Success Story: Sonic Coring in Fortymile Wash

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Presented to
U.S. Nuclear Regulatory Commission Advisory Committee on Nuclear Waste
June 23, 2004

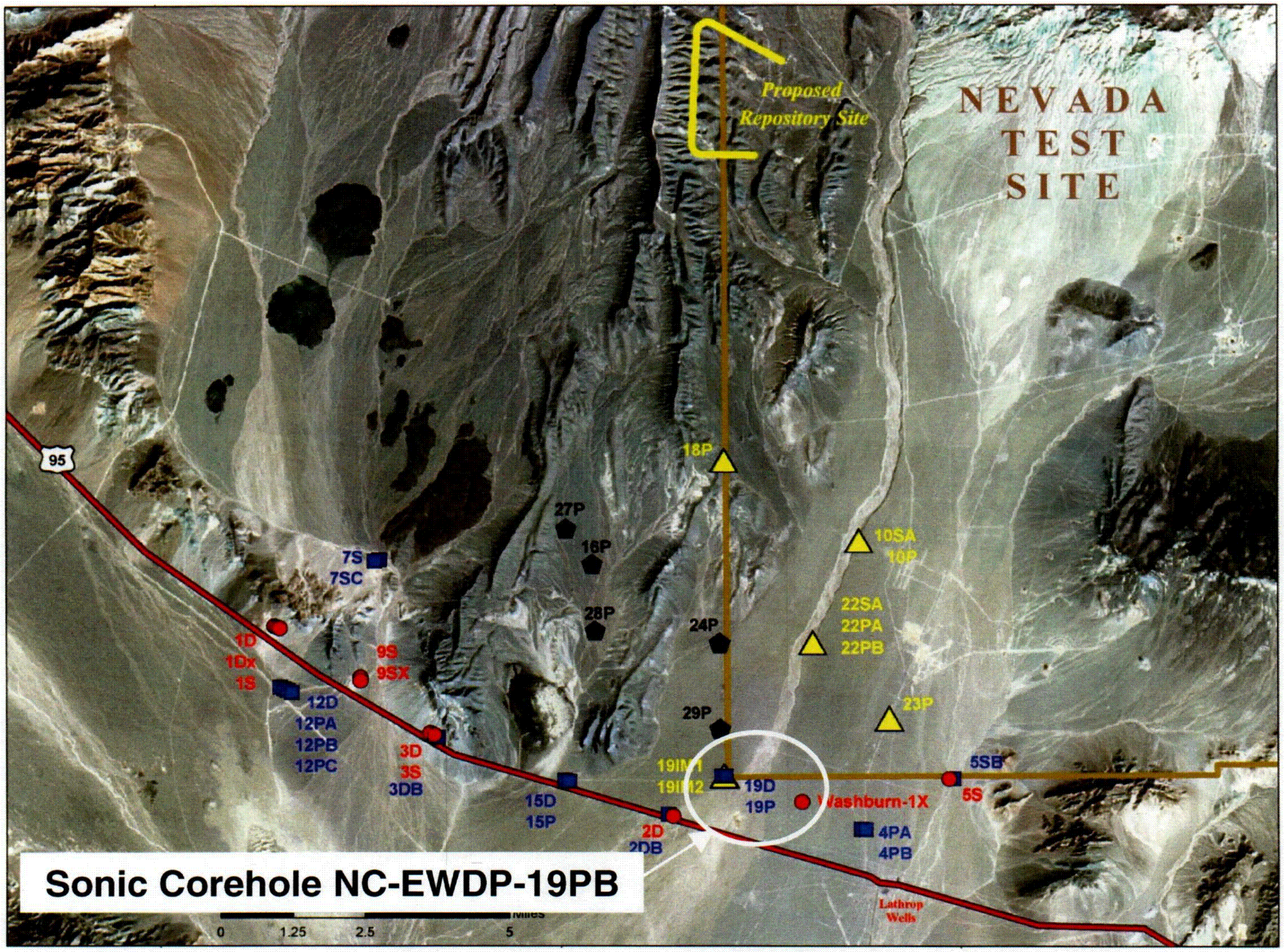
Overview

- Key points.
- Drilling, coring, and well completion.
- Field geologic and geophysical logging.
- Field and laboratory testing.
- Some significant results.
- Future work.

Key Points

- Nearly 300 feet of continuous sonic core from the alluvial aquifer were collected, logged, and tested.
- Core recovery exceeded 95 percent.
- Samples were minimally disturbed and suitable for description and testing.
- Preliminary field and laboratory results begin to fill data gaps.

Location of Sonic Corehole



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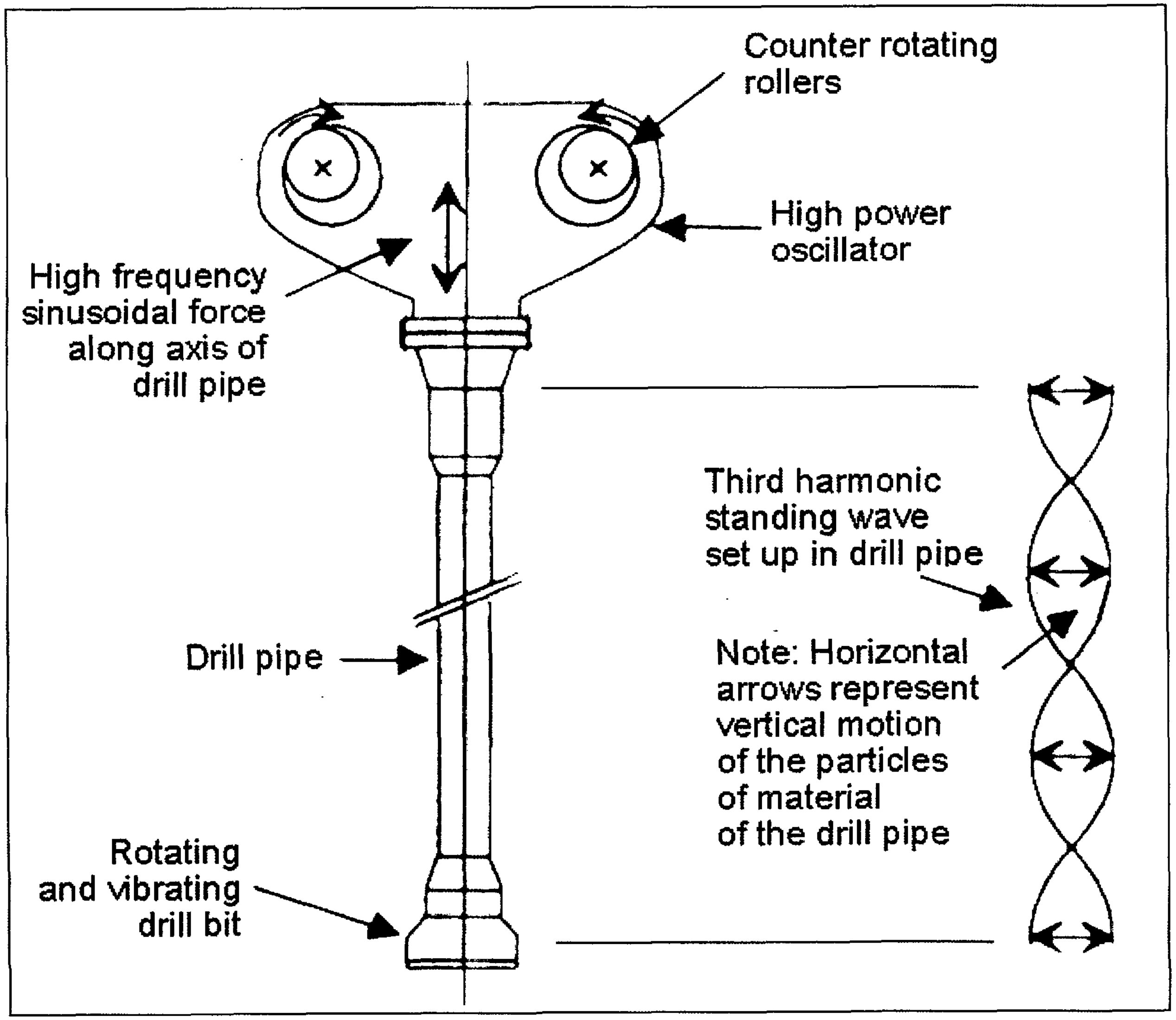
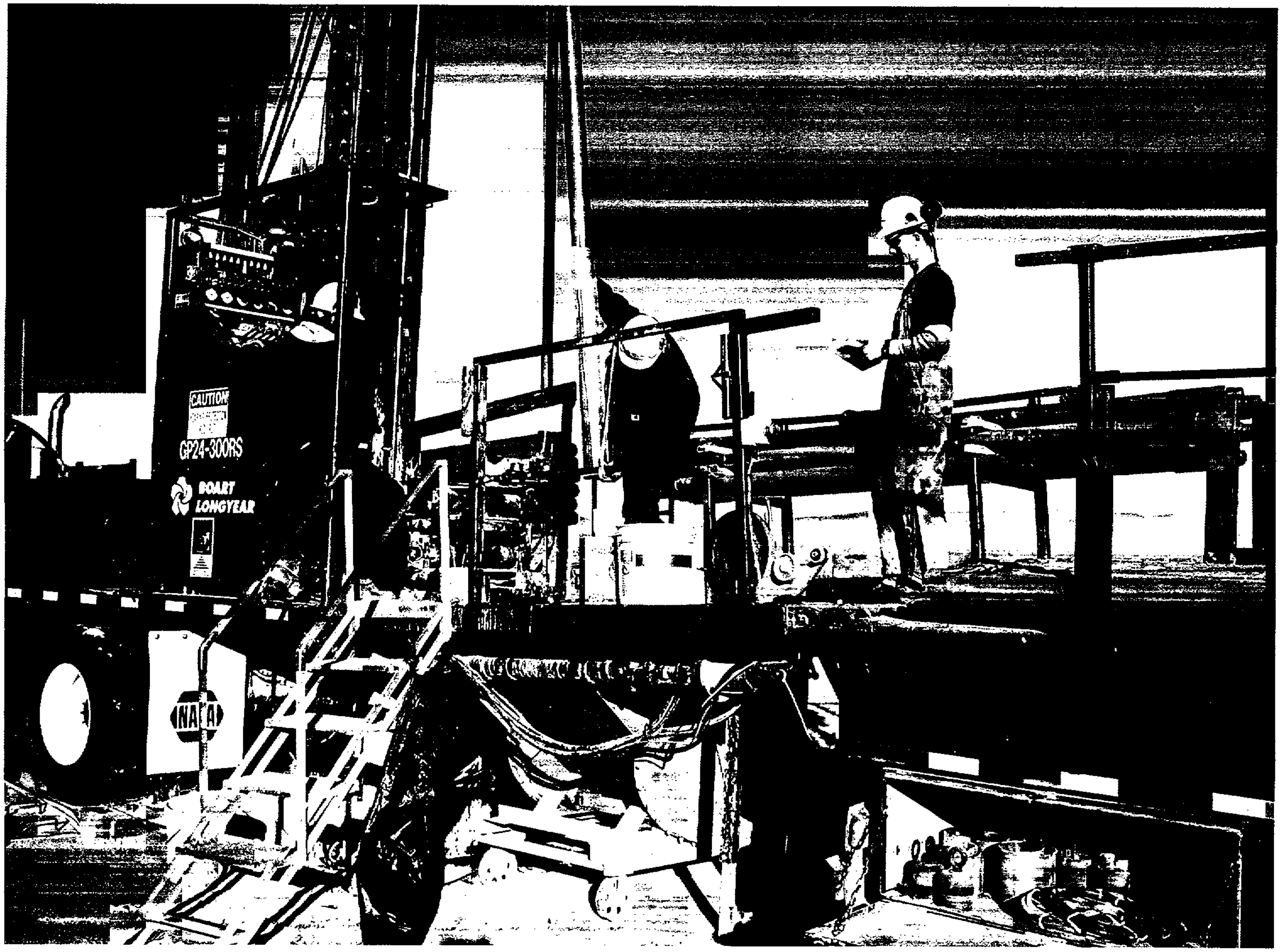
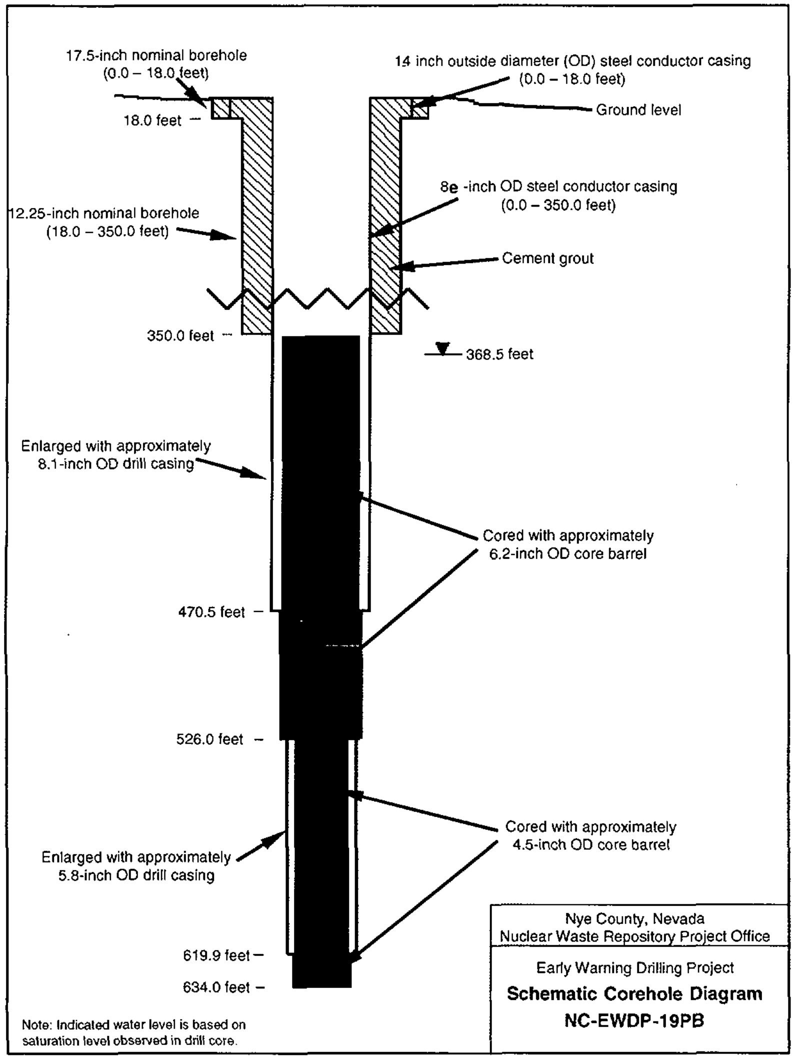
Sonic Drilling Equipment/Method



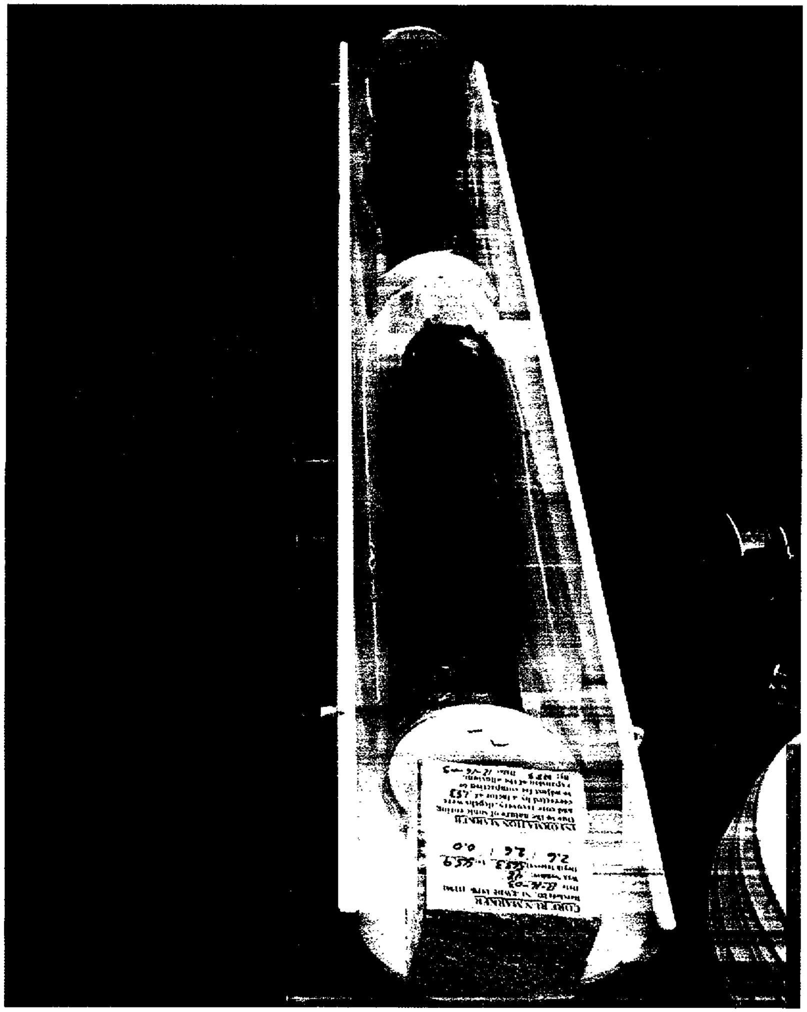
Sonic Core Extrusion Process



Schematic of Sonic Corehole Intervals



Core Tray with Samples Ready for Logging and Subsampling



Geologic Logging Form

NOTE: UNCENSORED DATA

Alluvium Core Logging Form - Nye County Nuclear Waste Repository Office

Preliminary Data

Key for Sample Number: SC = Sonic core; C = Drive core. Key for Sample Type: L = Logging, D = Density; F = Fill; LC = Lost core; R = Entire run; X = End of run (overlaps with next run).

Borehole ID: NC-EWDP-19PB (Phase 4) Driller/Drilling Company Shawn Cain/Boart Longyear Drilling Method: Sonic Coring Alluvium Depth (ft bgs): 350.8 to 633.8 Start Date: 12/2/2003 End Date: 12/18/2003 Page 1 of 17

Date Logged	Logged By (Initials)	Date Checked	Checked By (Initials)	Core Run Number	Sample Type	Sample Number	Depth Interval (feet bgs) From	Depth Interval (feet bgs) To	Coring Data: Coring Rate (feet/min)	Coring Data: Sample Recovery (feet)	Coring Data: Core Diameter (inches)	Sample Density Data: Tare Weight (kg)	Sample Density Data: Sample Plus Tare Weight (kg)	Sample Density Data: Sample Weight (kg)	Munsell Color Symbol	Moisture Content: Dry	Moisture Content: Moist	Moisture Content: Wet	Particle Size Distribution (%): Gravel	Sand	Silt	Clay	Fines (Silt plus Clay)	Grading: Well Graded	Grading: Poorly Graded	Estimated Plasticity: None	Low	Moderate	High	USCS Group Symbol	Gravel/Sand Grain Shape: Angular	Subangular	Subrounded	Rounded	Cementation: None	Weak	Moderate	Strong	HCL Reaction: None	Weak	Strong	Major Rock Type (%): Volcanics	Carbonates	Other
12/2/2003	JSW	12/2/2003	DPH	1	R	19PB-350.8-353.6-SC	350.80	353.60	0.6	2.9																																		
12/2/2003	JSW	12/2/2003	DPH	1	D	19PB-350.8-351.9-SC	350.80	351.90			6.2	0.20	12.20	12.00																														
12/2/2003	JSW	12/2/2003	DPH	1	D	19PB-351.9-353.6-SC	351.90	363.60			6.2	0.20	20.30	20.10																														
12/2/2003	JSW	12/2/2003	DPH	1	L	19PB-350.8-352.4-SC	350.80	352.40							5YR 5/6		✓		40	47	6	7	13	✓			✓			SW-SC			✓		✓				✓			100		
12/2/2003	JSW	12/2/2003	DPH	1	L	19PB-352.4-352.9-SC	352.40	352.90							5YR 5/6		✓		18	53	9	20	29					✓		SC			✓		✓				✓			100		
12/2/2003	JSW	12/2/2003	DPH	1	L	19PB-352.9-353.3-SC	352.90	353.30							5YR 6/4		✓		75	16	4	5	9	✓			✓			GW-GC			✓		✓				✓			100		
12/2/2003	JSW	12/2/2003	DPH	1	LX	19PB-353.3-353.6-SC	353.30	353.60							5YR 6/4		✓		11	67	8	14	22					✓		SC			✓		✓				✓			100		
12/2/2003	JSW	12/2/2003	DPH	2	R	19PB-353.6-355.0-SC	353.60	355.00	0.7	1.3																																		
12/2/2003	JSW	12/2/2003	DPH	2	LC	19PB-353.6-353.7-SC	353.60	353.70																																				
12/2/2003	JSW	12/2/2003	DPH	2	D	19PB-353.7-355.0-SC	353.70	355.00			6.2	0.20	14.15	13.95																														
12/2/2003	JSW	12/2/2003	DPH	2	LX	19PB-353.7-354.3-SC	353.70	354.30							5YR 6/6		✓		13	70	8	9	17				✓			SC			✓		✓				✓			100		
12/2/2003	JSW	12/2/2003	DPH	2	LX	19PB-354.3-355.0-SC	354.30	355.00							5YR 6/6		✓		28	59	5	8	13	✓			✓			SW-SC			✓		✓				✓			100		
12/2/2003	JSW	12/2/2003	DPH	3	R	19PB-355.0-359.3-SC	355.00	359.30	0.9	4.3																																		
12/2/2003	JSW	12/2/2003	DPH	3	D	19PB-355.0-355.6-SC	355.00	355.60			6.2	0.20	6.30	6.10																														
12/2/2003	JSW	12/2/2003	DPH	3	D	19PB-355.6-357.5-SC	355.60	357.50			6.2	0.20	21.00	20.80																														
12/2/2003	JSW	12/2/2003	DPH	3	D	19PB-357.5-359.3-SC	357.50	359.30			6.2	0.20	20.15	19.95																														
12/2/2003	JSW	12/2/2003	DPH	3	LX	19PB-355.0-356.6-SC	355.00	356.60							5YR 5/6		✓		29	64	3	4	7	✓			✓			SW-SC			✓		✓				✓			100		
12/2/2003	JSW	12/2/2003	DPH	3	L	19PB-356.6-356.9-SC	356.60	356.90							5Y 7/1		✓		54	38	3	5	8	✓			✓			GW-GC			✓		✓					✓		100		
12/2/2003	JSW	12/2/2003	DPH	3	L	19PB-356.9-357.9-SC	356.90	357.90							5YR 5/6		✓		38	53	3	6	9	✓			✓			SW-SC			✓		✓				✓			100		
12/2/2003	JSW	12/2/2003	DPH	3	LX	19PB-357.9-359.3-SC	357.90	359.30							5YR 6/4		✓		29	53	6	12	18					✓		SC			✓		✓				✓			100		
12/3/2003	BW			4	R	19PB-359.3-363.1-SC	359.30	363.10	1.0	3.8																																		
12/3/2003	BW			4	D	19PB-359.3-361.4-SC	359.30	361.40			6.2	0.20	25.90	25.70																														
12/3/2003	BW			4	D	19PB-361.4-363.1-SC	361.40	363.10			6.2	0.20	18.85	18.65																														
12/3/2003	BW			4	LX	19PB-359.3-360.0-SC	359.30	360.00							5YR 4/3		✓		39	44	3	14	17				✓			SC			✓		✓				✓			100		
12/3/2003	BW			4	L	19PB-360.0-361.7-SC	360.00	361.70							5YR 4/6		✓		38	50	2	10	12	✓			✓			SW-SC			✓		✓				✓			100		
12/3/2003	BW			4	L	19PB-361.7-362.0-SC	361.70	362.00							5YR 5/4		✓		62	30	2	6	8	✓			✓			GW-GC			✓		✓				✓			100		
12/3/2003	BW			4	LX	19PB-362.0-363.1-SC	362.00	363.10							5YR 5/6		✓		41	41	4	14	18				✓			SC			✓		✓				✓			100		
12/3/2003	BW			5	R	19PB-363.1-367.0-SC	363.10	367.00	1.0	4.0																																		
12/3/2003	BW			5	D	19PB-363.1-365.0-SC	363.10	365.00			6.2	0.20	23.60	23.40																														
12/3/2003	BW			5	D	19PB-365.0-367.0-SC	365.00	367.00			6.2	0.20	23.60	23.40																														
12/3/2003	BW			5	LX	19PB-363.1-364.6-SC	363.10	364.60							5YR 5/4		✓		39	45	3	13	16				✓			SC			✓		✓				✓			100		

Nye County Department of Natural Resources and Federal Facilities

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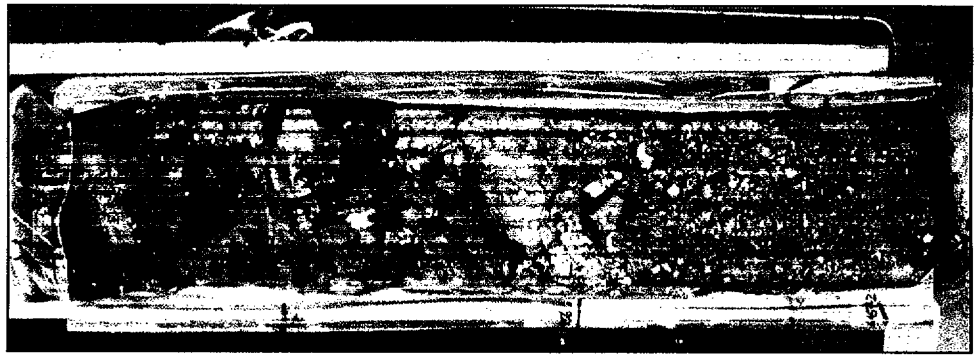
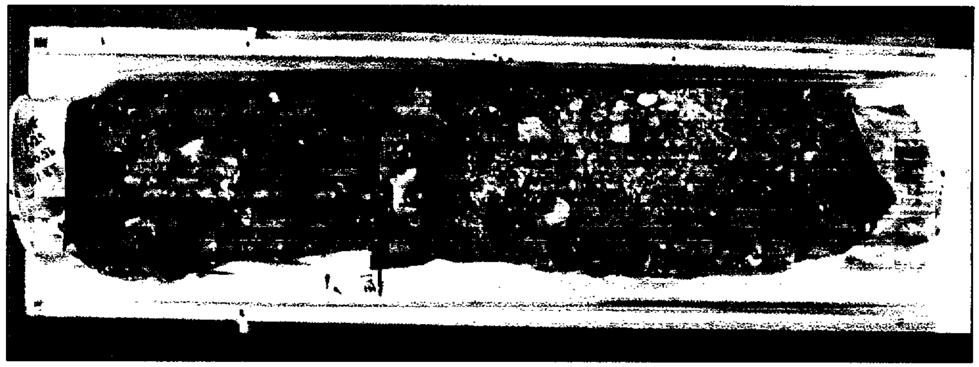
Transitions in Textural Layers

Cobbles and coarser gravel to finer gravel at 456.6 feet.



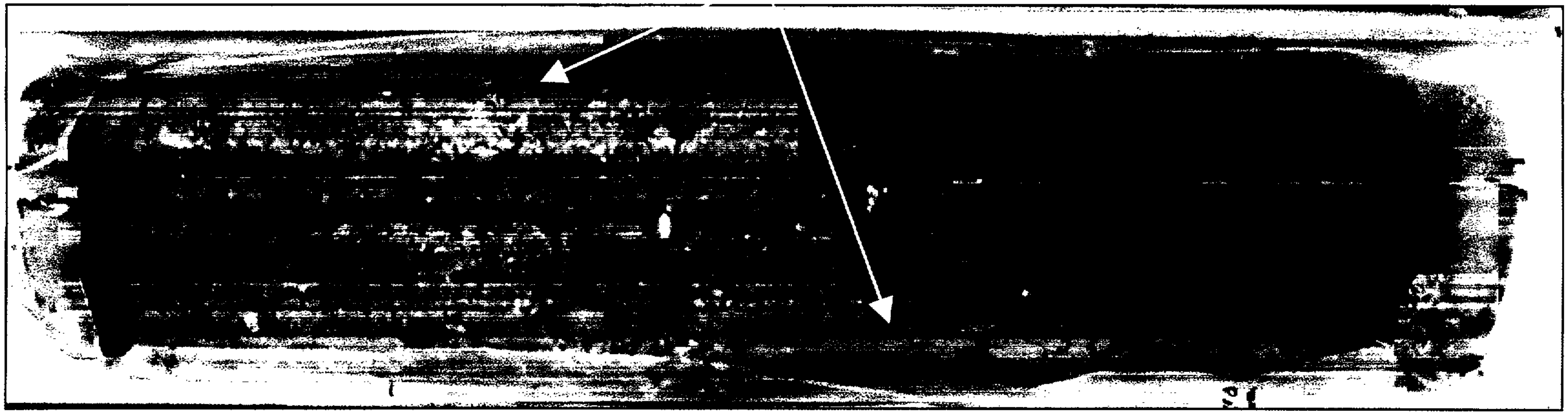
21 to 12% fines at 581.1 feet.

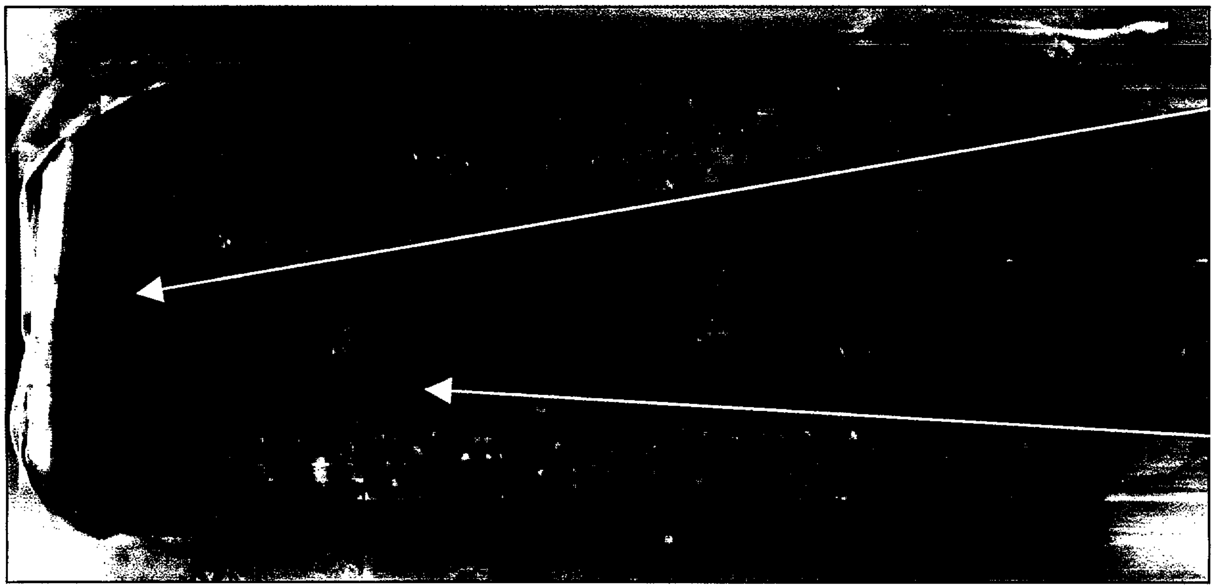


Cobbles and gravel from 570.5 to 570.9 feet.

Examples of Sample Disturbance

Fines that have migrated outward.

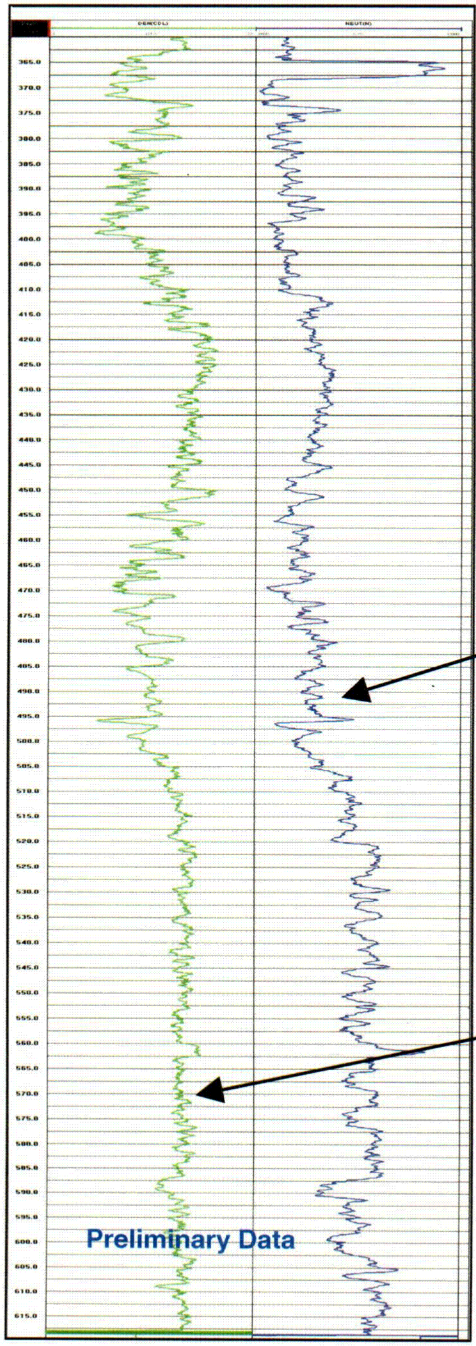




Wetter, darker colors at start of core run.

Lighter reddish brown (oxidized) colors in drier region of core.

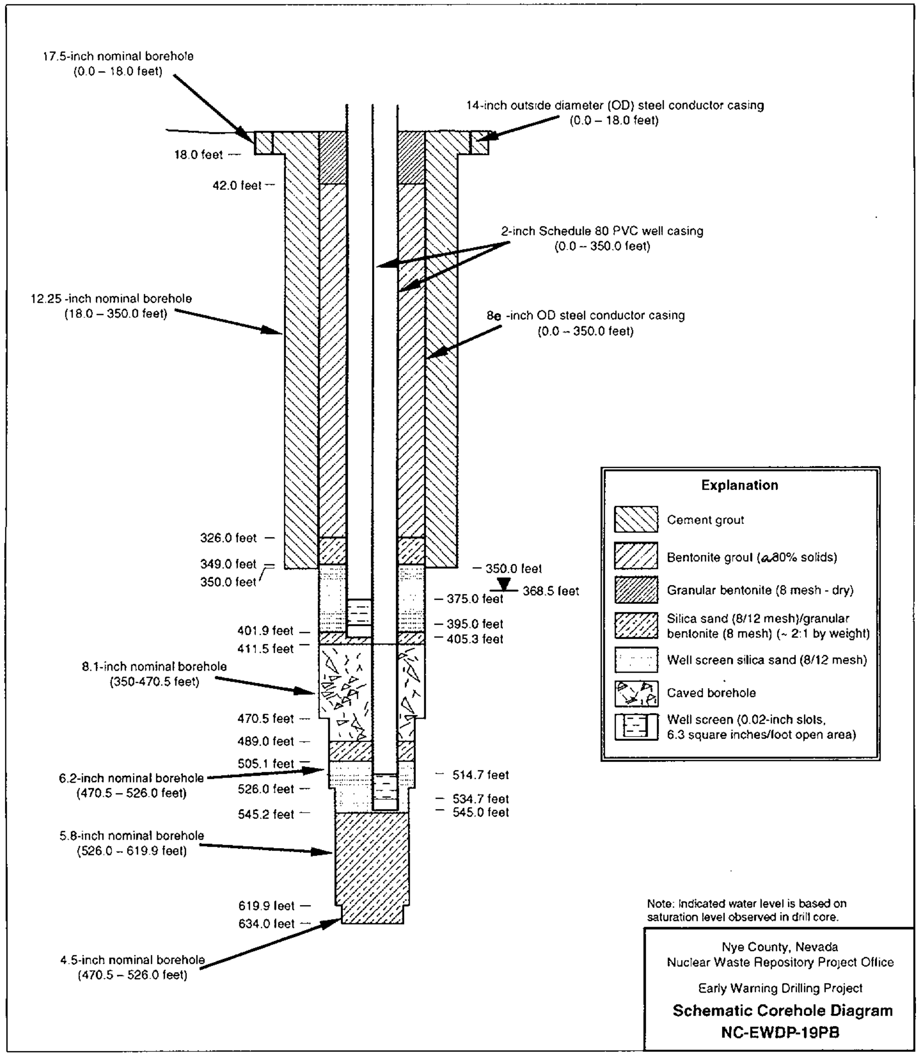
Geophysical Logs



Epithermal neutron porosity log

Gamma-gamma compensated density log

Well Completion Diagram



Field Measurements

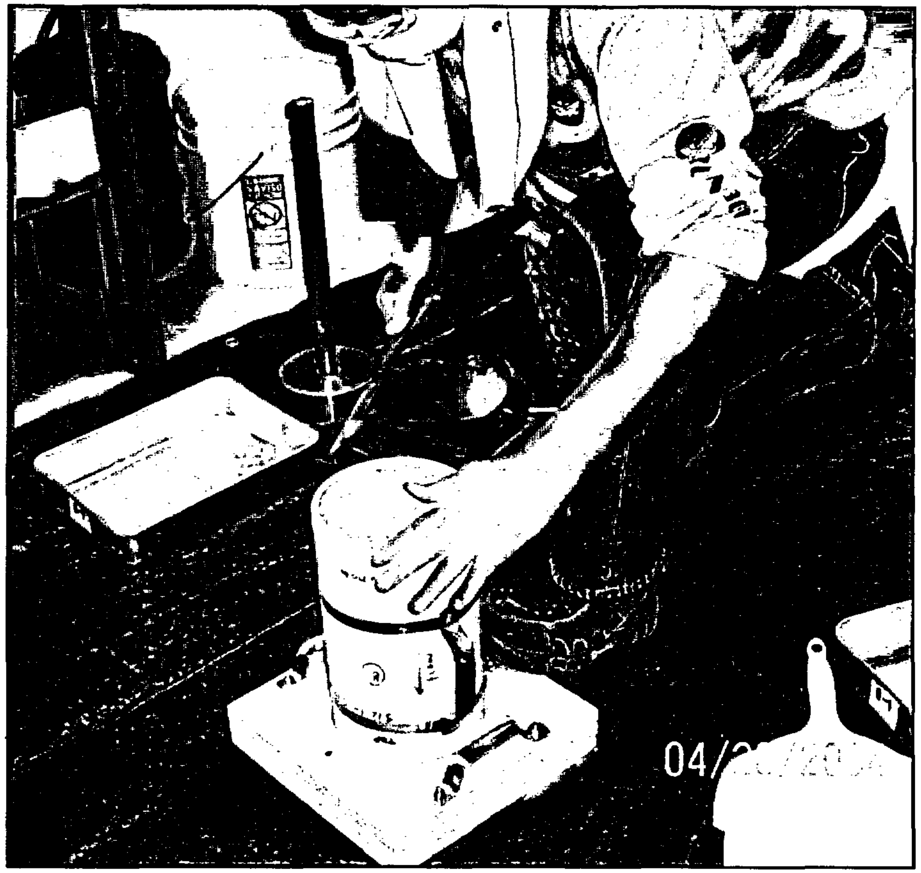
Preparing a sock sample for wet mass measurements.

Laboratory Tests of Particle Size Distribution

Wet sieve analysis test

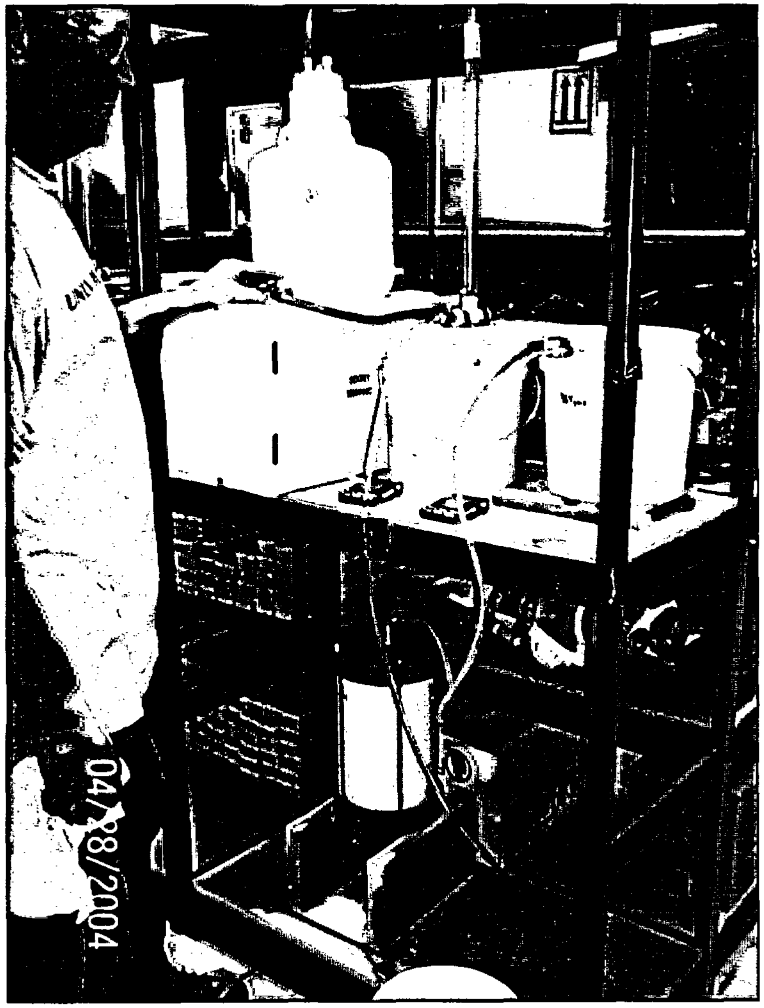
Hydrometer test.

Laboratory Core Repacking

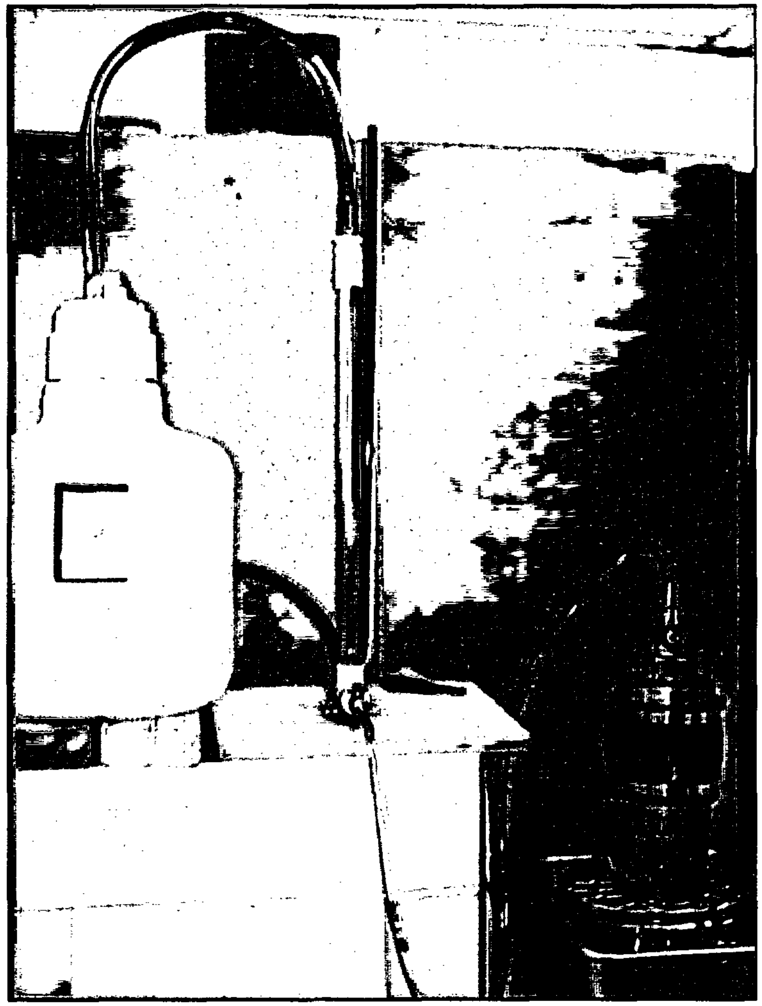


Repacking sonic core for saturated hydraulic conductivity (Ksat) tests.

Laboratory Constant-Head Ksat Tests

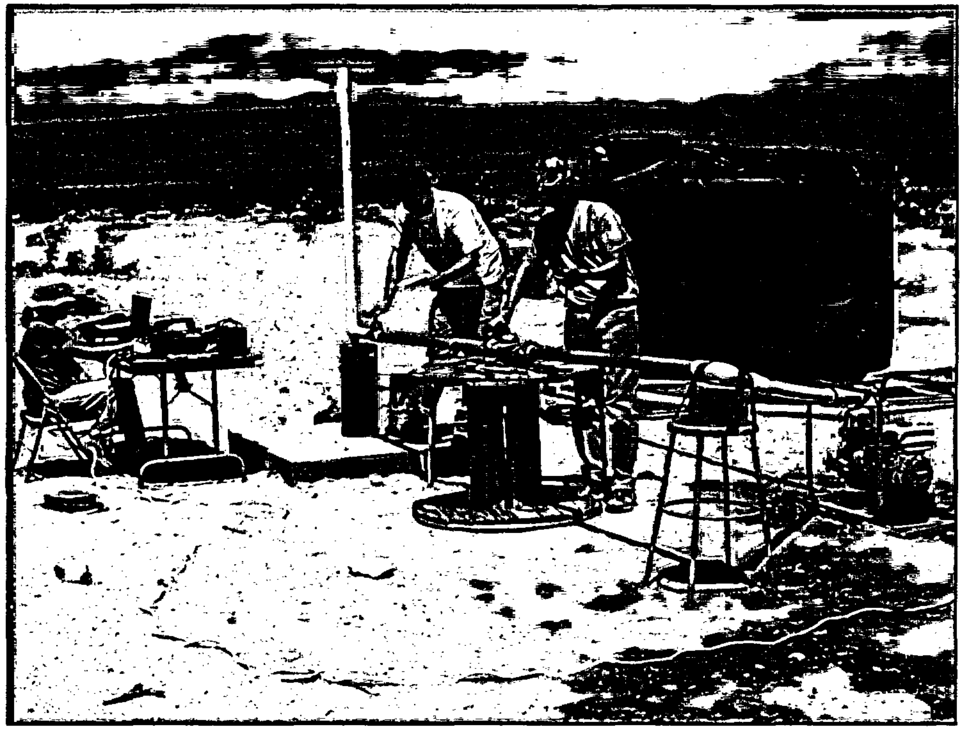


Testing repacked sonic core.

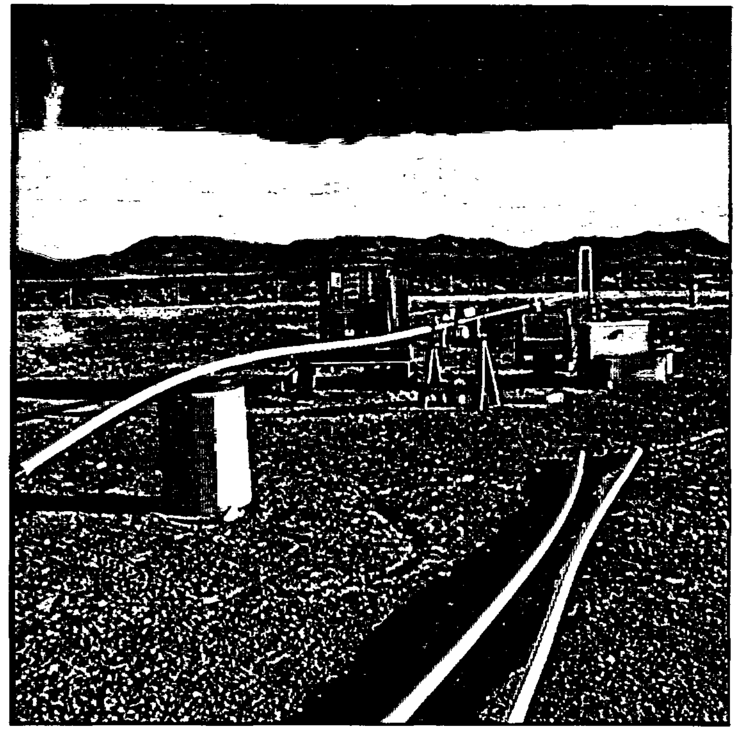


Testing modified drive core.

Field Tests



Constant-head injection test in NC-EWDP-19PB.

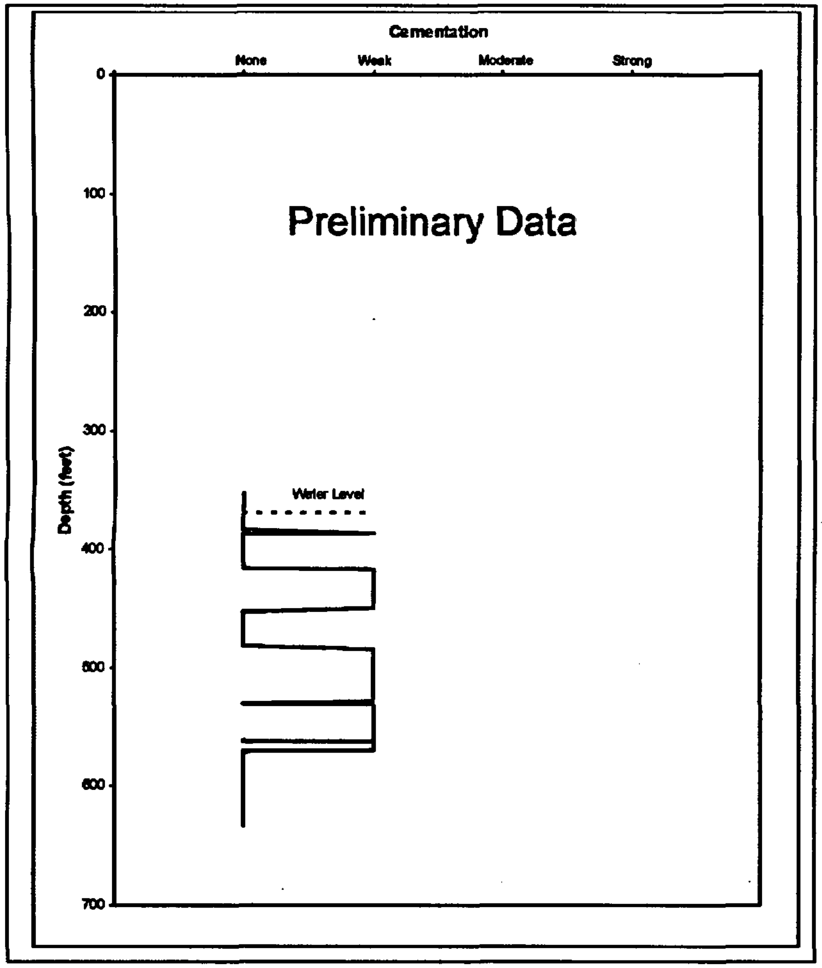


48-hour pump test in an adjacent well.

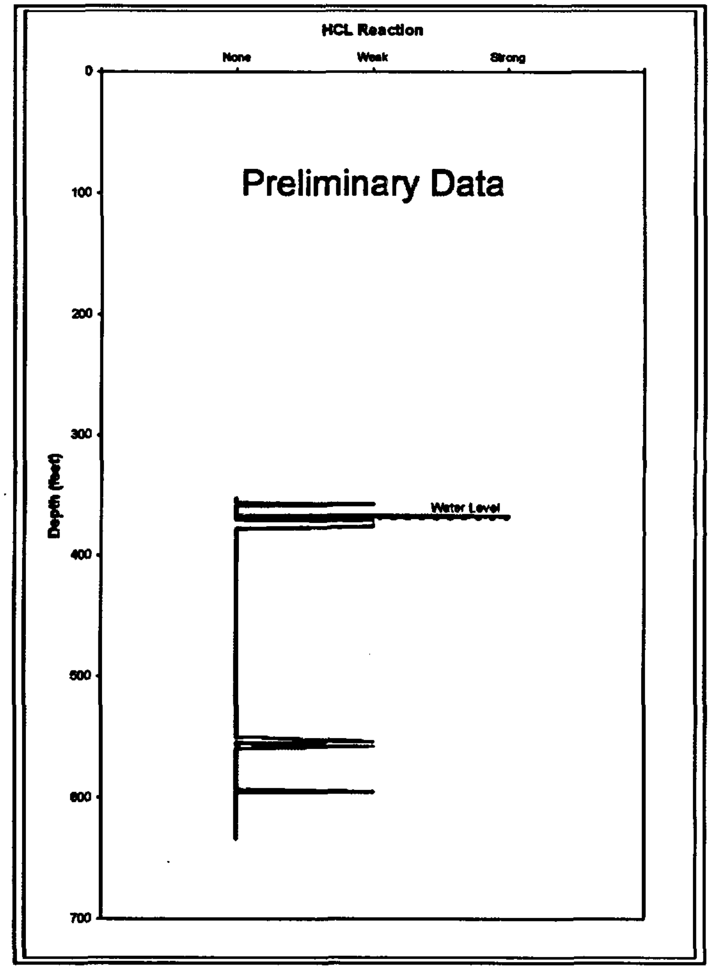
Results: Geologic Logging

- Little evidence of buried soils.
  - Little cementation was observed throughout the cored interval.
  - Little calcium carbonate (HCL reaction) cementation was observed.
- Munsell colors indicate oxidizing conditions.
- Coarse fractions were subangular to subrounded.

Cementation and HCL Reaction

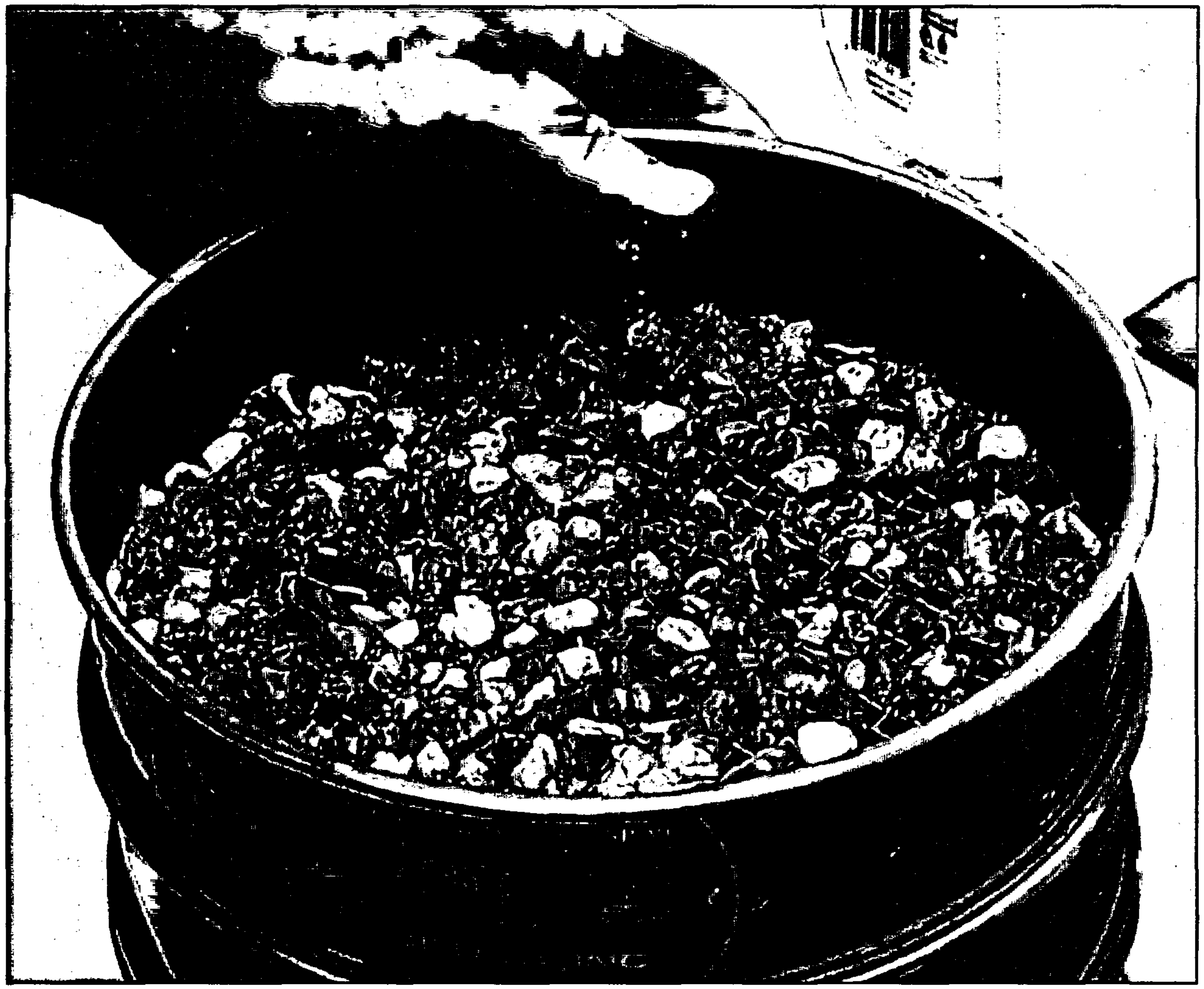


Cementation versus depth (350.8 to 633.8 feet).



HCL reaction versus depth (350.8 to 633.8 feet).

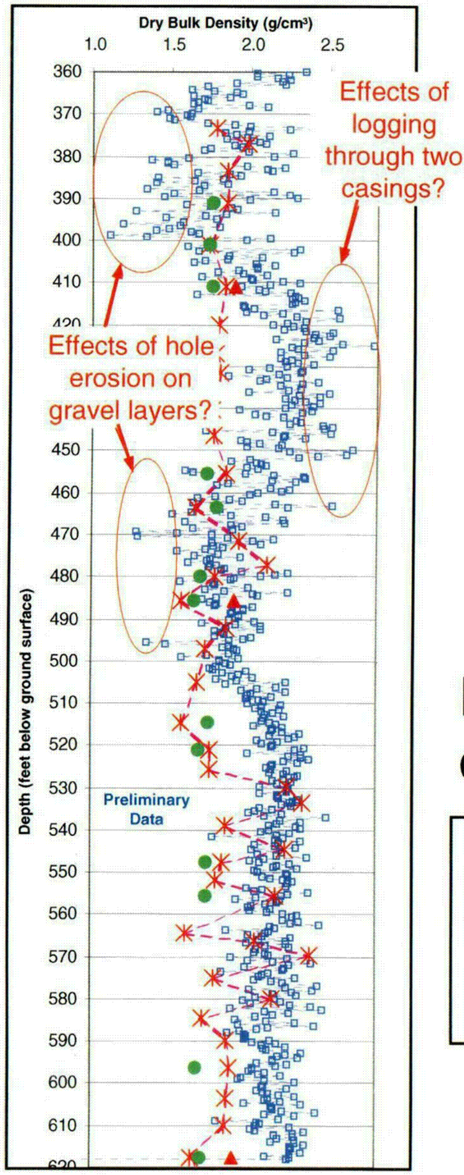
Subangular to Subrounded Finer Gravel Fraction



Results:
Formation Densities/Porosities

- Determined by several field and laboratory methods.
- Produced generally consistent values.
- Calculated porosities were in the upper range of values used by the U.S. Department of Energy (i.e., 25 to 31%).

Dry Bulk Density Depth Profiles



Dry bulk density depth profiles using different measurement methods.

- Gamma-gamma compensated density
- Core run density
- Repacked core density (approximately 1.7 g/cm^3)
- Maximum repacked core density (approximately 1.9 g/cm^3)

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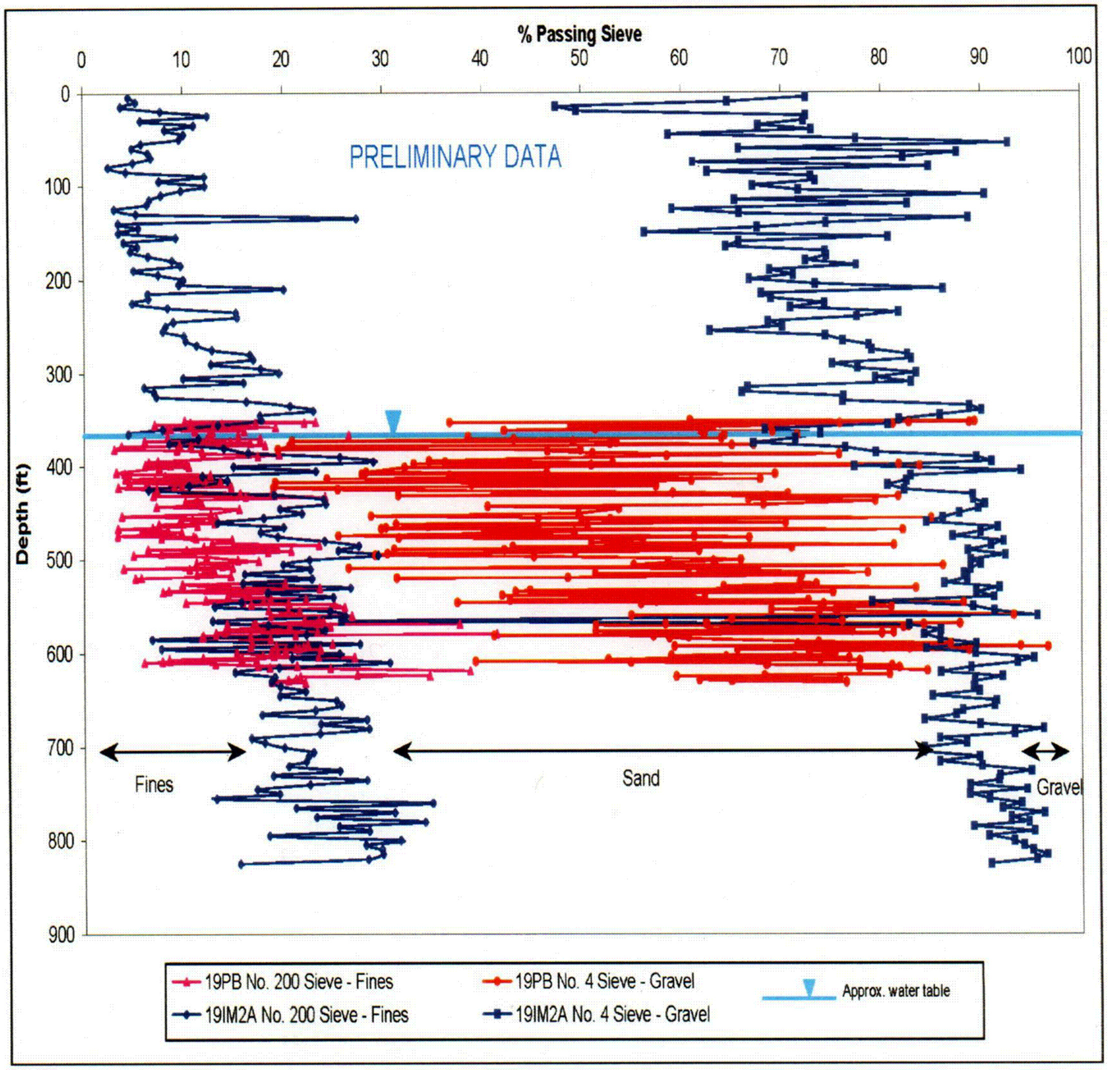
Results:
Laboratory Particle Size Distribution

- Depth profiles of sonic core were compared to those of drill cuttings collected in an adjacent borehole using air-rotary reverse circulation methods.
  - Core contained much more gravel, much less sand, and generally less fines.
  - Drill cuttings particle sizes were significantly disturbed.
    - Large particles were ground into smaller particles.
    - More so beneath the water table.

Particle Size Distribution

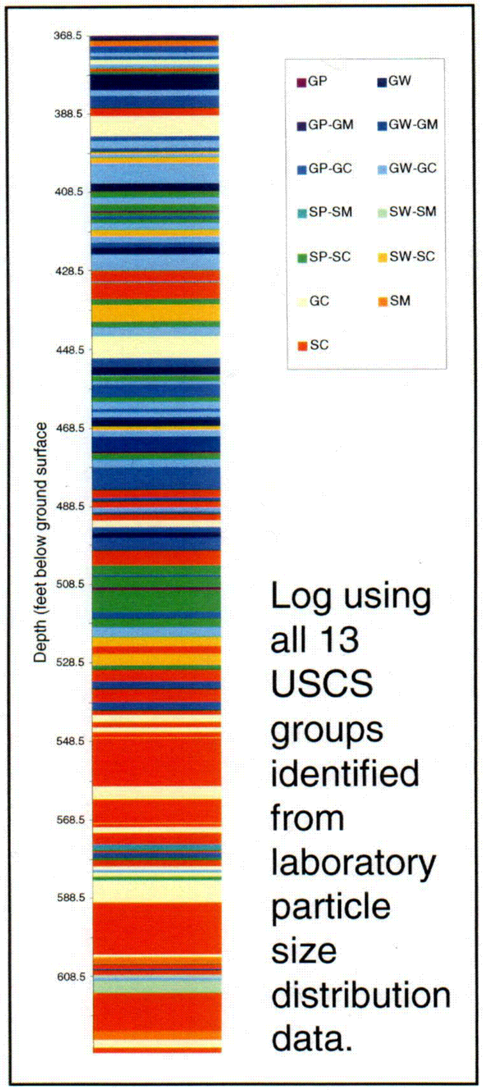


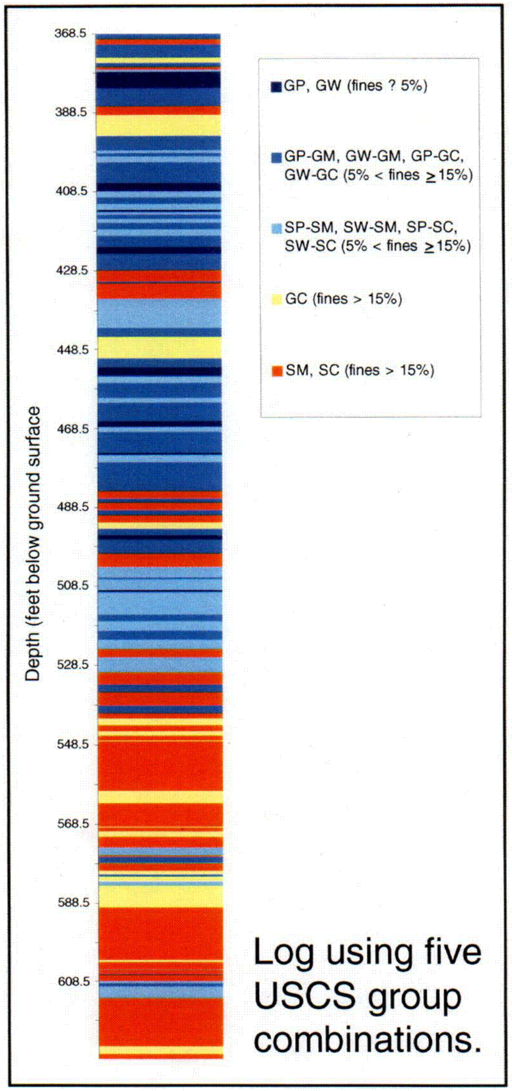
Particle size distribution versus depth for NC-EWDP-19PB core and NC-EWDP-19IM2A drill cuttings.

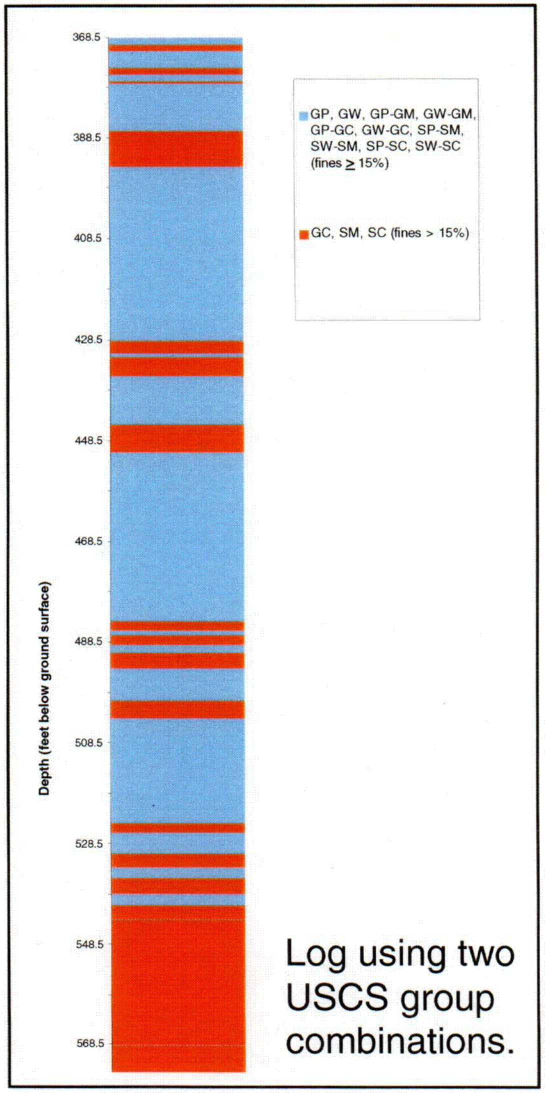
Results: USCS Textural Layers

- Based on laboratory particle size distribution data.
  - Wet sieve and hydrometer methods.
  - Atterberg Limit tests are in progress.
- Classified as coarse-grained.
  - Mainly gravels and sands with fines in the upper 160 feet of the corehole.
  - Fines classified as clays.
  - Poorly graded layers predominated.
  - Mainly clayey sands in the lower 100 feet of the corehole.
- Preliminary Atterberg Limits data classify fines primarily as silts rather than clays.
  - Many of the USCS “C” groups in the following slide are more likely “M” groups.

Preliminary Summary Lithologic Logs







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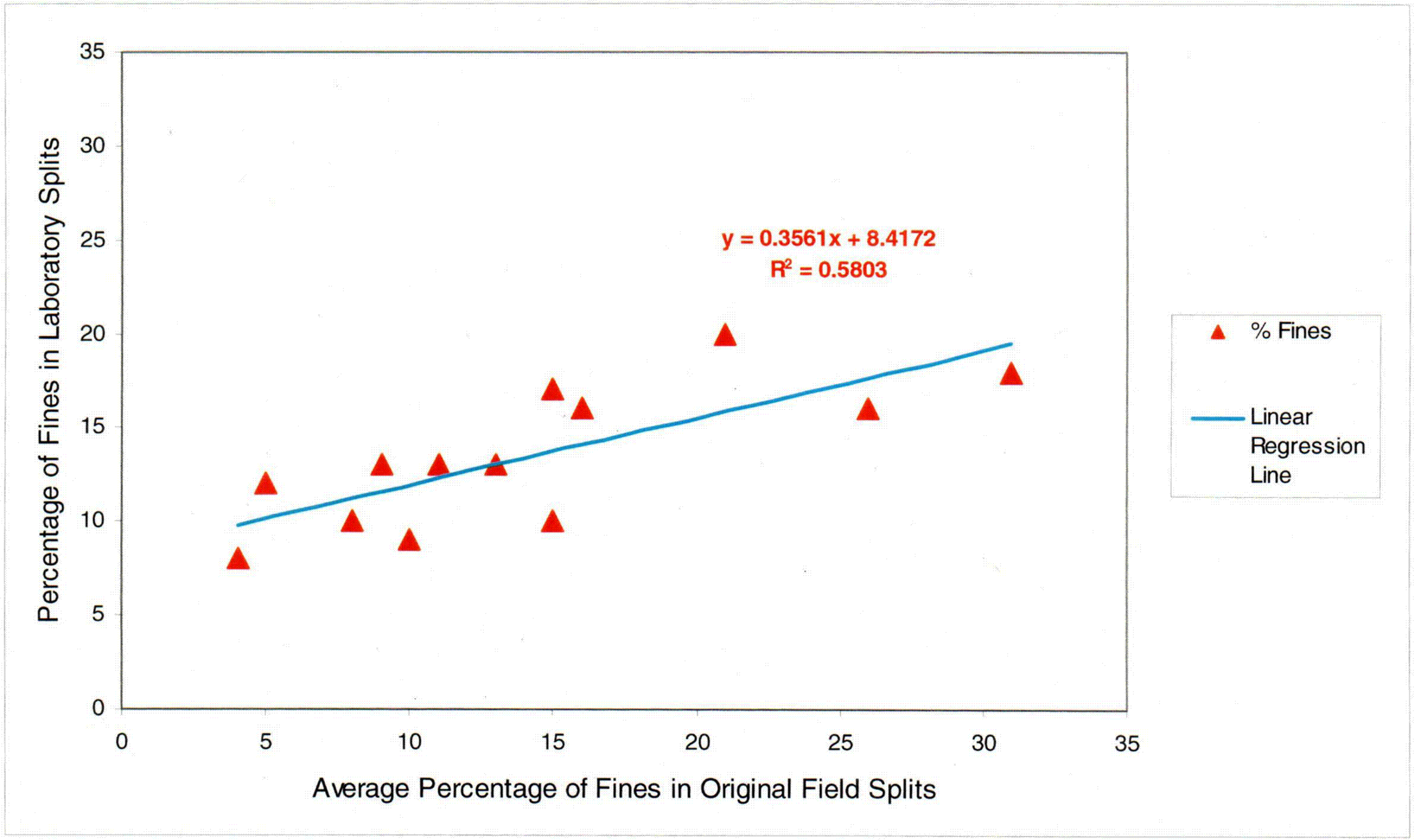
Difficulties in Subsampling (Splitting) Core Samples

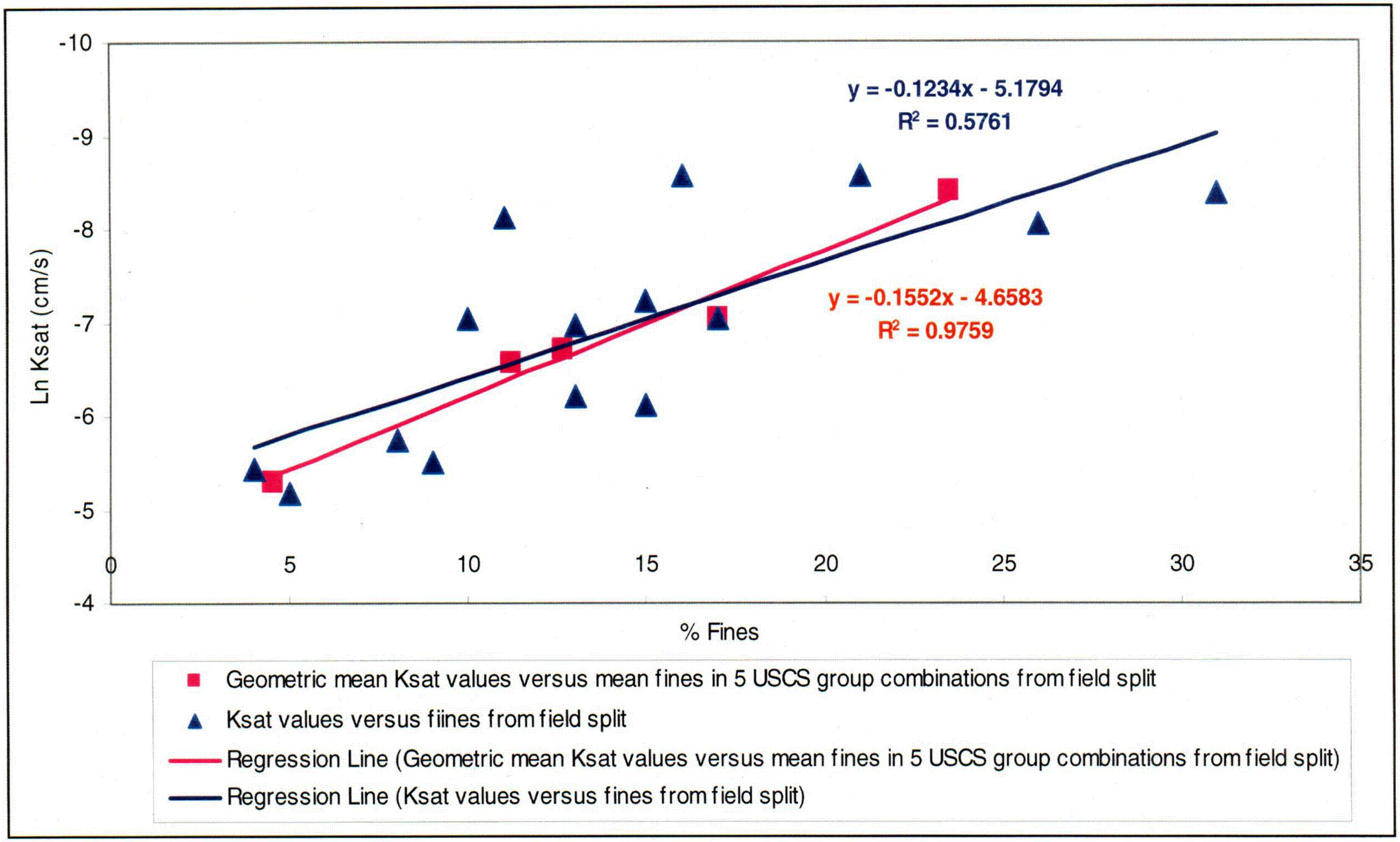


Percentage of Fines in Sample Splits From the Same Depth Intervals

Results:
Ksat Values

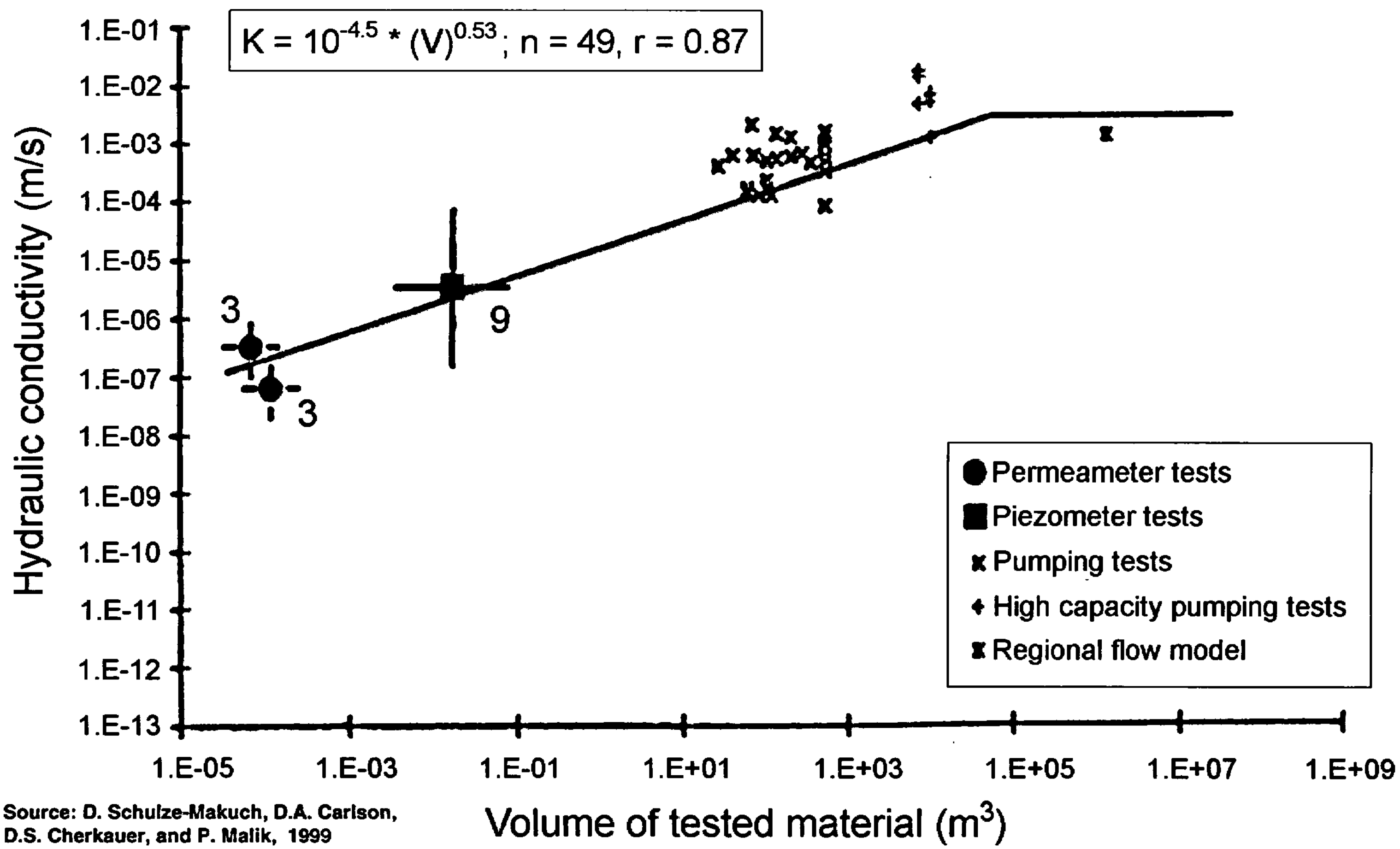
- Cooperative testing program on 15 repacked samples with Los Alamos National Laboratory (LANL).
  - Ksat tests conducted in the Nye County laboratory.
  - Transport parameter tests conducted at LANL.
- Laboratory Ksat values of 15 samples from USCS layers repacked to dry bulk density of approximately 1.72 g/cm^3:
  - Values ranged from 17 to 0.6 feet per day.
  - Values decreased with increasing fines.
  - Similar to the findings of others.

Ksat versus Natural Log (Ln) of Fines



Core repacked to approximately 1.7 g/cm³.

Relationship of Ksat to Measurement Scale



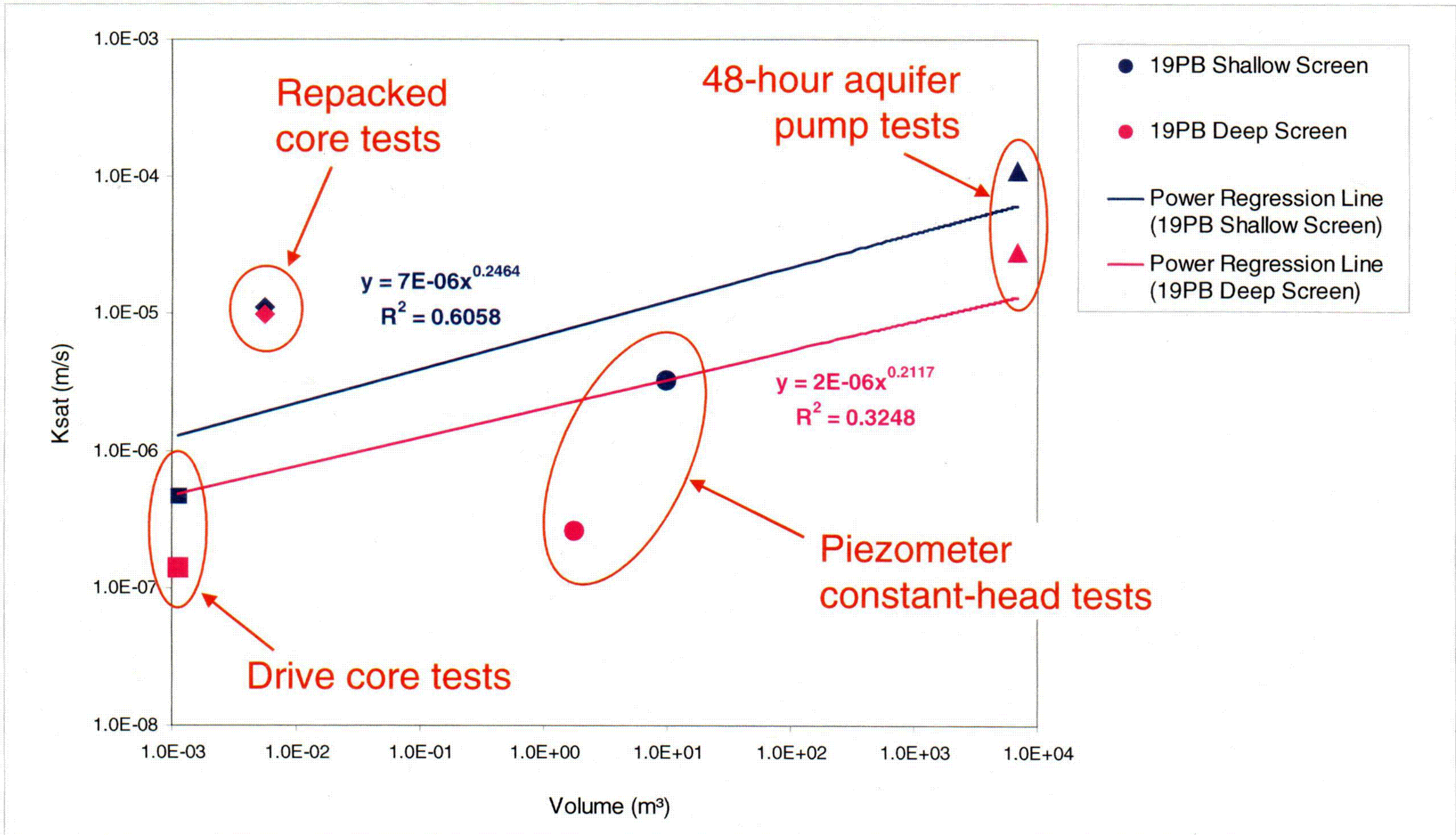
Source: D. Schulze-Makuch, D.A. Carlson, D.S. Cherkauer, and P. Malik, 1999

Results: Comparison of Ksat Values at Different Scales

Scales of Ksat from NC-EWDP-19PB and an Adjacent Well

ID	Measurement Location	Material Tested	Approximate Dry Bulk Density (g/cm^3)	Appoximate Total Porosity (%)	Relative Measurement Scale
1	Laboratory	Drive core (4 inches in diameter by 6 inches long)	1.9	25	Smallest
2	Laboratory	Repacked core (6 inches in diameter by 12 inches long)	1.7	35	Small
3	Laboratory (test in progress)	Repacked core (6 inches in diameter by 12 inches long)	1.9	25	Small
4	Field	Formation in vincinity of piezometer screen	1.9 - 2.1	25 - 20	Intermediate
5	Field	Formation between pump and observation wells	1.9 - 2.1	25-20	Large

Ksat Values versus Test Volume in NC-EWDP-19PB and Adjacent Well



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Results: Comparison of Ksat Values

- Laboratory values smaller than those from large-scale aquifer pump testing.
  - Similar to the findings of others.
- Repacked laboratory values larger than those from intermediate-scale field constant-head injection testing.
  - Not similar to the findings of others.
  - Possibly due to:
    - Migration of fines to corehole walls.
    - Higher porosity of repacked core compared to formation porosity.

Results: Ksat Values from Core Repacked to Maximum Density

- Three core samples repacked to approximately 1.9 g/cm^3.
  - Sample A: fines $\leq$ 5%.
  - Sample B: 5% $<$ fines $\leq$ 15%.
  - Sample C: fines $>$ 15%.
- Ksat values decrease with increasing fines.
  - Sample A: 0.2 feet/day.
  - Sample B: 0.07 feet/day.
  - Sample C: less than Sample B (test in progress).
- Ksat values two or more orders of magnitude less than samples repacked to approximately 1.7 g/cm^3.

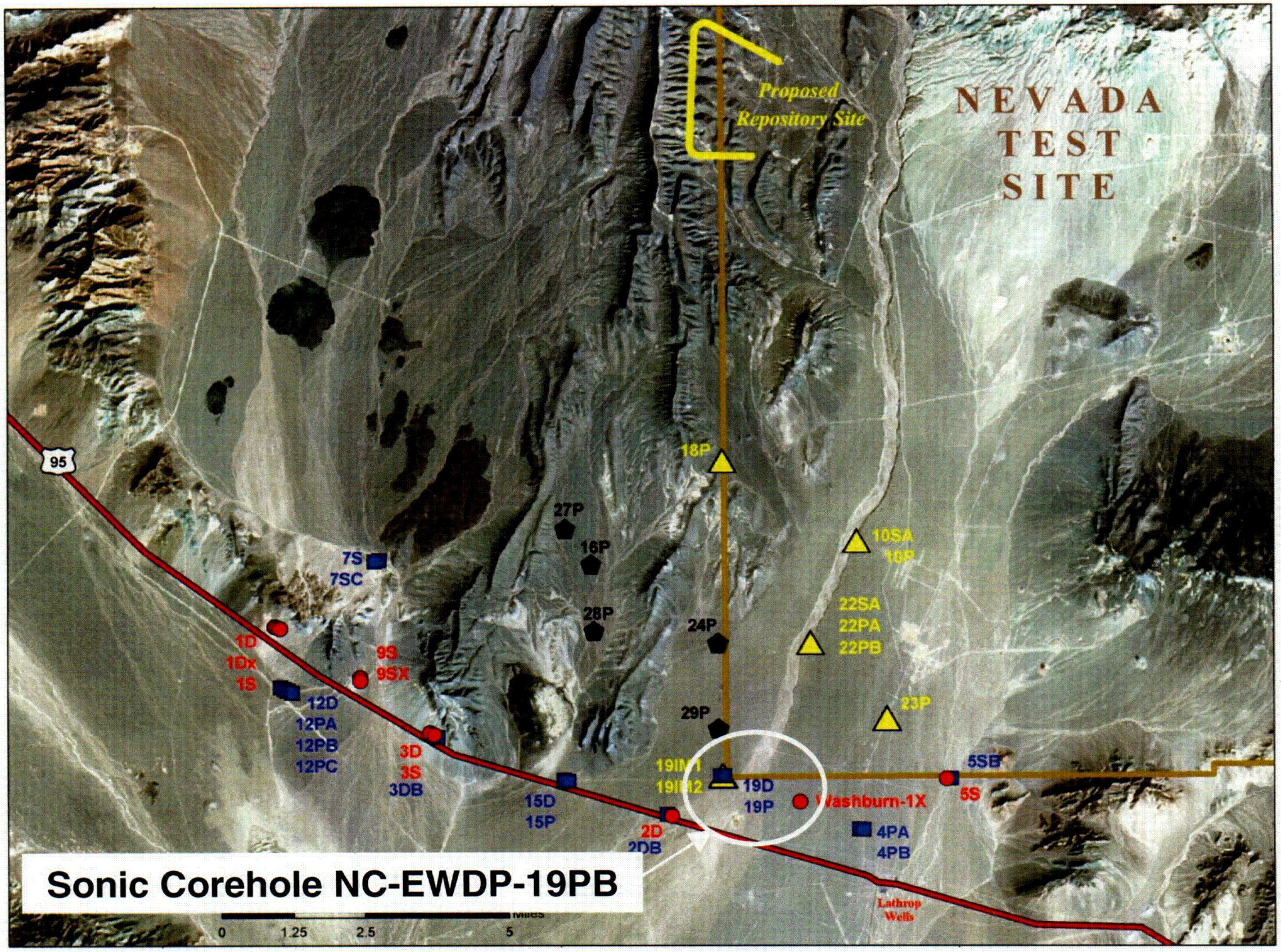
Future Laboratory Work

- Nye County laboratory:
  - Complete Atterberg Limits testing.
  - Revise USCS textural groups.
  - Propose hydrologic units.
- Los Alamos National Laboratory:
  - Determine transport parameters versus porosity and particle size distribution on repacked core.

Future Field Work

- Existing Nye County sonic corehole:
  - Develop piezometer screens further.
  - Rerun constant-head injection tests.
- New Nye County sonic corehole:
  - Site 22 (site of the Nye County tracer test).
  - Continuously core unsaturated and upper saturated zone.
- One or two additional 2,000- to 3,000-foot exploratory boreholes/water table piezometers in Flat Tire Flat.
- Single and crosshole tracer tests at Site 22 in Fortymile Wash.

Location of Sonic Corehole



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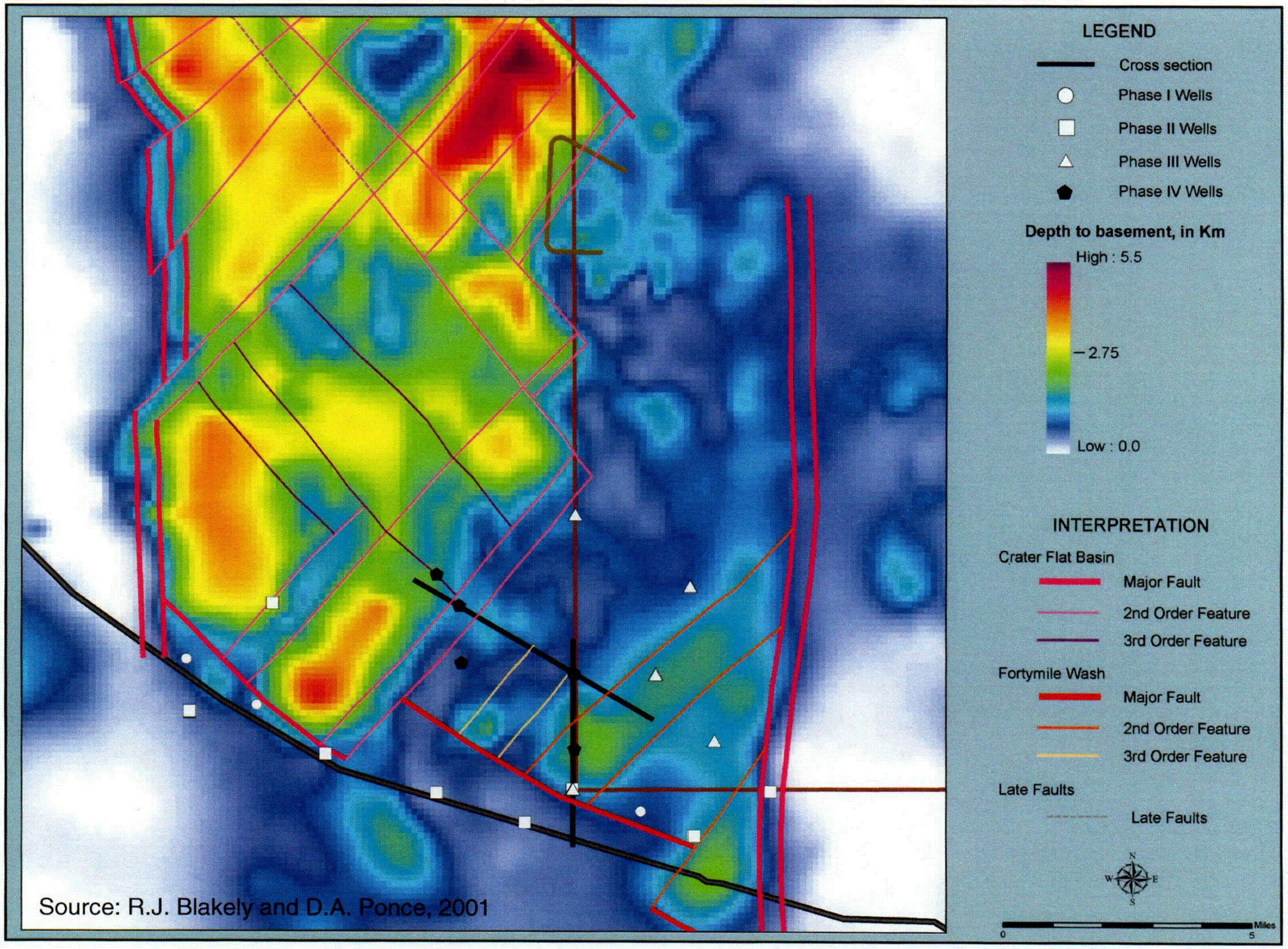
Backup Slides

Depth to Pre-Cenozoic Basement



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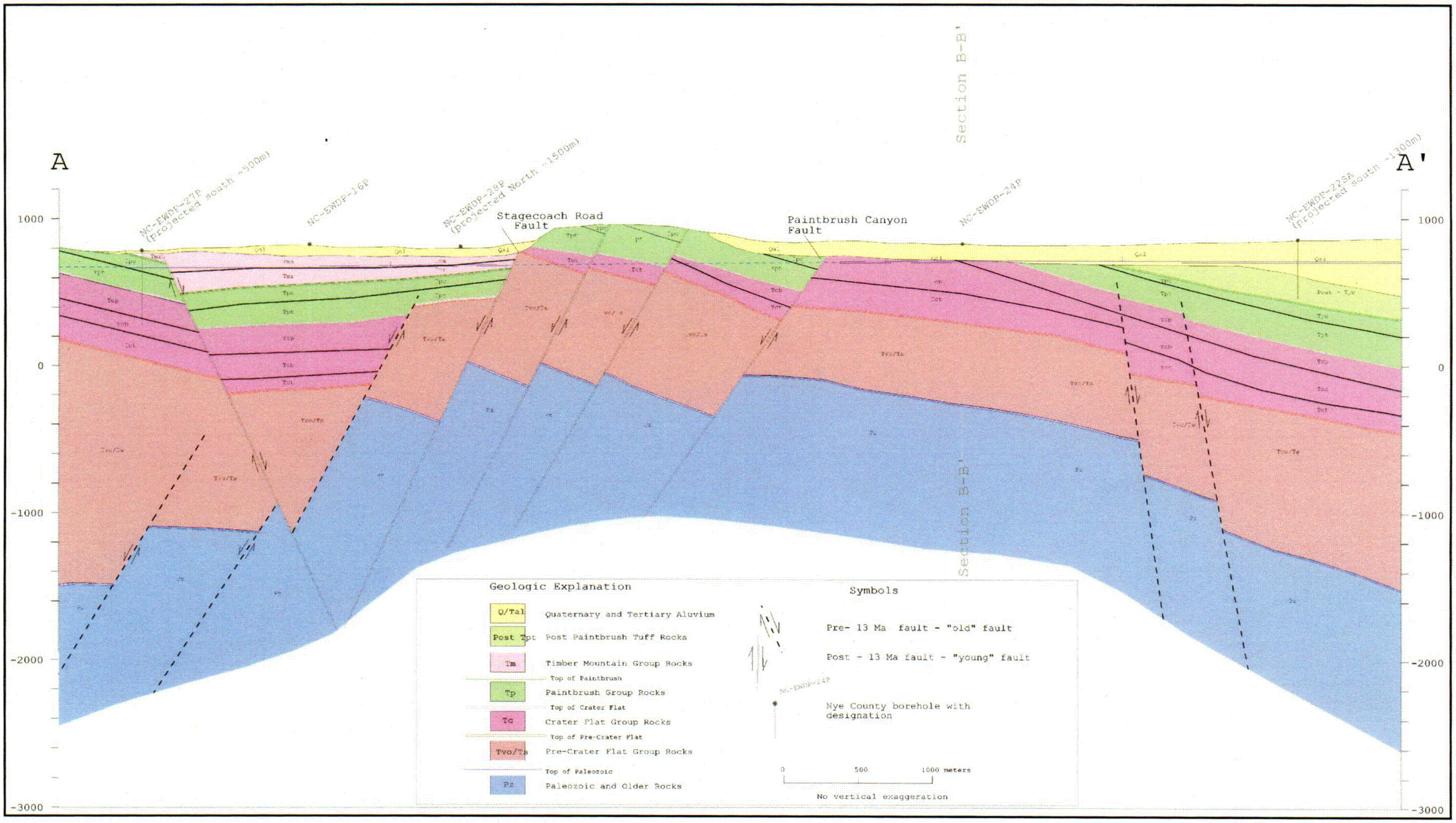
Interpretive Cross Section A-A'



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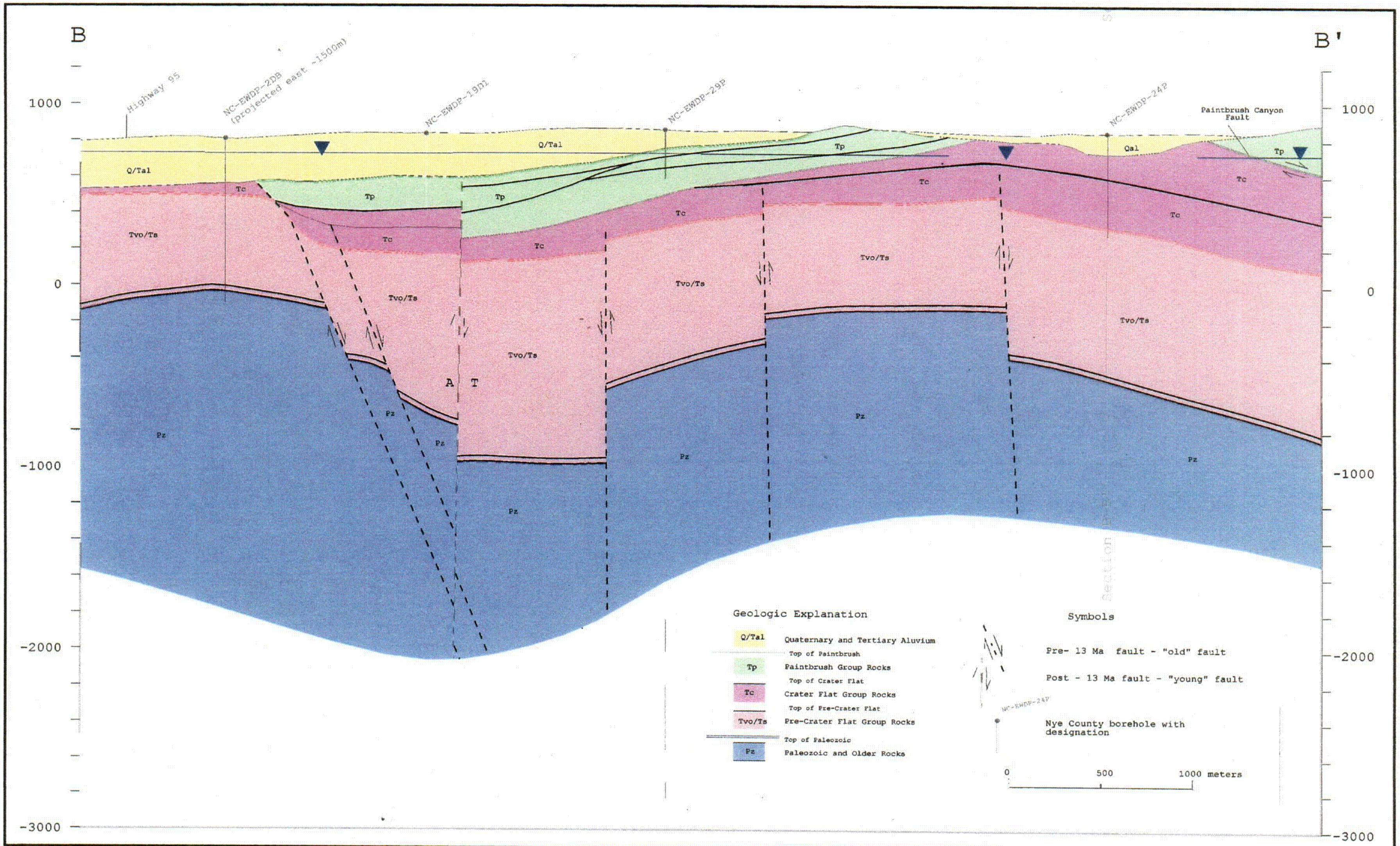
Interpretive Cross Section B-B'



C 28

Basin-Wide Coordination of Water Resources Definition, Development and Management

Nye County Department of Natural Resources and Federal Facilities
Les W. Bradshaw

151st ACNW Meeting
June 22-24

1

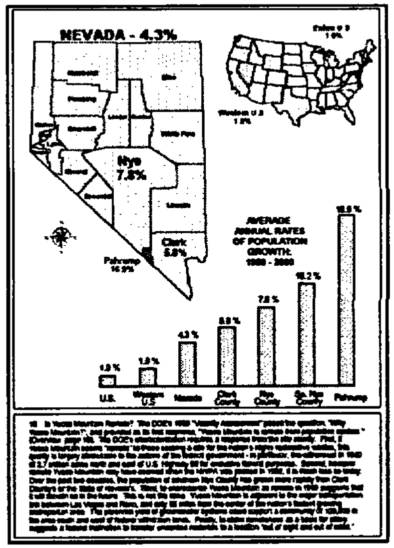
- Nye County Land Use Pattern.
- Nye County Growth Patterns.
- Federal Agencies Active in Nye County.
- Cumulative Impacts of Federal Resource Management Actions.
- Call for Coordinated Water Resources Definition, Development and Use.

2

Nye County Growth Patterns

- Explosive Growth 1990 to Present.
  - Growth expected to continue.
  - About 41,000 in Nye County, 75% in Southern Nye County.

3



4

11+ million acres in the County

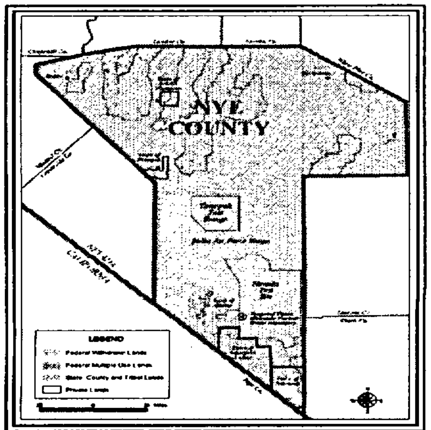
- Nye County tax base based on 2% private, taxable acres.
- Towns landlocked.
- Federal land management policies determine County growth management policies.

5

Who Manages The County's Land Mass?

- 98% Federally managed lands.
  - BLM
  - Forest Service
  - Fish & Wildlife
  - Park Service
  - BIA
  - DOE,DOE
  - DOD

6



15. Federal and Private Lands. Nye County is Larger than four eastern states combined (New Jersey, Delaware, Rhode Island and Massachusetts). However, 87.8 percent of its land area is managed by federal agencies, and 4,445 square miles, including much of the county;s center, has been withdrawn from multiple use for exclusive federal purposes. Less than 2 percent of the county's land is available for ordinary community and economic development. Much of the "private land" on this map is patented mining claims, not land intended or suited for community development.

Federal Regulatory Burden

- Air in Pahrump.
- Tortoise habitat in Southern Nye County.
- Spotted frog habitat in Northern Nye County.
- Amargosa Toad in Beatty area.
- 30+ year old WSAs.
- 2 Wilderness Areas.
- ACECs.
- All sorts of ad hoc land management policies (species, habitat, cultural, recreational, grazing, etc.).
- Federal 'law enforcement' issues.

State-Level Issues

- Southern Nevada Water Authority water 'grab'.
  - Nye County Financial inability to participate effectively.
- Septic and Sewer issues in Pahrump.
- Elk Management Policies in Northern Nye County.
- Over-allocated basins.
- Water Speculators.

9

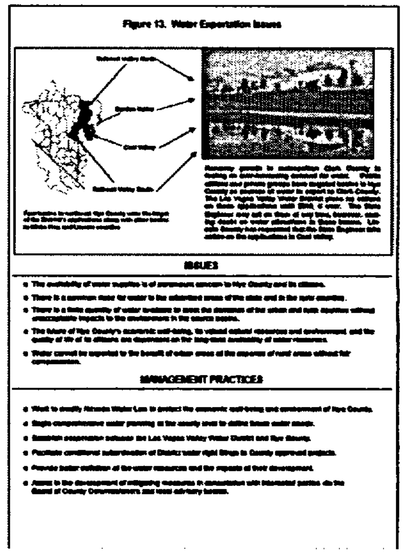


Figure 13. Water Exportation Issues

ISSUES

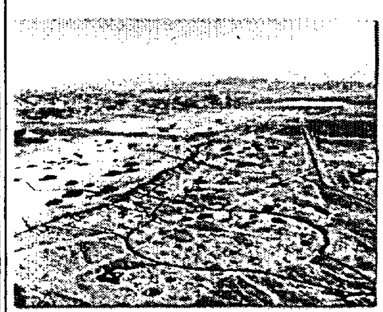
MANAGEMENT PRACTICES

10

Federal Activities on Nevada Test Site

- Bomb testing.
- Migration of contaminants.
- Lack of effective Nye County involvement in NNSA groundwater monitoring programs.

11



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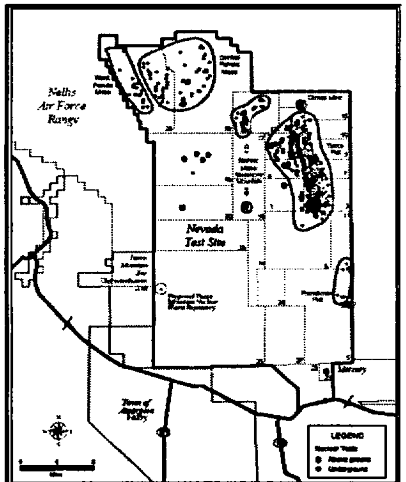
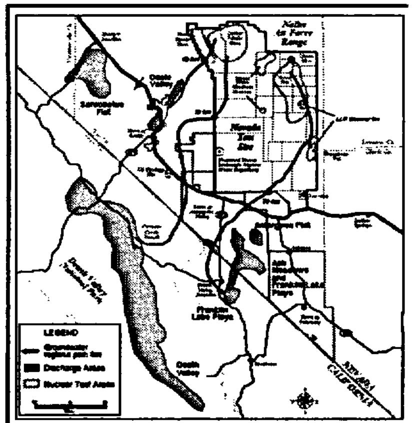


Nellis
Air Force
Range
Nevada
Test Site
Mercury
LEGEND

13



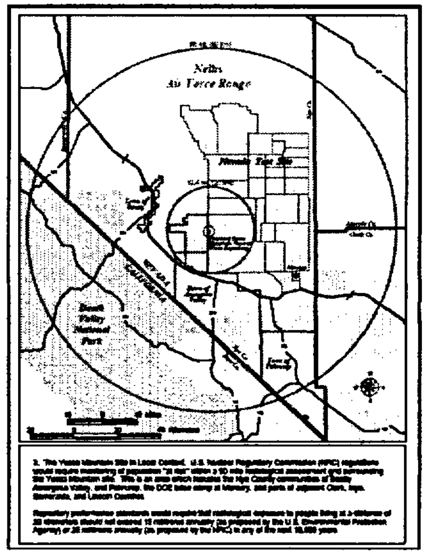
Nevada
Test
Site
LEGEND
Discharge Areas
Nuclear Test Areas
NEVADA
CALIFORNIA

14

Federal Activities on Nevada Test Site cont'd

- Yucca Mountain Project.
- Nye County concern: Regional and local groundwater flow paths.
  - Cooperative work with ORD on hydrogeology in northern Amargosa Valley.
- Yucca Mountain Project, continued.
  - Nye wants long-term permanent statutory involvement in performance confirmation.

15



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Nye County Government Must Understand Quantity and Quality of Groundwater Resources

- Without accurate and understandable data county officials cannot plan for growth.

Draft Nye County Water Resources Plan

- Drafted 2 years ago.
- Being considered for inclusion in the Nye County Comprehensive Plan.
- Public hearings underway.

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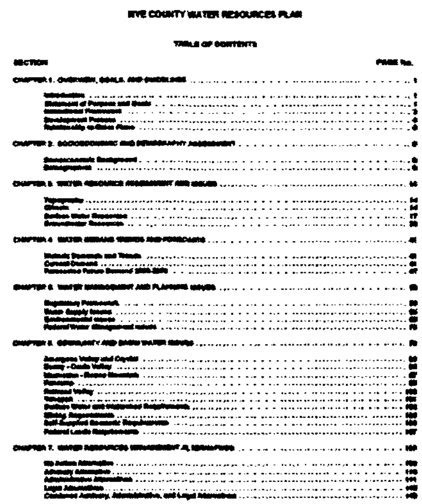
Draft Nye County Water Resources Plan



20

Water Resources Plan Alternative Actions

- No Action Alternative
  - No County involvement in water resource definition, development or use.

21

Water Resources Plan Alternative Actions, cont'd

- Advisory Alternative
  - Nye County would only be involved in advisory role.
  - Intermediatory between state regulatory agencies and water users.

22

Water Resources Plan Alternative Actions, cont'd

- Administrative Alternative
  - Nye County would be actively involved in water planning process through the development of a management authority.
  - General Improvement District.
  - Water Planning Commission, Comprehensive Regional Plan and Remediation Districts.
  - Regional Water Authority.

23

Water Resources Plan

- Will be adopted by mid-summer.
- Follow-up actions will be taken.
- Nye County desires to plan its own future, not abdicate to others.

24

Disparate groups are not coordinating their research

- No common data base.
- Data not easily accessible for local government planning.
- Competing agency objectives/goals impede coordination and collaboration.
- No central data repository to collect, collate, preserve and retrieve data.
- Lots of data is in peoples' heads.

25

All agencies work toward the goals of:

- Coordinating all water resource definition, development, use and management activities.
- Creating a basin-wide permanent repository for water resource data.
- A collaborative, non-confrontational, coordinated regional water planning effort.

26

U.S. Nuclear Waste Technical Review Board

Field and laboratory observations and analyses presented by the DOE and others suggest that the natural system provides an effective barrier to migration of some radionuclides over time periods that may be comparable to the regulatory period. However, several key hydrogeologic features or processes that may significantly affect fluid flow and radionuclide transport are presently not well understood, are constrained by limited or poor data, or both.

Conservatism, Realism, Understanding

DOE often deals with uncertain features and processes by making conservative estimates of their effects on radionuclide transport. Such conservatisms tend to emphasize more-rapid advective transport processes. More realistic estimates could lead to slower transport predictions for some radionuclides. However, there is a possibility that some other poorly understood features or processes may lead to faster radionuclide transport. It is important that DOE develop a better fundamental understanding of the overall behavior of the natural system.

Examples in May 2004 Board letter to DOE

- Large-scale hydraulic tests of major faults
- Characterization of saturated alluvium
- Matrix diffusion
- Colloids
- Updating site-scale saturated zone flow model
- Use of natural analogs

Observations from June 22 ACNW Meeting

- Aqueous geochemical heterogeneity can be a significant factor in radionuclide mobility

- Alternative flow paths in the well-calibrated CNWRA saturated zone model may be significant to non-advective radionuclide transport

- Hydrogeologic interpretations in the well-calibrated CNWRA saturated zone model (e.g. Fortymile Wash high permeability feature) merit field investigation

Observations from June 23 ACNW Meeting