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RECEIVED 2001

October 5, 2001

Ms. Eliza Frank
State of New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East
Building One
Santa Fe, New Mexico 87505-6303

Reference: Work Assignment No. Y513, 06082.500; State of New Mexico Environment Department, Santa Fe, New Mexico; General Permit Support Contracts; Los Alamos National Laboratories (LANL)-1B; Draft Mesa-Top Material Disposal Area; Review of Additional Supporting Technical Documents Referenced in the Interaction Matrix; Task 02a Deliverable

Dear Ms. Frank:

Enclosed please find the deliverable for the above-referenced work assignment. This deliverable consists of two individual summaries for the additional references selected by NMED and used by LANL in developing the site conceptual model for the LANL Material Disposal Areas (MDAs). These additional references include the 1990 Mendoza and Frind article and the 1997 Neeper reference. Both articles have been summarized and reviewer comments are also provided. The deliverable was e-mailed to you on Friday, October 5, 2001, at eliza_frank@nmenv.state.nm.us. The deliverable was formatted in Microsoft Word 2000.

If you have any questions, please feel free to contact Ms. Paige Walton at (801) 582-9329.

Sincerely,

June K. Dreith

June K. Dreith
Project Manager

Enclosure
cc: Mr. John Kieling, NMED
Mr. James Bearzi, NMED
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# TASK 02a DELIVERABLE

# SUMMARY OF ADDITIONAL SUPPORTING TECHNICAL DOCUMENTS REFERENCED IN THE INTERACTION MATRIX

**Los Alamos National Laboratories (LANL)-1B**
**Draft Mesa-Top Material Disposal Area**

**Submitted by:**

**TechLaw, Inc.**
**300 Union Boulevard, Suite 600**
**Lakewood, CO 80228**

**Submitted to:**

**Ms. Eliza Frank**
**Mr. James Bearzi**
**State of New Mexico Environment Department**
**Hazardous Waste Bureau**
**2905 Rodeo Park Drive East**
**Building One**
**Santa Fe, New Mexico 87505**

**In response to:**

**Work Assignment No. Y513, 06082.500**

**October 2001**

*Advective-Dispersive Transport of Dense Organic Vapors in the Unsaturated Zone: 2. Sensitivity Analysis.* **Carl A. Mendoza and Emil O. Frind. Waterloo Centre for Groundwater Research, University of Waterloo, Ontario, Canada. Water Resources Research, Volume 26, Number 3, pages 388-398. March 1990.**

A sensitivity analysis revealed that, for compounds with high vapor pressures and molecular weights, in high permeability environments (coarse sands or gravels), the mass transported by density-dependent advection may greatly exceed that transported by diffusion alone. The opposite is true for a diffusion-controlled system. For either case, an open ground surface contributed to a more rapid depletion of the residual liquid source.

## 1.0 INTRODUCTION

The stated objective of this paper was to gain insight into the parameters and conditions that control vapor transport in general and those that control density-driven advection in particular. This was accomplished by performing a sensitivity analysis on the relevant transport parameters. The scope of the effort was limited to vapor transport in the unsaturated zone in the presence of an immobile soil moisture phase. The time scale considered was short so infiltration (and associated "flushing" of contaminants from the unsaturated zone) was not considered. The vapor was assumed to originate from an immobile source suspended in the pore space. Advection due to external factors such as barometric pressure variations, water table fluctuations, infiltration, and forced advection was not investigated.

## 2.0 PHYSICAL SYSTEM

The system consisted of partially saturated homogeneous sand extending vertically from the top of the capillary fringe to the ground surface. The immobile organic in the pore spaces of the sand was assumed to be at residual saturation.

In the analysis, vapor transport was described by two coupled differential equations: the fluid continuity equation and the advective-dispersive transport equation. The following causes of advective transport were considered:

- The flux arising when vapors are generated at the source; and
- The density gradient arising when the gas mixture locally attains a density greater than that of air.

Both of these processes depend on the source vapor concentration.

Two cases were considered. First, the ground surface was assumed to be open to the atmosphere. Then, the ground was assumed to be covered and impervious. The open ground surface was constrained to be at constant atmospheric pressure and zero concentration. The following factors were investigated: the medium permeability, the source vapor density, the ground surface cover, the medium heterogeneity, and the source and domain geometry (as well as the effect of

source depletion). Time periods of 4 to 16 days were considered. A long-term, steady-state analysis was performed to develop an estimate of the equilibrium vapor distribution that would be reached under idealized, constant conditions.

## 3.0 BASE CASE

It was assumed that a generic organic liquid was spilled into a coarse sand with a permeability of 1.0e-10 $m^2$ (aqueous hydraulic conductivity of $10^{-3}$ m/s). The unsaturated zone was 3 meters deep and had a uniform residual water saturation of 8% with a 30 cm linear transition to full saturation at the top of the capillary fringe. The spill/source had a radius of 1.05 meters and a height of 0.9 meters for a volume of about 3.1 $m^3$ (starting about 0.3 m below the surface). Temperature was assumed uniform at 20°C. The ground was open to the atmosphere.

Conditions found favorable to advective transport were: MW = 100.625 g/mol; free-air diffusion coefficient (Da) = 9.0e-6 $m^2$/sec; viscosity ( $_c$) = 1.0e-5 Pa-sec; $VP_{sat}$ = 182.4 mm Hg; source concentration = 240,000 ppm; relative vapor density = 1.60; Henry's constant (H) = 0.25; aqueous concentration of source = 4,000 mg/L (the compound properties are similar to those for 1,1-dichloroethane). Based on these values most of the domain had a Retardation Factor of 2.0.

The base case was analyzed for advective-dispersive-diffusion transport AND for diffusion only. For the diffusion only case, the plume spread more uniformly over the depth of the unsaturated zone. The rate of advance of the plume was retarded with respect to the advective-dispersive-diffusion transport plume. The slower rate of advance affected the rate of vaporization so that after 16 days the vaporized mass was only 24% of the mass vaporized in the full transport mechanism run. 68% of the vaporized mass was vented to the atmosphere. The effect of atmospheric losses was greater in the pure diffusion case since there were no counteracting downward velocities. Under the full transport mechanism, the plume front advanced twice as far and the plume had about 4 times the volume of the purely diffusive mechanism. In addition, about 4 times as much mass was vaporized at the source and about 10 times as much mass was retained within the domain with less than half as much mass lost to the atmosphere. The paper concluded that the contamination residing in the source was mobilized much more rapidly with advection than with diffusion only.

## 4.0 SENSITIVITY ANALYSIS

### 4.1 Permeability

As the permeability decreased with respect to that of the base case, advection became less important. At a permeability of 1.0e-11 $m^2$ (an order of magnitude lower than that of the base case), transport became dominated by diffusion. The value of permeability at which advection began to play a role (in this analysis) corresponded to that of coarse sand or gravel, while diffusion prevailed for values corresponding to medium or fine sand. The transition from an advection dominated to a diffusion dominated system occurred over a fairly narrow permeability range.

## 4.2 Mass Fate as a Function of Physical Processes

Under a pure diffusion mechanism, the mass vaporized and the net mass in the system increased directly with the source concentration but was insensitive to variations in permeability. Similarly, when the advective mass flux due to vaporization at the source was included, the vaporized and net masses remained insensitive to permeability variations. However, increases in source concentration led to even greater increases in the mass vaporized and the net mass retained. With advection due to density gradients, an increase in the source concentration resulted in a disproportionate increase in the mass vaporized and in the net mass in the domain. At the highest source concentration, the increase in permeability (one order of magnitude) caused a 3-fold increase in the mass vaporized and a 4-fold increase in the net mass. The reason for the increased mass retention was attributed to the sinking of the plume and the corresponding reduction in passive venting to the atmosphere.

The mass mobilized by the vaporization flux and that due to density gradients were of the same magnitude at lower permeabilities. However, at higher permeabilities, the flux due to density quickly dominated. There was a rapid dominance of vapor density as permeability and source strength increased within the sensitive range.

## 4.3 Ground Surface Boundary

In a diffusion controlled system with an open ground surface, relatively large amounts of vapor mass escape to the atmosphere thus slowing plume development relative to the closed surface case. On the other hand, in an advection controlled system, an open ground surface permits a downward directed air stream to pass directly through the source, causing increased vaporization. Downward advection also tends to counteract the diffusive loss of vapor to the atmosphere. Thus, the open surface retards plume spreading in the diffusion only case and enhances it in the advection-diffusion case.

## 4.4 Source Geometry

A simulation was performed assuming that the source extended from 30 cm below ground surface to 30 cm above the top of the capillary fringe. This change produced little effect on the behavior of the system.

## 4.5 Heterogeneities

Common geologic settings exhibit various heterogeneities that may affect flow. An order of magnitude change in permeability for horizontal layers was performed. With respect to density dependent transport, the layered system behaved much like a uniform system having a permeability corresponding to that of the least permeable unit of the layered system.

## 5.0 STEADY STATE

For a given set of constant boundary conditions and a nondepleting source, the vapor plume will expand until it reaches a steady state configuration where the influx from vaporization equals the combined losses. The diffusive plume extends only about half as far radially as the full mechanism plume. Under purely diffusive conditions the plume always expands at a slower rate. The total mass loss to the atmosphere is large for both cases.

In a real situation with a finite source, the boundary conditions would likely change before steady state is reached and the plume would eventually vanish as a consequence of source depletion, flushing, and venting. These procedures determined that the identification of chloroform and 1,2-dichloroethane was incorrect as the mass spectrum scans were actually the result of interferences from other compounds rather than a positive identification of the two compounds.

## 6.0 APPLICATION TO REAL SOLVENTS

The authors point out that to extend the results of their study to real organic solvents, the actual compound properties must be considered. Vapor pressure (which controls the amount of advective transport) and Henry's constant (which controls the retardation) are among the most critical compound properties that must be known for a real problem. Adsorption onto the porous medium must also be included in the retardation factor in real situations.

## 7.0 CONCLUSIONS

The primary controls on density-dependent advection are the vapor pressure and molecular weight of the compound and the permeability of the porous material. Increases in these parameters can lead to large increases in advective transport. The effect of density gradients declines with increasing dilution of the dense vapors. For a localized source, this dilution occurs closer to the source compared to an areal or linear source due to radial spreading.

The transition from a diffusion dominated to an advection-dominated system occurs over a fairly narrow range of permeabilities. Since this transition also depends on the compound properties, density driven advection should be considered in vapor transport analyses whenever the permeability is in the range of a medium sand or higher.

> **<u>Reviewer Comment</u>: In considering an actual case such as the Bandelier Tuff at TA-54, Mendoza and Frind point out that among other property values, the Henry's Law Constant must be known as it controls retardation. This underscores the need to determine the retardation in the Tuff at TA-54 as suggested in Reference 12, *Conceptual Model for Vapor Movement at MDAs: Organic Vapor Plume Movement at MDA L*. Based on the documents reviewed for this work assignment, it is not known if retardation has been studied.**

**<u>Reviewer Comment</u>: Similarly, Reference 12 suggested that consideration should be given to the reliability of the permeability values presented in other LANL documents for the Bandelier Tuff. This is supported by the information presented in Mendoza and Frind which points out that the transition from advective dominated transport to diffusion dominated transport occurs over a fairly narrow range of permeabilities. Further, the upper end of the range of permeabilities reported in Reference 12 for the Tuff (1e-11 $m^2$) corresponds to the maximum value of permeability indicative of diffusion dominated transport reported by Mendoza and Frind. Therefore, LANL and NMED should be sure that the upper range of Tuff permeabilities has been adequately defined. (Reviewer's Note: A typographical error in Reference 12 was identified after review of the Mendoza and Frind paper. Mendoza and Frind found that a permeability of 1e-11 m2 was the maximum value indicative of diffusion dominated transport. This value was reported as 1e-11 cm2 in Reference 12, leading to confusion as the range of permeabilities reported for the Tuff was greater than 1e-11 cm2, indicating that transport should be dominated by advection. Based on the text of Reference 12, this appears to have been a typographical error as all comparisons and conclusions were based on the value reported in Mendoza and Frind.)**

**<u>Reviewer Comment</u>: The Mendoza and Frind paper referenced in Reference 12 described a sensitivity analysis performed on a model derived to determine the importance of advection in the transport of organic vapors. However, the physical scenario considered in the derivation of the model and in the sensitivity analysis differed from the physical conditions at TA-54. LANL applied the results of the Mendoza and Frind analysis to TA-54 without documenting the applicability of the study to conditions at TA-54. Further, it is not clear that consideration was given to chemical property values such as vapor pressure, Henry's Law constant, and molecular weight as suggested by Mendoza and Frind. The review underscores the need for LANL to relate the conditions and findings from the Mendoza and Frind paper to TA-54 as originally suggested in the reviewer comments on Reference 12. Such a discussion would improve the clarity and transparency of the information presented by LANL on vapor transport in the Bandelier Tuff Comment on the need to relate conditions assumed in this paper to conditions at TA-54.**

***Monitoring of Pore Gas Pressures and Chemical constituents at Wells 54-1015 and 54-1016 During 1995 and 1996.*** **Donald A. Neeper. Science and Engineering Associates, Inc., Santa Fe, New Mexico. SEA-SF-TR-97-170. Los Alamos National Laboratory, Los Alamos, New Mexico. LA-UR-01-3808. October 1997.**

Pore gas pressures and pore gas concentrations beneath MDA L at well 54-1015 and 54-1016 were measured during 1995 and 1996.

The pore gas pressure measured in the vesicular basalt underlying MDA L closely followed barometric changes, indicating that the basalt was "connected" to the atmosphere by a low impedance path. In the Bandelier Tuff, the response to barometric pressure decreased with depth from the surface to the Tsankawi pumice layer and increased with depth from that layer to the basalt. In response to barometric fluctuations, the pore gas appeared to flow vertically above and below the Tsankawi. But the Tsankawi appeared to combine different vertical flows horizontally.

Chemical concentrations ($SF_6$ tracer gas) in the pore gas did not show clear-cut responses to changes in barometric pressure. The concentration measurements indicated that the pore gas in the basalt was being replaced by fresh atmospheric air at a maximum rate of 1% per day.

## 1.0 INTRODUCTION

It was anticipated that barometric pumping, forced vapor extraction, or a combination of the two could be utilized to remove unwanted VOCs or water vapor from the vadose zone. As such, the objective of the work described in this paper was to characterize subsurface flow of gas induced by natural forces or by mechanically applied vacuum. The document provided interim archival documentation of pore gas flow at MDA L.

## 2.0 GEOLOGIC SETTING AND WELL CONSTRUCTION

Wells 54-1015 and 54-1016 were drilled in late 1994 to March 1995 to investigate the nature and extent of contamination at depths greater than 300 feet beneath MDA L. The boreholes were angled at approximately 30° from vertical.

Although the Bandelier Tuff beneath the mesas is usually quite dry, moisture was encountered during drilling in a soil layer that lay atop the basalt.

Well 54-1015 was drilled first. Backfilling of 54-1015 was suspended while 54-1016 was being drilled in the basalt because drill air blew upward out of 54-1015. This was attributed to a high permeability connection across a horizontal distance of approximately 400 feet (i.e., the wells were separated by approximately 400 feet).

## 3.0 INTERACTION OF THE BASALT WITH THE ATMOSPHERE

Pressure histories from well 54-1015 were as expected at angle depths of 43 and 188 feet. At 351 feet, the pressure variation was greater than at 43 feet. Pressures measured in the basalt (angle depths from 379 through 526 feet) were closest to atmospheric pressure and responded to barometric changes in a fraction of a day. This suggested the existence of a low-impedance pneumatic connection like a lava tube or a rubble layer that was open to the atmosphere.

Detailed monitoring of both wells began in the spring of 1996. Data acquisition problems were encountered at 54-1016 for ports B through F. Reliable data were available for ports 16A and 16G only. A comparison of the results for Ports A and G of both wells showed that the response to barometric change was nearly identical. This indicated that resistance to horizontal flow in the basalt was small. Based on the observed, regular behavior of the pressure difference between ports 15G and 16G (port 16G was approximately 50 feet deeper) and the peaks in barometric pressure, it appeared that the basalt received barometric pressures from a depth below that of 16G, with a consequent vertical component of flow.

It was concluded that the Tuff experiences barometric pressures both from the ground surface and from the basalt. And further, the basalt is vented to the atmosphere at some unknown location and locally offers little resistance to flow across horizontal and vertical distances of hundreds of feet.

## 4.0 CHEMICAL CONSTITUENTS OF THE PORE GAS

LANL looked for TCA, TCE, PCE, $CO_2$, $SF_6$, and $H_2O$ for about ten days at each well. Analysis of gas from the ports of the completed wells yielded the most reliable data. It was believed that only TCA was detected in the basalt in the range of 2 to 5 ppmv. Collected data suggested that $SF_6$ (injected with drill air) concentrations in the basalt may have decreased by about 1% per day.

The report presented a seven day history of pressure and concentration data for 54-1016. No firm conclusions could be drawn from the data on the short-term effects of barometric fluctuations on concentrations in the Tuff. Data taken from the basalt showed pronounced decreases in $SF_6$ concentration coincident with barometric pressure rise. It was concluded that rising barometric pressure might be introducing air into the basalt at a region lower than the port depths with corresponding flow into the overlying Tuff. In the Tsankawi pumice the $SF_6$ concentration appeared to reduce by about 1% per day during the seven day period. However, no consistent trend could be discerned from $SF_6$ concentration data collected from the basalt over the same time frame. When $SF_6$ concentrations at various depths were considered, it was concluded that advection replaced less than 1% of the pore gas each day. While the basalt received nearly the full magnitude of barometric pressure changes, it was not swept by fresh air on a weekly or even a monthly basis. It was concluded that an accurate assessment of concentrations in the basalt would require a few weeks of dedicated monitoring.

## 5.0 ANALYSIS OF PRESSURE DATA

The balance of the paper describes the analysis of detailed pressure data collected at 54-1015 over a sixty four day period in 1996. The data were analyzed by harmonic analysis. Appendix B of the document provided an overview of this technique.

At each depth, a distribution of pressure amplitudes exists. Harmonic analysis showed that higher frequency components were attenuated more rapidly with depth than the lower frequencies. An absence of high frequency components was observed at an angle depth of 188 feet (i.e., the horizon of the Tsankawi pumice). The high frequency components reappeared as the depth approached the basalt supporting the conclusion that the basalt was vented to the atmosphere by a path more direct than through the overlying Tuff.

## 6.0 CAVERN AND MATRIX MODELS OF THE BASALT

The connection of the basalt to the atmosphere was analyzed via amplitude ratios (fraction of barometric amplitude of a particular frequency component that penetrates to a given depth) and phase shifts (time required for a particular frequency component to travel from the atmospheric connection to the given depth) of pressure components. Two models were proposed, the matrix and cavern models. Data from four ports were examined to determine which model provided the best fit.

> Matrix model: The basalt is considered as a uniform layer with one dimensional flow in a matrix having large, but finite, permeability and porosity. The model assumes that the permeability of the layers above and below the basalt is much smaller, thus, vertical flow through the basalt may be neglected. The amplitude of pressure and the volume of a periodic flow become smaller as the flow penetrates deeper into the layer.
>
> Cave model: This model represents the periodic flow of air into and out of a large volume. All flow resistance is located at the atmospheric boundary (e.g., mouth of a cave).

At port 15A, the matrix model provided the best fit for amplitude ratio. At the Tsankawi pumice (port 15B), the amplitude ratio appeared to be a poor indicator of flow. This was attributed to the larger permeability of the unit, especially compared to adjacent units. It was hypothesized that horizontal flow occurs in the Tsankawi pumice and local pressure amplitude is the result of flow from multiple pathways to the atmosphere. At port 15D (basalt), the cavern model provided a significantly better fit to the amplitude ratio data.

The phase shifts at ports 15A and 15C were best fit by the matrix model. At port 15D, the matrix model deviated from the phase data for large periods and the cavern model deviated systematically at short periods (high frequencies). This was attributed to all of the resistance to flow being concentrated in the neck of the cavern for high frequencies. The observed deviation at high frequencies suggested that not all flow resistance was at the connection to the

atmosphere. Enough of the resistance was distributed along the flow path to shift the phase of the higher frequencies. At port 15B (Tsankawi pumice), the phase shift data exhibited almost no correlation with period, except for periods longer than ten days. If, as hypothesized, the flow in the Tsankawi pumice occurs via multiple pathways, the low frequency components would be dominated by a single vertical path through the rock matrix and, therefore, best described by a matrix model.

The document concluded that for periods longer than one day, the basalt responded like a cavern with a flow resistance at the mouth. Further, it was stated that the amplitude and phase data supported the conjecture that significant horizontal flow occurs in the Tsankawi pumice.

## 7.0 CONCLUSIONS

The basalt behaves like a medium with permeability of hundreds or thousands of darcies. It appears to be vented to the atmosphere and transmits atmospheric pressure fluctuations to the bottom of the Bandelier Tuff.

The quantitative rate of vapor removal could not be ascertained from the analyses described in this document. The quality and duration of the efforts were cited as problem areas.

The analyses appeared to support the hypothesis that the Tsankawi pumice layer conducts flow horizontally by combining pressure signals that arrive at different horizontal locations.

The analyses determined that the Bandelier Tuff at MDA L is exposed to atmospheric pressure fluctuations at the ground surface and at the top of the basalt.

For the soil layer overlying the basalt, the near saturation conditions suggested that water may not penetrate through to the basalt. While it was hypothesized that the soil layer and the moisture present might protect the basalt from VOC contamination, no firm conclusions were drawn from the analyses performed and described in this document. The authors stated further that due to the irregularity of the overlying soil layer, a direct measurement of the gas permeability of the soil layer at one location would not facilitate a firm conclusion regarding the influence of the layer on gas flow and vapor exchange with the Bandelier Tuff. Future efforts might include the use of harmonic analysis to estimate an area-average permeability of the soil layer from the data collected at wells 54-1015 and 54-1016.

> **<u>Reviewer Comment</u>: Based on the documents reviewed under this work assignment, it is not known if an area-average permeability was determined for the soil layer overlying the Basalt beneath MDA L. Knowing this parameter value would aid in understanding the effect that the soil layer has on vapor flow between the Tuff and Basalt.**

While the basalt is closely coupled to atmospheric pressure, the analyses performed and described in the document were not sufficient to determine if the ventilation rate in the basalt was

great enough to remove vapors before they reached the aquifer. Based on this study, it was concluded that the upper limit for replacement pore gas beneath MDA L was approximately 1% per day.

Other studies at LANL included achieving automatic monitoring of pore gas contaminants near MDA L with variation of a few percent or less during weeks of duration. Similar monitoring at 54-1015 and 54-1016 using $CO_2$, $O_2$, and $SF_6$ as tracers could provide a firm estimate of the desired ventilation rate. It was hypothesized that such a monitoring effort should be at least 30 days in length.

> **<u>Reviewer Comment</u>: Based on the documents reviewed for this work assignment, it is not known if this type of monitoring was implemented at wells 54-1015 and 54-1016. Further, it is not known if any analysis or monitoring of any kind was performed for the purpose of developing an estimate of the ventilation rate in the Basalt beneath MDA L.**

> **<u>Reviewer Comment</u>: Reference 12, *Conceptual Model for Vapor Movement at MDAs: Organic Vapor Plume Movement at MDA L*, cited this document as the source of air permeabilty values for the Basalt in the range of $2x10^{-6}$ to $10^{-4}$ $cm^2$ (240 to 1200 darcies). According to the Neeper document, the range represented the upper limit of permeability in the Basalt, calculated in the harmonic analysis for the 0.33-day component of the pressure distribution and corresponded to porosities in the range of 0.1 to 0.5, respectively. The text stated further: "The connected porosity in the basalt may be sufficiently nonuniform that Darcy's law, and the associated parameter of permeability, do not apply."**

> **Reference 12 also cited the Neeper document as the basis for stating that the Basalt was readily connected to the atmosphere. The information contained in Neeper does suggest that pore gas pressure in the Basalt closely follows barometric changes. This was concluded from measurements and supported by the results of the harmonic analysis.**

> **<u>Reviewer Comment</u>: Reference 26, *Interaction Matrix No. 11.11, Intermediate Groundwater - Observation of Perched Groundwater in Cañada del Buey*, states that methylene chloride and trichlorofluoromethane were detected in well 54-1015 at 523 feet beneath the mesa top. Benzene, bromochloromethane, 1,1,1-trichloroethane, truchlorofluoromethane were detected in well 54-1016 at depths from 129 to 597 feet beneath Mesia del Buey. It should be noted that the pore gas concentration measurements described in Neeper 1997 looked at only six gases. Of the compounds reported as detected in Reference 26, only 1,1,1-trichloroethane was addressed in the analyses described in the Neeper document. Neeper concluded that TCE contamination likely did not extend into the Basalt. Reference 26 must be reviewed to determine if TCE detection occurred within the Basalt. Reference 26 also discussed an area of perched ground water found at 592 feet beneath Mesita del**

**Buey. This was confirmed in the Neeper document where the unit was described as an irregular soil layer experiencing near saturation conditions.**