HIGH RESOLUTION 3D SEISMIC REFLECTION SURVEYS TO CHARACTERIZE AND PLAN REMEDIATION AT HAZARDOUS WASTE SITES

(805) 982-1005

PROBLEM

DNAPL Contamination Sites:

- **Detection of subaqueous, free phase DNAPL is difficult.**

  - limited to extrapolation of soil gas survey results & coincidental soil sampling

- **Cleanup methods consist of long-term treatment of dissolved phase DNAPLs.**

  (i.e. treating the symptom, not the problem)

  - typically a costly and relatively ineffective effort

3D SEISMIC TECHNIQUE

- **Determine local stratigraphy:**
  - **develop basic model from background research**
  - **interpret seismic profiles**

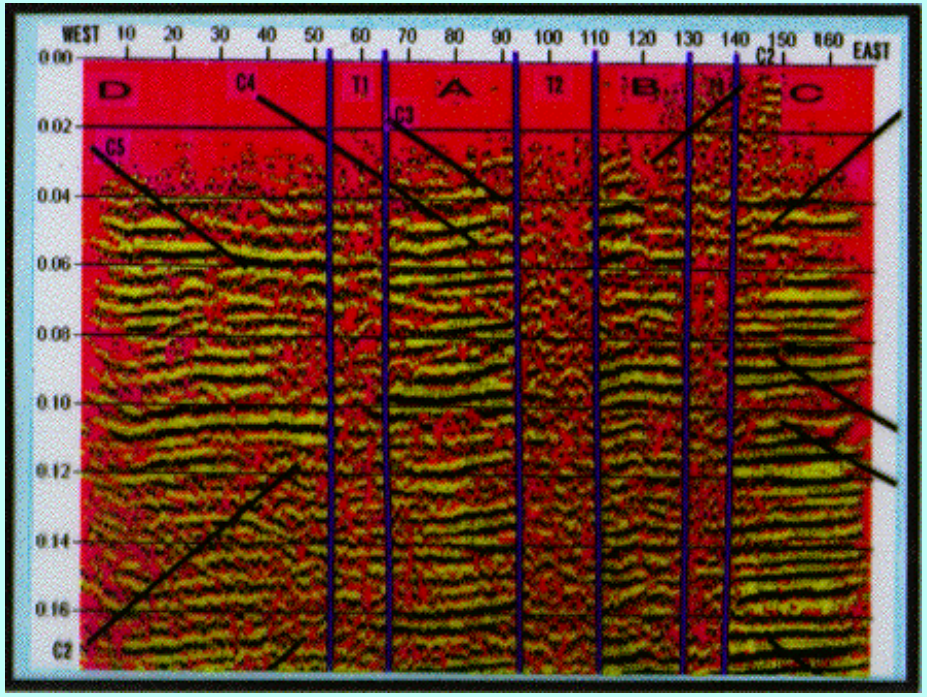
- **Detect DNAPL:**
  additional analysis of signal attributes:
  - **amplitude**
  - **frequency**
  - **phase**

DATA COLLECTION

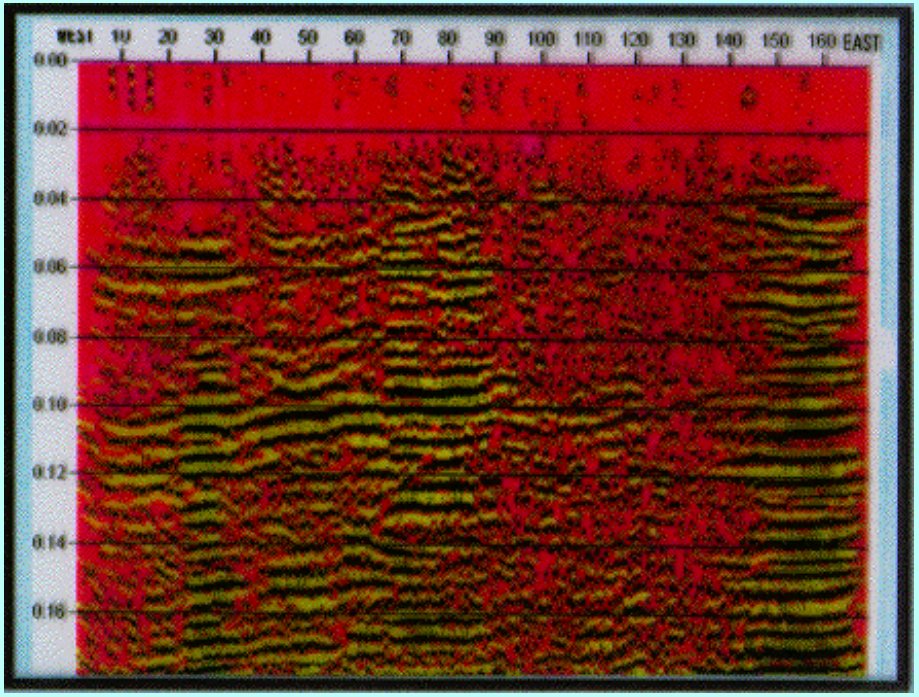
SEISMIC SOURCE

SEISMOGRAPHS & GEOPHONES

SEISMIC PROFILES DISPLAYING AMPLITUDE (NAS NORTH ISLAND SITE)



INTERPRETED FRACTURES



PROFILE AT CONTAMINATED AREA

PROJECT DESCRIPTION:

DEMONSTRATION/VALIDATION OF 3D SEISMIC SURVEYS

- **Perform 3D seismic surveys at four DoD installations that have differing geology and DNAPL contamination.**
- **Verify these survey results by comparing to conventional site characterization methods**
- **Document the capabilities and cost effectiveness of this technology.**
- **Transfer this information to project managers responsible for site clean-ups.**

DEMONSTRATION SITES

- NAS Alameda, CA - saturated sediment
- Tinker AFB, OK - interbedded sand and shale
- Letterkenny Army Depot, PA - Karst (limestone)
- Allegany Ballistic Lab, WV - deformed, fractured bedrock

PROGRESS

- **Contract delivery order awarded to Battelle/RRI in June 1996**

Task	Allegany	Alameda	Letterkenny	Tinker
3D survey:	**Mar 96***	**Oct 96**	**Nov 96**	**Feb 97**
Verify:	*May 97*	*Apr 97*	*Jun 97*	*July 97*
Report:	*Jul 97*	*Jun 97*	*Aug 97*	*Sep 97*

EXPECTED BENEFITS

- Install fewer wells
- Optimize location of wells
- Improve design of remediation systems
- Reduce chance of spreading contaminants
- Better define complex geology
- Monitor cleanup effectiveness
- Support intrinsic bioremediation studies

USERS

- Personnel responsible for characterizing a site or designing a monitoring/remediation system
  - Remediation Project Managers (RPMs)
  - Cleanup contractors

BARRIERS

- Demonstrating technical feasibility
- Regulatory acceptance
- Greater upfront costs
- Limits drilling revenues

FUNDING SOURCE

- **Demonstration project:**

  ESTCP - DoD agency sponsoring demonstration & validation of innovative technologies

- **Future work:**

  BRAC, DERA, NAVFAC, base funds

TRANSITION PLAN

- Identify users

- Develop technology transfer tools
  - technology data sheet
  - generic SOW & cost estimate
  - promotional video
  - internet home page
  - newsletter articles & conference papers

- Coordinate with various environmental agencies:

  EFA, EFD, ARTT; AFCEE, AL/EQW; AEC, HTRW-CX; EPA/DoD/DOE Roundtable; ITRC Work Group; CMECC, NERL (EMSL)

JOINTNESS

Demonstrations being performed at Navy, Air Force, and Army facilities:

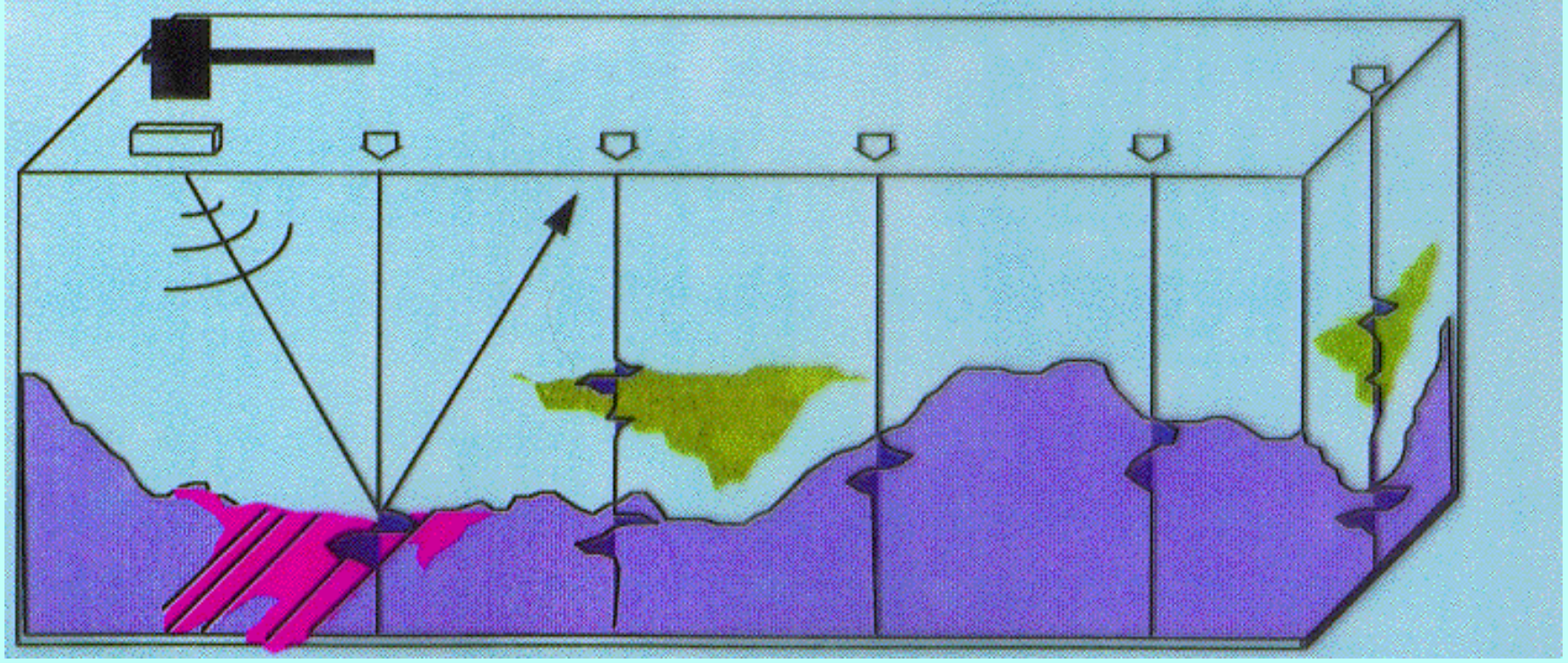
- **Naval Air Station Alameda, CA**
- **Letterkenny Army Depot, PA**
- **Tinker Air Force Base, OK**
- **Allegany Ballistic Lab, WV**

ISSUES

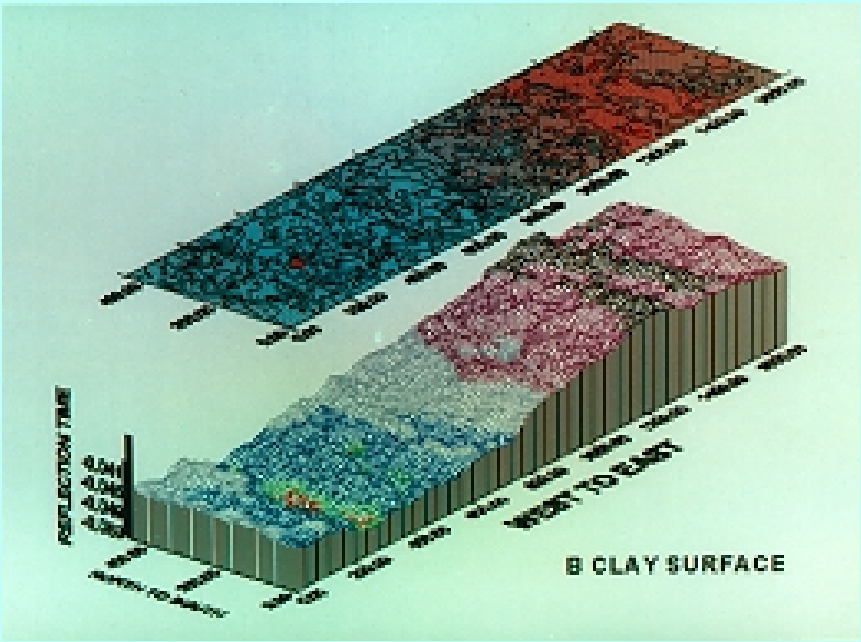
- Finding DNAPL free-product at the sites
- Demonstrating the capability of this technique to directly detect DNAPLs

BASIC PRINCIPLE

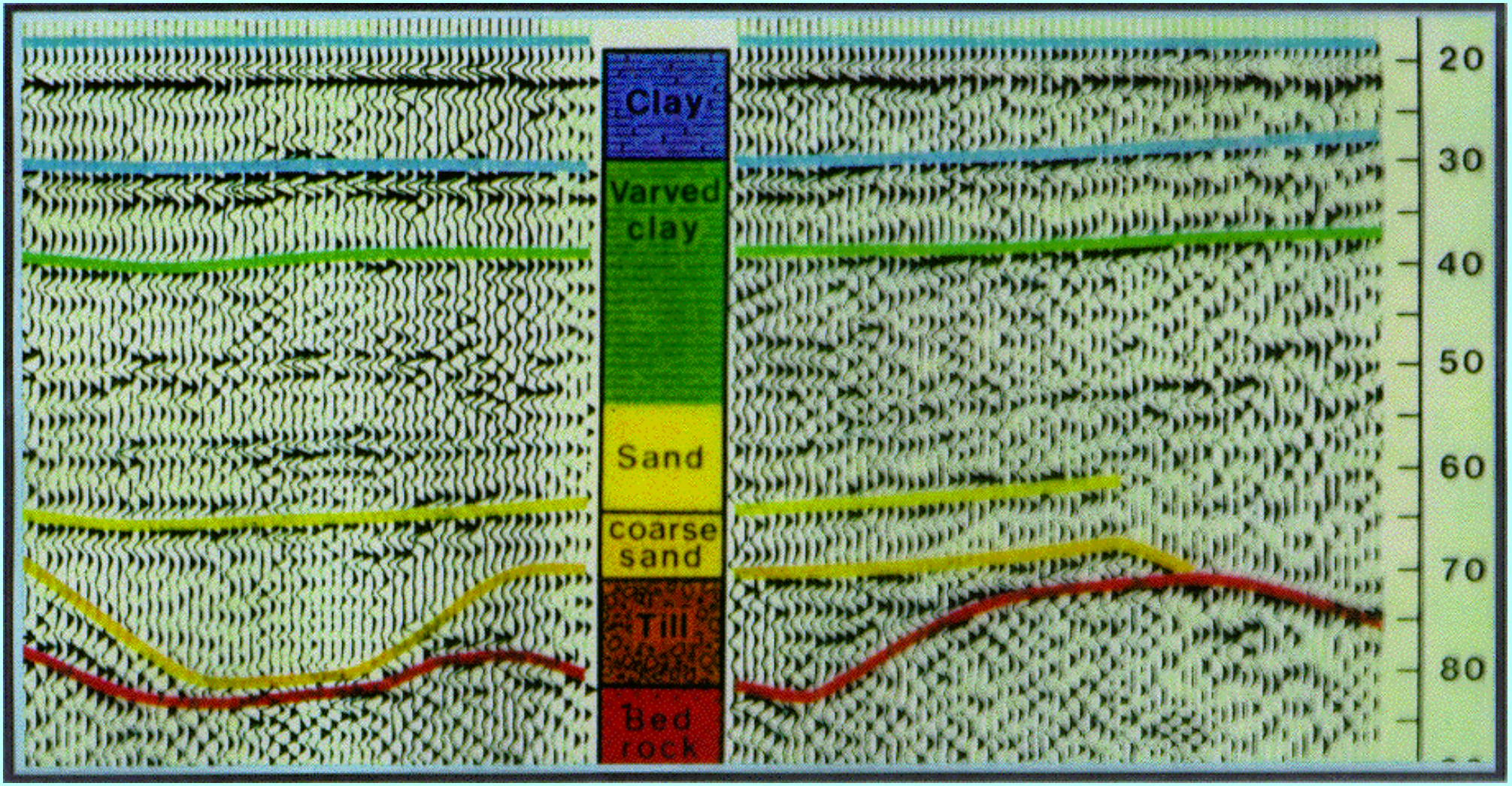
- SOUND IS REFLECTED OFF EARTH LAYERS
- REFLECTIONS ARE DIGITIZED
- DIGITIZED SIGNALS ARE PROCESSED
- TRUE 3D IMAGE IS CREATED



3D DATA DISPLAY: STRATIGRAPHIC LAYER



INTERPRETED SEISMIC SECTION WITH BORING LOG



3D ELECTRO-MAGNETIC RESISTIVITY SURVEYS FOR HIGH RESOLUTION IMAGING OF SUBSURFACE CONTAMINATION

(805) 982-1005

PROBLEM

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  (i.e. treating the symptom, not the problem)

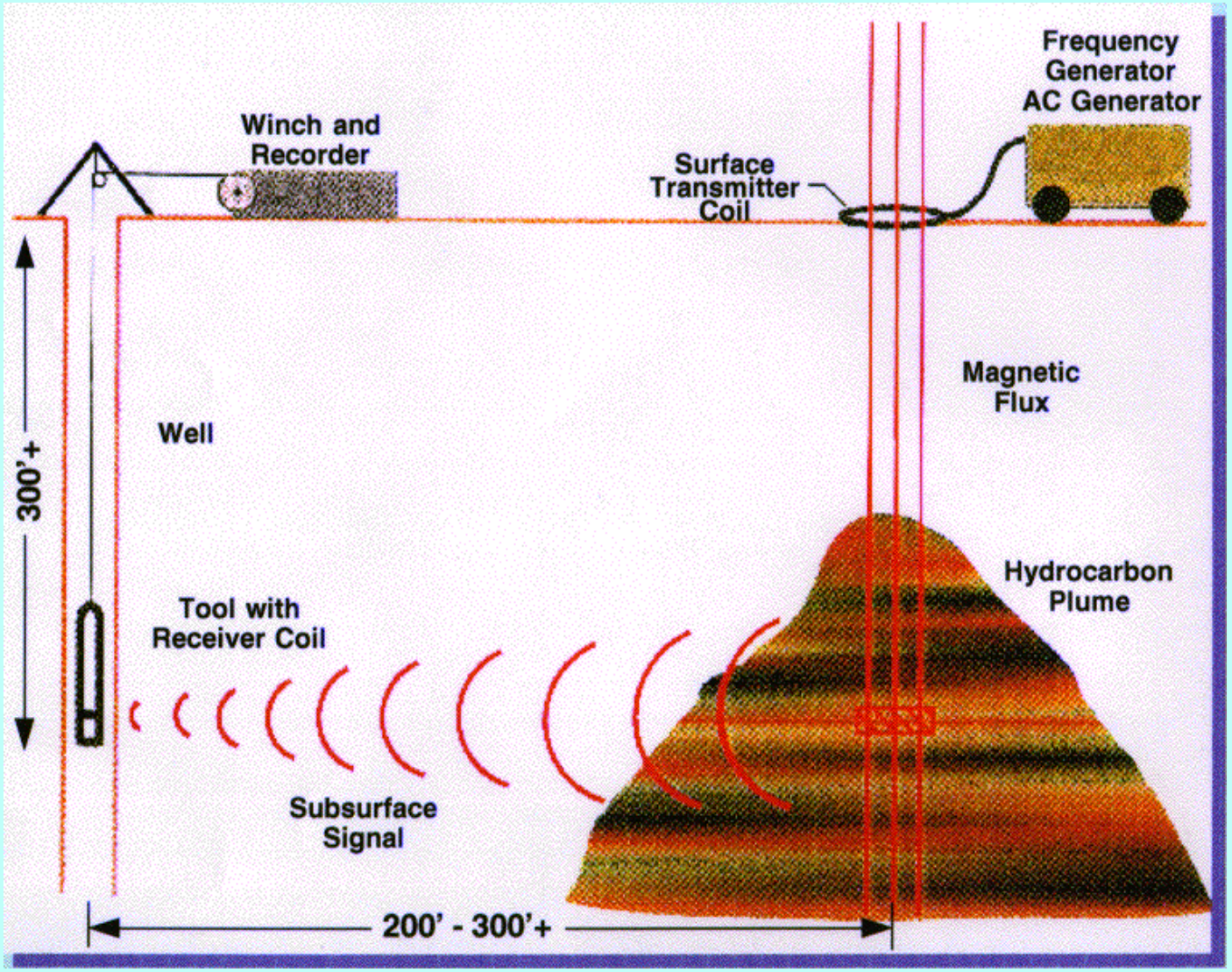
  - typically a costly and relatively ineffective effort

3D ELECTROMAGNETIC TECHNIQUE

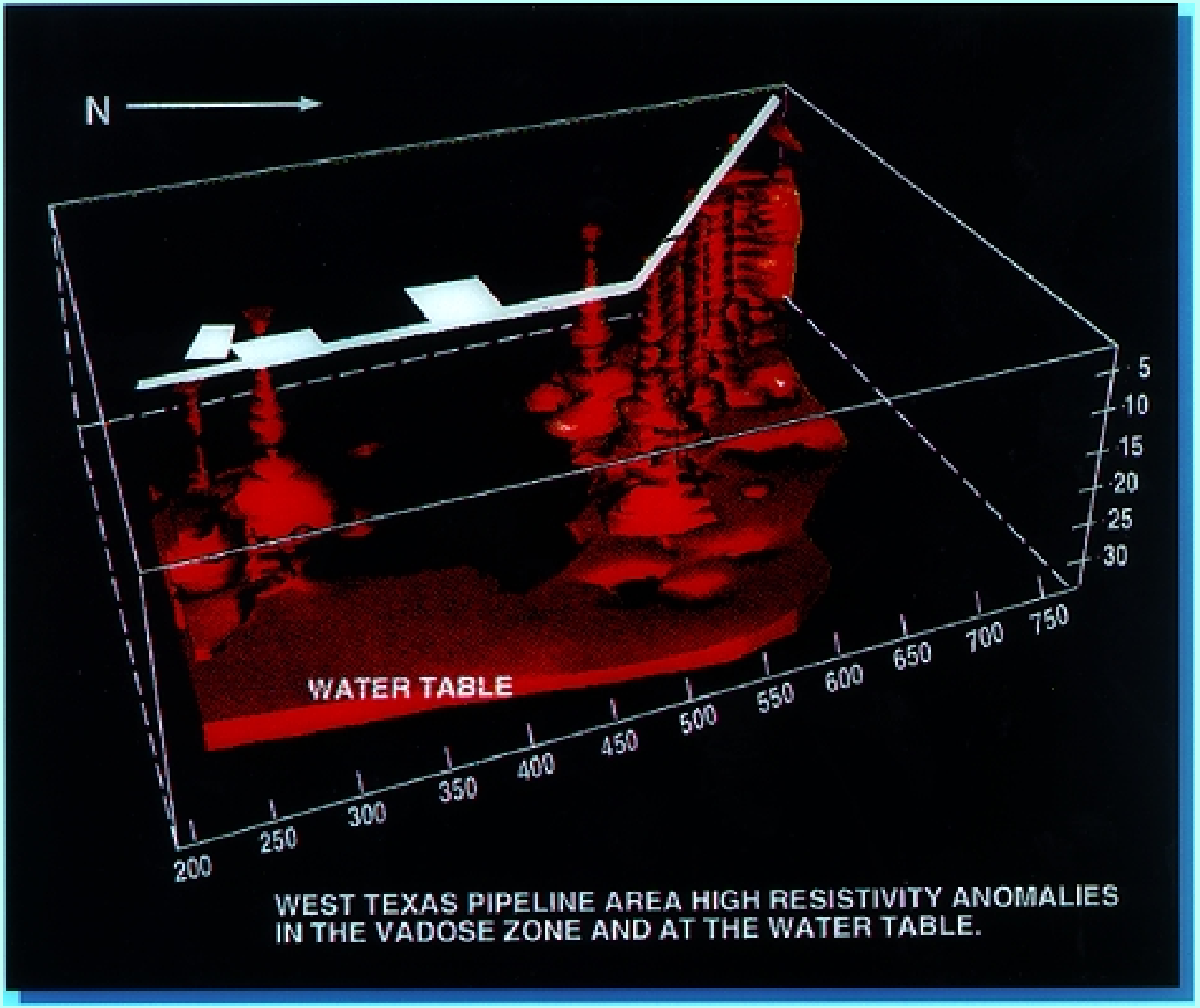
- **Determine local stratigraphy:**
  - **Develop basic model from background research**
  - **Interpret zones of varying resistivity**

- **Detect DNAPL:**
  - **Identify high-resistivity anomalies which represent the presence of contamination**

DATA COLLECTION



DATA DISPLAY



WEST TEXAS PIPELINE AREA HIGH RESISTIVITY ANOMALIES IN THE VADOSE ZONE AND AT THE WATER TABLE.

PROJECT DESCRIPTION

DEMONSTRATION/VALIDATION OF 3D EM SURVEYS

- **Perform 3D EM surveys at four DoD installations that have differing geology and DNAPL contamination.**
- **Verify these survey results by comparing to conventional site characterization methods**
- **Document the capabilities and cost effectiveness of this technology.**
- **Transfer this information to project managers responsible for site clean-ups.**

DEMONSTRATION SITES

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PROGRESS

- **Contract to be awarded in** *April 1997*

Task	Alameda	Tinker	Letterkenny	Allegany
3D survey:	*Jun 97*	*Aug 97*	*Oct 97*	*Dec 97*
Verify:	*Aug 97*	*Oct 97*	*Dec 97*	*Feb 97*
Report:	*Oct 97*	*Dec 97*	*Feb 97*	*Apr 97*

EXPECTED BENEFITS

- Install fewer wells
- Optimize location of wells
- Improve design of remediation systems
- Reduce chance of spreading contaminants
- Estimate volume of DNAPL/LNAPL contamination
- Better define complex geology
- Monitor cleanup effectiveness
- Support intrinsic bioremediation studies

USERS

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EOL SYSTEM DESCRIPTION

Transmitter Loop	Receiver	Data
4 meter^2 area	2.5’ length	16 byte A/D converter
32 turns	1.6” diameter	1/100 scale resolution
11 amps	30,000 turn, 28 gage wire	263 Hz

RESISTIVITY VALUES

saturated soil	ohm-m	saturated rock	ohm-m
• clay/mud	2-5	shale	1-10
• silt	5-20	sandstone	10-50
• sand	10-50	limestone	$50\text{-}10^4$
• gravel	20-50	volcanic rock	100-500
•		metamorphic rock	$300\text{-}10^3$

vadose zone soils: **10-50 times resistivity**

minimum resistivity contrast = 1.5

contaminants	ohm-m
• non-dissolved DNAPL	$>10^6$
• non-dissolved LNAPL	$>10^6$