NMSHTD District 1 Headquarters

Case Study Abstract

New Mexico State Highway and Transportation Department (NMSHTD)
Underground Storage Tank (UST) Investigation
Deming, New Mexico

Site Name and Location: NMSHTD UST Investigation Deming, NM	**Geophysical Technologies:** Magnetometry Electromagnetics Natural gamma logging Soil gas analysis	**Date of Investigation:** July 1997
Period of Site Operation: 1955 to present **Operable Unit: N/A**		**Current Site Activities:** Planning for Soil Vapor Extraction Remedy
Points of Contact: Phil Ramos, 505-827-5528 Richard Meixner, 505-822-9400 Jim Viellenave, 303-278-1911	**Geological Setting:** Quaternary bolson alluvium underlain by Cretaceous Mesa Verde and Mancos shale	**Technology Demonstrator:** Sunbelt Geophysics P.O. Box 36404 Albuquerque, NM 87176 505-266-8717 TEG Rocky Mountain 400 Corporate Circle, Suite R Golden, CO 80401 303-278-0104
Purpose of Investigation: The overall goal of this environmental investigation was to identify and characterize the source of chlorinated VOC contamination in groundwater beneath the NMSHTD site. The goal of the magnetic and electromagnetic survey was to locate buried materials that might be potential sources of contamination. The goal of the gamma log survey was to guide the placement of the soil vapor sampling points.		
Number of Images/Profiles Generated During Investigation: 33 natural gamma profiles.		
Results: Magnetometry and electromagnetics identified two areas of concern. Natural gamma logs of direct-push boreholes identified stratigraphic units that influenced the migration of contaminant vapors in the vadose zone. Permanent soil gas sampling points were installed in the units identified by the gamma logs. The soil gas survey provided a representative distribution of the contamination in the vadose zone.		

EXECUTIVE SUMMARY

The New Mexico State Highway and Transportation Department (NMSHTD) District 1 Headquarters site is located in Deming, New Mexico in the southwestern part of the state. The site covers approximately 15 acres. The site lies within 10 miles of the U.S./Mexico border. The topography is generally flat with little or no relief across the site. The Mimbres River is located north of the site and is the only nearby water body. The property has been used since 1955 by the NMSHTD for vehicle maintenance, steam cleaning, and other activities. During years of heavy roadbuilding, a materials testing laboratory used 1,1,1-tetrachloroethane (1,1,1-TCA) on a regular basis for asphalt analyses. Spent solvent was either disposed off site or recycled in an on-site still. The aggregate used in testing was apparently rinsed with water, and the contaminated water was regularly rinsed down the drain and into the septic system.

Site geology consists of deposits typical of an arid zone basin that has been filled in by erosion of materials from the surrounding uplands. Locally interlayered sandy clay and clayey sand are present with some gravel. A thick gravel layer was present at depths between eight and 15 feet below ground surface (bgs). Depth to groundwater is 100 to 150 feet bgs.

A geophysical investigation was completed as part of a soil gas survey conducted at the site in 1997. The information presented in this report was derived from the interpretive report of the geophysical investigation. Geophysical methods were used to identify buried materials and to find optimal locations for the placement of soil gas sampling points. A reconnaissance survey was performed over the study area using magnetometry and electromagnetics (EM) to identify buried materials that might be sources of contamination. The reconnaissance survey was conducted over a 25-acre area from July 7 to July 22, 1997. The survey identified numerous areas of buried materials, but only two were of interest. A septic tank was identified to the southeast of the building that had housed the materials testing laboratory. Also identified was another area located approximately 75 feet to the north of the septic tank on the east side of the building. Natural gamma logs taken in direct push boreholes were used to identify clay lenses that might impede the migration of soil gas vapors. Soil gas sampling points were installed just below these lenses.

The gamma logs were successful in locating the clay lenses that were controlling vapor migration in the vadose zone. The resulting soil gas survey identified areas of groundwater contamination related to the septic field that was acting as a source area.

SITE INFORMATION

Identifying Information

New Mexico State Highway and Transportation Department (NMSHTD)
District 1 Headquarters Underground Storage Tank (UST) Site
2912 East Highway 80
Deming, NM

Background

Physical Description: The NMSHTD District 1 Headquarters Underground Storage Tank (UST) site is located in Deming, New Mexico in the southwestern part of the state, as shown in Figure 1. The site covers approximately 15 acres. This investigation was extended off site to investigate various properties that may have contributed to the on-site contamination [1].

Figure 1: Site Location

The site lies within 10 miles of the U.S./Mexico border. The topography is generally flat with little or no relief across the site. The Mimbres River is located north of the site and is the only nearby water body [2].

Site Use: The property has been used since 1955 by the NMSHTD for vehicle maintenance, steam cleaning, and other activities. Figure 2 shows a map of the site and the immediate area. During years of heavy road building, a materials testing laboratory used 1,1,1-tetrachloroethane (1,1,1-TCA) on a regular basis for asphalt analyses. Spent solvent was either disposed off site or recycled in an on-site still. The aggregate used in testing was apparently rinsed with water, and the contaminated water was regularly rinsed down the drain and into the septic system. This improper disposal of 1,1,1-TCA-contaminated water contributed to the contamination of the site [1, 2, 3, 4].

Release/Investigation History: During a tightness test of underground storage tanks at the Deming site in July and August 1989, NMSHTD found leaks in underground storage tanks and petroleum hydrocarbon contamination of subsurface soil. Subsequent investigations confirmed the presence of gasoline-derived and chlorinated volatile organic compounds (VOCs) in groundwater at concentrations in excess of New Mexico Water Quality Control Commission health standards [1, 3, 4].

In June 1996, Daniel B. Stephens & Associates (DBS&A) conducted a shallow soil gas survey using passive soil gas samplers to detect contamination in the vadose zone. The survey was conducted over an area of known VOC-contaminated groundwater, but the only VOC detected was perchloroethene (PCE). Furthermore, the distribution of PCE was not representative of the distribution of chlorinated VOCs known to be present in the groundwater beneath the site. The investigators from DBS&A believed that the local geology affected the movement of contaminant vapors beneath the site, possibly preventing the shallow samplers from registering chemicals known to be present in groundwater approximately 100 feet below ground surface (bgs) [1, 3].

SITE INFORMATION

Regulatory Context: New Mexico UST Regulations and New Mexico Water Quality Control Commission standards [1, 3].

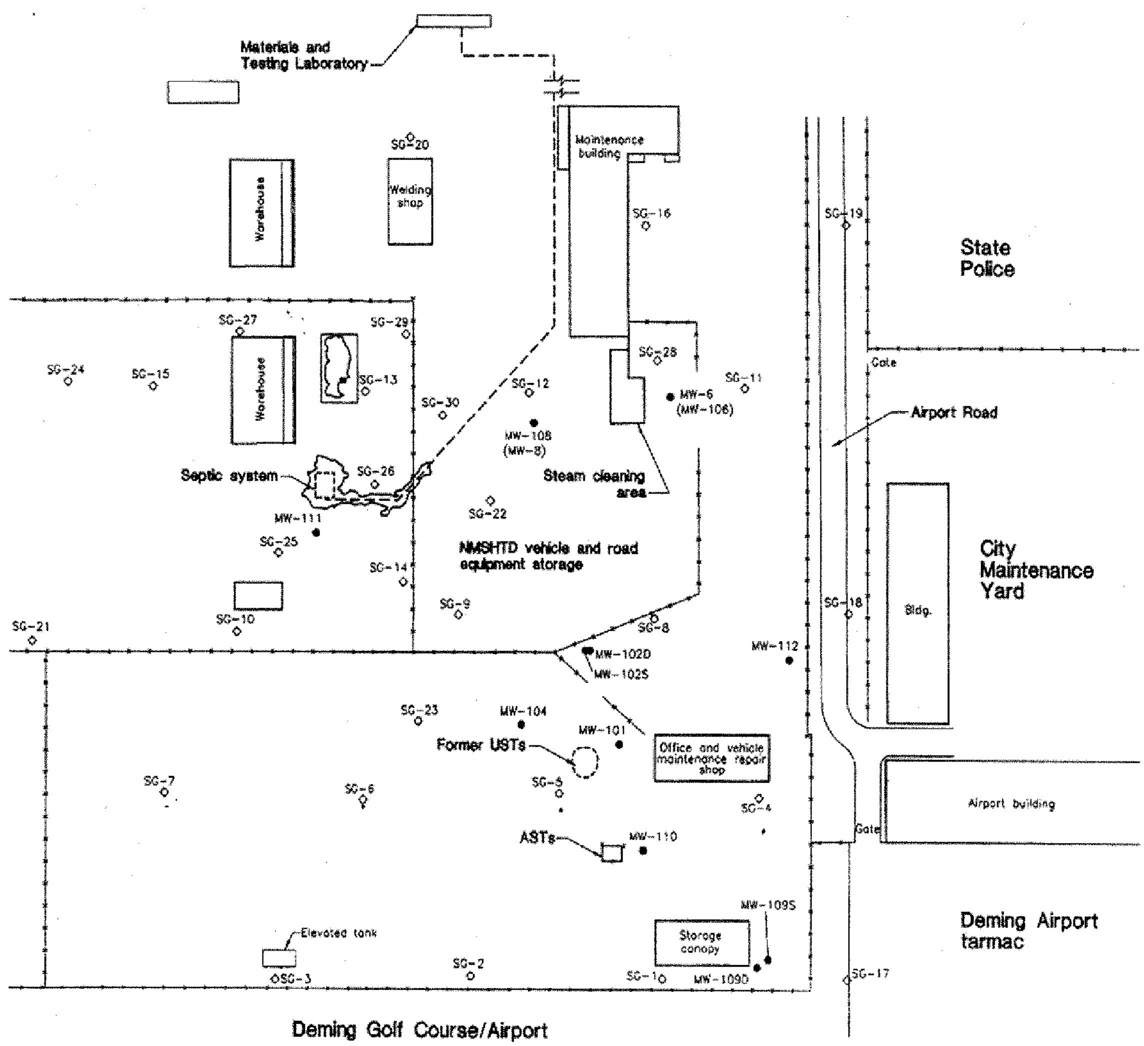

Figure 2: NMSHTD District 1 Headquarters Site [3]

SITE INFORMATION

Site Logistics/Contacts

State Lead Agency: NMSHTD
Federal Oversight Agency: Not applicable

Remedial Project Manager:
Richard Meixner
Daniel B. Stephens and Associates, Inc.
Albuquerque, NM 87176
505-822-9400

Site Contact:
Phil Ramos
New Mexico Highway and Transportation Department
Albuquerque, NM 87176
505-827-5528

Geophysical Subcontractors:
David Hyndman
Sunbelt Geophysics
P.O. Box 36404
Albuquerque, NM 87176
505-266-8717

James Viellenave
TEG Rocky Mountain
400 Corporate Circle, Suite R
Golden, CO 80401
303-278-0104

MEDIA AND CONTAMINANTS

Matrix Identification [3]

Type of Matrix Sampled and Analyzed: Subsurface clays, sands, and gravels.

Site Geology/Stratigraphy [3, 4, 5]

Regional geology in the area of the site consists of Quaternary alluvium underlain by Cretaceous Mesa Verde and Mancos shale. In some areas the eroded materials have been reworked by local streams. The local stratigraphy consists of deposits typical of an arid zone basin that has been filled in by erosion of materials from the surrounding uplands. Locally interlayered sandy clay and clayey sand are present with some gravel. A thick gravel layer was present at depths between eight and 15 feet bgs. Some confining layers are present that may influence the migration of contaminant vapors. Depth to groundwater is 100 to 150 feet bgs.

Contaminant Characterization [1, 3]

Primary Contaminant Groups: The primary contaminants of concern include trichloroethene (TCE), perchloroethene (PCE), 1,1-dichloroethene (1,1-DCE), and 1,1,1-dichloroethane (1,1,1-DCA). A combination of benzene, toluene, ethylbenzene, and xylene (BTEX) was also present but was not addressed in the investigation described here. The most frequently detected chlorinated VOC in soil gas was 1,1-DCE.

MEDIA AND CONTAMINANTS

Matrix Characteristics Affecting Characterization Cost or Performance

The magnetometry survey was affected in three areas by the presence of sources of magnetic interference, such as fences, buildings, etc, to the degree that the survey in those areas was replaced by an electromagnetic survey [3].

The natural gamma detector used at the Deming site was found to be sensitive to temperature change. After it was lowered into the hole, the field team allowed it to equilibrate to the lower subsurface temperature before recording the counts of natural gamma radiation. Later models of the detector are designed to be impervious to temperature differences and has been used in 100°F temperatures [3, 6]. The detector is impervious to humidity and water. It functions in groundwater and has been used in the rain and snow [5].

Certain geologic materials, such as granite-derived cobbles and gravel in conglomeratic deposits, organic rich deposits, and phosphate and potash (K_2CO_3) deposits, have low natural gamma radiation levels, and natural gamma logging may be insufficient to distinguish layers composed of these materials. However, these materials were not present in the alluvial deposits examined at this site [3, 5, 6].

The presence of a gravel layer between eight and 15 feet bgs and a tendency of the deeper materials to collapse when the probe was advanced led the investigators to conduct the gamma logging inside of the drive rods [3].

GEOPHYSICAL INVESTIGATION PROCESS

Investigation Goals [1, 3]

The overall goal of this environmental investigation was to identify and characterize the source of chlorinated VOC contamination in groundwater beneath the NMSHTD site. The goal of the magnetic and electromagnetic survey was to locate buried materials that might be potential sources of contamination. The goal of the gamma log survey was to guide the vertical placement of the soil vapor sampling points.

Geophysical Methods

A reconnaissance survey was performed over the study area using magnetometry and electromagnetics (EM). The magnetometry survey was carried out using a Geometrics G-858 cesium magnetometer. Magnetic data were acquired every two feet along parallel traverses separated by 10-foot intervals. The EM data were acquired using a Geonics EM-61 high precision metal locator every 0.6 feet along parallel traverses separated by five-foot intervals.

Natural gamma data were gathered using a Mt. Sopris Slim Line prototype instrument with a sodium iodide detector to measure the impinging natural gamma radiation. (A commercial version

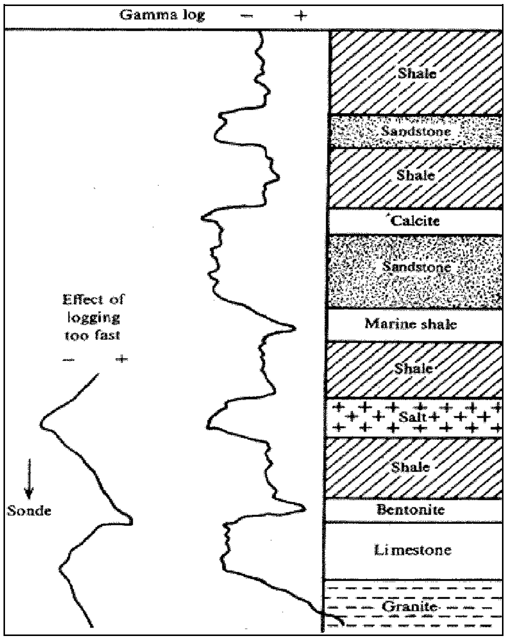

Figure 3 - Typical Gamma Log [7]

of this instrument has been developed since the date of this investigation [9]). The detector was 0.75 inches by 24 inches in size, and was attached to a 200 foot cable. An MGX data logger was connected to the cable. Gamma logging is useful in borings ranging from one to six inches in diameter [1, 3, 6].

Natural gamma logging is the physical measurement of the release of natural gamma radiation from the soil and rocks surrounding a borehole. Natural gamma logging is based on the principle that more intense natural gamma radiation is emitted from clay-rich formations, which are usually higher in naturally radioactive elements, than clay-poor formations. Most natural gamma radiation occurs in clays containing thorium, uranium, or potassium 40. Figure 3 shows a typical natural gamma log for some consolidated sedimentary deposits. Note the higher counts for clay-rich units like shale, particularly marine shale, and bentonite.

Natural gamma measurement begins with the lowering of the detector to the bottom of a hole, allowing it to equilibrate to the different subsurface temperature, and then reeling the detector up the hole at a steady rate of between five and 10 feet per minute (allowing the logging of a 50-foot hole in five to 10 minutes). The level of gamma radiation being emitted by a particular stratum is measured in counts per second (cps). Interpretation of the gamma log depends as much on the absolute value of the gamma counts as it does on the rate of change in gamma counts as the detector passes from one material to the next. Statistical variations in gamma emissions, significant at low counting rates, are smoothed out by integration over a short time interval. If the hole is logged too quickly, however, the smoothing effect leads to erroneous results by shifting the peaks in the direction of logging. The lower left-hand portion of Figure 3 illustrates the result of logging too fast [8].

Multiport soil gas wells were installed at depths between 20 and 60 feet bgs using direct push/hammer (Strataprobe®) technology. The Strataprobe® unit consisted of a dual ram with a hydraulic hammer vibrating component capable of producing a high-frequency impact with an 8,000 pound static reaction weight and more than 35,000 pounds of pullback capacity. The truck-mounted hydraulic percussion hammer unit was used to advance 1.75-inch outer diameter rods with an expendable 2-inch diameter tip into the subsurface until downward progress ceased due to refusal [1, 3].

After refusal, the rods were disconnected at the surface in order to conduct a subsurface natural gamma profile in the borehole to depths of approximately 50 feet bgs. The probe was pushed to total depth (averaging 50 feet), and the gamma logging was conducted from inside the pipe. Permanent vapor sampling points were installed as the pipe was withdrawn [1, 3, 6].

GEOPHYSICAL FINDINGS

Technology Calibration [1, 3]

No calibration of the magnetometer or the EM detector were performed, as this is not general practice.

To calibrate the natural gamma log readings for the Deming site, gamma logs were taken in three existing monitoring wells: MW-102, MW-109, and MW-111. The gamma readings were correlated with the lithology and stratigraphy that had been previously described for these wells. Figures 4 through 6 show the lithologic logs for these wells on the left and the corresponding gamma log on the right.

An examination of the logs revealed an acceptable level of correlation. In each of the gamma logs, the presence of a near-surface layer of silty clay was indicated by an increase in the gamma counts as the detector passed through that material. The individual logs, however, did show a difference in the absolute values of gamma counts for this layer, as gamma counts rose to levels of 115 to 135 cps in MW-109 and MW-111, and to levels of approximately 275 cps in MW-102. The difference in the absolute level of gamma counts probably indicated that the silty layer in MW-109 and MW-111 contained a smaller proportion of coarser materials than it did in MW-102. The near-surface silty layer was present in each of the lithologic logs.

The layer of coarse gravel that was identified in the monitoring well logs at depths ranging from eight to 15 feet bgs can be seen in each of the calibration logs as both a small decline in absolute gamma counts to levels of less than 100 cps and as an increase in the distance from peak to peak in the log. Again, there appears to be a higher proportion of silty materials mixed with the gravel in the log for MW-102, as evidenced by the higher gamma counts for similar materials shown in that log than in the other two gamma logs.

The layer of silty materials present in the lithologic log for MW-109 and MW-111 at approximately 25 feet bgs is identifiable in the gamma logs for those wells. The grading from coarser sand materials into a silty clay can be seen as the gamma count rises above 100 cps. That silty layer was not present in the lithologic log for MW-102, and no indication of such a layer can be seen in the gamma log for that well.

The next interval in the lithologic logs is composed of predominantly sandy materials, although the size of the interval varies across the three wells. In MW-102, this interval extends to an approximate depth of 40 feet bgs, and the gamma log for that well shows small variations in gamma counts which remain in the 150 to 225 cps range. In MW-109, the sandy layer extends deeper to an approximate depth of 48 to 50 feet bgs. This layer can be seen in the gamma log for MW-109 as an interval over which the gamma counts remain largely within a narrow range between 63 and 75 cps. The interval between 25 and 55 feet bgs in MW-111 is largely composed of sand with gamma counts varying between 50 and 100 cps. This interval is interrupted at a depth of approximately 38 feet bgs by a sandy clay material that can be seen in the gamma log as gamma counts rise to approximately 125 cps.

The lithology of these wells over the remaining interval is significantly different. The lithology of MW-102 below 40 feet bgs grades from sandy silt to sandy gravel and back to sandy silt at a depth of 84 feet bgs. The short interval of sandy gravel, shown on the lithologic log from 65 to 75 feet bgs, can be seen in the gamma log as a lower set of gamma counts beginning at approximately 68 feet bgs and extending to 78 feet bgs. The lithologic log shows a gradual coarsening of materials below a depth of 50 feet bgs in MW-109 to a depth of 78 feet bgs. The gamma log for this well, instead, shows a similar coarsening over the interval from 50 feet bgs to 60 feet bgs as the gamma counts gradually decline. From 60 feet bgs to a depth of approximately 75 feet bgs there appears to be a gradual increase in gamma counts. Such an increase may only indicate the presence of silty materials mixed in with the sand that are not readily evident in a visual inspection of the same materials.

Overall, there appears to be an adequate correlation between the lithologic logs and the gamma logs for the three monitoring wells for successful calibration. In addition, the gamma logs reveal the presence of fine-grain materials when the same materials are not noted in the lithologic logs. This may be due to the fact that the lithologic logs were developed for another use and were used here as a matter of convenience, or that gamma readings provide a more sensitive measure of subtle changes in stratigraphic units than can be achieved with a visual inspection.

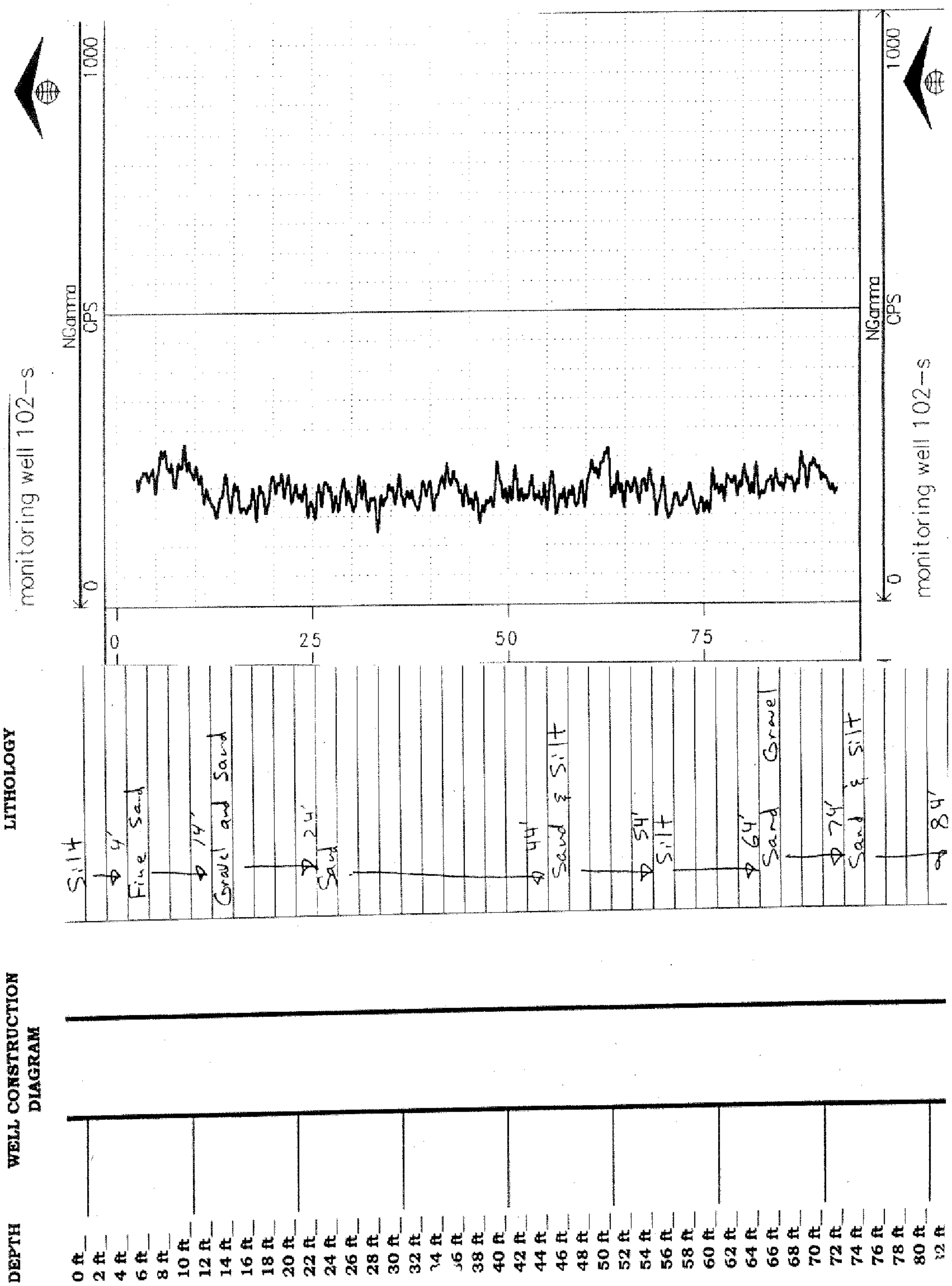

Figure 4: Calibration Logs for MW-102 [3]

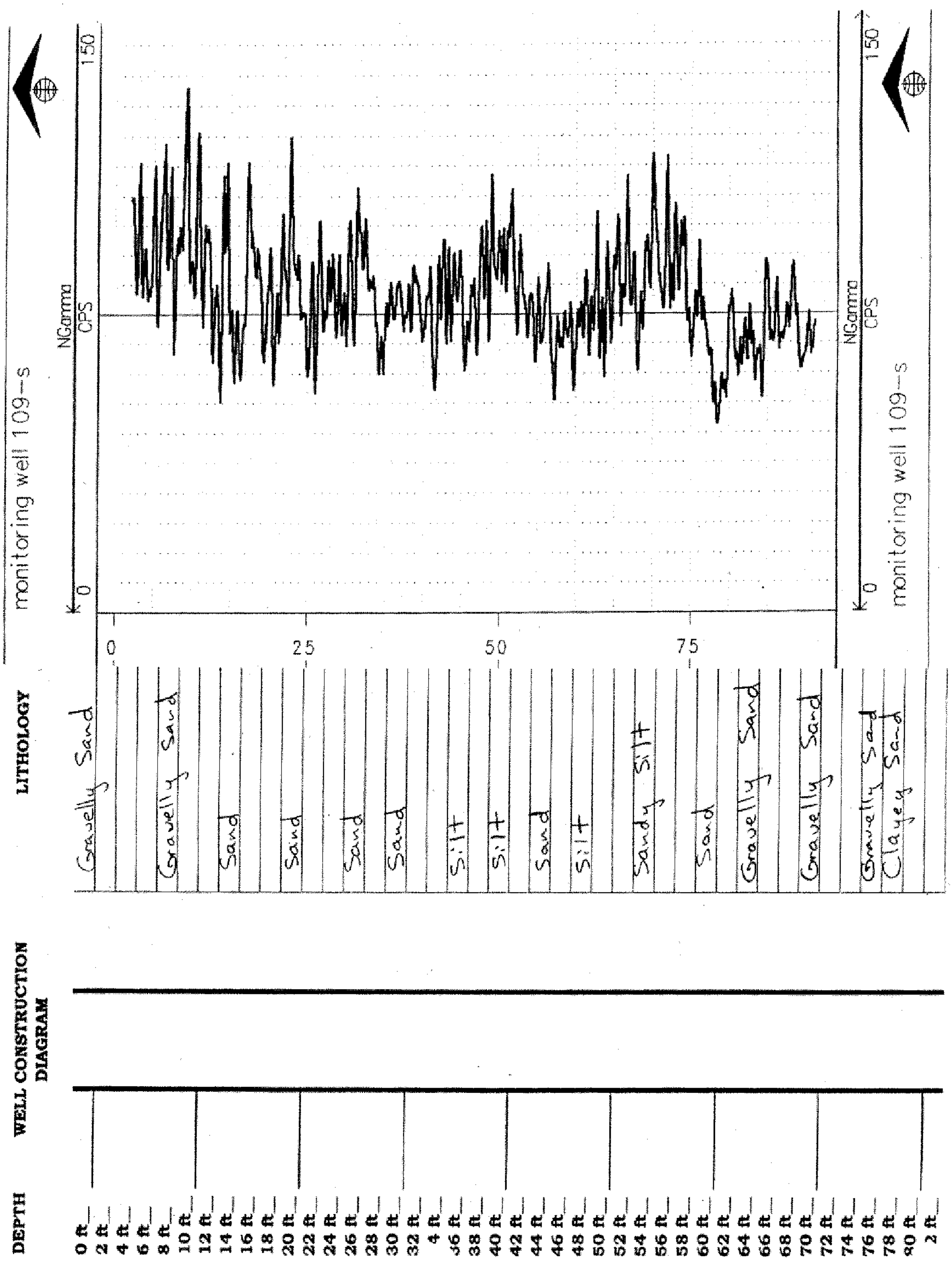

Figure 5: Calibration Log for MW-109 [3]

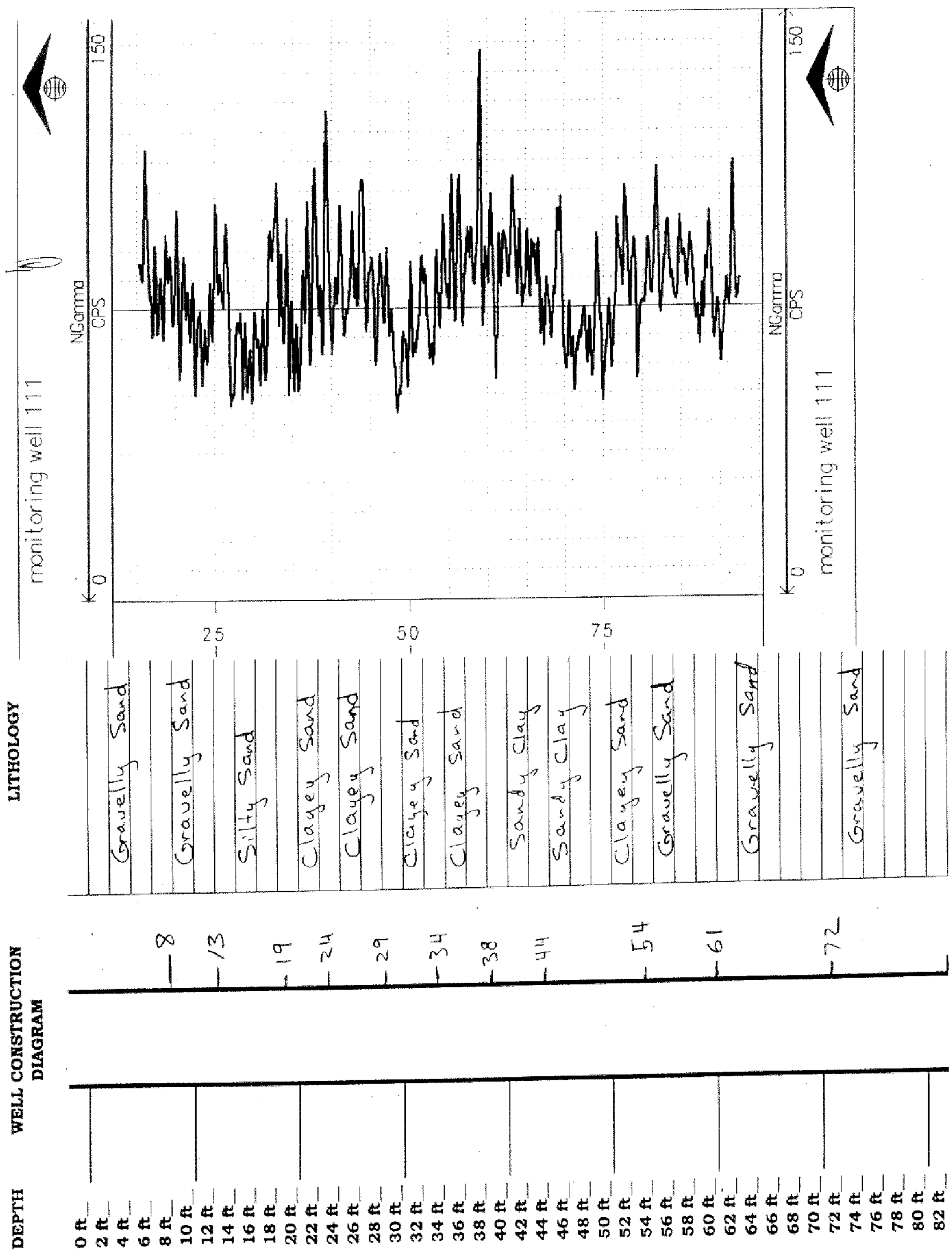

Figure 6: Calibration Log for MW-111 [3]

GEOPHYSICAL FINDINGS

Investigation Results [3]

The reconnaissance survey was conducted over a 25-acre area from July 7 to July 22, 1997. The survey identified numerous areas of buried materials, but only two were of interest. A septic tank was identified to the southeast of the building that had housed the materials testing laboratory. Also identified was another area located approximately 75 feet to the north of the septic tank on the east side of the building. The latter area was described as a concentration of buried metal materials of unknown origin.

The gamma logging and the installation of the soil gas wells occurred between July 8 and July 25, 1997. The installation of the soil gas wells began in the southern part of the Deming site near the septic tank and the area of buried materials to the north in order to determine whether chlorinated VOCs were present in the vadose zone. The area over which vapor sampling points would be placed was based on the results of the reconnaissance survey. The vertical placement of vapor sampling points was based on the field reading of geologic units as indicated by natural gamma logs. Specifically, the gamma logs were used to find permeable layers positioned below impermeable layers. This geologic setting forms a migration pathway for contaminant vapors, and the characterization of migration pathways is an important step in contaminant detection.

An examination of the gamma logs from several holes revealed the presence of a series of fairly consistent layers of sandy clay or similar material beginning at about 15 to 22 feet bgs (just below the gravel), 27 to 32 feet bgs, and finally at 38 to 50 feet bgs, particularly in those wells near the septic system. Beneath each of these layers the subsurface materials tended to grade into coarser, sandy materials. The gamma log signature was reviewed in the field, and from this information certain intervals were selected for the installation of gas points. A more permeable sampling interval (identified by lower gamma counts) was selected for each gas point location. Examples of three gamma logs indicating the presence of clay layers and the location of vapor sampling points are shown in Figures 7 through 9.

In Figure 7, the first vapor sampling point was placed in a screened interval between 25 and 30 feet bgs. At this level, the sampling point was located below the silty material that was present from 20 to 25 feet bgs, shown in the gamma log where the gamma count rises through 124 cps. The silty materials would impede the upward movement of contaminant vapors. The screen was placed in the relatively coarser material (located just below the silty material) through which vapors would be likely to migrate. The second and third screen intervals were similarly located in coarser materials located just below a less permeable layer, indicated in the gamma log by sharp increases in gamma counts.

In Figure 8, the first sampling point is located just below the thin silty layer encountered at a depth of approximately 21 feet bgs. At this depth, it appears that there is an interval of approximately 19 feet of coarse sandy material, and the screen was positioned at the top of this interval. The second sampling point was located in a screened interval between 38 and 43 feet bgs. At this depth, the screen is located toward the bottom of a layer of coarse materials that extends from 31 to 47 feet bgs. The silty layer that would be expected to impede the migration of contaminant vapors is at least eight feet above the top of the screened interval. The third sampling point is located in a screened interval between 55 and 60 feet bgs. In this position, the sampling point is located directly below the silty material that can be see at a depth of 53 feet bgs, where the gamma counts rise sharply to nearly 90 cps.

Figure 9 shows the gamma log for SG09, in which only two vapor sampling points were placed. The first point was located in a screened interval between 21 and 24 feet bgs. At this depth, the sampling point was located directly below the silty layer seen at 21 feet where the gamma counts peak at approximately 70 cps. The lower sampling point was placed in a screened interval between 46 and 55 feet bgs. This screen was placed more to take advantage of the coarse materials located in that interval than to use a distinct impermeable layer located directly above. The coarsing of the materials in this interval can provide a migration pathway for contaminant vapors.

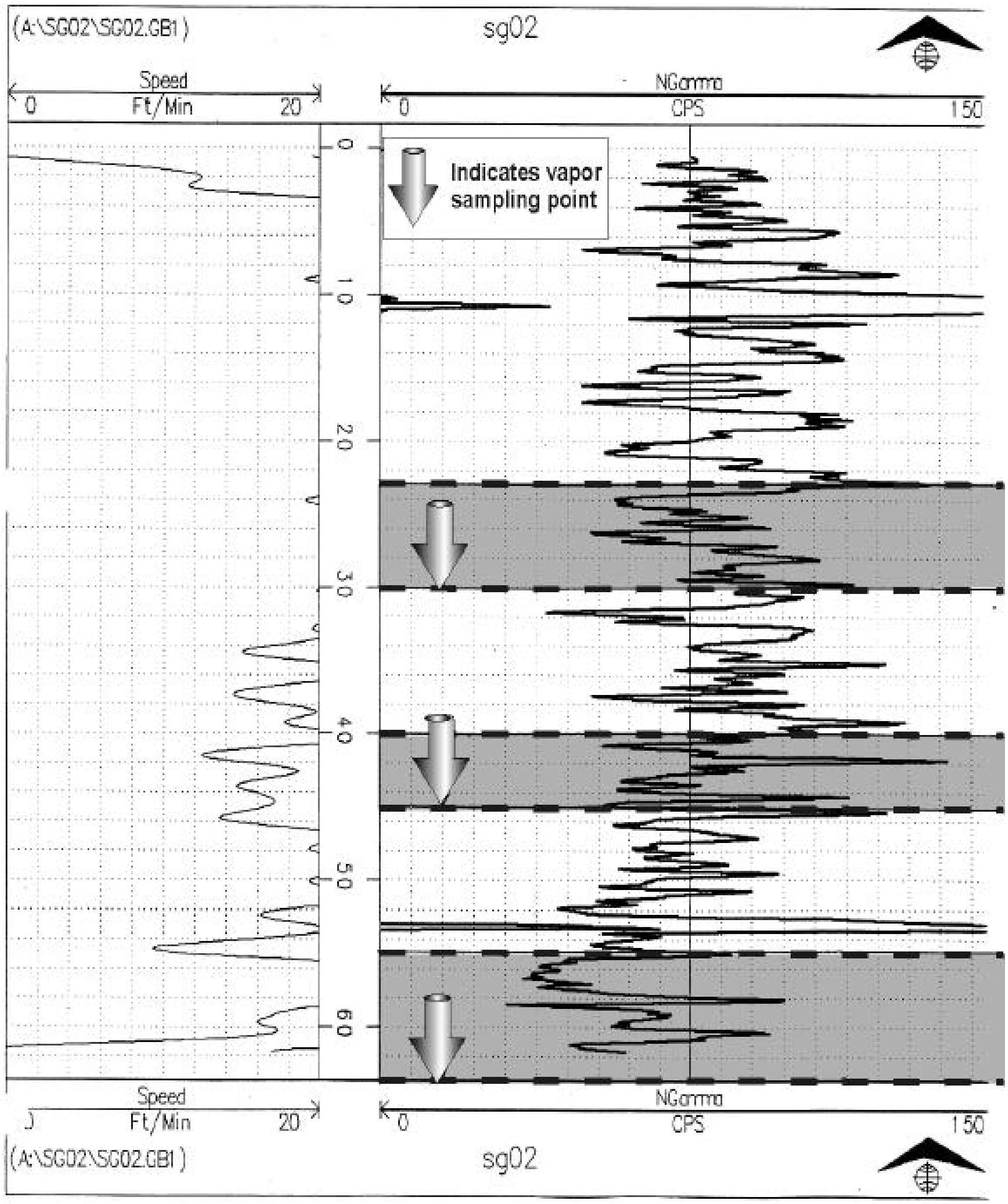

Figure 7: Vapor Sampling Points in SG02 [3]

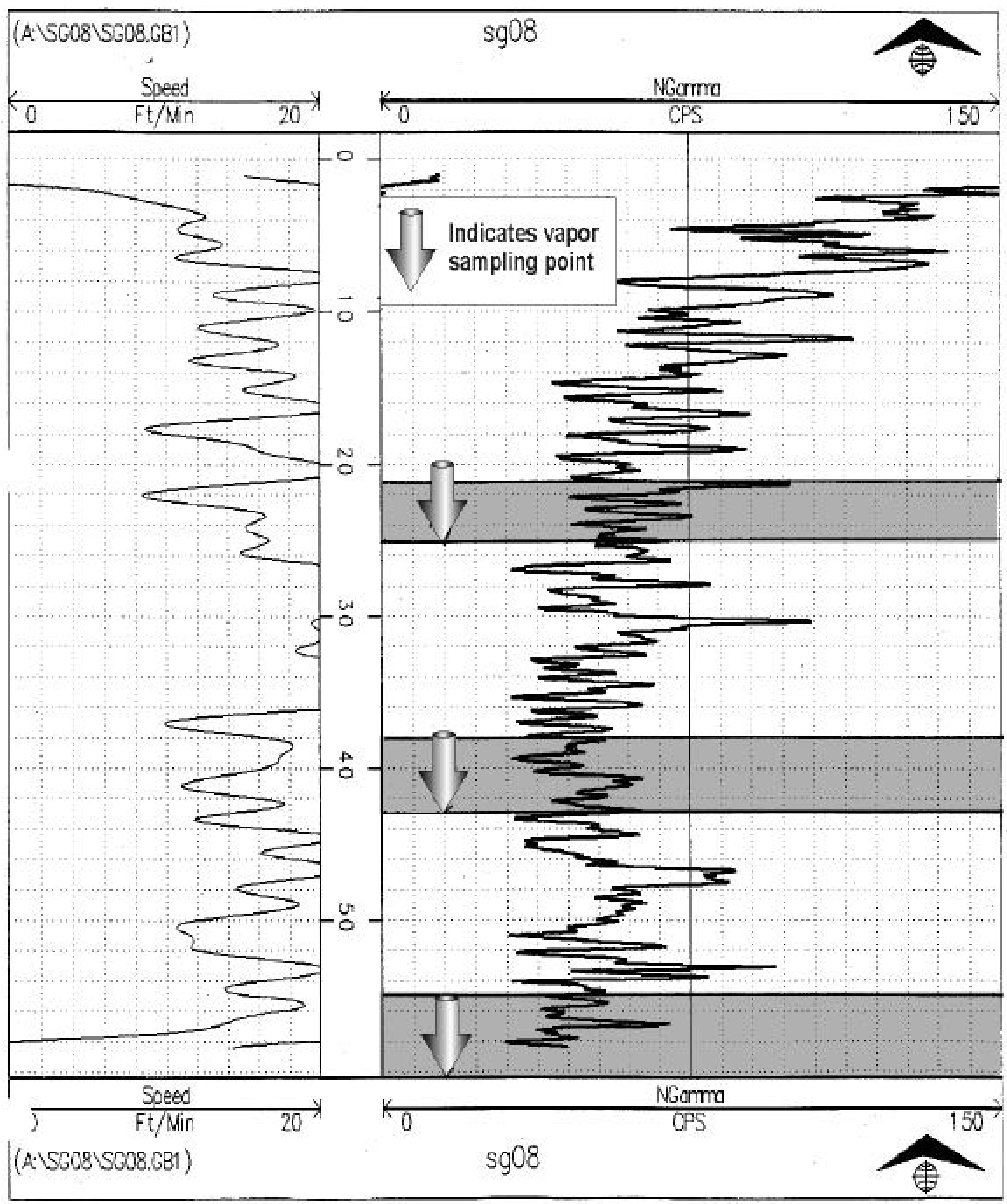

Figure 8: Vapor Sampling Points in SG08 [3]

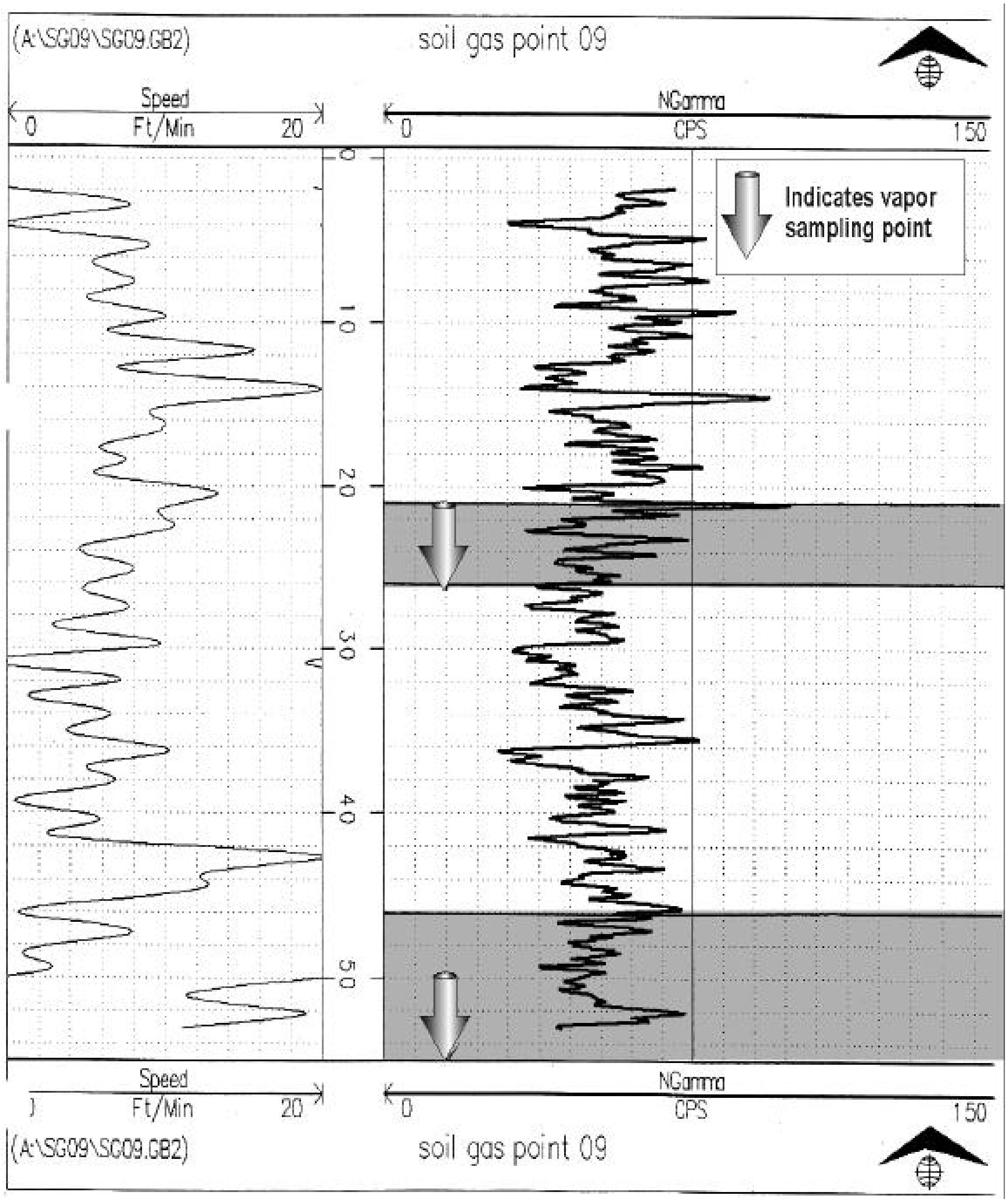

Figure 9: Vapor Sampling Points in SG09 [3]

GEOPHYSICAL FINDINGS

Results Validation [1, 3]

No additional activities were conducted to validate the findings of the natural gamma logging. The results of the soil gas sampling conducted after the installation of the permanent sampling points served as an indirect validation. The distribution of VOC contamination that was revealed was representative of previous sampling, and was centered around the two source areas that had been identified by the reconnaissance survey.

LESSONS LEARNED

There were several important lessons learned during the Deming investigation. These are discussed below.

- Natural gamma readings should be calibrated to the site stratigraphy using site-specific knowledge of local geology. The use of lithologic logs from existing wells can save the time and effort that would be expended if the logs had to be generated during the same investigation.

- Natural gamma logs appear to be more sensitive to subtle changes in stratigraphy than is the visual inspection of lithologic logs, which often is based on the personal interpretation of the geologist.

- The natural gamma logs were used successfully to make well point placement decisions in the field at the time when the sampling points were being installed. In less dynamic investigations, well point placement decisions might be delayed rather than made in the field, potentially resulting in delays in the investigation.

- Because the natural gamma signature does not degrade or decay over time, this information is representative for present and future investigations as well. The same information that was used to guide sampling point locations can be used at a later date to guide the installation of screening intervals for a soil vapor extraction system.

- Gamma logs are a useful tool for identifying interbedded impermeable layers that may be thin and difficult to locate. This tool can be used to guide the placement of subsurface sampling points, or screening intervals for soil vapor extraction or pump and treat systems in geologically heterogenous materials.

REFERENCES

1. Meixner, Richard, et al. *Combination of Downhole Gamma Logging and Soil Vapor Measurements to Track Low Level Chlorinated Solvent Contamination in the Deep Vadose Zone*. Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP 1998) pp. 369-378.

2. Personal communication with Phil Ramos, New Mexico State Highway Transportation Department. September 24, 1998.

3. Daniel B. Stephens & Associates, Inc. *Deming Surface Geophysical Survey and Multiport Soil Gas Well Installation and Sampling*. September 12, 1997.

4. Personal communication with Richard Meixner, Daniel B. Stephens & Associates, Inc. September 8, 1998.

5. L.W. LeRoy, editor. *Subsurface Geology*. Colorado School of Mines, Golden, CO. 1977.

6. Personal communication with Jim Viellenave, TEG Rocky Mountain, Inc. September 17, 1998.

7. Telford, W.M., et al. *Applied Geophysics*. Cambridge University Press. Cambridge, GB. 1984.

8. Personal communication with Jim Viellenave, TEG Rocky Mountain, Inc. September 11, 1998.

9. Personal communication with Jim Viellenave, TEG Rocky Mountain, Inc. September 15, 1998.

PAGE LEFT BLANK INTENTIONALLY