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Date: May 19, 2003
Refer to: RRES-WQH: 03-110

Ms. Vickie Maranville
Environmental Scientist
Hazardous Waste Bureau
New Mexico Environment Department
P.O. Box 26110
Santa Fe, New Mexico 87502

SUBJECT: TA-21-57 ABOVEGROUND STORAGE TANK DIESEL RELEASE, SUPPLEMENTAL INFORMATION

Dear Ms. Maranville:

Thank you for the opportunity provided to our staff to meet with you and Lorena Goerger, of the NMED Petroleum Storage Bureau, on May 5, 2003 to discuss the "TA-21-57 Aboveground Storage Tank Diesel Fuel Oil Environmental Assessment and Characterization" Report and "Tier 1 Evaluation" Report. As discussed during this meeting, the Laboratory conducted an initial assessment of the diesel release, and performed a diesel plume volume modeling application dated May 2002, to estimate the volume of diesel in the underlying geological matrix. Per your request, I have enclosed a copy of the "TA-21-357 Diesel Leak: Plume Volume Estimate" (Plume Volume Estimate) Report for your review (Please see Enclosure 1).

It should be noted that the Plume Volume Estimate Report was developed to provide an estimated volume of diesel in the underlying geological matrix based on sampling results from the analytical laboratory. The Laboratory used a nearest neighbor algorithm model to estimate a diesel plume volume. Conclusions and discussions concerning diesel plume extent and characteristics are further developed in the Characterization Report, dated May 2003, which was written with the benefit of much additional information. For example, it should be noted that no free product was measured during field observations of the boreholes during drilling operations. This was recently confirmed in March 2003, during depth assessments of the boreholes. Based on our meeting on May 5th, the Laboratory will update the aforementioned reports to address your comments and concerns. It is my understanding that you will provide these comments in writing in the near future.

Please contact Mark Haagenstad (505) 665-2014 or Mike Saladen at (505) 665-6085 should you have questions or need additional information regarding this matter.

Sincerely,

Steven Rae
Group Leader
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TA-21 Bldg 357 Diesel Leak: Plume Volume Estimate

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LA-UR-02-2938

Abstract

Diesel fuel leaking from an underground pipe at TA-21-0357 has resulted in high subsurface diesel concentrations to a depth of at least 150 feet below ground surface. The plume appears to be centered on the section of leaking pipe, with a maximum lateral extent of between 10 and 20 feet. A nearest neighbor growth algorithm was implemented to estimate the volume of the subsurface plume based solely on the measured data. We estimate that approximately 50,000 gallons of diesel fuel oil is contained in the subsurface. Given that the total volume of diesel available to create the plume is very close to 50,000 gallons, we believe that the entire volume of the tank could have easily drained into the unsaturated zone at this site. Calculations based on the physics of oil transport in porous rocks can be used effectively to shed light on the fate and transport of the diesel plume. For example, high diesel saturation (>40%) found at 85 ft below ground surface suggests that a slug of diesel is continuing to move deeper into the unsaturated zone.

Introduction

An above ground storage tank (TA-21-0057) containing back-up fuel oil for the TA-21 steam plant (TA-21-0357) was found to be virtually empty in February, 2002. The tank has a maximum capacity of 50,000 gallons and the tank was connected to the steam plant via an underground pipe. Analysis of fuel reciepts for the last 8 years (1994-2002) for this tank show that no more than 52,936. gallons of diesel were stored or added to the tank. This number provides a reasonable maximum upper bound on the plume volume estimate and constrains the maximum extent of potential migration in future studies of multi-phase transport in support of the remedial activites.

Removal of the underground pipe showed clearly that corrosion had compromised the pipe near the conjunction of the pipe and the building. Geoprobe sampling confirmed that the near surface region of contamination was centered on the area of the leak with concentrations dropping laterally from the source region. Eight vertical and two angled boreholes were installed to find the vertical extent and magnitude of the plume (Figure 1, Table 1). Vertical borehole V1, drilled to a total depth of 175 ft, was placed within a few feet of the surface expression of the leak. This location was chosen to be very close to the highest expected subsurface concentrations while facilitating drilling. Vertical boreholes V2-V8 were then installed radially around V1 with angled holes A1 and A2 designed to explore the extent of the plume beneath Building TA-21-0357.

Subsurface Plume Volume Model: Set-up and Assumptions.

To investigate the volume of the plume, we created a finite volume mesh that is 49.2 ft. x 49.2 ft x 164 ft. deep. The mesh is designed to encompass the majority of the data collected in the sampling boreholes, with borehole V1 located on Figure 2 at x=23.75 ft., y=23.75 ft. The mesh contains 97,061 points. Measured diesel concentrations were next mapped onto the nearest point of the finite volume grid. After the measured data were assigned, a nearest neighbor algorithm that allows only one generation of growth per loop through the grid was used to generate a plume volume estimate. Thus, each data value is a nucleus for a zone of influence that grows only one point in each orthoganl direction (x,y,z) during a single search loop through the grid. The nearest neighbor algorithm both maintains the measured data points with no smoothing and helps to show areas of the domain that are not well constrained by the data.

Assumptions in the volume estimate model include:

1) observations that porosity can be very low (26%) in the welded section of Tshirege Unit 2 from 105-155 ft depth, while the remaining porosity is probably close to 50% [LA-12934-MS],

2) Diesel N0. 2 has a density of 0.84 g/cc [Chevron website http://library.cbest.chevron.com/lubes/chevmsdsv9.nsf],

3) Grain density of the tuff is approximately 2.65 g/cc [LA-12934-MS],

4) Concentration has been converted from mg(diesel) per kg(rock) into mg(diesel) per liter of pore space.

Results and Discussion:

The nearest neighbor approach yields a plume estimate of approximately 50,000 gallons in the subsurface at this site.

Figure 3 displays a three dimensional view of the domain including cross-section A-A' and three horizontal planes at 45', 85', and 105'. Concentration is shown in log scale, with the maximum color (red) fixed at 100,000 mg/L.

Figure 4 shows cross-section A-A' which runs through (from east to west) boreholes V4, V3, A1, V1, A2, V5, and V6 . This estimate clearly shows the effects of having only one borehole below 125 ft. For example, boreholes V4 and V6 are seen to constrain the lateral limits of the plume to a depth of 105', while in the region of 145' depth, the only data point (V1) has grown laterally to encompass the entire domain from 140 to 150 feet depth .

Figures 5-7 show the nearest neighbor plume estimate on horizontal planes 45', 85', and 105' below the surface. Limited data for regions of y>35 ft.(top of the figure) leads to probable overestimation of the plume in this region, because the only data with y>35 ft comes from borehole A2. However, boreholes near the bottom, left and right boundaries show that the extent of the plume in these directions is well constrained at these three depths.

Finally, we estimate diesel saturation in the subsurface below borehole V1. Residual water content is assumed to be zero. Porosity in assumed to be 26% in the interval from 105 ft. to 155 ft. depth and 50% everywhere else. Bulk rock density is only a function of grain density and porosity. Figure 8 shows a vertical profile of estimated diesel saturation on cross-section A-A'. Although the estimated saturations are below 100%, multiphase flow dynamics [Fetter, 1999; Kostecki and Calabrese, 1992] suggest that downward flow is probably occurring in the region between 85 - 105 feet depth, while downward flow may be occuring between 105-145 feet depth.. Additionally, although the maximum measured concentration is 141,000 mg/Kg, the possiblilty exists for higher concentrations to be found near borehole 1V which would yield higher estimates of in-situ saturation. Simple measurements of residual diesel saturation in the rocks below the leak could provide much needed data on the ability of the plume to continue migrating. Additionally, collecting diesel in the bottom of borehole V1 from a screned interval located between 85-125 ft. could help considerably to remove free product and reduce the future potential of the plume to migrate.

Conclusions

The nearest neighbor approach yields a plume estimate of approximately 50,000 gallons in the subsurface at this site. This estimate is very close to the total amount of diesel available during the years 1994 - 2002. The plume extent has been well characterized by the borehole sampling plan, showing that a region of significant diesel saturation exists from 85-105 ft. below the surface, with the potential for continued migration to greater depths.

References

"Contaminated Soils: Diesel Fuel Contamination", 1992, P.T. Kostecki and E.J. Calabrese, Lewis Publishers, 227 p..

"Contaminant Hydrogeology", 1999, C.W. Fetter, Prentice Hall, 500 p..

"Earth Science Investigations for Environmental Restoration- LANL TA-21", June 1995, D.E. Broxton and P.G.Eller, LA-12934-MS.

"Design of Remediation Systems", 1997, J. Wong, C. Lim, G. Nolen, CRC Press.

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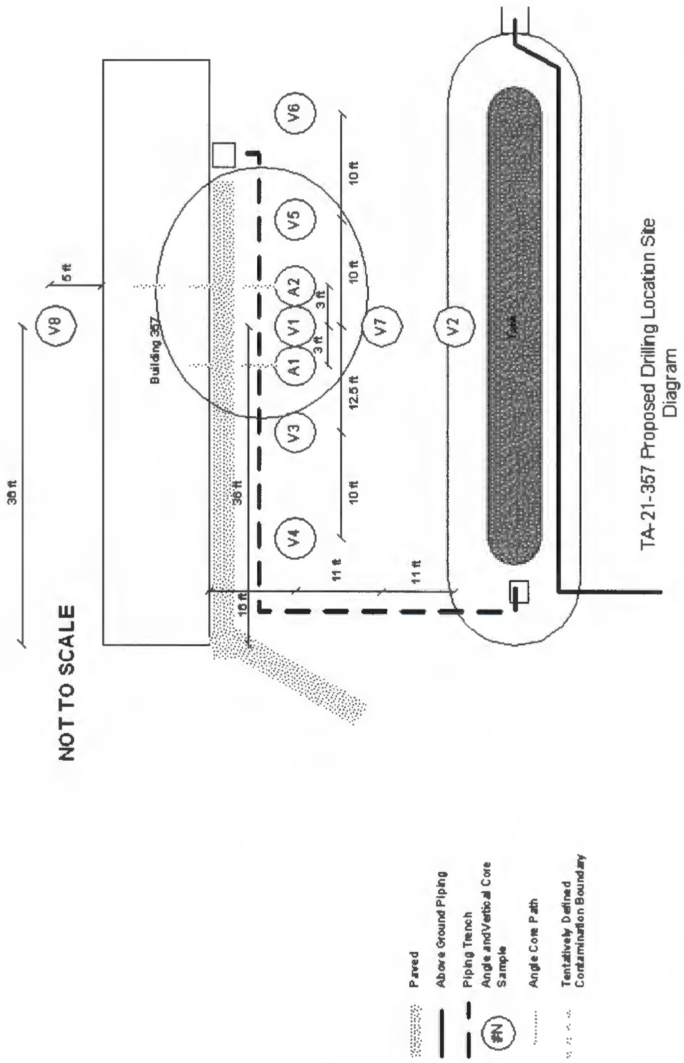
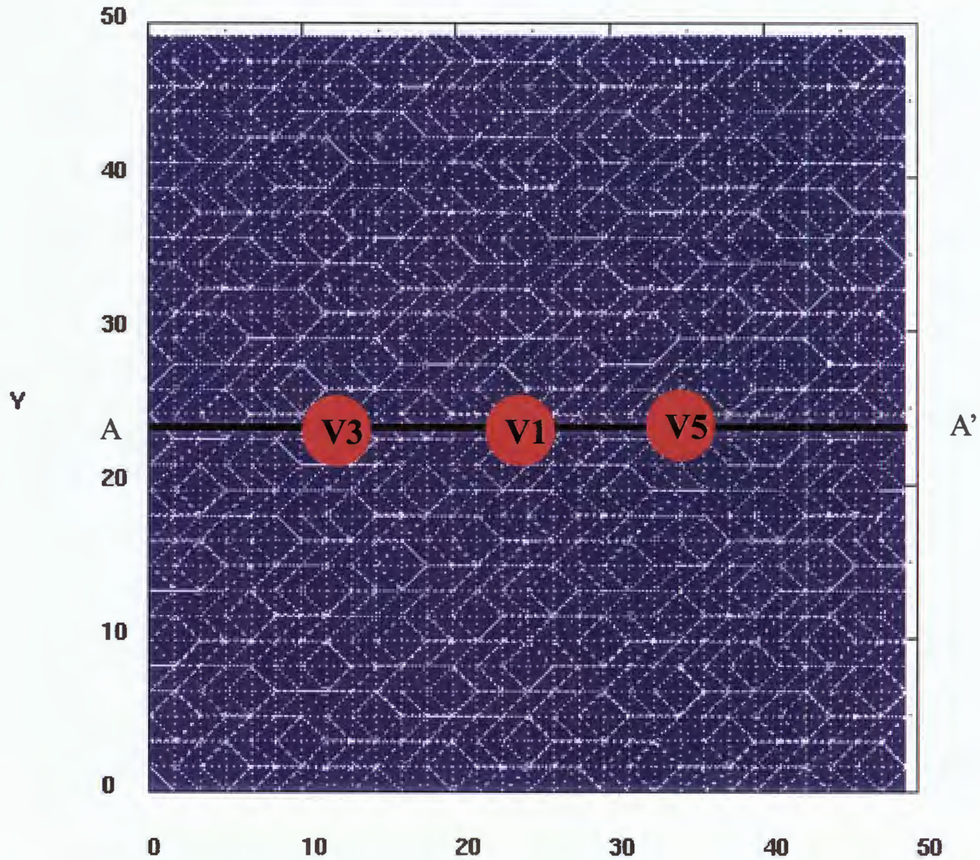
Table 1: Selected Data from Boreholes V1, V5, A1, and A2 [FWO/General Engineering Labs] Concentration in mg of petroleum per Kg of core.

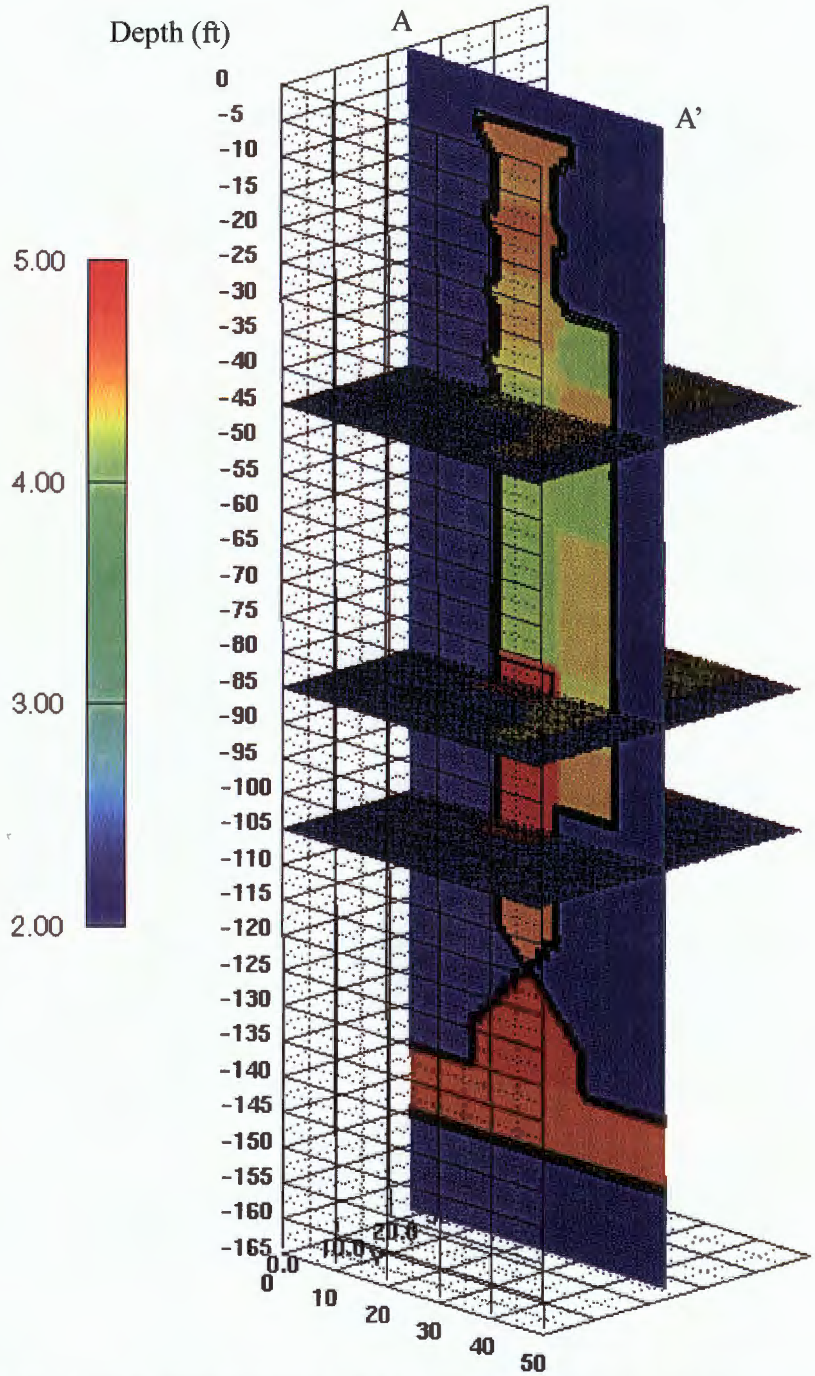
V1 depth (ft) : concentration mg/ Kg	V5 depth (ft) : concentration mg/ Kg	A1 actual depth (ft) : concentration mg/ Kg	A2 actual depth (ft) : concentration mg/Kg
8 : 31900.	25 : 20.	16.4 : 14700.	13.6 : 13600.
25 : 30800.	35 : 12900.	24.6 : 25000.	22.7 : 27300.
45 : 14600.	45 : 25200.	32.8 : 12500.	31.7 : 13600.
65 : 12600.	55 : 13300.		40.8 : 16700.
85 : 141000.	65 : 21800.		49.9 : 204.
95 : 88000.	75 : 22100.		58.9 : 2.8
105 : 44500.	85 : 18700.		
135 : 29800.	95 : 27600.		
145 : 22300.	105 : 22.9		
155 : 48.7	125 : 1.3		



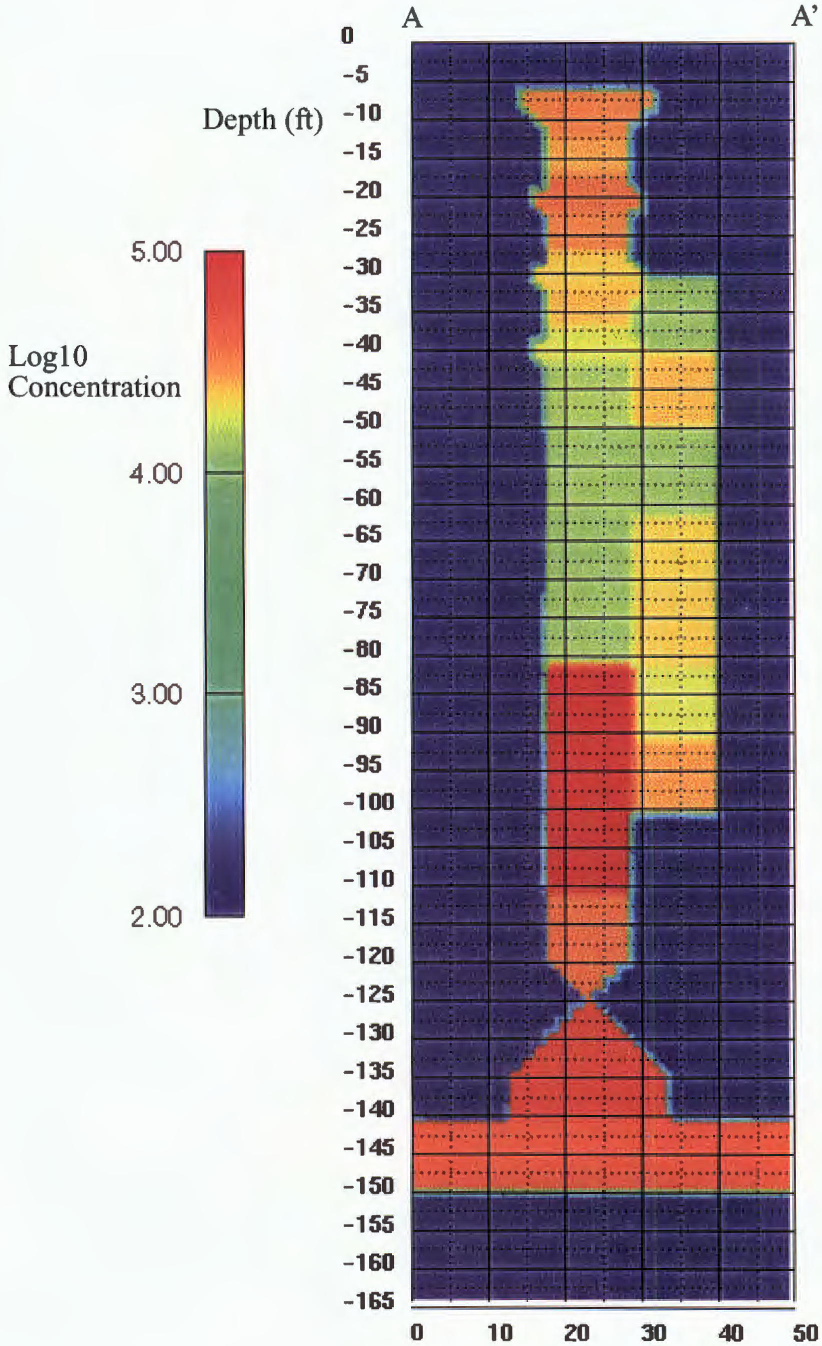
1. Figure 1) Borehole locations with respect to Building TA-21-0357 and Tank TA-21-0057.



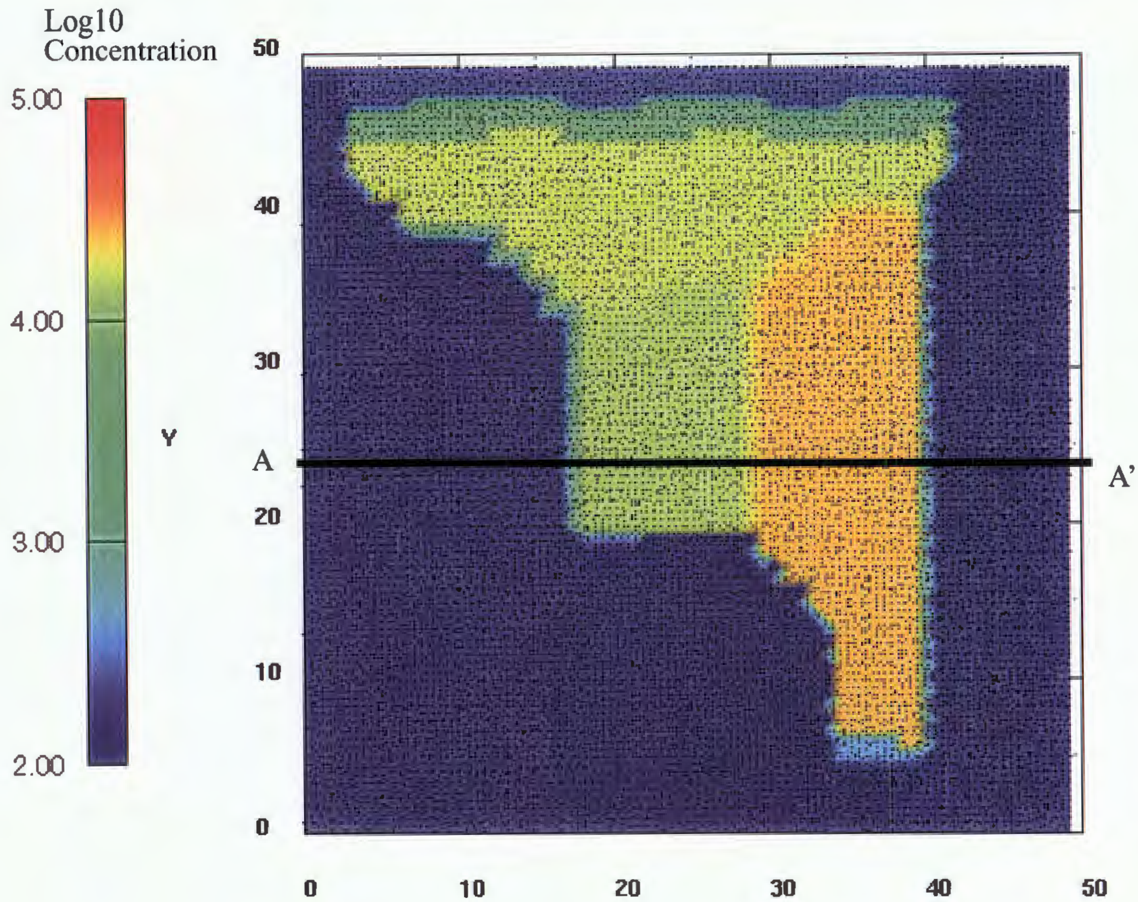
2. Figure 2) Map view of the finite volume mesh created for plume volume analysis. Boreholes are marked, and the cross-section A-A' is shown.



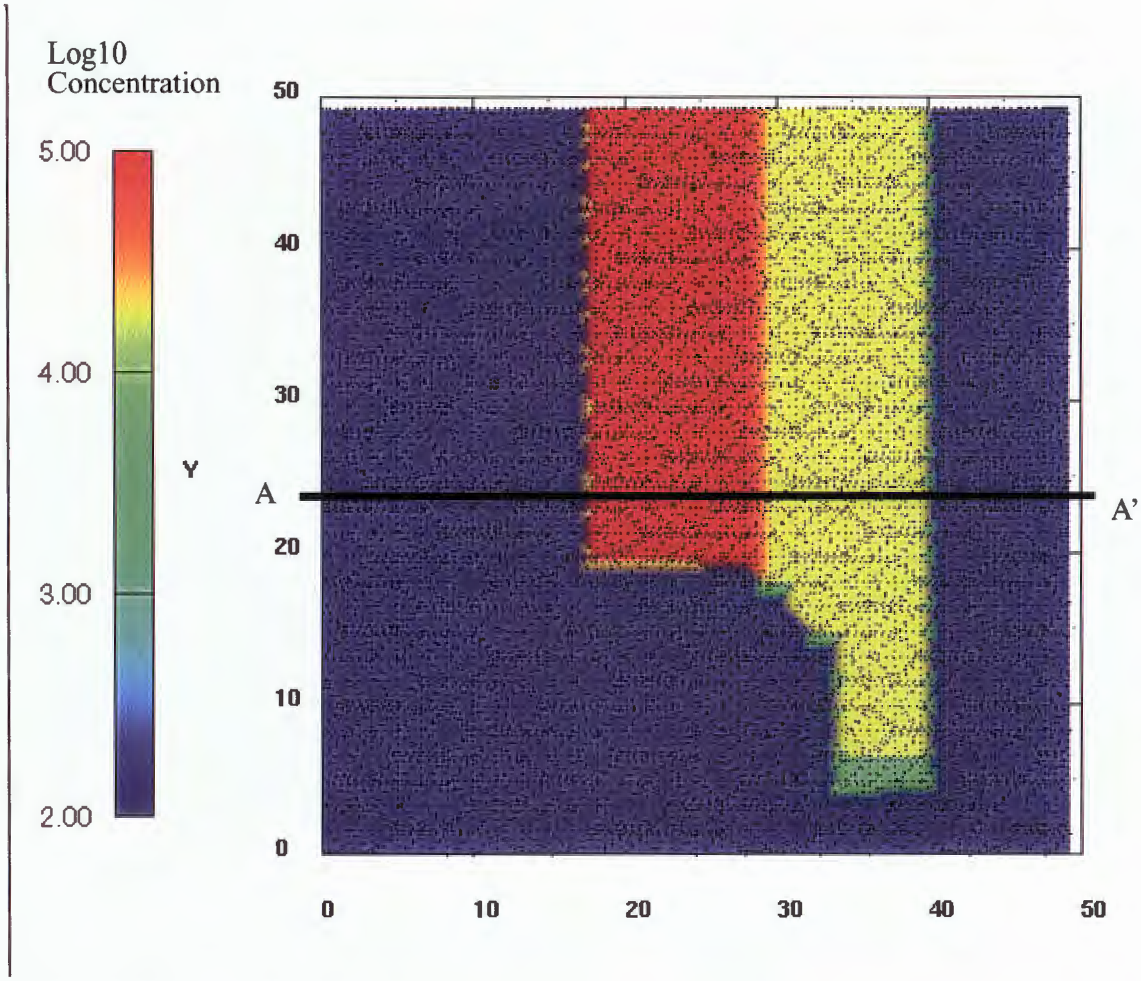
3. Figure 3) Nearest neighbor plume estimate showing cross-section A-A' and horizontal planes at 45 ft, 85 ft., and 105. ft. depth. The plane at 85' has the highest measured concentrations while the plane at 105' is the best data coverage at a given depth. Plume estimates below 125' are poorly constrained.



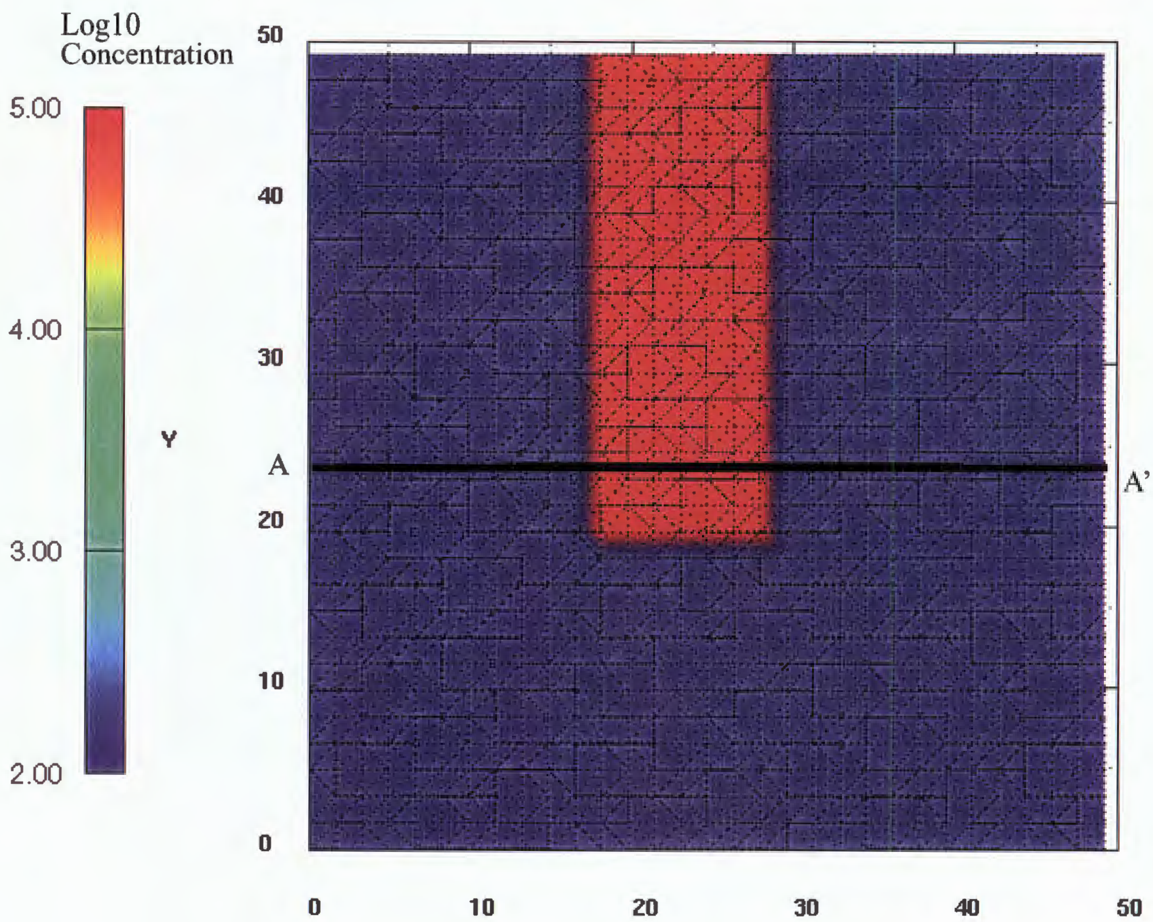
4. Figure 4) Plume estimate shown on cross-section A-A'. This estimate clearly shows the effects of having only one borehole below 125 ft. Also, boreholes V4 and V6 constrain the lateral limits of the plume to a depth of 105'.



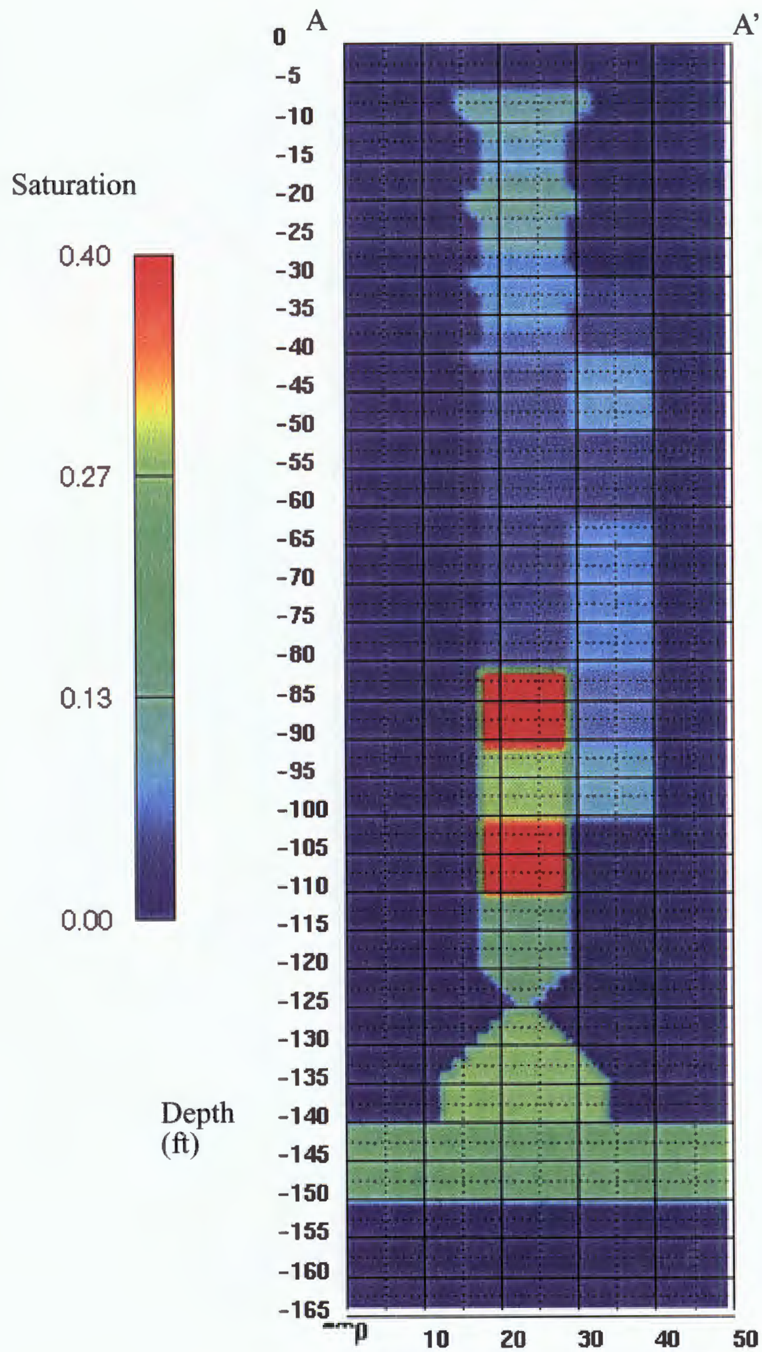
5. Figure 5) Nearest neighbor plume estimate on a plane 45' below the surface. Lack of data for regions of y>35 ft.(top of the figure) leads to probable overestimation of the plume in this region, however low values seen near the bottom, left and right boundaries show that the extent of the plume in these directions is well constrained at this depth.



6. Figure 6) Nearest neighbor plume estimate on a plane 85' below the surface. Lack of data for regions of y>35 ft.(top of the figure) leads to probable overestimation of the plume in this region, however low values seen near the bottom, left and right boundaries show that the extent of the plume in these directions is well constrained at this depth.



7. Figure 7) Nearest neighbor plume estimate on a plane 105' below the surface. Lack of data for regions of y>35 ft.(top of the figure) leads to probable overestimation of the plume in this region, however low values seen near the bottom, left and right boundaries show that the extent of the plume in these directions is well constrained at this depth.



8. Figure 8. Estimated diesel saturation on cross-section A-A'. Multiphase flow dynamics suggest that diesel is continuing to move downward under the influence of gravity from a depth of 85 ft to the leading edge of the plume at a depth of approximately 150 feet.