VOID DETECTION DEMONSTRATION PROJECT STATUS REPORT

Underground Mine Mapping Benchmarking Workshop
Interstate Mining Compact Commission (IMCC) / Office of Surface Mining (OSM)

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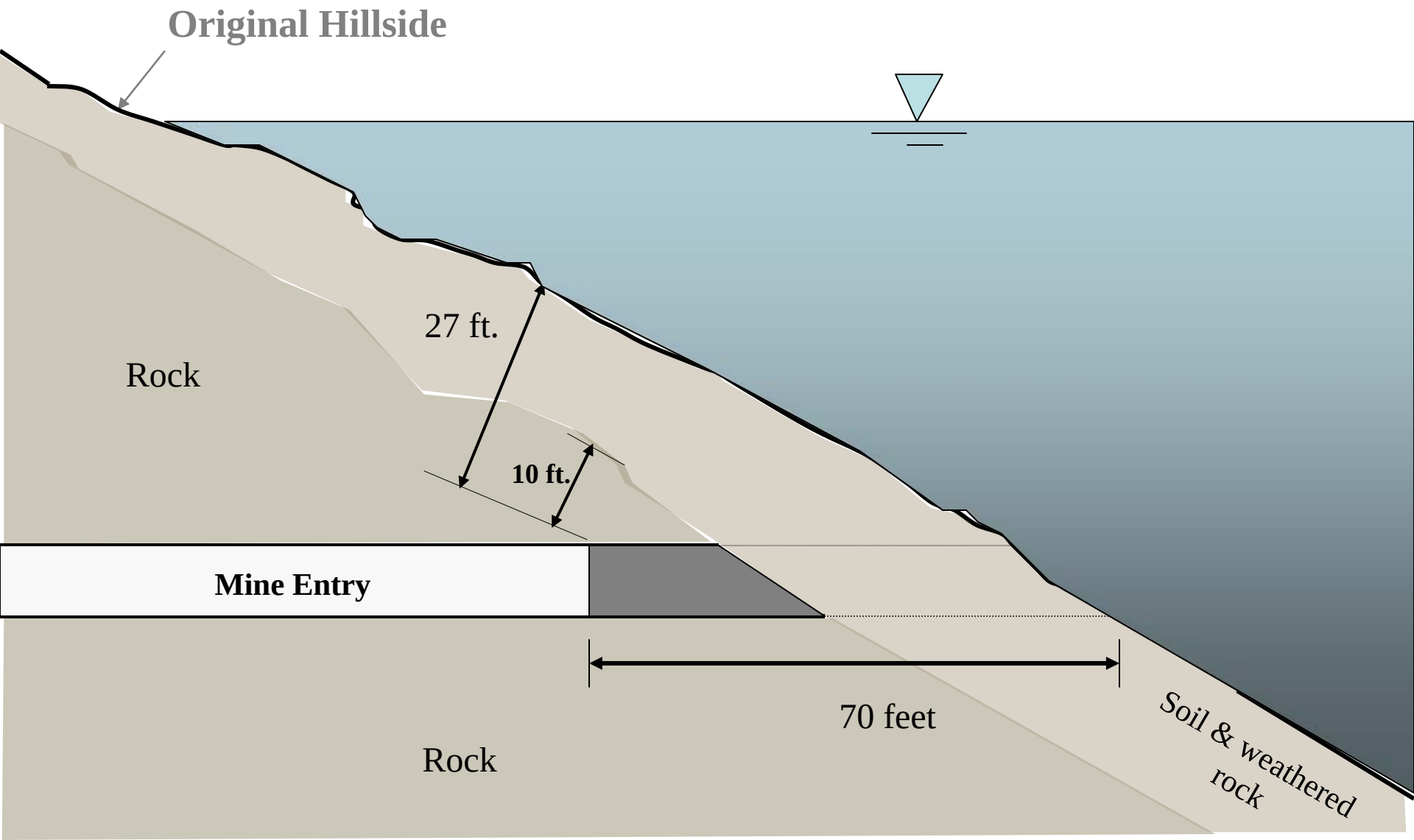
Pittsburgh Technical Support Center

Recent High-Profile Incidents Related to Underground Mines

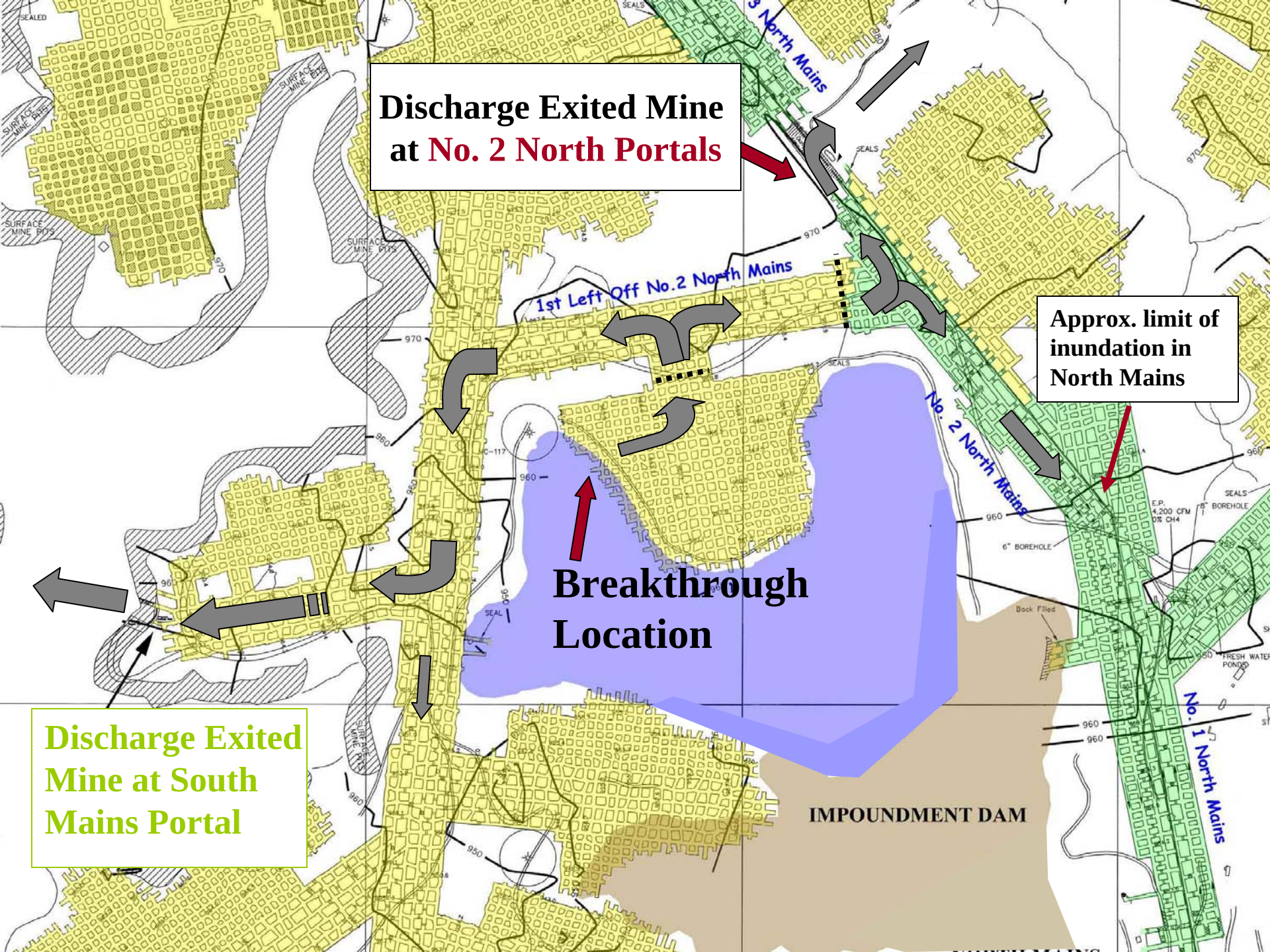
- Impoundment Breakthrough Incidents
  - Miller's Cove, Lee Co. VA, August, 1996
  - Miller's Cove, Lee Co. VA, October, 1996
  - Buchanan, Buchanan Co. VA, November, 1996
  - Big Branch, Martin Co., KY, October, 2000

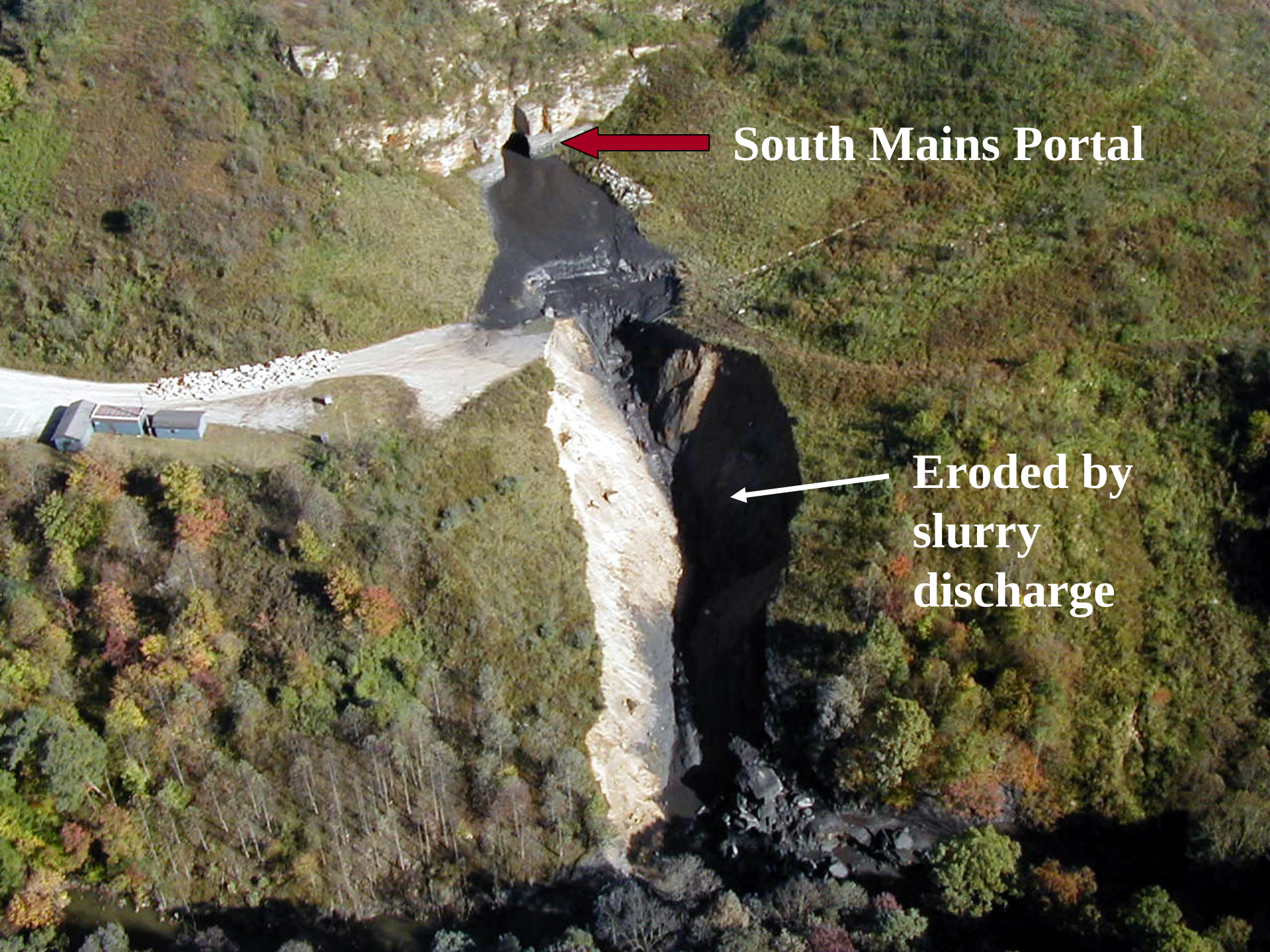
- Mine Inundation
  - Quecreek No. 1 Mine Inundation and Rescue, July 2002

Example of potential for breakthrough created by mine workings located near an impoundment.




Martin County Coal Company
Big Branch Refuse Impoundment
October 2000
Approx 300 Million Gallons Released


Discharge Exited Mine at No. 2 North Portals
1st Left Off No.2 North Mains
Approx. limit of inundation in North Mains
No. 2 North Mains
Breakthrough Location
Discharge Exited Mine at South Mains Portal
IMPOUNDMENT DAM
No. 1 North Mains
SURFACE MINE PITS
SEALED
SEALS
Back Filled
6" BOREHOLE
FRESH WATER POND


South Mains Portal
Eroded by slurry discharge


No. 2 North Belt Entry

Coldwater Creek

PITTSBURGH POST-GAZETTE

NATIONAL

Coal sludge slimes Kentucky

Mine pond collapses, pollutes streams and fouls area's water

By Roger Alford
The Associated Press

INEZ, Ky. — When Delmer Moore looks out his window in mid-October, he ordinarily sees the beautiful yellow and orange leaves of autumn.

This year, the predominant color is black.

It's been that way since a coal-mine pond gave way last week, releasing 200 million gallons of sludge into eastern Kentucky streams, killing fish, washing away roads and bridges, and fouling the region's water supply.

Moore has watched as the molasses-like substance topped the banks of Coldwater Creek and began claiming his property outside of Inez, which is 140 miles east of Lexington. The sludge covered most of

Associated Press

fail," said MSHA spokesman Rodney Brown. "It's just that we consider it a highly dangerous situation and it should be looked at closely."

The impoundments need to be eliminated altogether, said Hazel King, a Harlan activist who has crusaded for decades against mine ponds.

"There's just too many of them," she said. "If they know there's a potential for collapse, why do they allow it to happen in the first place? An ounce of prevention is worth of pound of cure. I've hollered that as loudly as I could. I guess the almighty dollar hollers louder."

Martin County Coal had crews working around the clock dredging the ooze from streams. The state has ordered the company, a subsidiary of A.T. Massey Coal Inc., to replace fish and other aquatic life killed and to rebuild the roads and bridges it ripped away.

Fred Stroud, a member of an emergency response team from the Environmental Protection Agency, said it could take at least five to six months to clean up the spill, a project expected to cost millions.

SLUDGED! ...BY Big Coal

'WE WANT ANSWERS'

MSHA opens Inez command center; McAteer, Rogers vow national study

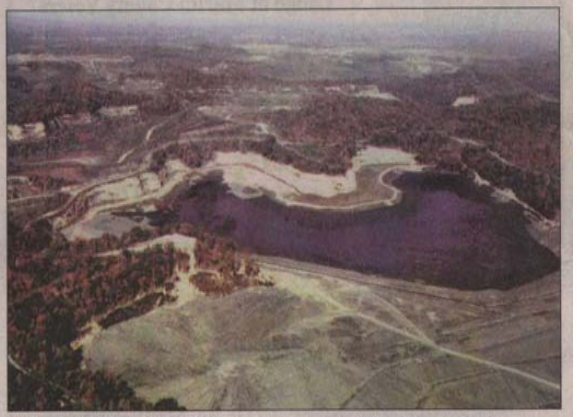
Paper calls spill 'worst ever'


Region 4 Federal EPA official Art Smith

Lead, zinc, and chromium found in water, but not in toxic levels, EPA says

"WITH THE COMPANY KEEPING THE MEDIA OUT, AND NOT TALKING TO US, IT SEEMS LIKE WE'RE LIVING UNDER MARSHAL LAW."
COLDWATER RESIDENT – LARRY PREECE

—See pullout section INSIDE


SUN aerial photo by LILLY ADKINS (Special thanks to The Southern Alliance for Clean Energy)

THE BIG SPILL! – There's 2 billion gallons of coal slurry left in the giant pond shown above that was the origin of the worst blackwater spill in the nation's history. Spillage from the slurry pond at Martin County Coal has reached the Ohio River and threatens water systems all along the way. See more photos INSIDE.

Reuter - Oct. 18th - "A massive spill of slowly spreading coal slurry triggered water shortages and school closings across eastern KY...**prompting the governor to declare a state of emergency."**

"Communities throughout the affected 10 county area were forced to close off water intake pipes.

"Some public schools were forced to close indefinitely pending restoration of safe water supplies...

Anatomy of a disaster

A step-by-step analysis of what occurred in nation's worst coal waste spill

BY GARY BALL
CITIZEN EDITOR

INEZ — Uncertainty looms in the wake of the nation's worst coal slurry spill. Everyone is on edge after 250 million gallons of sludge poured out of Martin County Coal's Big Branch impoundment in the early morning hours of Oct. 11, stranding homeowners, destroying bridges,

Abandoned Coal Mines

State	No. of Abandoned Mines
Kentucky	150,000
West Virginia	100,000
Pennsylvania	40,000
Virginia	6,000

Impoundments and Mining

- 220 Impoundments in Appalachia built over or adjacent to mine workings
- MSHA rated and prioritized impoundments in terms of potential and consequences of failure
- 54 Sites had a high potential for breakthrough
- Mine Operators were required to evaluate potential for breakthroughs and design against them

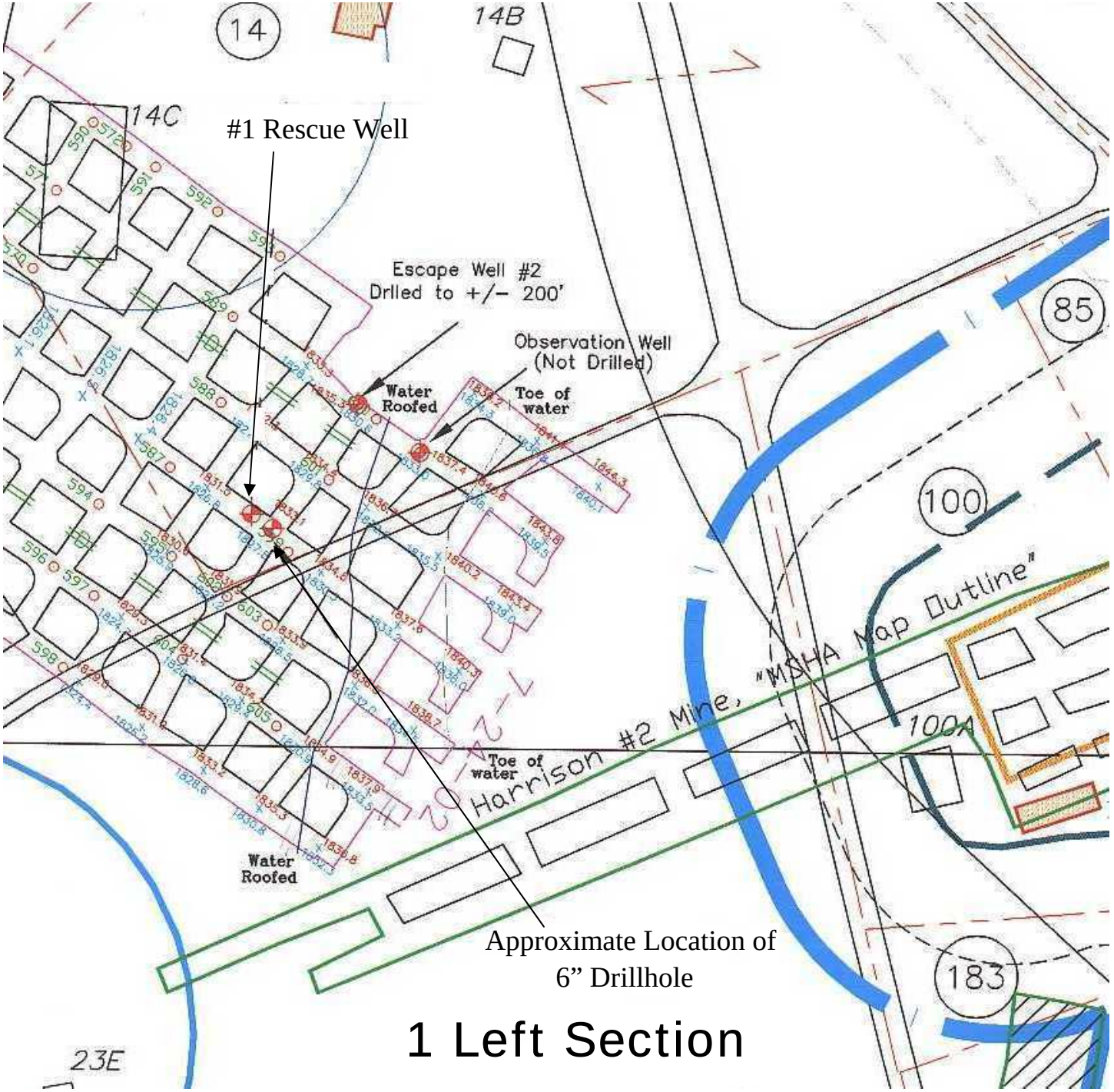
Congressional Study

- National Research Council , Committee on Coal Waste Impoundments
- $2,000,000
- Developed report, “Coal Waste Impoundments: Risks, Responses, Alternatives, 2002

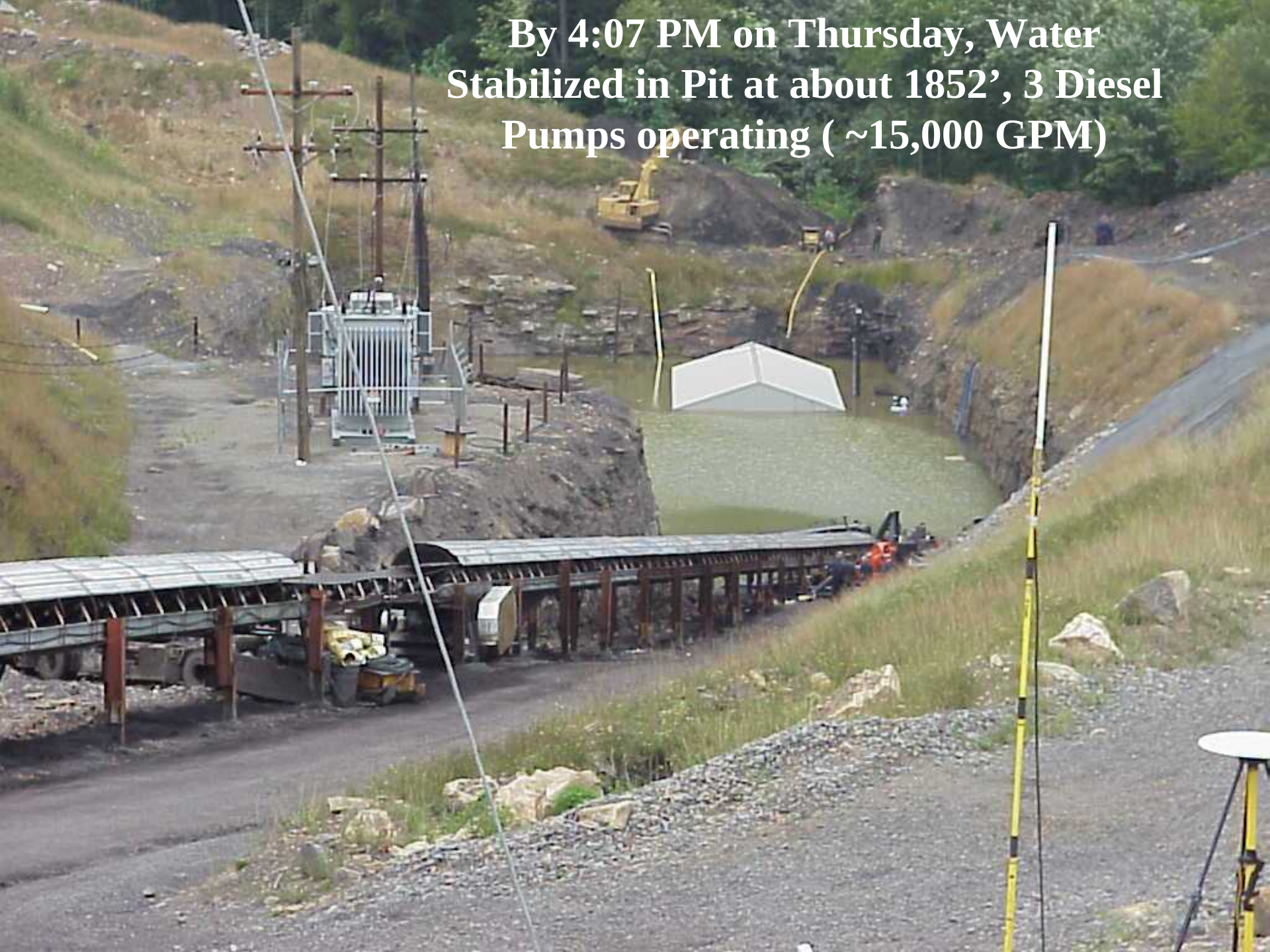
NRC Recommendation

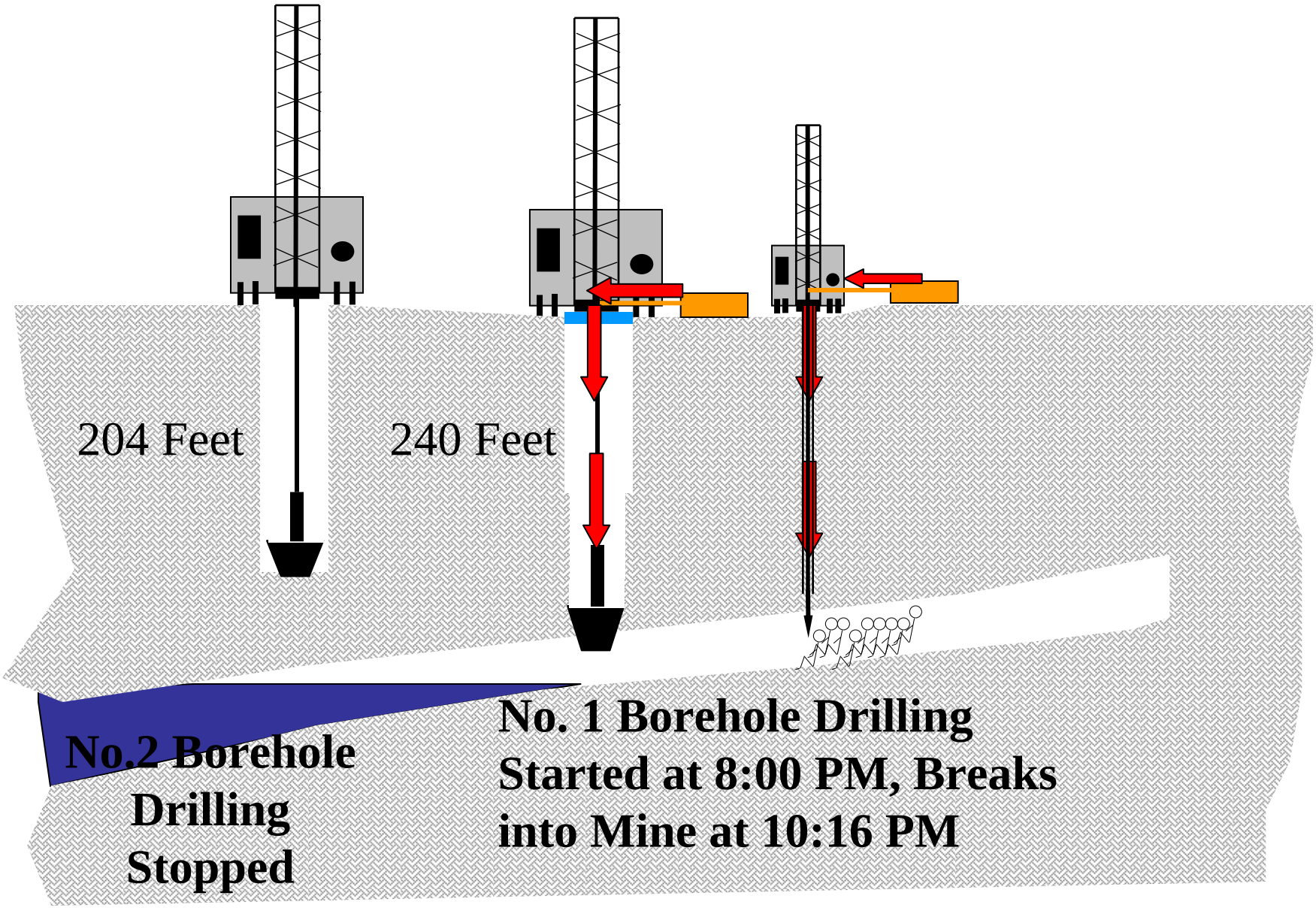
- *The council recommends that demonstration projects using modern geophysical techniques be funded, and that results be widely conveyed to the mining industry and to government regulatory personnel through workshops and continuing education.*

Quecreek No. 1 Mine Inundation and Rescue, July 24-28,2002



1 Left Section


By 4:07 PM on Thursday, Water Stabilized in Pit at about 1852’, 3 Diesel Pumps operating (~15,000 GPM)


204 Feet
240 Feet
No.2 Borehole Drilling Stopped
No. 1 Borehole Drilling Started at 8:00 PM, Breaks into Mine at 10:16 PM


FIRE
54

Active Mines: Inundation Accidents Magnitude of the Problem

- From 1995 through June 2002, mine operators reported 181 mine inundations.
- Of these, at least 107 were unplanned cut-throughs that resulted in water inundations.

House/Senate Conference Agreement

- "$10,000,000 for digitizing mine maps and developing technologies to detect mine voids, through contracts, grants, or other arrangements, to remain available until expended.“
  - MSHA Allocation:
    - $3.9M to Mine Mapping – Disbursements to States
    - $6.1M to Void Detection – Funded Projects to Demonstrate available technologies for void detection.

Request for Proposals (RFP)

- *Purpose: "The U.S. Department of Labor, Mine Safety and Health Administration is seeking sources to conduct demonstration projects for advancing the current state of technology in detecting underground mine voids."*

Progress of Demonstration Projects

- Pre-solicitation Notice
- Request For Proposals
- Objective Scoring System Developed
- MSHA Contracted with outside technical reviewers
- Review Teams Formed
  - MSHA Representative
  - Other Government (generally USACE) Representative
  - University Professor of Geophysics
- Down-selection process (5/26/2004)
  - 11 Respondents to receive further consideration
- Oral Presentations (7/27-30/2004)
- Negotiations 8/2004 - Present
- Final Selections 8/2004 – 4/2005

Response to RFP

- 58 Proposals
- 23 Sources
- Methods Covered
  - Surface Seismic Reflection
  - Inseam Seismic Reflection
  - DC Resistivity
  - Seismic Land Streamer
  - Synthetic Aperture Radar
  - Underground Electomagnetics
  - Microgravity
  - SASW
  - Ground-penetrating Radar
  - Look-Ahead Radar
  - Forward-Looking Seismic
  - Mobile Field Robotics (dry voids)
  - Mine Fish (wet voids)
  - Gravity Gradiometer
  - Time Domain Electromagnetics
  - Airborne Electromagnetic Conductivity
  - Drillstring Radar
  - MASW
  - 3-D Sonar
  - Cross-hole Seismic Tomography
  - Radio Imaging
  - 3-D Downhole Laser
  - Residual Potential Mapping

14 Selected Projects Now Underway

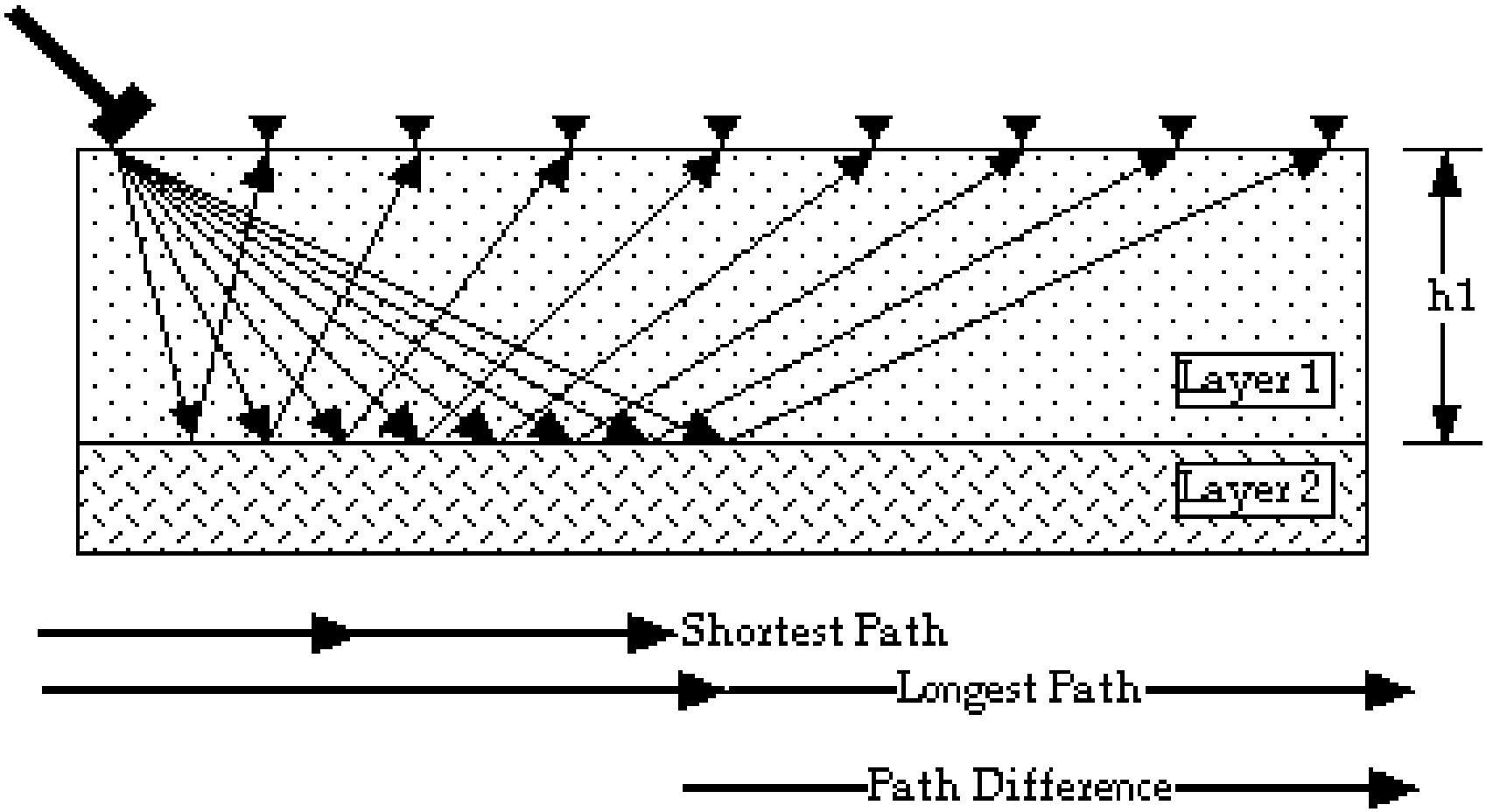
- Surface Seismic Reflection (2)
- Borehole Seismic Tomography (2)
- Vertical Seismic Profiling (1)
- In-seam Seismic (ISS) (various sources) (4)
- Electrical Resistivity (1)
- Time Domain Electromagnetics (1)
- Look Ahead Radar (1)
- Borehole Radar Tomography (1)
- Delta EM Gradiometry (1)

Surface Seismic Reflection Projects

- Blackhawk GeoServices
  - Black Beauty Coal Co., Riola Mine Complex

- LM Gochioco Associates
  - Sterling Coal Corp., Carroll Hollow Mine

Surface Seismic Reflection

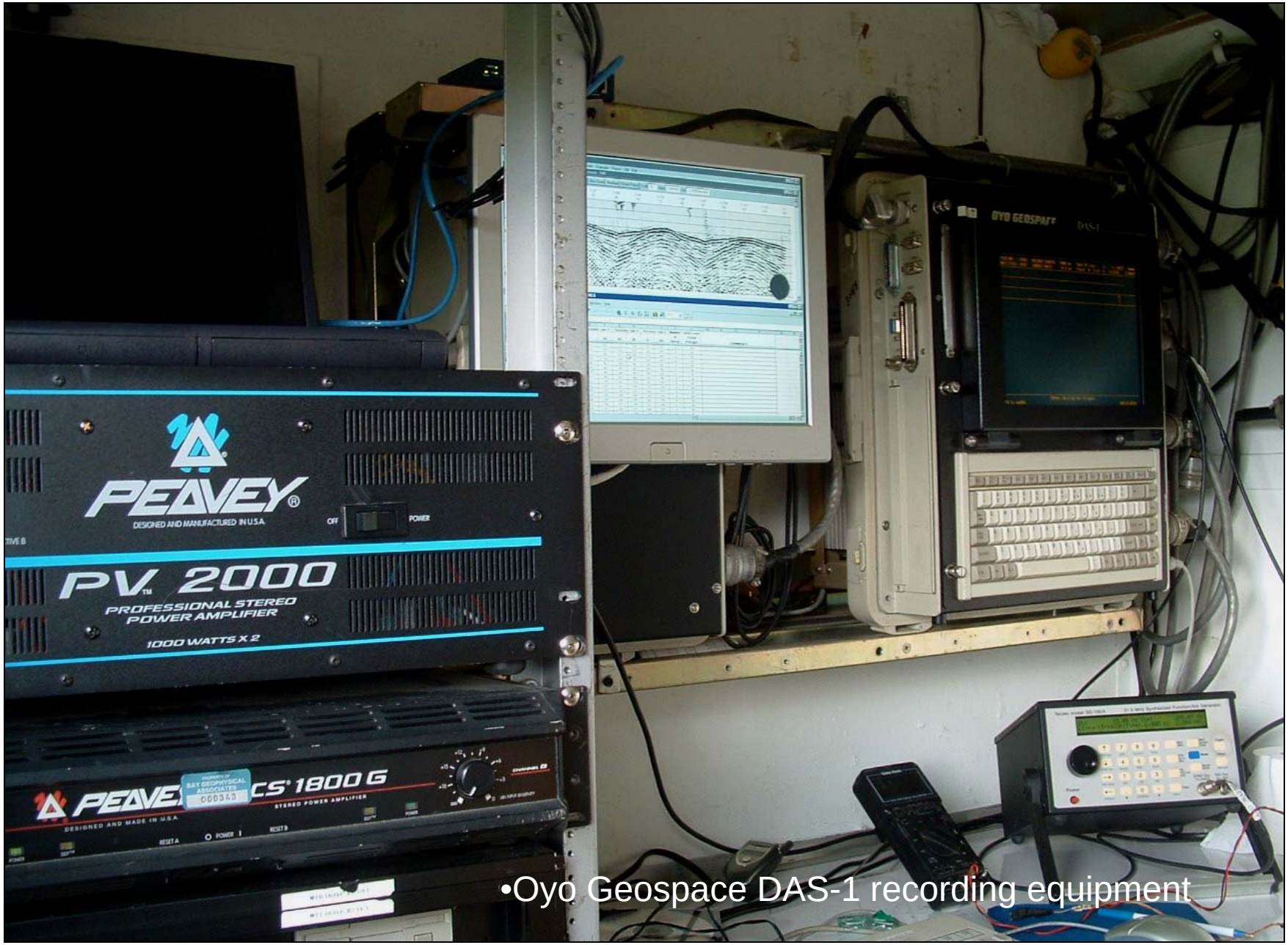



•6 receiver (geophones) lines, 1050’ long, 10’ geophone spacing along each line (105 geophones per line/630 total geophones), marked by Pink flags
•15 source lines, 1050’ long, 10’ source location spacing along each line (105 source locations per line/1575 total source locations), marked by Blue flags

•Close-up of Oyo Geospace 40 Hertz geophone, positioned vertically

- MicroVibrator source units setup along designated source location capable of generating shear (S) waves or primary (P) waves independent of one another
- Two source units were required to provide a stronger signal during shear (S) wave data acquisition


Jeep
TEXAS
C09-VXJ

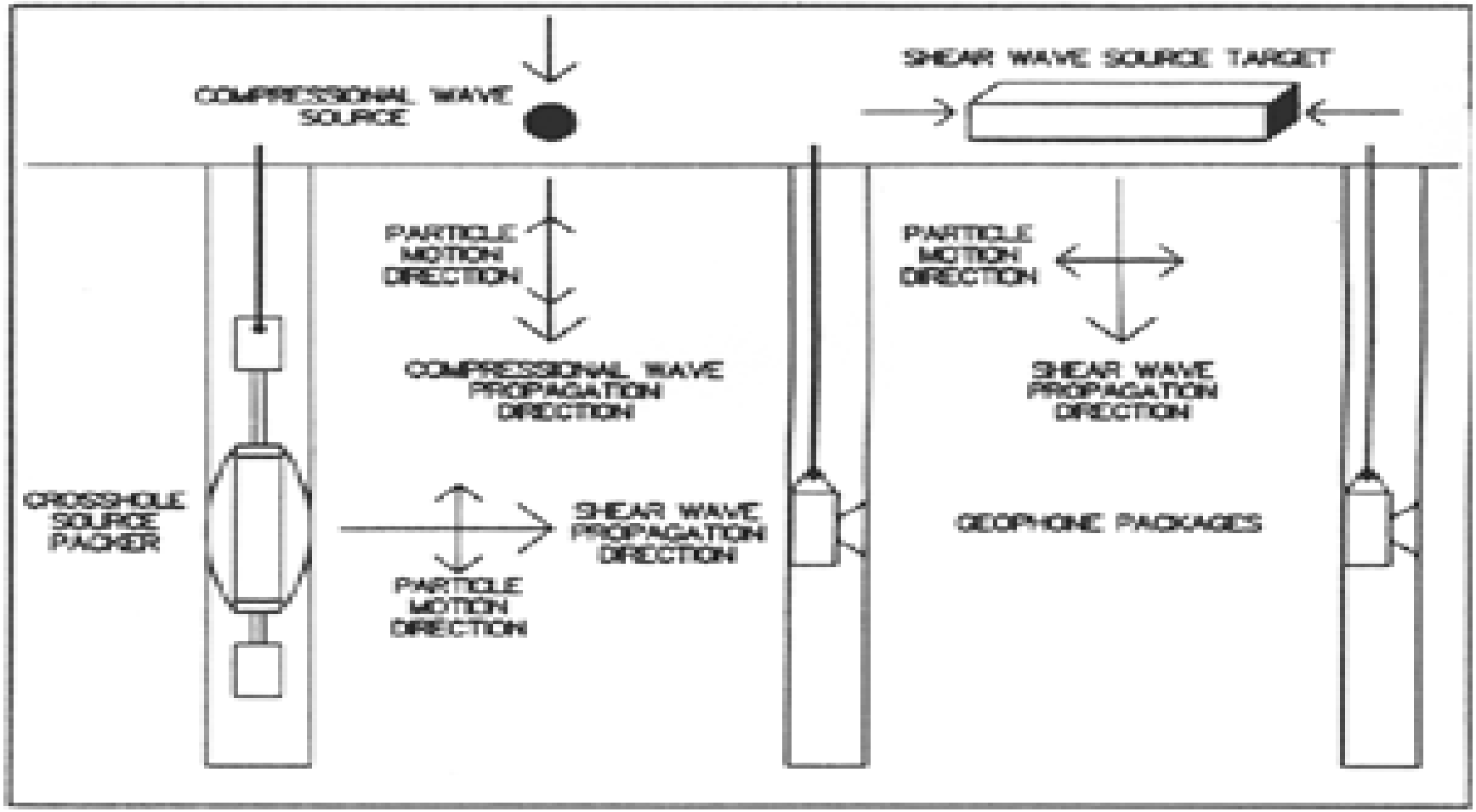


•Oyo Geospace DAS-1 recording equipment

Borehole Seismic Tomography Projects

- Blackhawk GeoServices
  - Black Beauty Coal Co., Riola Mine Complex
- Colorado School of Mines
  - Edgar Experimental Mine, Army Tunnel

Borehole Seismic Tomography

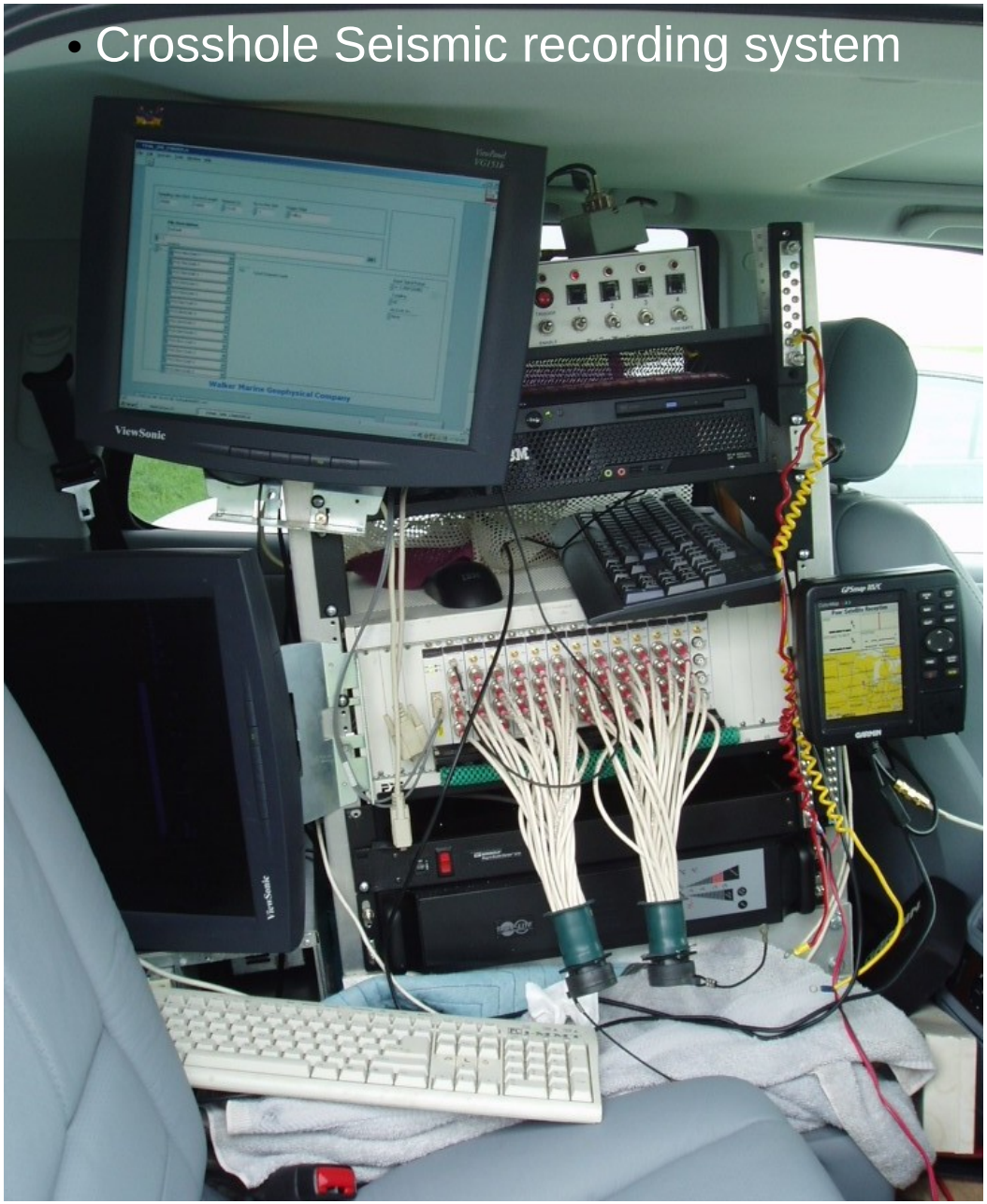


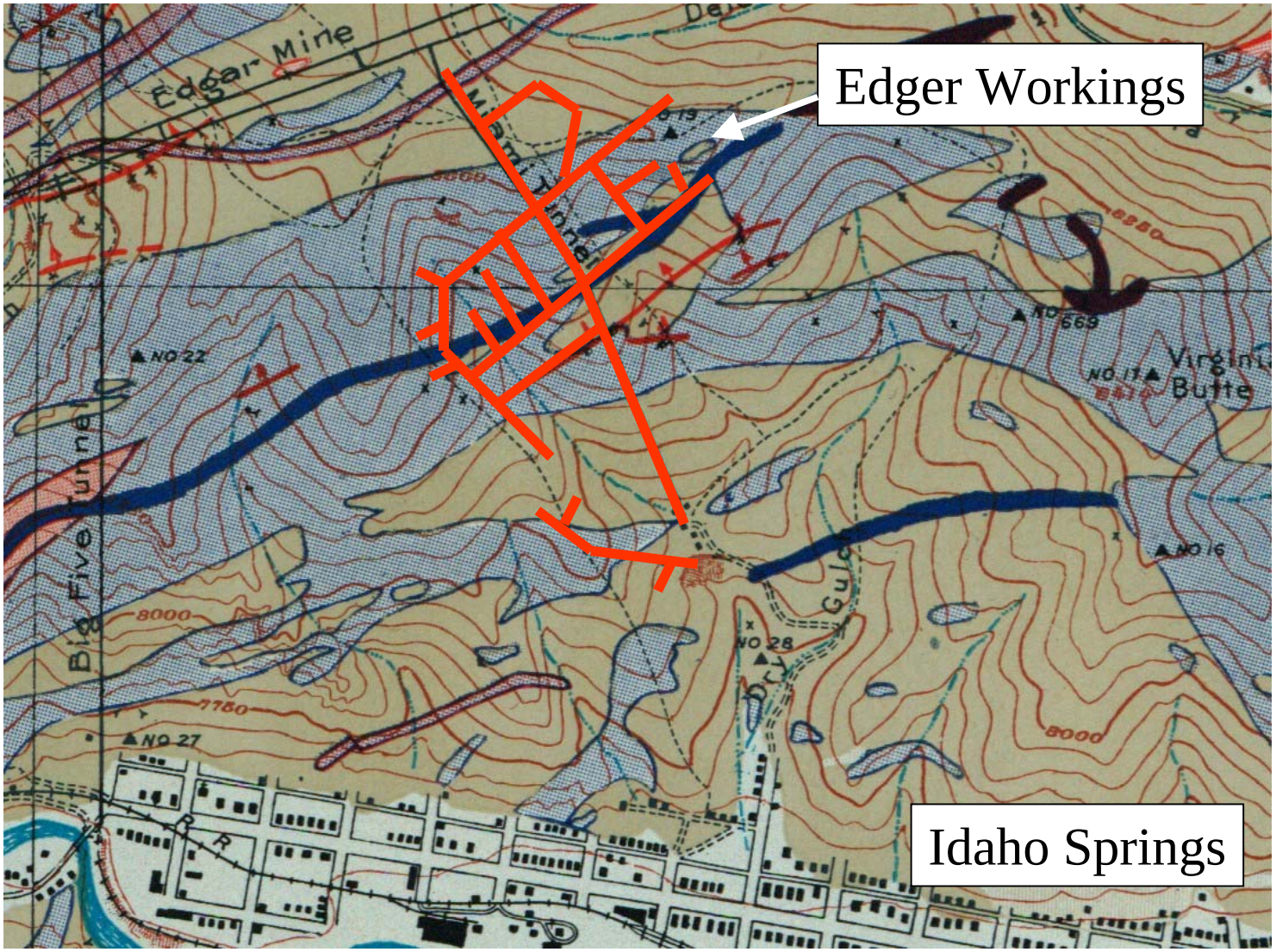

• Borehole XHT-NS#3
• 6-inch-diameter steel casing


Downhole source is a DHSS-5500 air gun, 2000 psi

- Full-waveform Sonic probe – measures velocity within rock strata

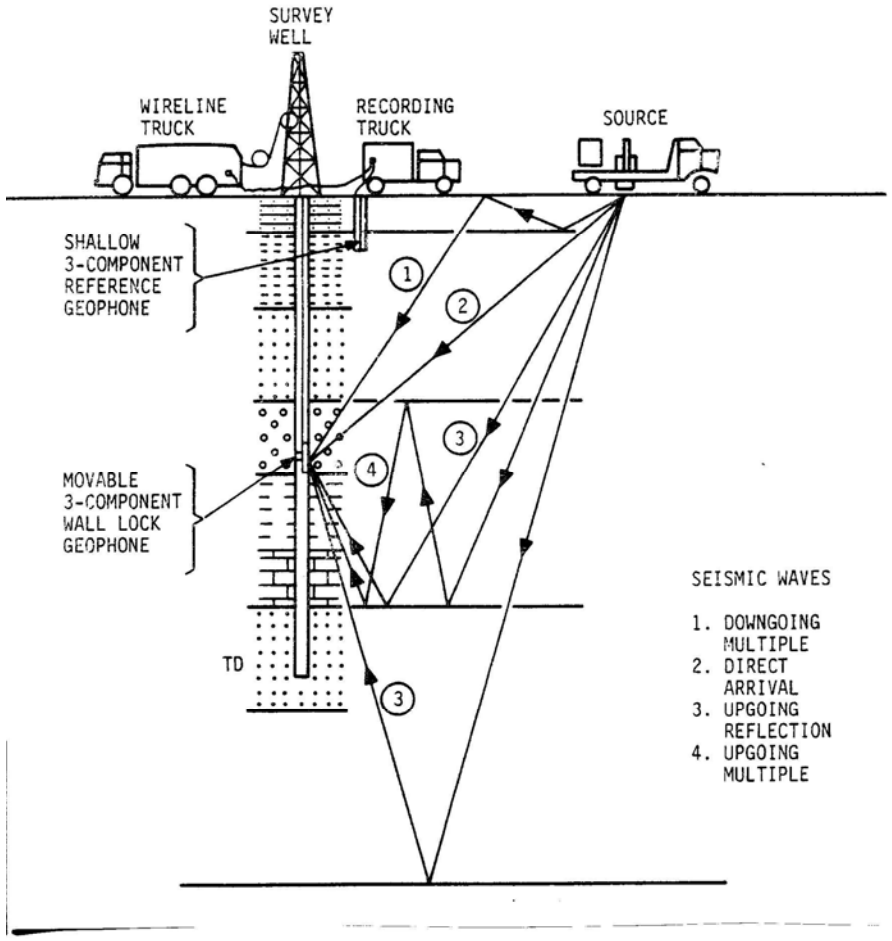
- Crosshole Seismic recording system





Edgar Mine is located in Idaho Springs, CO, about 30 miles west of Denver

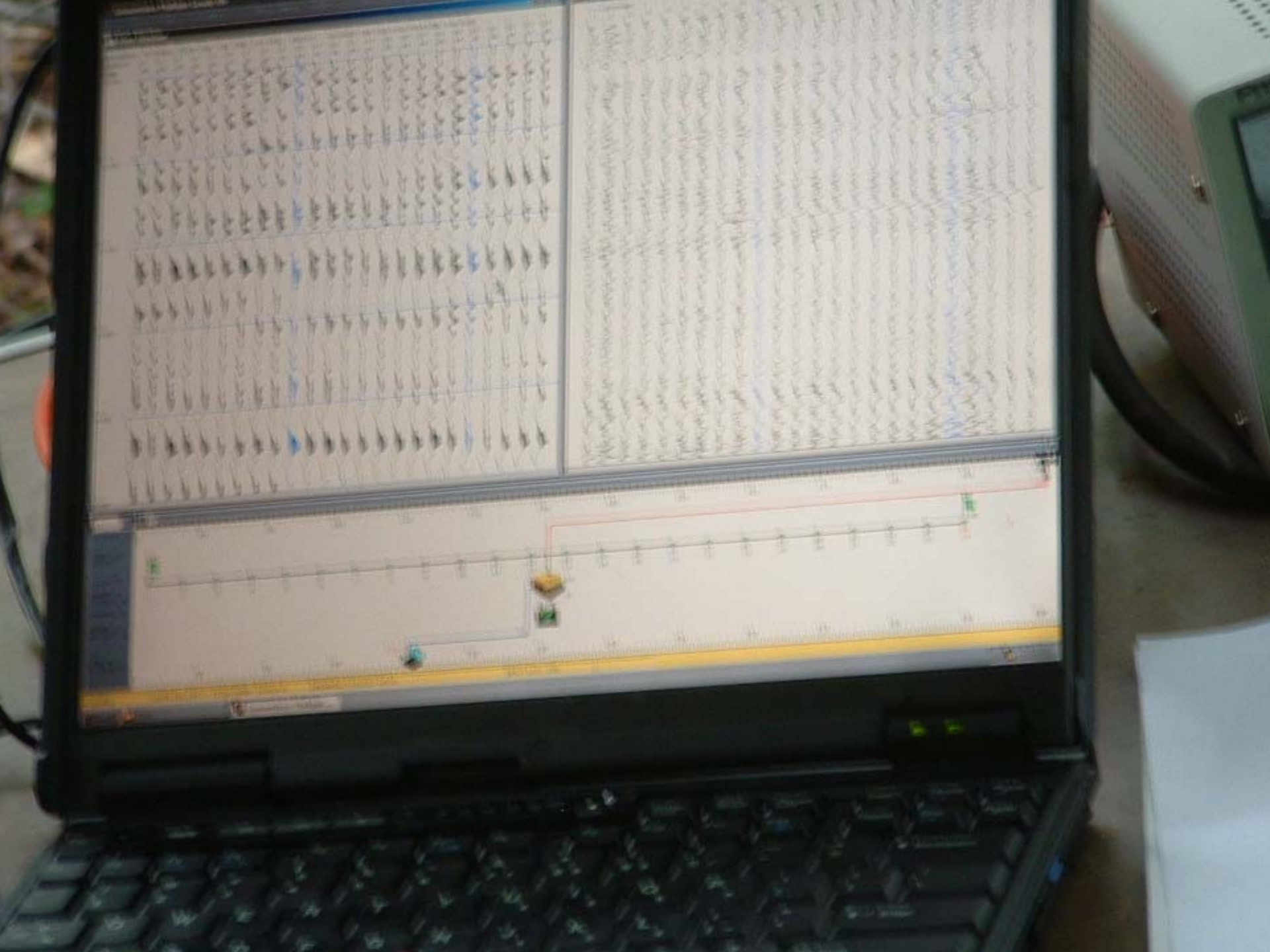
Vertical Seismic Profiling (VSP)



Vertical Seismic Profiling (VSP) Project

- L.M. Gochioco & Associates Inc.
  - Sterling Coal Corp., Carroll Hollow Mine

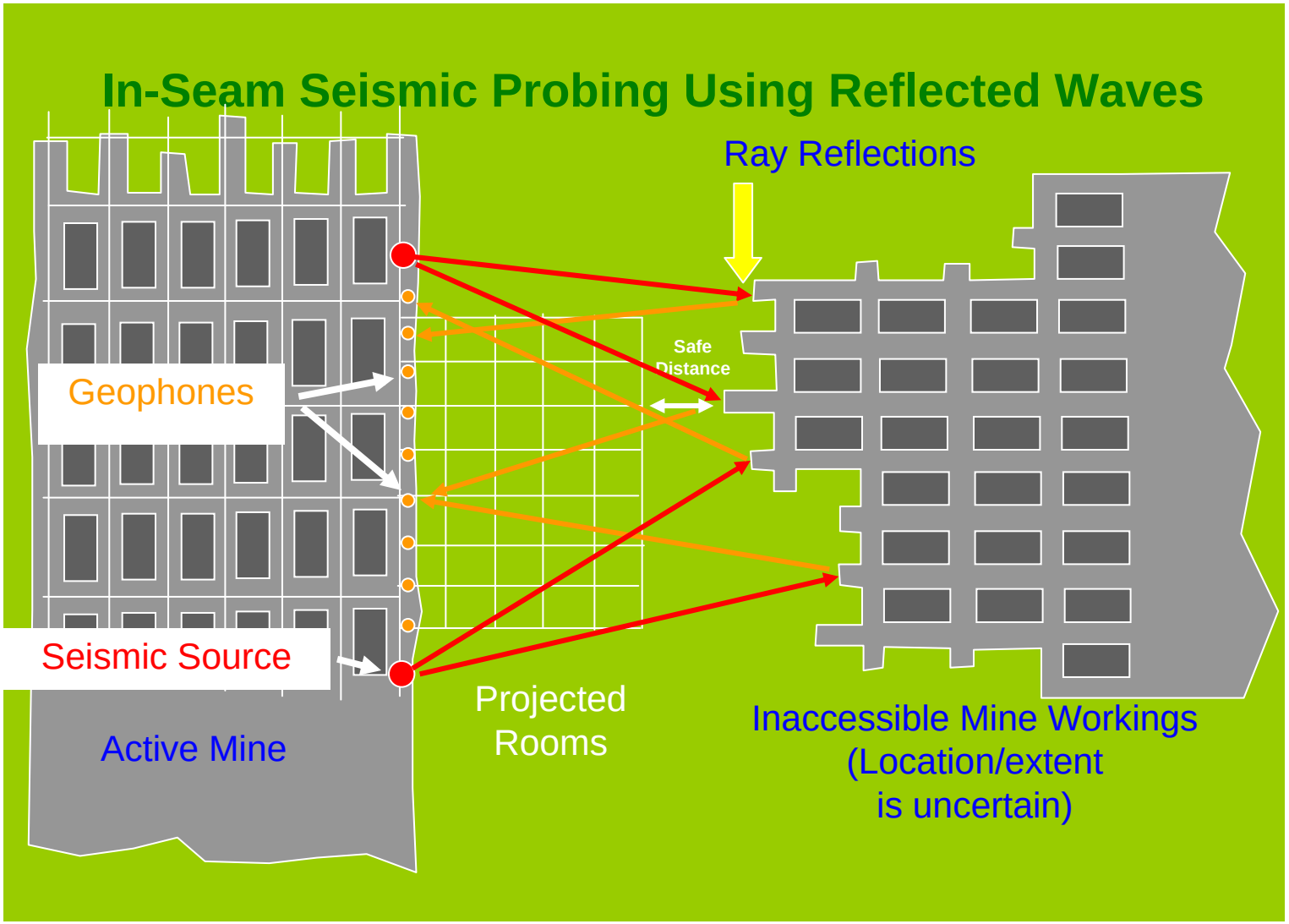

4X4



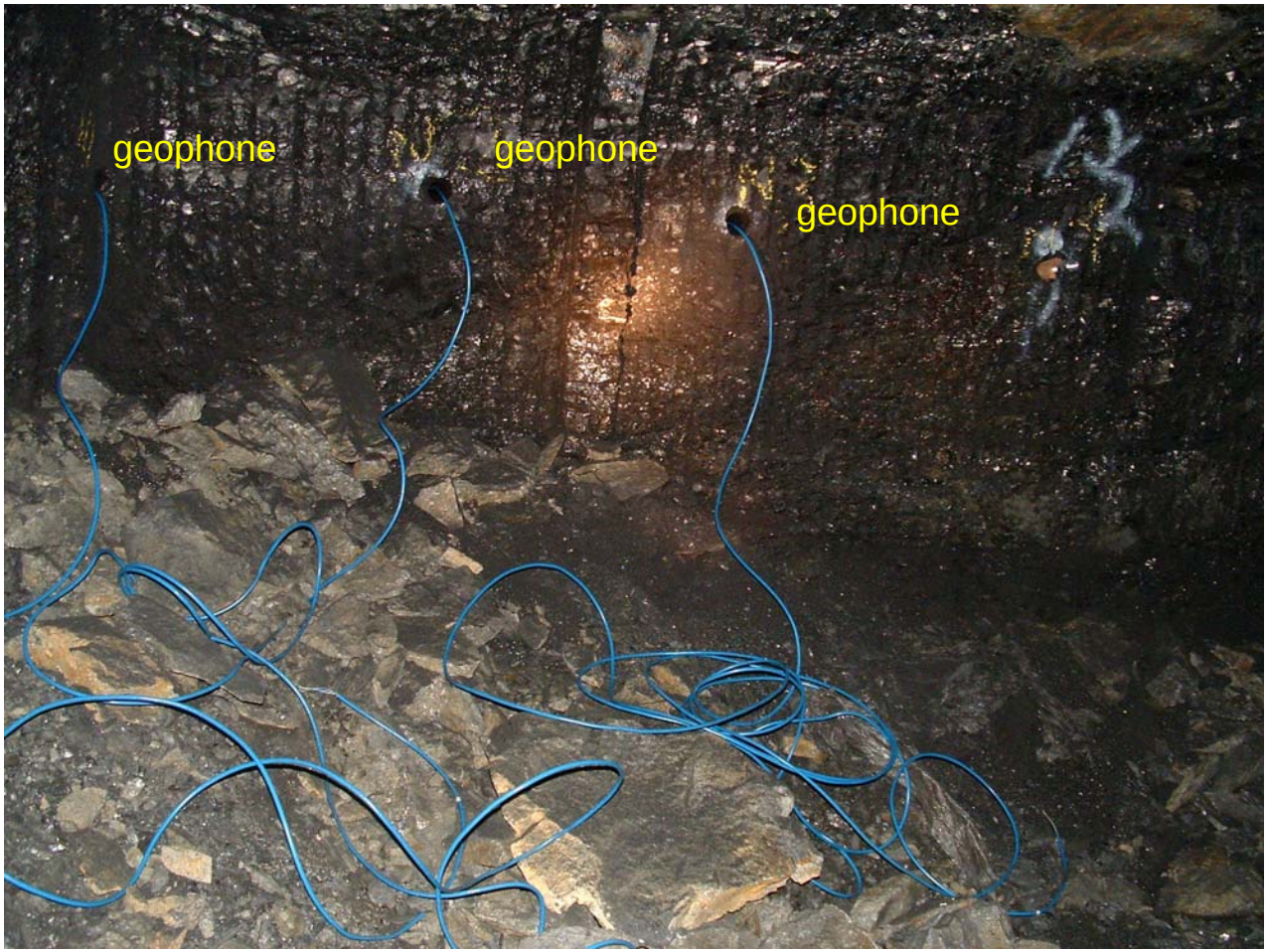
Inseam Seismic Reflection Projects

- Pennsylvania State University
  - Anthracite Coal Mine
  - Bituminous Coal Mine
  - Trona (Soda Ash) Mine
- L.M. Gochioco & Associates Inc.
  - Sterling Coal Corp., Carroll Hollow Mine
  - Paramount Coal Corp., Mine No. 4
- Mashall Miller Associates, Inc.
  - Sources and Receiver at Outcrop
- Wright State University
  - Continuous Miner vibration source, receivers on Surface

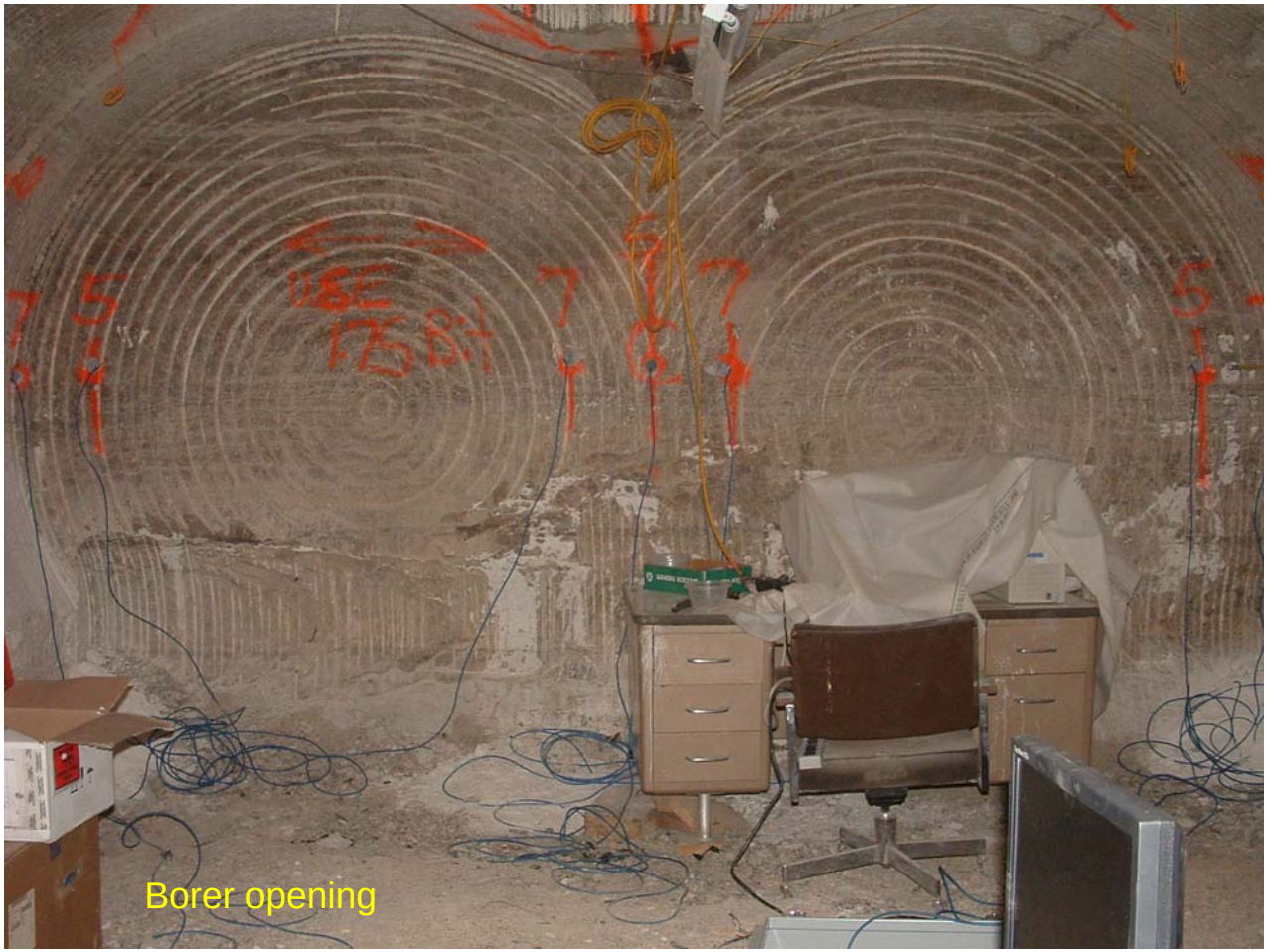
Inseam Seismic (ISS)



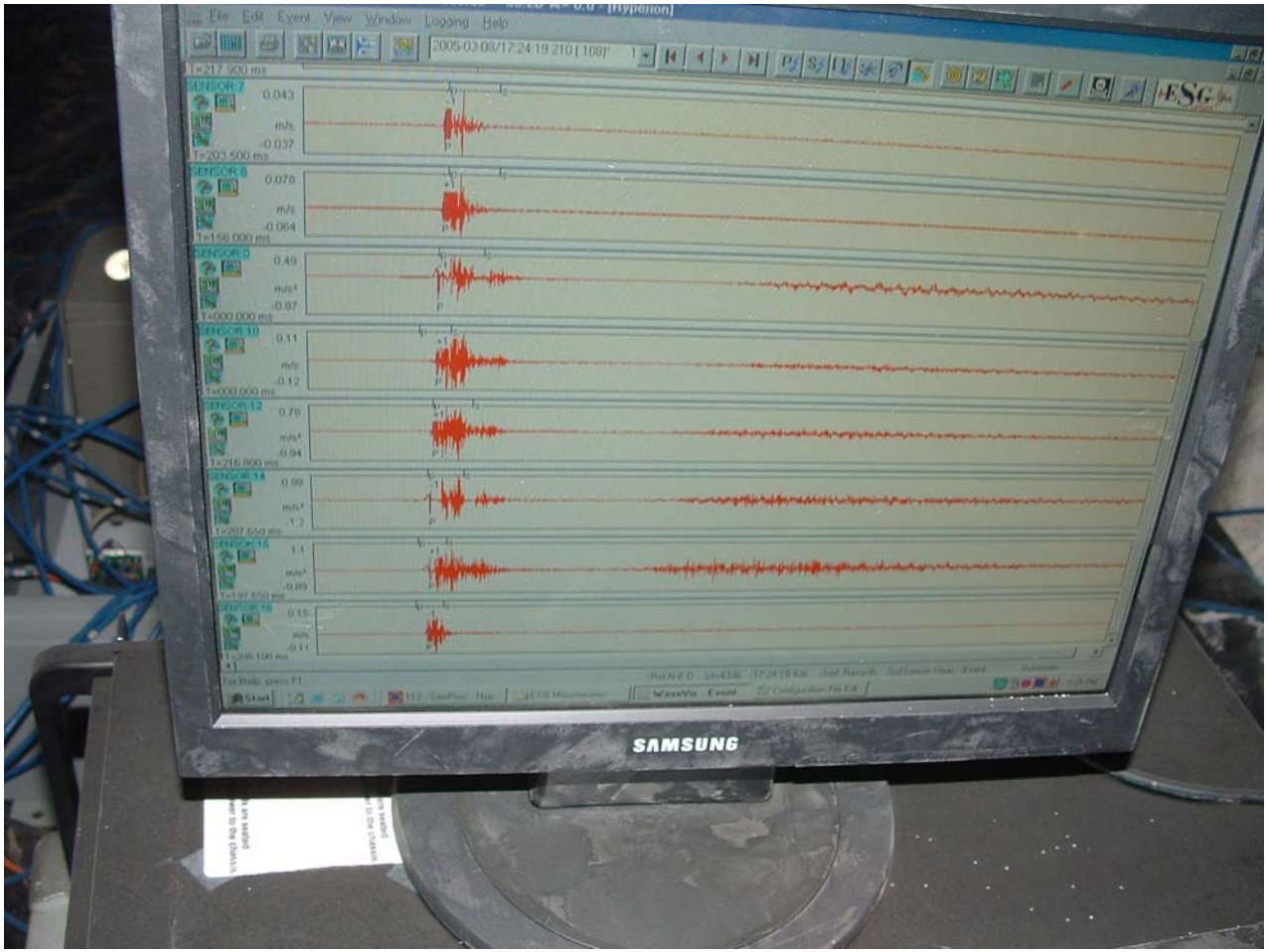
Installed Sensors in a Barrier



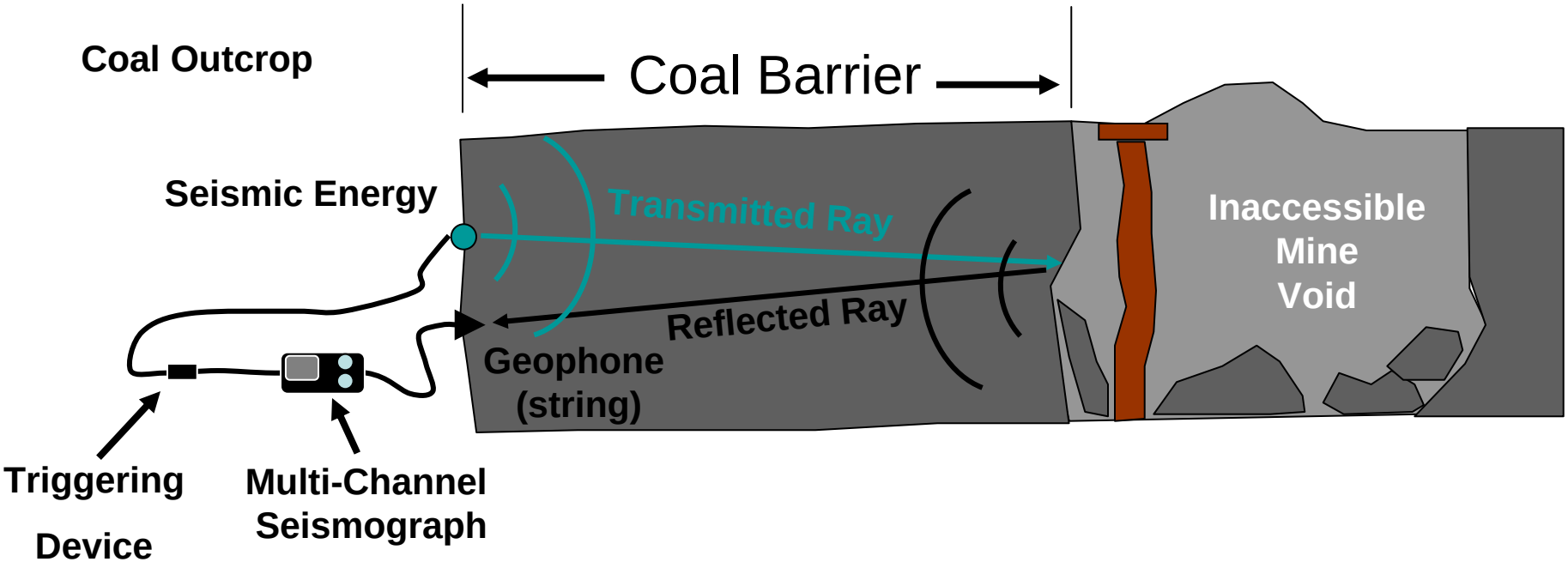
Trona Mine Sensors at Shop Area



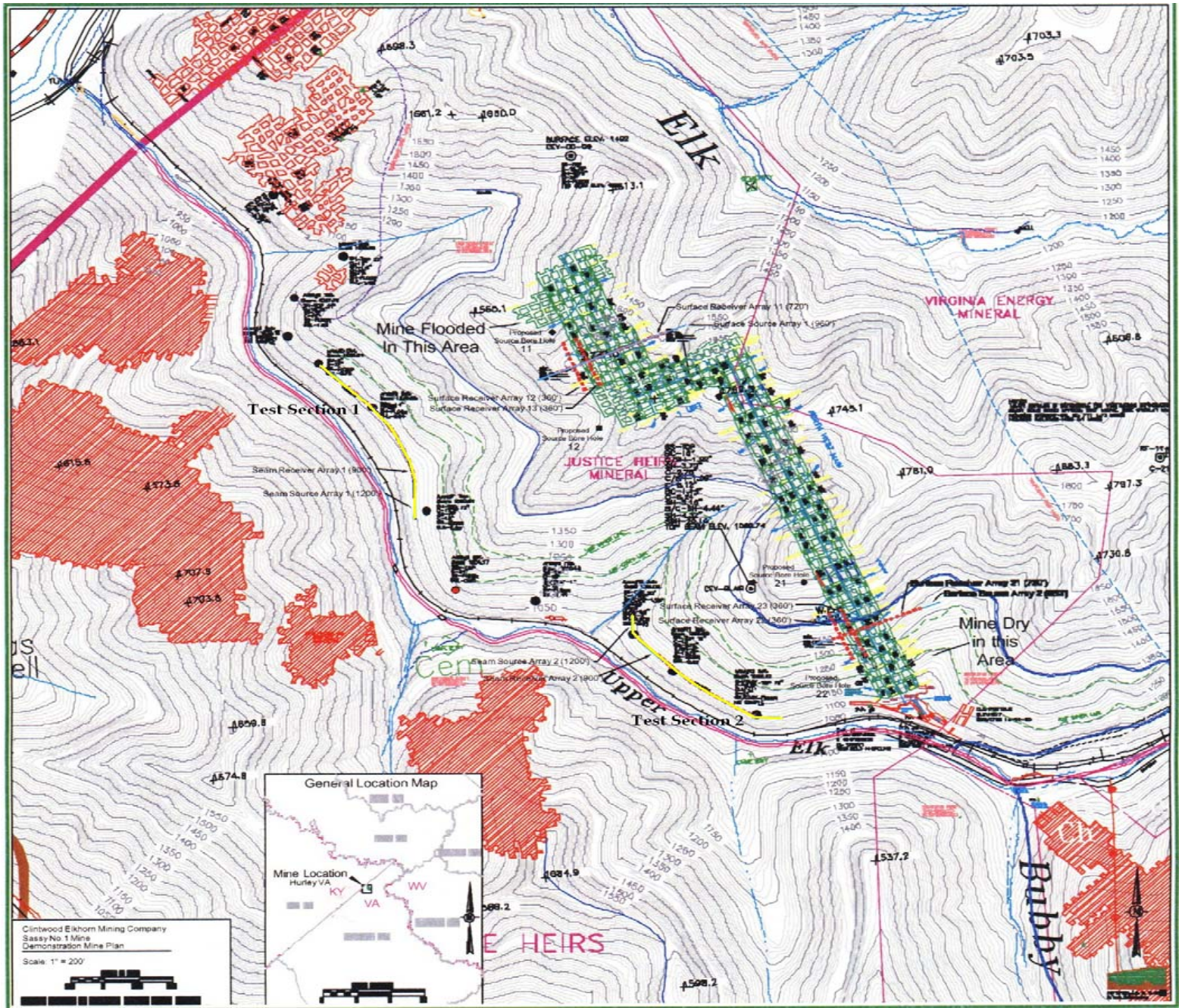
Reflection Test Wave Forms



In-seam Seismic Reflected Wave Principles



Plan View of Test Site



1) Pink line represents the data acquisition points for preliminary readings.

2) 60 vertically mounted geophones were placed along the end of the current production panel and the 160 feet to lower left.

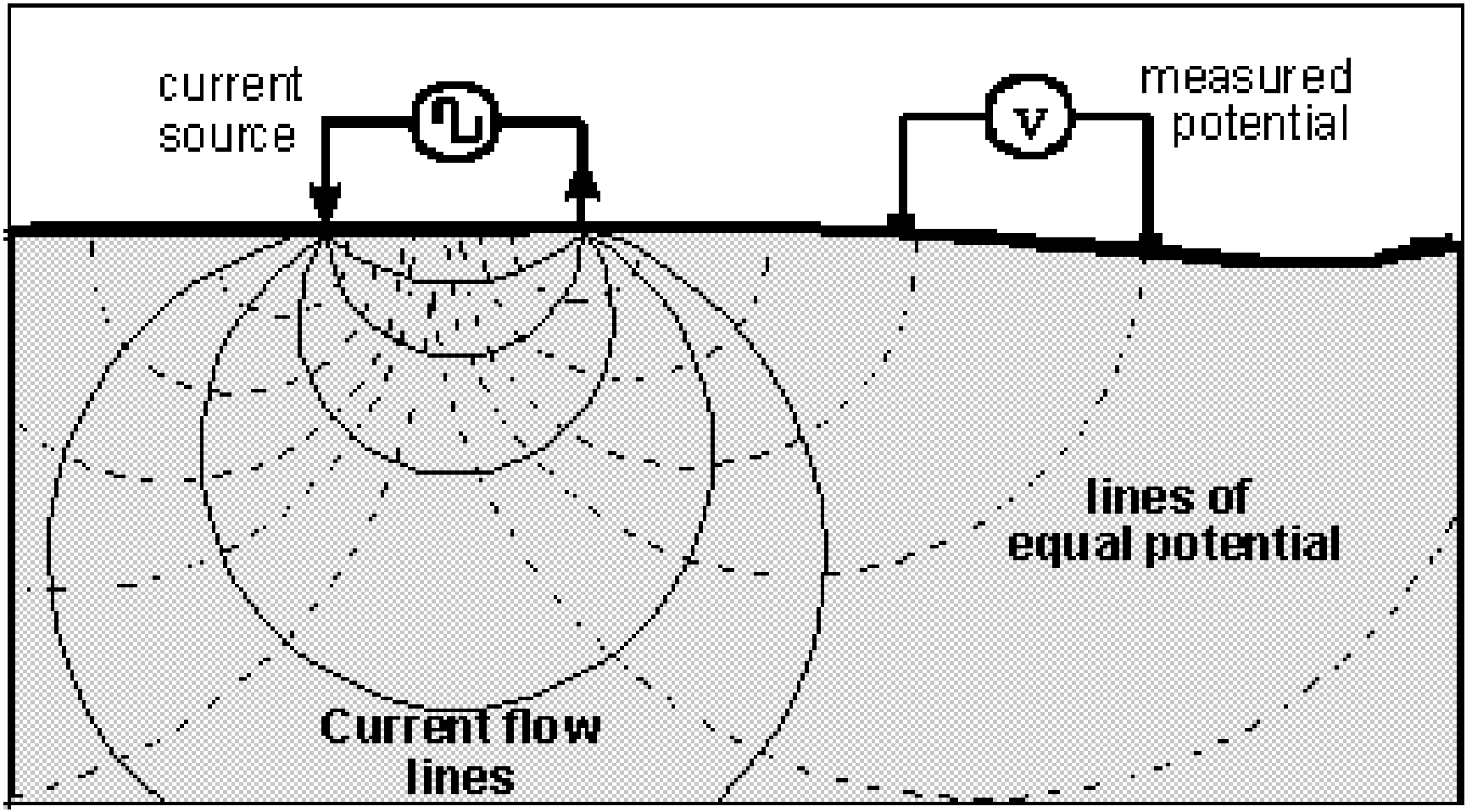
3) 120 phones, in 2 parallel lines 60 phones per line were placed perpendicular to panel. Crossing barrier pillar to abandoned Bunsen mine. (60 vertical, 42 horizontal, 6 individual 3 component settings)

These are the geophones placed perpendicular to current mining. Crossing the anticipated barrier to the abandoned Bunsen mine. Flags represent the location of 60 vertically mounted geophones. Just to the right of the flags (you can see the cables and the first 3-component set-up) are the horizontally mounted and the 3-component geophones.
(Nov 23, 2004)

Close-up view of the 3 component system.
Notice the orientation of the orange spring housings.
(Nov 23, 2004)

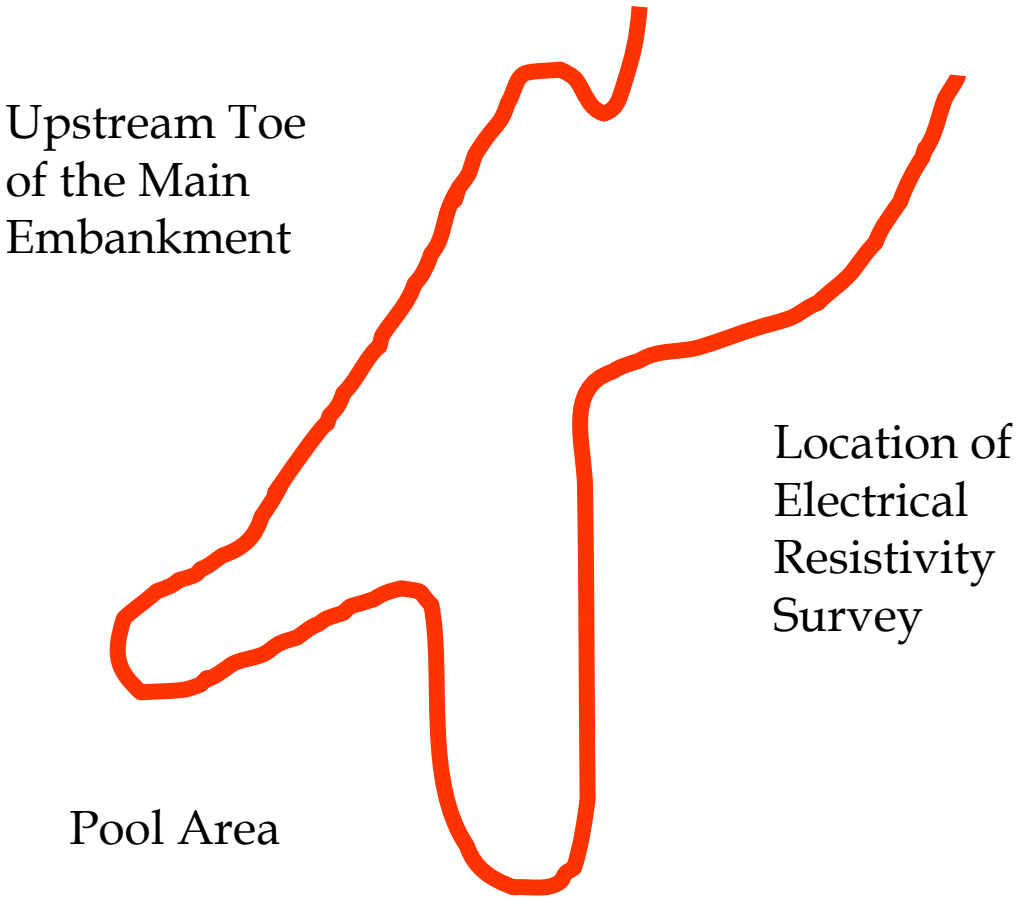
Dr. Hauser during data acquisition. (Nov 23, 2004)

Electrical Resistivity



Electrical Resistivity Project

- D’Appolonia Engineering Division of Ground Technology Incorporated
  - Pine Ridge Coal Company, Lot’s Branch Impoundment


Upstream Toe
of the Main
Embankment
Location of
Electrical
Resistivity
Survey
Pool Area

How Electrical Resistivity Exploration Works

- An electrical current is injected into the ground through two current electrodes and the resulting voltage measured at two potential electrodes.
- The difference between the current and voltage values provide the resistivity of the subsurface material.
- Since resistivity is an intrinsic physical property, the subsurface material is identified by comparing its resistivity to that of know materials.
- The process is repeated along survey lines laid out in parallel or in series to obtain a subsurface profile.
- This technique is generally effective to depths of 50 to 100 feet.

Electromagnetic and Radar Methods

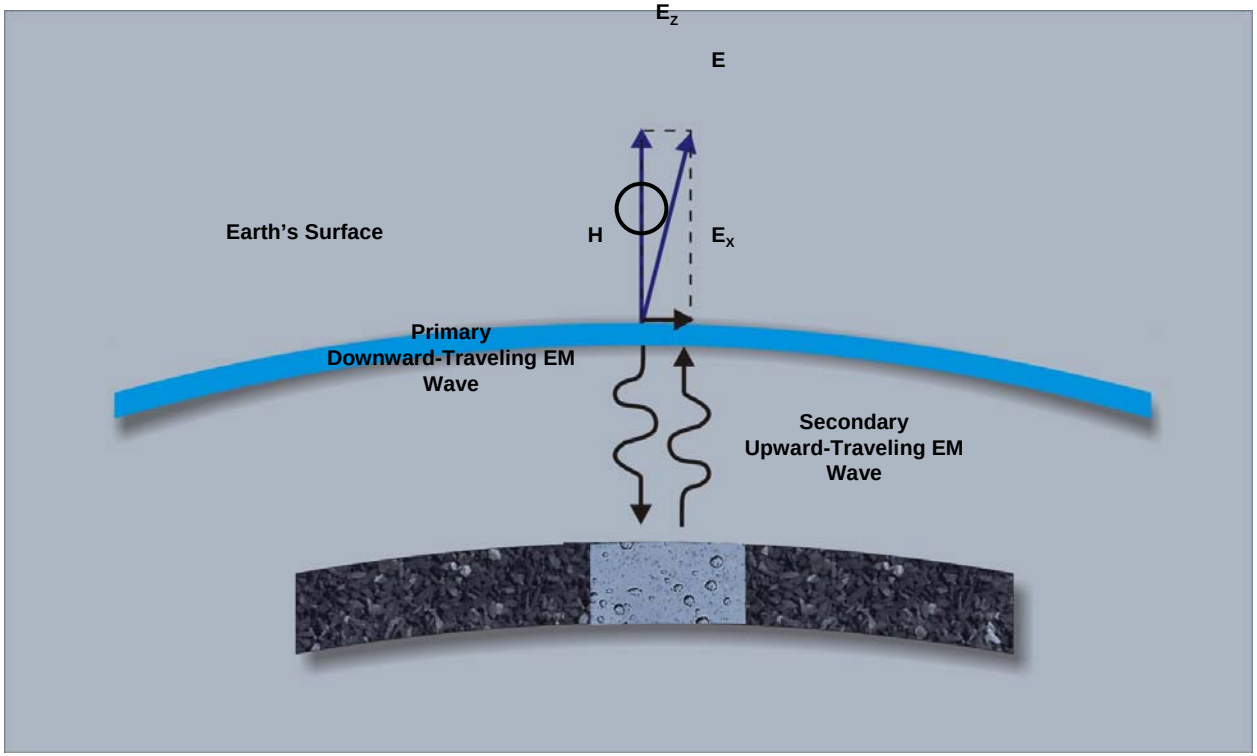


Figure 6-3. *Traveling electric field components illustrate the tilt in the vertical electric field component*

When the downward-traveling

Electromagnetic and Radar Projects

- D'Appolonia Engineering Division of Ground Technology Incorporated
  - Pine Ridge Coal Company, Lot's Branch Impoundment
- Stolar Research Corporation – EM Gradiometer
  - Consolidation Coal Company, Emery Mine
- Colorado School of Mines – Borehole Radar Tomography
  - Edgar Experimental Mine

Upstream Toe
of the Main
Embankment

Location of
First Trial
Run of EM
exploration

Pool Area

How Time Domain Electromagnetic (TDEM) Exploration Works

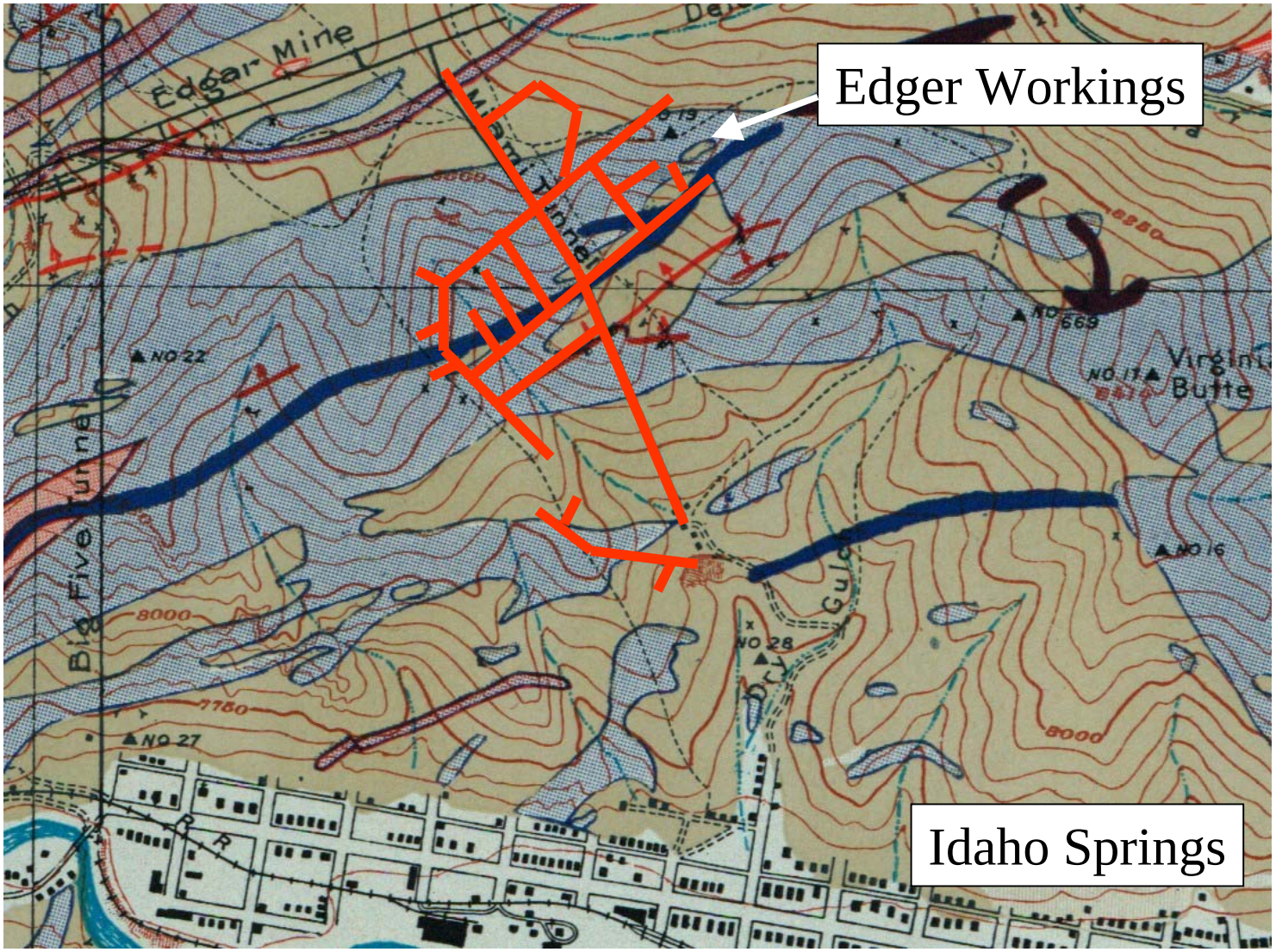
- A transmitter induces an alternating current into the ground at equal time intervals.
- Secondary EM fields are created in the ground when the transmitter is switched off.
- Measurements of the secondary EM fields are used to map variations in the subsurface electrical resistivities.
- D’Appolonia indicates that TDEM may be preferable over Frequency Domain Electromagnetics (FDEM) where overburden thickness exceeds 50 meters.

Pulling the mobile transmitter parallel to the receiver survey line.

Gradiometer receiver at first survey area. Depth of cover over the entries is approximately 80 to 100 Feet.

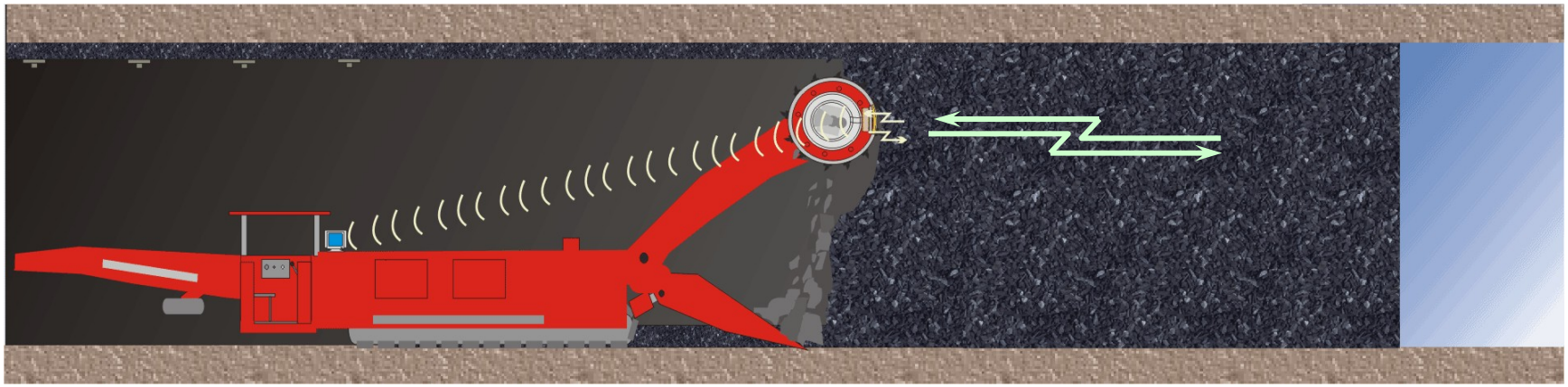
Colorado School of Mines - Borehole Radar

- Measures electromagnetic wave propagation through various ray paths and relates attenuation and phase shift to geologic anomalies
- Can be used as a tomographic method



Edgar Mine is located in Idaho Springs, CO, about 30 miles west of Denver

Look-Ahead Radar



Look-Ahead Radar Project

- Stolar Research Corporation – Handheld Device
  - Consolidation Coal Company


U.S. Department of Labor
MSHA
Mine Safety & Health Administration