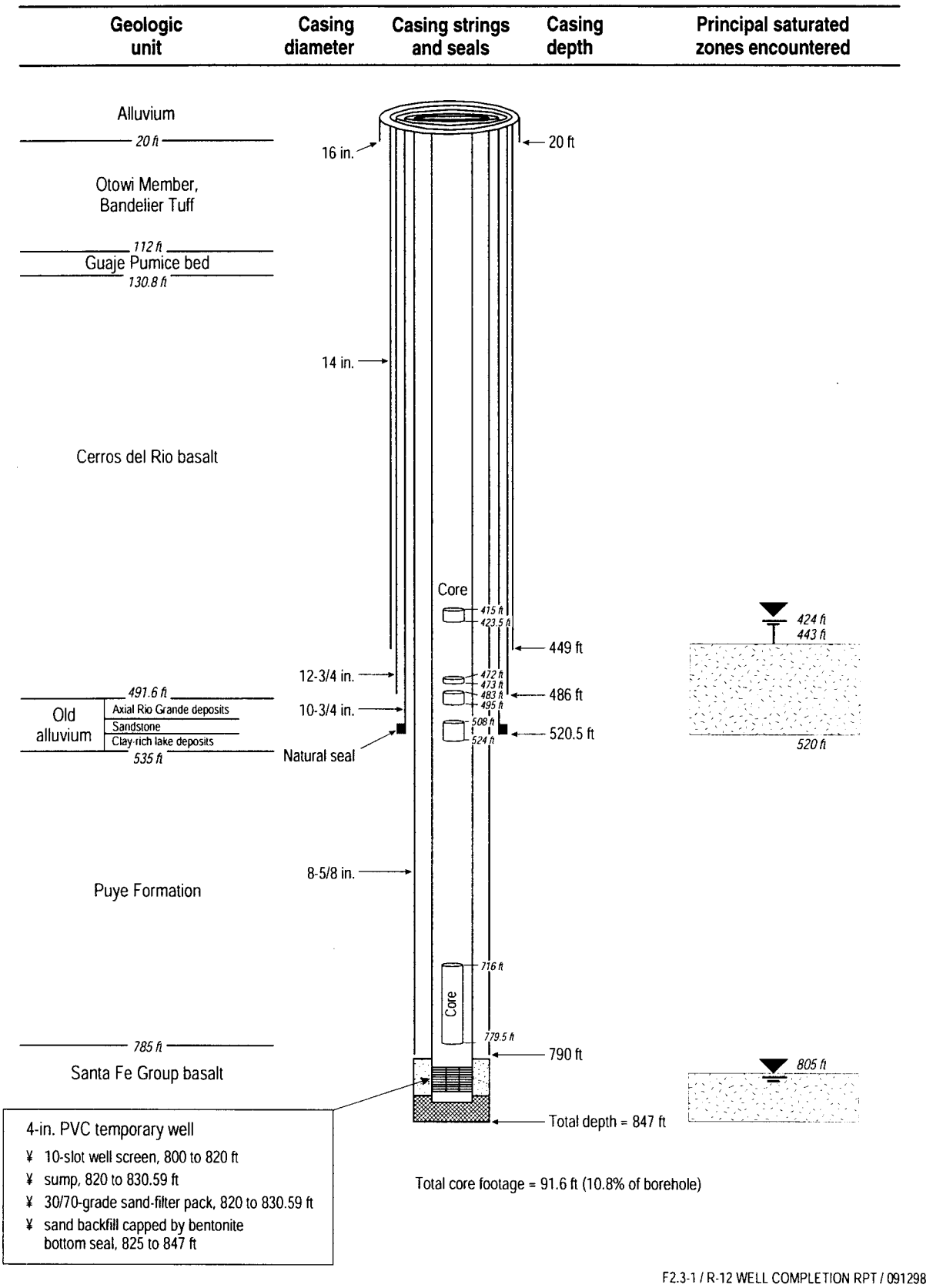


Figure 2.3-1. Configuration of R-12 as of June 10, 1998.

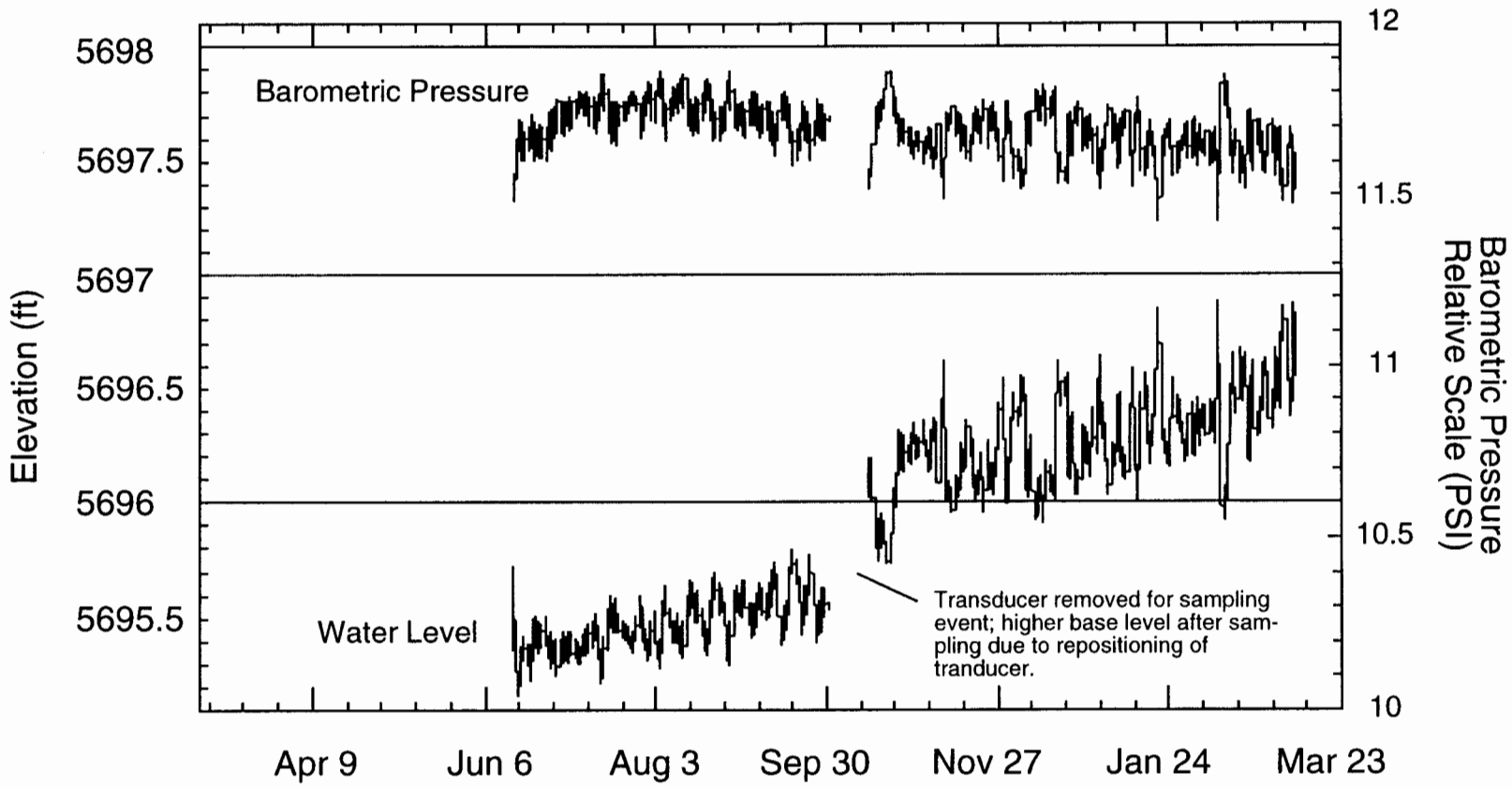
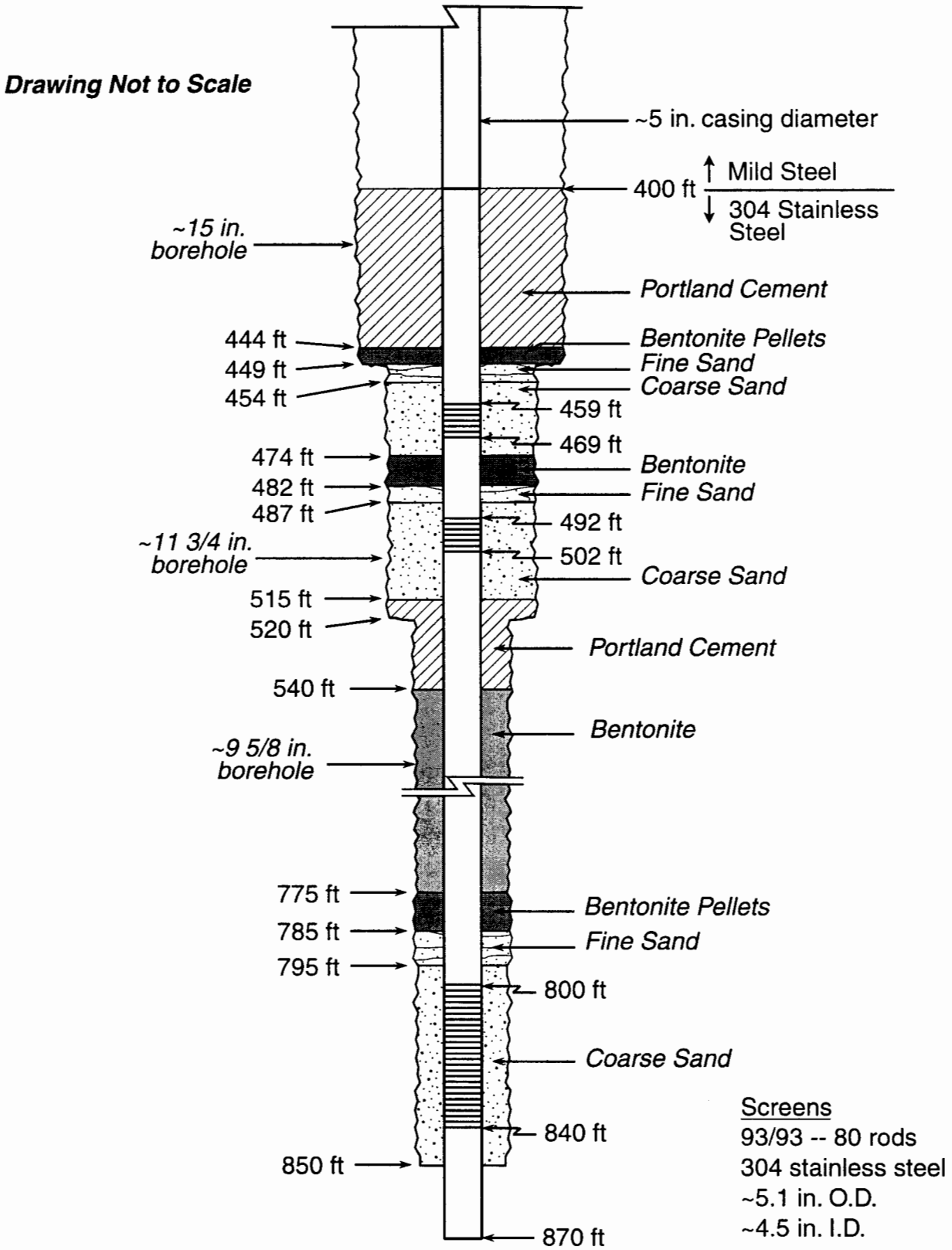


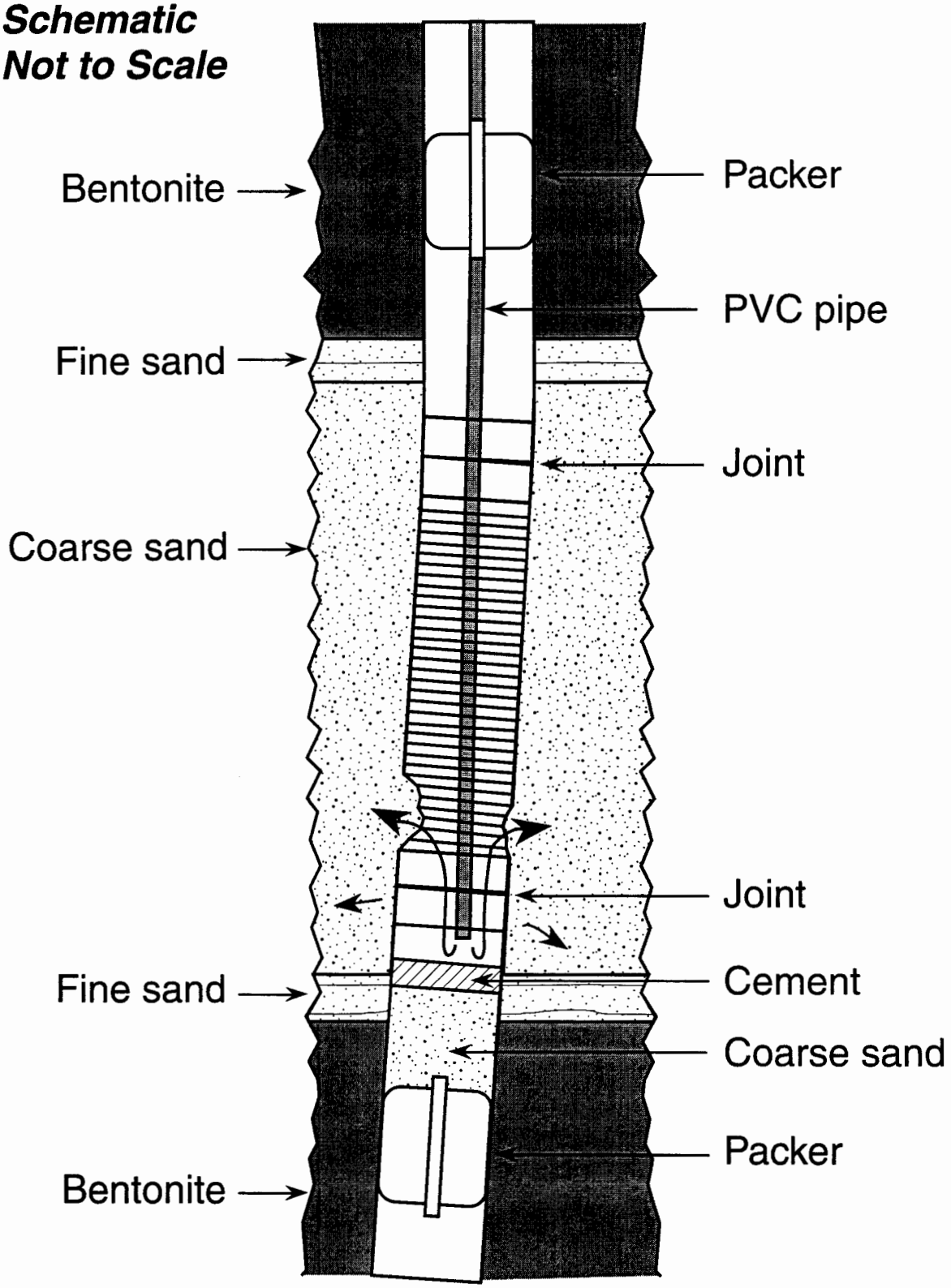
Figure 4.2-1. Water level of regional aquifer in borehole R-12 from from June 16, 1998 to March 8, 1999.

Well R-12 Completion
(Draft 10-13-99)



Well R-25 Screen #3 Repair
(Draft 10-13-99)

Schematic
Not to Scale



Remediation of the R-25 Well

Background

- During well installation it was found that screen number three had become partially collapsed in about the lower 18-24 inches

- Since the well was designed to accept a Westbay multi-completion string inside the well this collapse had to be corrected

- An approach was developed to cement up the collapsed part of the screen – drill it out – then ream the hole to the size needed for the Westbay installation – the intent was to save the screen three interval for monitoring

- The approach was to:
  - "set" an inflatable packer below the collapsed screen
  - place sand inside the well above the packer
  - pour Halliburton Micro-Matrix Cement which would permeate the sandpack annulus and the well to an elevation just above the collapsed screen interval
  - core the cemented interval and ream it to size
  - wash out the sand
  - remove the packer
  - develop all of the screened intervals
  - install the Westbay System

Remediation of the R-25 Well

Data Evaluation Prior to Implementation

- **Review of downhole videos showed that:**
  - **most of the 4 ½ threads connecting the screen to the casing below were visible – suggesting the lower part of well was supporting itself**
  - **the camera was leaning to one side of the casing – suggesting that the screen was not plumb in the hole**

- **Examination of water level transducer-data generated while screen three was packed off below indicated a substantial "head" influence due to the upper two screened intervals**

- **Batch-tests performed at the Field Support Facility using the Micro-Matrix Cement (MMC) showed that due to density gradients alone the MMC would not penetrate the sand/filter pack enough to hold the screen while the collapsed interval was being cored**

Remediation of the R-25 Well

Redirection of the Approach

- **Since density/gravity flow of MMC through the screen was shown to have a low likelihood of success it was decided that a bridging-packer approach (i.e., one packer above and one below) would be used to seal-up the whole screen interval**

- **It was also decided that hydraulic testing of screen three would allow a better estimation of the quantity and characteristics of the cementing operation**

- **Options to seal-off screen three using materials other than MMC were explored (e.g., Portland Cement and Epoxy) but discounted due to technical problems or materials availability**

- **Due to the need to at-a-minimum cement the collapsed portion of the screen it was decided that a "stinger" constructed of both steel and PVC would be used to carefully "place" cement in the well below the screen**

Remediation of the R-25 Well

Task Execution

Phase I – Cementing the Screened Interval (August 21st)

- A TAM inflatable packer was set a few feet below the screen and detached from the setting tools

- Several feet of fine sand were placed in the well above this lower packer to protect it from the operation above

- A small base of Portland Cement was set on top of the sand but still a few feet below screen three to act as a seal to keep the MMC away from the packer

- A second TAM inflatable packer with a 1" access tube through the center was set in the casing immediately above the screen but high enough to not become cemented in – a 2" diameter stinger was attached to the bottom of the packer extending to a point just above the Portland Cement base – the upper joint of the stinger was steel – the lower part Schedule 40 PVC

- A transducer lowered into the access tube recorded a significant head drop – the head of the screened interval became static only a couple of feet above the screen

- Hydraulic testing from water injection was conducted to evaluate the water-bearing zone's ability to take fluids – results suggested that it would easily take the MMC

- About 25 ft^3 of MMC was poured into the access tubing at the top of the well head

- The MMC was "chased" with 2 ½ ft^3 of Type II Portland Cement mixed with nylon fiber led and followed by a dart

Remediation of the R-25 Well

Task Execution

Phase II – Coring-out the Screened Interval (Sept 14th)

- **The upper packer and metal-portion of the stinger were removed from the well**
- **A "Stepped" diamond core bit with wire-line retraction was used to core the cement – this was initially followed by a 20 ft centralizing barrel that would insure coring straight**
- **An iterative process of coring, re-cementing short intervals, video-taping, and coring again was used to insure the coring was proceeding in the correct orientation**
- **Because of the out-of-plumb relationship between the screen and the casing above it a portion of drill rod was re-worked at the Field Support Facility to establish a 1-3° kick-off**
- **We are currently coring through the kick-off which permits the core barrel to turn into the collar/end at the bottom of the screen and thereby re-orient the hole down the casing string**
- **Subsequent passes through this pilot hole will be used to ream the hole larger to accommodate the Westbay System**

Issue: Response to Contamination

- NMED has repeatedly asked what actions will be taken when contamination is encountered
- Responses to date have varied:
  - R-9 and R-12: no further investigation to date
  - R-25: Plume definition plan developed and implementation begun
- Consistent approach for responding is important

Response to Contamination Issue Resolution

- Present proposed response to NMED at Quarterly Meeting on 10/14
- Response includes:
  - Triggered by confirmed detection above regulatory standard
  - Review of analytical results from nearest water wells, with immediate action to define plume if detected in water supply above regulatory standard

Response to Contamination Issue Resolution (cont.)

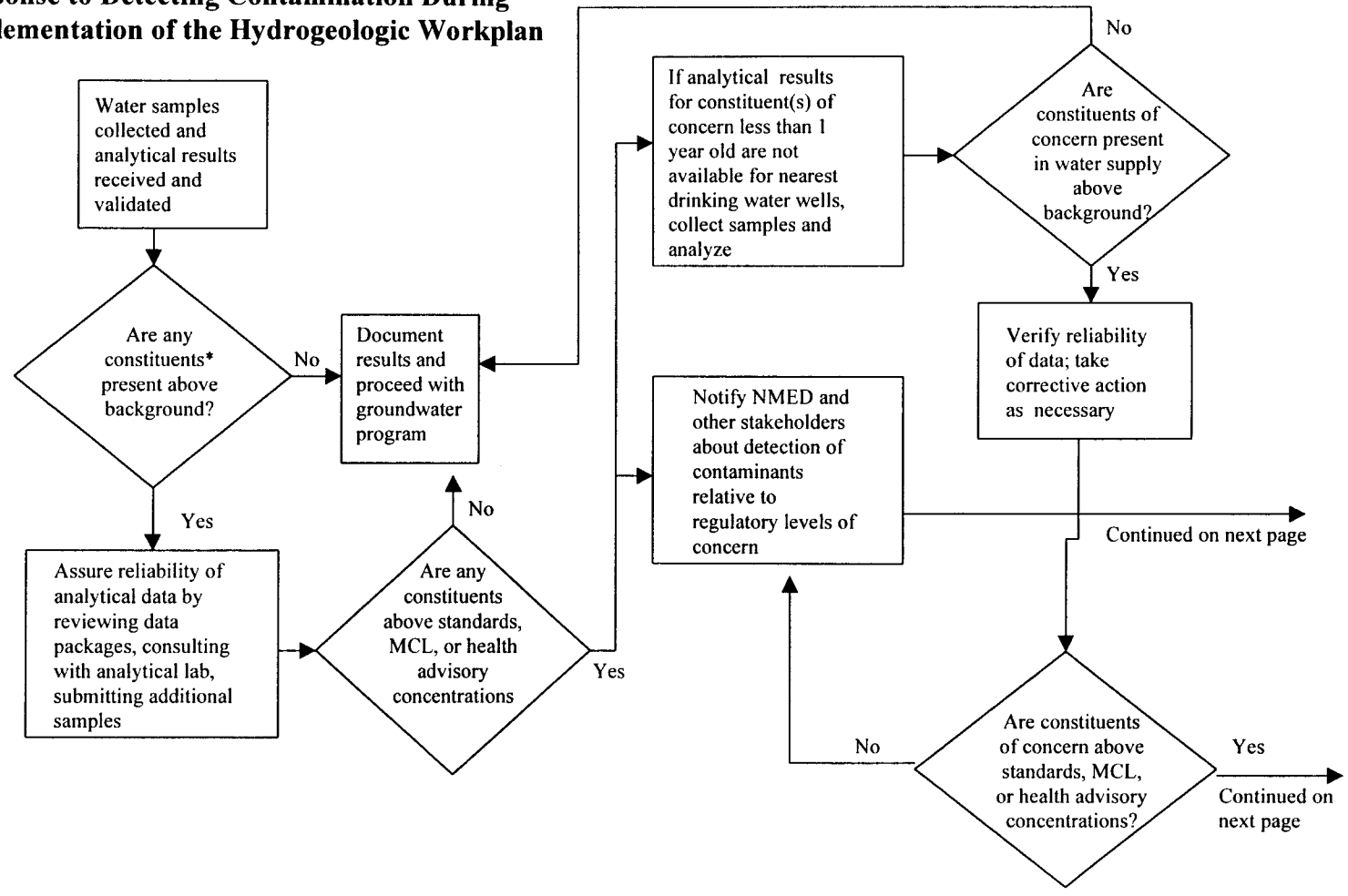
- Joint GIT/NMED prioritization of plume using 15 Contaminant Response Criteria
- Action (plan and characterization) will be in these priority levels:
  - **High** - Within 6 months using current year contingency funds
  - **Moderate** - Within 1 year using funds requested at time of detection
  - **Low** - within 3-5 years using funds requested in 5-year planning

Response to Contamination Issue Resolution (cont)

Contaminant Response Criteria

1. Physical and chemical characteristics of the constituent(s)
2. Hydrogeologic characteristics of the immediate area
3. Quantity of groundwater and direction of groundwater flow
4. Proximity and withdrawal rates of water-supply wells
5. Current and future uses of the water
6. Existing quality of the groundwater, including other sources of contamination and their cumulative impact on the ground-water quality
7. Potential for health risks caused by human exposure to the constituent(s) of concern
8. Potential to damage wildlife, vegetation or physical structures caused by exposure to the constituents
9. Persistence and permanence of adverse impacts from exposure to the constituents
10. Location with respect to the Lab boundary
11. Well construction issues (intermediate perched zones require special construction)
12. Schedule for drilling nearby wells
13. Facilitate finishing an RFI Report
14. Programmatic consistency
15. Budget/Priorities

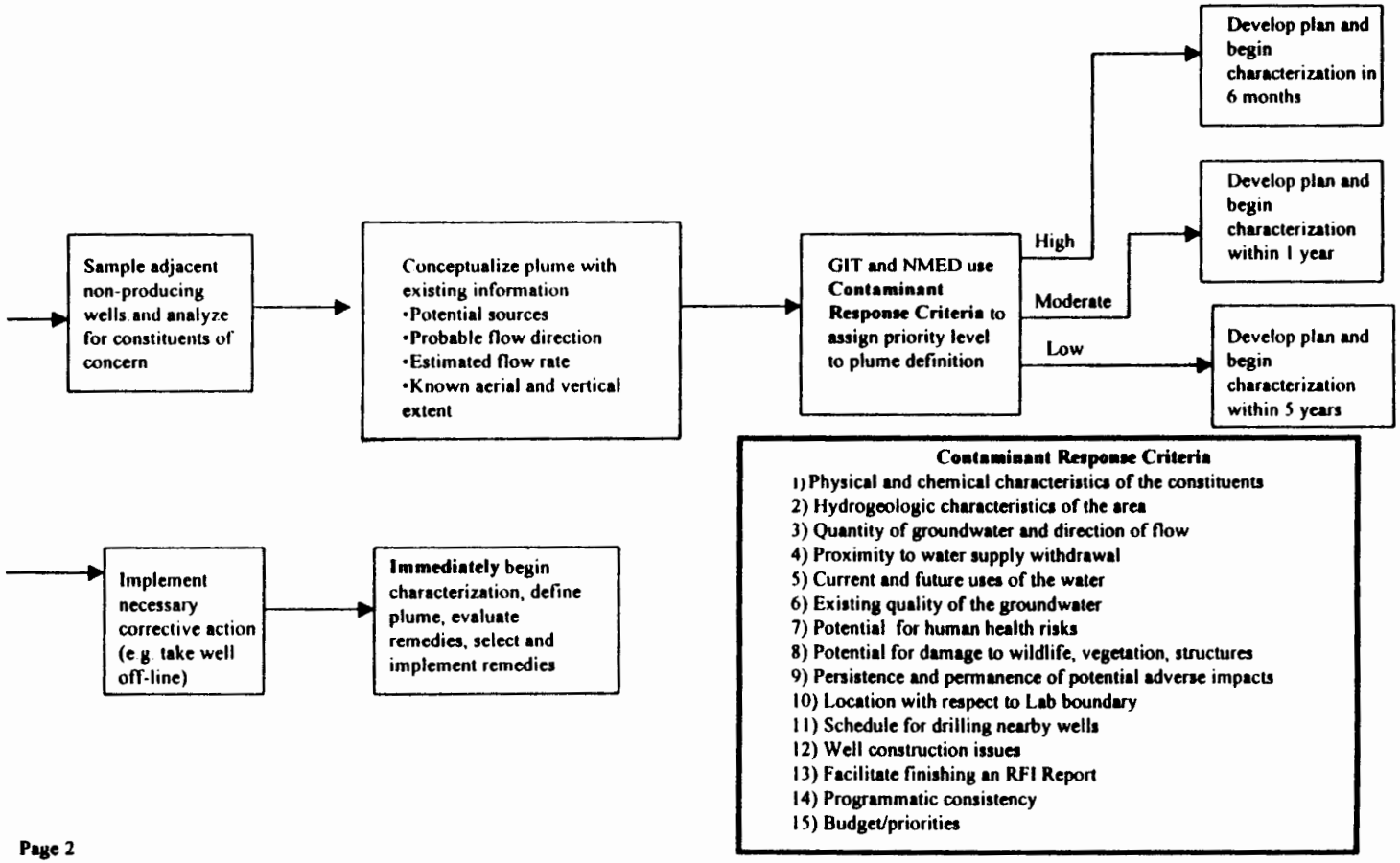
Response to Detecting Contamination During Implementation of the Hydrogeologic Workplan



* Various constituents fall within the jurisdiction of different divisions within the NMED. This diagram intends to address all constituents without ascribing jurisdiction for their regulation.

Page 1

Los Alamos National Laboratory
Proposed Response to Detection of Contamination During Implementation of Hydrogeologic Workplan Activities



FY00 DRILLING SCHEDULE

WELL	PROGRAM	TECHNIQUE	TIME FRAME
R-12	ER	Air	October – December
R-19	ER	Air	November – March
TA-15	ER	Mud	November – April
R-31	NWT	Mud	November – January
R-5	NWT	Mud	March – September
R-7	ER	Air	March – September
R-28	NWT	Mud	Start August
R-27	ER	Mud	Start September
I-9 (R-9i)	ER	Air?	Not Scheduled
Alluvials	ER	Auger	As Determined

R-25 LESSONS LEARNED AND CORRECTIVE ACTIONS

Issue	Lesson Learned	Corrective Action
Geologic conditions	Unstable borehole slows drilling down by locking up casing and blocking circulation	• Use water, bentonite, foam, and reaming to keep the casing loose • Use the stratigraphic model to predict when unstable geologic units are likely to be encountered. • Incorporate additional time in the schedule and budget to drill through these zones. • Include contingency in the budget to deepen wells if conditions warrant.
	Air pressure insufficient at depths below 1500 feet to lift cuttings	At depths below 1500 feet use a booster

R-25 LESSONS LEARNED AND CORRECTIVE ACTIONS
(Continued)

Issue	Lesson Learned	Corrective Action
Intermediate zone seal	Finding a competent perching zone may require some searching	• When selecting a suitable perching unit, look for materials competent to support the weight of the casing. • schedule and budget for each well should include some contingency for sealing intermediate water-bearing zones. • Use tracers to ensure the integrity of the seal.

R-25 LESSONS LEARNED AND CORRECTIVE ACTIONS
(Continued)

Issue	Lesson Learned	Corrective Action
Time spent "fishing" items out of the borehole	Prevent the dropping of items downhole	• Safety inspections of the rigging equipment • Tailgate safety meetings should regularly emphasize awareness of holding tools over the open borehole. • Operate within the specifications of the drilling equipment so that excess torque is not applied. • Drill crew will attend the "Hoisting and rigging" class offered by the Lab. • Use factory-made slings and avoid equipment assembled on-site that has not been tested or rated.

R-25 LESSONS LEARNED AND CORRECTIVE ACTIONS
(Continued)

Issue	Lesson Learned	Corrective Action
Incorrect placement of backfill materials	Use a procedure that specifies how to take a reliable measurement of backfill material depth	Develop and follow a procedures for well construction, including specifications for sounding depth of materials
Blockage of screen # 9	Pending	Pending
Collapsed screen # 3	Field crew should have well design specifications monitor interaction between well casing and drill casing	• Assign a crew member the responsibility to monitor the stainless steel well casing. Pull up the tremie line prior to retracting the drill casing to minimize the space problem.
	Use heavy gauge well screen	Inspect casing prior to emplacement
Crew experience	Keep experienced crew working on wells	Have extensive on-the-job training of new crew members by experienced crew members

R-25 LESSONS LEARNED AND CORRECTIVE ACTIONS
(Continued)

Issue	Lesson Learned	Corrective Action
Safety incidents	Focus on safety to maintain status of no lost time due to injuries	Document daily tailgate safety meetings in memo to file
Drilling schedule	24-hour drilling schedule results in missed data, ineffective oversight, and increased safety issues.	Use multiple rigs with 12-hour shifts to meet Hydrogeologic Workplan schedule
Avoidable rig downtime	Material orders may take longer than planned and new materials, e.g. cement, may not perform as originally expected	Order new materials and bench-test them long before mobilizing rig to avoid rig downtime and associated costs
Cost reimbursement for subcontractor errors or omissions	Address subcontractor errors and omissions expeditiously	Establish process to document errors and omissions, work with BUS to address issues within specific time frame

Issue	Lesson Learned	Corrective Action
Incorrect type of PVC	Grey PVC left in place during repair of screen #3 "gummed up" drill bit and caused downtime	Use white PVC when necessary as it will shatter and be carried out of the hole as cuttings instead of becoming "gummy"
Well casing integrity	Integrity of casing should be verified prior to backfilling so that any necessary repairs can be made with less effort and cost	Video log the casing string both before and after backfilling the borehole. On multiple completion wells, consider video logging during backfilling procedures, e.g., halfway or after 2 or 3 screens have been packed
Crooked casing string	Uneven heating of casing while welding threaded end caps causes crooked casing string.	Develop or use appropriate methods to avoid creating crooked joints