GEOPHYSICS ADVISOR EXPERT SYSTEM VERSION 2.0

by

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U.S. Geological Survey preliminary computer program for Geophysics Advisor Expert System. Written in True BASIC 2.01 to run under Microsoft MS-DOS 2.0 or later on IBM-PC or true compatible computers with 640k or greater memory available to the program. No source code is available.

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Geophysics Advisor Expert System Version 2.0

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This expert system program was created for the U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, Nevada. The expert system is designed to assist and educate non-geophysicists in the use of geophysics at hazardous waste sites. It is not meant to replace the expert advice of competent geophysicists. It is written to run on any IBM MS-DOS compatible computer and to be very simple to use. This is version 2.0 of the program.

Version 1.0 of the program was published as Olhoeft (1988), and asks questions about a site and the contamination problem. Then, based upon the answers given, it recommends what types of geophysics will most likely be useful at the site to solve problems such as contaminant location and hydrogeological characterization of the site. It also annotates why various geophysical techniques will likely work or not work at the site. The questions and their allowable answers are tightly focused to decide on the use of geophysics to locate contaminants and acquire hydrogeological information about the site.

Version 2.0 improves upon version 1.0 by adding a database of the physical and chemical properties of the top Superfund organic contaminants. Version 1.0 asks questions about the properties of the contaminants, such as "Are the organics miscible with water?" Version 2.0 presents a list of contaminants to select from (such as benzene). For the top Superfund organic contaminants, it will know the answers to most questions. For other contaminants, it will still ask the questions about properties. For some organic contaminants, the answers are not known as the physical properties of the contaminants are unknown. The database on which the answers are based is found in Lucius and others (1992).

To run this program, place the floppy diskette in drive A:, type 'A:' (without the quotes) and press the 'Enter' key, then type 'EXPERT' and press the 'Enter' key. Follow the instructions shown on the screen from that point on. Press 'Ctrl Break' (hold down the 'control' key and press 'break' key at same time) to exit the program without saving at any point (this is not recommended when the program is writing to the disk), or press 'Alt-S' (hold down the 'Alt' key and press 'S' at the same time) to exit and save a partial session. During a session, questions may be answered and later changed by backing up with the 'Esc' (escape) key, or by using the F10 key at the end when the recommendations are made. After answering the questions posed by the program, it will recommend the types of geophysics to use, then the session may be saved to disk (for later 'what if?' scenarios) and printed. The appendix lists a typical session printout. As version 2.0 contains more questions and allows the saving of partial sessions, old files created with version 1.0 are incompatible with version 2.0 -- old sessions must be repeated starting from NEWFILE.

Quality Assurance requirements mandate that the program only be available in compiled form and that datafiles be encrypted. However, the program and datafiles are not copy protected and may be freely copied and distributed for no more than the cost of copying. This program is not subject to U.S. Copyright Law. The program (EXPERT.EXE) and datafiles (NEWFILE.EPA and DATABASE.ORG) may be copied and run from a hard disk drive.
References


APPENDIX 1: List of Chemicals in Database

<table>
<thead>
<tr>
<th>Organic Contaminant</th>
<th>Chemical Abstract Service Registry Number</th>
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<tbody>
<tr>
<td>Acetic acid</td>
<td>64-19-7</td>
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<tr>
<td>Acetone</td>
<td>67-64-1</td>
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<td>Acrolein</td>
<td>107-02-8</td>
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<tr>
<td>Acrylonitrile</td>
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<td>Aldrin</td>
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<td>Ammonia</td>
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<td>Aniline</td>
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<td>Aroclor 1260 (PCB 1260)</td>
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<td>Benz(e)acephenanthrylene</td>
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<td>Benz[a]anthracene</td>
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<td>Benzene</td>
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<td>Benzidine</td>
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<td>Benzoic acid</td>
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<td>Benzo[a]pyrene</td>
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<td>Bis(2-chloroethyl) ether</td>
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<td>Bis(chloromethyl) ether</td>
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<td>Bis(2-ethylhexyl) phthalate</td>
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<td>Bromoform</td>
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<td>2-Butanone</td>
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<td>Carbon tetrachloride</td>
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<td>Chlorobenzene</td>
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<td>6-Chloro-m-cresol</td>
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<td>DNAPL (Generic chlorinated solvent)</td>
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<td>Hydrocarbon (Generic gasoline, diesel, etc.)</td>
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<td>NONE OF THE ABOVE</td>
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</table>
APPENDIX 2: Typical session printout.

Disclaimer:

NOTICE

The information in this program has been funded wholly or in part by the United States Environmental Protection Agency under interagency agreement DW14934976 to the United States Geological Survey. It has been subject to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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SITE NAME: Test Example

This is a test example session.

EXPLANATION: (This is the first question.)

'Continuous leak (fixed)' means it is no longer leaking.

QUESTION: The source of contamination was:

ANSWERS:

Unknown
-----Single event-----
Continuous leak (fixed)
Continuing leak
EXPLANATION: 'Surface spill' includes all types of contamination that start at the surface (such as an oil slick, leaking surface tank or pipe, or any others than those listed separately).

'Not a spill or leak' is something like an intact, lost barrel of waste.

If several sources are involved, do one session for each...

QUESTION: The contaminants originated from:

ANSWERS:
- Unknown
- Surface spill
  - Land treatment facility
  - Surface impoundment
  - Leaking landfill
  - Leaking underground storage tank
  - Leaking underground pipeline
  - Leaking trench
  - Deep injection well
  - Not a spill or leak

EXPLANATION: For 'Yes' or 'no' questions like this, 'Unknown' means you don’t know. 'Maybe' is closer to 'Yes' than 'no', and 'Need to know' means you’d like to know this.

QUESTION: Did the contaminants reach the surface? (or are they on the surface?)

ANSWERS:
- Unknown
- No
- Maybe
- Yes
- Need to know

QUESTION: Are the contaminants in the unsaturated subsurface? (above the water table)

ANSWERS:
- Unknown
- No
- Maybe
- Yes
- Need to know

QUESTION: Are the contaminants in the saturated subsurface? (at or below the water table)

ANSWERS:
- Unknown
- No
- Maybe
- Yes
- Need to know

EXPLANATION: An areal search is a search across the surface of the earth for the location of the contaminant problem.

A depth search is a search for the location of the contaminant problem versus depth.

QUESTION: Is this an areal search, a depth search, or both?

ANSWERS:
- Unknown
- Areal
- Depth
- Need to know

- Both
QUESTION: What is the urgency of the site investigation?
ANSWERS:
  Unknown
  Emergency Response (Hours)
  Days
  Weeks
  Months
  -----Years-----

EXPLANATION: 'Container' includes barrels and drums as well as pond and trench liners.

QUESTION: Are the contaminants in a plume or in a container?
ANSWERS:
  Unknown
  Surface plume
  -----Subsurface plume-----
    Intact container
    Leaky container
    Both

QUESTION: Are radioactive contaminants present?
ANSWERS:
  Unknown
  -----No-----
    Maybe
    Yes
    Need to know

QUESTION: Are non-radioactive inorganic contaminants present?
ANSWERS:
  Unknown
  -----No-----
    Maybe
    Yes
    Need to know

EXPLANATION: 'Organics' includes hydrocarbons.

QUESTION: Are organics present?
ANSWERS:
  Unknown
    No
    Maybe
    -----Yes-----
    Need to know

---------------------------------------------------------------------
DATABASE CHOICE: Hydrocarbon (Generic gasoline, diesel, etc.)
Geological Survey Open File Report 92-527, 554p. (Order from: Books and Open
File Reports Section, Branch of Distribution, U. S. Geological Survey, P.O.
Box 25425 DFC, Denver, CO 80225, 303-236-7476)
EXPLANATION: Soluble or insoluble in water. Soluble means they chemically dissolve in water (such as alcohol).
QUESTION: Are the organics water soluble or insoluble?
ANSWERS:
  - Unknown
  - -----Insoluble-----
  - Soluble
  - Mixed

EXPLANATION: Immiscible means they do not physically mix with water (such as oil). Miscible means they mix with water.
QUESTION: Are the organics water miscible or immiscible?
ANSWERS:
  - Unknown
  - Miscible
  - -----Immiscible-----
  - Mixed

EXPLANATION: Lighter than water means they float. Heavier than water means they sink.
QUESTION: Are the organics heavier or lighter than water?
ANSWERS:
  - Unknown
  - Neither
  - Heavier than water
  - -----Lighter than water-----
  - Both

EXPLANATION: Anionic means they are negatively charged in water. Cationic means they are positively charged in water.
QUESTION: Are the organics polar?
ANSWERS:
  - Unknown
  - Nonpolar
  - Anionic
  - Cationic
  - -----Mixed-----

EXPLANATION: A soil is not wet by a liquid if the liquid forms beads on the surface of the soil. Most silicate soils prefer to be water wet. Many carbonates prefer to be organic-wet. (But the detailed chemistry can make it go either way.)
QUESTION: Are the soils preferentially water-wet or organic-wet?
ANSWERS:
  - Unknown
  - Neither
  - Water
  - -----Organic-----
  - Both

EXPLANATION: (Aqueous means in the water.) (NAPL is NonAqueous Phase Liquid)
QUESTION: Are the organics mostly in the water phase, adsorbed on soil solids, in a separate organic phase, or in the gas phase?
ANSWERS:
  - Unknown
  - Aqueous
  - Soil
  - Gas
  - Separate Phase (NAPL)
  - -----All-----
EXPLANATION: Modification processes include biodegradation, catalysis, volatilization, and any other reactions.

QUESTION: Are the organics being modified by any processes?

ANSWERS:
- Unknown
- No
- Maybe
- -----Yes-----
- Need to know

EXPLANATION: Are bacteria or other biological activity changing the chemistry of the contaminants?

QUESTION: Is biodegradation of the organics occurring?

ANSWERS:
- Unknown
- No
- Maybe
- -----Yes-----

EXPLANATION: For example, toluene is catalyzed on the surface of montmorillonite to polymerize into bibenzyl.

QUESTION: Is catalysis of the organics occurring?

ANSWERS:
- Unknown
- No
- -----Maybe-----
- Yes

QUESTION: Is adsorption of the organics occurring?

ANSWERS:
- Unknown
- No
- Maybe
- -----Yes-----

EXPLANATION: Volatile means they produce a gaseous vapor at room temperature. (typically that means they may smell.)

QUESTION: Is volatilization of the organics occurring?

ANSWERS:
- Unknown
- No
- Maybe
- -----Yes-----

EXPLANATION: Volatile means they produce a gaseous vapor at room temperature. (typically that means they may smell.)

QUESTION: Are the organics volatile?

ANSWERS:
- Unknown
- Non volatile
- -----Volatile-----
- Both
EXPLANATION: Organics present at the surface means in the air, on the ground or in leaking containers at the surface.

QUESTION: Are there volatile organics present at the surface in the area of study?
ANSWERS:
- Unknown
- No
- Maybe
- ------Yes------

QUESTION: Are the volatile organics present at the surface the same organics as the contaminants?
ANSWERS:
- Unknown
- No
- Maybe
- ------Yes------

QUESTION: How old is the organic/hydrocarbon contamination?
ANSWERS:
- Unknown
- Hours
- Days
- Weeks
- Months
- ------Years------

EXPLANATION: $k'$ = relative dielectric permittivity (dielectric constant)

QUESTION: Are the organics good dielectrics?
ANSWERS:
- Unknown
- ------$k'<10$------
- $k'>10$

QUESTION: What is the electrical resistivity of the organics?
ANSWERS:
- Unknown
- ------$>100$ ohm-m (insulator)------
- $<100$ ohm-m

QUESTION: Are the organics known to react with clay minerals?
ANSWERS:
- Unknown
- No
- Maybe
- ------Yes------
EXPLANATION: Empty means land with few or no manmade features of any kind.
Rural means farm country (or 2 or less houses per acre suburbs).
Suburban means 3 or more houses per acre site density.
Urban means high density center-city housing and utility density.
Industrial means setting with high building and utility density.
Landfill means low surface density, high subsurface density clutter.
Military means active military base with many interference sources.
Service station means gasoline/diesel service station or refinery.
Choose the lowest density of buildings and utilities that characterize the
site itself.

QUESTION: What is the environment at the site?

ANSWERS:

Unknown
-----Empty-----
Rural
Suburban
Urban
Industrial
Landfill
Military base
Service station

QUESTION: Are metallic well casings installed at the site?

ANSWERS:

Unknown
-----No-----
Maybe
Yes

EXPLANATION: In this context, 'buildings' means current or former buildings or
t heir foundations.

QUESTION: How much of the site is covered by buildings?

ANSWERS:

Unknown
-----None-----
<10%
10-25%
25-50%
50-75%
>75%

EXPLANATION: 'Difficult' means it is difficult to walk around the site.
'Walking' means most of the site is available to access on foot.
'ATV' means access by all terrain vehicle is possible.
'4-WD' means four-wheel drive jeeps can drive over most of the site.
'2-WD van' means two-wheel van-like vehicles can drive over most of the site.

QUESTION: What is the site access like?

ANSWERS:

Unknown
Difficult
Walking
ATV
4-WD
-----2-WD van (easy access)-----
EXPLANATION: 'Inaccessible' includes site access problems due to property ownership and trespass, excessive safety hazards such as explosive hazard, and difficulties due to quicksand, swamp or other similar problems.

QUESTION: How much of the site is inaccessible?

ANSWERS:
- Unknown
- None
- <10%
- 10-25%
- 25-50%
- 50-75%
- >75%

QUESTION: What is the annual precipitation?

ANSWERS:
- Unknown
- <5 cm <2 in
- 5-20 cm 2-8 in
- 20-50 cm 8-20 in
- >50 cm >20 in

EXPLANATION: (If so, what is the wet season?)

QUESTION: Does most precipitation occur in one season of the year?

ANSWERS:
- Unknown
- No
- Spring
- Summer
- Fall
- Winter

QUESTION: Are there natural organics present? (from forest, jungle, farm, swamp, etc.)

ANSWERS:
- Unknown
- No
- Maybe
- Yes

EXPLANATION: Radio, TV and radar transmissions may interfere with some geophysical methods.

In this context, also consider nearby active airports, police stations, and other non-commercial radio stations.

Arc-welders in welding shops may also qualify as 'radio' transmitters.

QUESTION: Are there radio, TV or radar transmitters within 2 km of the site?

ANSWERS:
- Unknown
- No
- Maybe
- Yes
EXPLANATION: Some sounds may interfere with some geophysical methods. Sources of acoustic noise include railroads, heavily travelled roads, airport flight paths, and industrial plants. Continuously windy sites also qualify as acoustically noisy.

QUESTION: Is the site acoustically noisy?

ANSWERS:
   Unknown
   ------No------
   Maybe
   Yes

EXPLANATION: These permeability features may modify the results of a soil gas survey.

QUESTION: Are streams (past or present), utility or other trenches, glacial scours or drains present in the site?

ANSWERS:
   Unknown
   ------No------
   Maybe
   Yes
   Need to know

EXPLANATION: Concrete will interfere with some geophysical techniques.

QUESTION: How much of the areal extent of the site is surfaced by concrete?

ANSWERS:
   Unknown
   ------None-----
   <25%
   25-50%
   50-75%
   >75%

EXPLANATION: Asphalt will interfere with some geophysical techniques.

QUESTION: How much of the areal extent of the site is surfaced by asphalt?

ANSWERS:
   Unknown
   ------None-----
   <25%
   25-50%
   50-75%
   >75%

EXPLANATION: Some geophysical techniques require topographic correction for proper interpretation.

QUESTION: What is the range of topographic relief across the site?

ANSWERS:
   Unknown
   ------<1m <3ft flat-----
   1-3m 3-10ft
   3-10m 10-30ft
   >10m >30ft

EXPLANATION: (Indications either from Karst geology or human activities like trenches or fluid withdrawals.)

QUESTION: Are there sinkholes or evidence of subsidence present at the site?

ANSWERS:
   Unknown
   ------No------
   Maybe
   Yes
   Need to know
QUESTION: What is the approximate area of the site?
ANSWERS:
- Unknown
- <100 sq-m <0.03 acres
- 100-1,000 0.03-0.3
- 1,000-10,000 0.3-0.3
- >10,000 sq-m >0. acres

QUESTION: Is this a four-season site with freezing winters?
ANSWERS:
- Unknown
- No
- Maybe
- Yes

QUESTION: What is the average depth of freeze?
ANSWERS:
- Unknown
- <0.3m <1ft
- 0.3-1m 1-3ft
- 1-3m 3-10ft
- >3m >10ft
- Need to know

QUESTION: What is the average depth to bedrock?
ANSWERS:
- Unknown
- <3m <10ft
- 3-10m 10-30ft
- 10-30m 30-100ft
- >30m >100ft

QUESTION: Is the zone of interest above or below the bedrock interface?
ANSWERS:
- Unknown
- Above
- At
- Below
- All

QUESTION: What is the average depth to the water table?
ANSWERS:
- Unknown
- <3m <10ft
- 3-10m 10-30ft
- 10-30m 30-100ft
- >30m >100ft
QUESTION: Is the zone of interest above or below the water table?
ANSWERS:
   Unknown
   Above
   -----At-----
   Below
   All

EXPLANATION: In this context, consider lakes, rivers and other permanent surface water bodies.

QUESTION: How much of the surface areal extent of the site is covered by water?
ANSWERS:
   Unknown
   ------None------
   <10%
   10-25%
   25-50%
   50-75%
   75-90%
   >90wt%

QUESTION: How much of the surface areal extent of the site is regularly irrigated?
ANSWERS:
   Unknown
   ------None------
   <10%
   10-25%
   25-50%
   50-75%
   75-90%
   >90%

EXPLANATION: Resistivity in ohm-meters or (conductivity in millimho/meter).

QUESTION: What is the electrical resistivity of the ground water?
ANSWERS:
   Unknown
   <30 ohm-m (>30 mmho/m) [not fresh]
   ------=> 30 ohm-m (<30 mmho/m) [fresh]------

QUESTION: How far away from the site is the nearest saltwater (ocean, bay, etc.)?
ANSWERS:
   Unknown
   ------->1000m >3000ft------
   100-1000m 300-3000ft
   <100m <300ft

EXPLANATION: 'Brine layers' include seawater intrusions and other salty waters.

QUESTION: Are there brine layers present at the site?
ANSWERS:
   Unknown
   ------No------
   Maybe
   Yes
   Need to know
EXPLANATION: Some geophysical techniques are influenced by rock and soil type. The sequence gravel to clay indicates coarse to fine particle size (not mineralogy).

QUESTION: What is the dominant soil type at the site?

ANSWERS:
- Unknown
- Rock - no soil
- Gravel
- Sand
- Till
- Clay

EXPLANATION: Lacustrine means soils derived from old lake beds. Fluvial means old rivers or streams. Glacial means the leftovers after glacial retreat. Aeolian means airborne particle deposition. Colluvial means soils derived from degrading cliffs, and avalanche or landslide debris. Diluvial means deposited by floods. Deltaic soils are formed at the mouth of a river. (Alluvial is the 'modern' version of several of these.)

QUESTION: What is the origin of the dominant soil type at the site?

ANSWERS:
- Unknown
- Lacustrine
- Fluvial
- Glacial
- Aeolian
- Colluvial
- Diluvial
- Deltaic
- Marine
- Volcanic

EXPLANATION: The presence of clay helps some geophysical techniques and hinders others. Clay in this context means mineralogical clay (such as montmorillonite) not engineering-size-fraction 'clay'. The depth penetration of ground penetrating radar in particular is strongly limited by clay.

QUESTION: Is clay present at the site? (exclude a basal clay below depths of interest)

ANSWERS:
- Unknown
- No
- Maybe
- Yes
- Need to know

EXPLANATION: 'Quickly' means in less than one day.

QUESTION: Does rainfall on the site surface sink in slowly or quickly?

ANSWERS:
- Unknown
- Run off
- Pond
- Sink in slowly
- Sink in quickly
EXPLANATION: Resistivity in ohm-meters or (conductivity in millimho/meter).

QUESTION: What is the average electrical resistivity of the site in ohm-meters?

ANSWERS:

Unknown
<1 ohm-m (>1000 mmho/m)
1-10 (100-1000)
10-30 (33-100)
30-100 (10-33)
100-300 (3-10)

------> 300 ohm-m (<3 mmho/m) ------

SITE: Test Example

0026 Ground penetrating radar methods recommended.
0007 Soil gas methods recommended.
0007 Electromagnetic induction methods recommended.
0007 Complex Resistivity methods recommended.
0000 Gravity methods not recommended.
-001 Seismic effectiveness is uncertain.
-001 Magnetic methods not recommended.
-010 Radiometric methods not recommended.

SITE: Test Example

Site specific comments: 0007 Electromagnetic induction methods recommended.
Use time domain EM for deep sounding.
EM techniques are better for areal searches.
EM induction may detect organics that displace water from soil surfaces.
EM induction methods can sometimes (but rarely) find some organic insulators.
Bedrock is too deep to see with shallow frequency-domain EM.
Use time-domain EM to find deep bedrock.

0007 Electromagnetic induction methods recommended. EMI are electromagnetic
techniques that induce currents in the earth. They measure the secondary
magnetic field generated by the induced currents. The electrical conductivity
of the earth is proportional to the secondary magnetic field. The depth of
investigation is a function of the instrument coil spacing and orientation,
frequency of measurement, and the electrical conductivity of the ground. By
measuring and mapping the changes in electrical conductivity, EMI techniques
may directly locate plumes of inorganic contaminants, clay lenses, metallic
objects such as buried drums, and inhomogeneities in geology such as
fractures. EMI techniques are ineffective in areas with many fences,
pipelines, rebar, telephone cables, and other metallic interferences. EMI
techniques require topographic correction. EMI techniques are readily
available commercially, relatively inexpensive, and require 1 or 2 man crews.
EMI methods acquire data very quickly over large areas, whereas resistivity
methods are preferred for sounding to acquire depth information. For further
information, see: Greenhouse, J. and Harris, R., 1983, Migration of
contaminants in ground water at a landfill: a case study, 7. DC, VLF, and
inductive resistivity surveys, J.Hydrol., v.63, p.177-197. McNeill, J.D.,
1990, Use of electromagnetic methods for groundwater studies: in Geotechnical
p.191-218.

Site specific comments: 0026 Ground penetrating radar methods recommended.  
Radar can detect some kinds of organics.  
Radar can find some insoluble organics.  
Radar can detect some immiscible organics.  
Radar can detect some organics that float on the water table (but not the aqueous plume).  
Radar can detect pooled DNAPL sources (but not the aqueous plume).  
Radar can detect soil texture scattering changes from organic wet soils.  
Radar can find some organic dielectrics.  
Radar can find some organic insulators.  
Perform radar during winter to exploit high resistivity of frozen ground.  
Bedrock is too deep to see with radar.  
Radar may determine the depth to the water table.  
Ground (fresh) water resistivity is good for mapping hydrogeology with radar.  
Radar may determine the depth to the clay.  
High resistivity is good for mapping hydrogeology with radar.  
DC resistivity techniques are better for depth searches.

0007 Complex Resistivity methods recommended. Resistivity techniques use electrodes in contact with the ground to measure electrical resistivity (reciprocal of conductivity). The depth of investigation is a function of the electrode spacing and geometry, (larger spacings see deeper). By measuring and mapping the changes in electrical resistivity, these techniques may directly locate plumes of inorganic contaminants, clay lenses, metallic objects such as buried drums, and inhomogeneities in geology such as fractures. Resistivity techniques are ineffective in areas with many fences, pipelines, rebar, telephone cables, and other metallic interferences, and may be difficult to do through concrete or asphalt. Resistivity techniques require topographic correction, are readily available commercially, relatively inexpensive, and require 1 or 2 man crews. Resistivity methods are preferred for sounding to acquire depth information, whereas EM induction provides easier and faster areal mapping. Complex resistivity measures resistivity as a function of frequency. It can detect organic contaminants when they react with clay minerals, but it is much more time consuming, expensive, and not readily available commercially. For further information, see: Ward, S.H., 1990, Resistivity and induced polarization methods: in Geotechnical and Environmental Geophysics, v.I, S.H.Ward, ed., Tulsa, Soc.Explor.Geophys., p.147-190. Olhoeft, G.R., 1992, Geophysical detection of hydrocarbon and organic chemical contamination: in Proc.of the Symp.on the Appl.of Geophys.to Engrg. and Environ.Problems, R.S.Bell, ed., Oakbrook, IL, Soc. Engrg. & Min.Explor.Geophys., Golden, CO, p.587-595.

SITE: Test Example
Site specific comments: -001 Magnetic methods not recommended. No magnetic materials were identified at the site.

SITE: Test Example
SITE: Test Example

Site specific comments: -010 Radiometric methods not recommended.

There are no radioactive materials present.

-010 Radiometric methods not recommended. Radiometric techniques measure the radiation emitted from radioactive isotopes. Radiactive contaminants may be masked by high background levels of natural radioactivity or by roughly a meter of overlying soil cover (depending upon the type and strength of the source and of the covering soil). These are generally only useful at radioactive waste disposal sites. However, they may be useful in locating natural radioactive hazards (such as radon gas sources), early radium processing plants, mining mill tailings, and other similar sites. Basic references are: EG&G Idaho Inc., 1983, Low-level radioactive waste management handbook series: Environmental monitoring for low-level waste-disposal sites, DOE/LLW-13Tg, available from NTIS, Springfield, VA, var.pag.; Morse, J.G., ed., 1977, Nuclear methods in mineral exploration and production, NY, Elsevier, 280p. Gregg, L.T. and Holmes, J.J., 1990, Radon detection and measurement in soil and groundwater: in Geotechnical and Environmental Geophysics, v.I, S.H.Ward, ed., Tulsa, Soc.Explor.Geophys., p.251-262.

SITE: Test Example

Site specific comments: 0007 Soil gas methods recommended.

Contaminants on the surface may interfere with soil gas.

Soil gas can detect volatile organics. Soil gas detects volatile organics.

Soil gas may detect the products of organic biodegradation.

Soil gas may detect the products of organic catalytic reaction.

Surface contamination will interfere with soil gas (requires deep soil gas probing). Older organic contamination is more likely degraded.

Soil gas probes should sample below depth of freeze in winter.