SEATAC NW AIRLINES FRONT HANGAR
SeaTac Airport
LUST # 2053

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4 October 1993

11-07999-01

Northwest Airlines, Inc.
Dept. C1510
5101 Northwest Dr.
St. Paul Minnesota 55111

Attention: Mr. Edward Olson

Subject: Modified Vapor Extraction Pilot Test
Sea-Tac International Airport Facilities
Northwest Airlines Hangar: Results and Recommendations

Dear Mr. Olson:

This letter provides an update on the progress of the vapor extraction system (VES)/biofilter pilot test being conducted at the above referenced site. Following evaluation of the results of the original VES/biofilter pilot test (phase I), conducted between November, 1992 and January, 1993, RZA AGRA recommended some alterations to the extraction well and some additional testing of the VES/biofilter system (phase II). The purpose of this additional testing was to determine if the proposed well modifications would result in the increased volatilization of petroleum mineral spirits compounds. During the first phase of the pilot test the off-gas from the extraction well consisted of relatively large amounts of chlorinated solvents and minimal quantities of mineral spirits. This distinction is important because the biofilter was inoculated with microorganisms that are capable of biodegrading petroleum mineral spirits (which comprises approximately 93% of the contaminant compounds at the site), but not chlorinated solvents.

The results of the phase II pilot test suggest that the modifications to the well did not greatly increase the rate of mineral spirits volatilization. This is due to the great difference between the partial pressures of mineral spirits and chlorinated compounds, as well as site specific subsurface conditions such as the elevation of the local watertable. The two pilot studies have demonstrated, however, that the chlorinated compounds present in the subsurface matrix can be volatilized in large quantities, and that the relative ratio of chlorinated compounds to petroleum mineral spirits has decreased during the course of the pilot tests. We estimate that roughly 35 pounds (lbs.) of chemical constituents (petroleum mineral spirits and chlorinated

Department Number

C8980

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NORTHWEST AIRLINES

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January 3, 1994

Mr. Ching-Pi Wang
Unit Supervisor, Toxics Cleanup Program
Department of Ecology
State of Washington
3190 160th Ave. SE
Bellevue, WA 98008-5452

RE: Independent Clean-up Action, Modified Vapor Extraction Pilot Test Report; Northwest Airlines Hangar, SEA-TAC Int'l Airport;

Dear Mr. Wang:

Northwest (NW) is pleased to submit the enclosed report in accordance with WAC 173-340-300. This report summarizes the professional remedial services provided by RZA AGRA, Inc. at two former underground tank sites at subject location. The vapor extraction pilot test study was conducted at monitoring well (MW) EP-3 for the period, November 1992 to August 1993, and follows progress reports I submitted to WADOE last March 19, 1993.

RZA AGRA has estimated contaminant recoveries at roughly 11 pounds of mineral spirits and 24 pounds of chlorinated solvents, and reported the absence of free product on the (shallow) groundwater in MW EP-3. Based upon the apparent success of this work, NW intends to proceed with RZA AGRA's recommendation to scale up the remedial system comprised of the essential elements, vapor extraction, biofiltration, and carbon filtration. The effort has been scoped out at two years or a completion estimated at first quarter, 1996.

Please contact me at (612) 727-4843 if you have any questions with this submittal.

Sincerely,

Edward P. Olson, C.E.P.
Environmental Projects Consultant

Enclosure
cc: B. Barnhill/SEA
P. Chapla/A5140
K. Duell/SEA
J. Jenkins/A1180
K. Bahnick/Port of Seattle

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compounds) have been volatilized from the subsurface over the course of the two pilot tests. Free phase product is no longer evident on the groundwater surface in monitoring well EP-3.

In addition to providing some interim remediation, these studies have provided the information necessary to evaluate the feasibility of using vacuum extraction as a technology for site remediation. Based on this information, several technologies for treating the exhaust gas from the VES are available and applicable to this project. A summary of these technologies, along with cost estimates and our recommendations follows under separate cover.

We appreciate the opportunity to be of continuing service to Northwest Airlines. If you have any questions, please call at your earliest convenience.

Respectfully submitted,
RZA AGRA, Inc.

Carol A. Hutley, P.E.
Project Engineer

Micheal C. Moore
Associate

RHA/MCM/ch

MODIFIED VAPOR EXTRACTION PILOT TEST
SEA-TAC INTERNATIONAL AIRPORT FACILITIES: MAINTENANCE HANGAR
PROJECT STATUS REPORT

1.0 BACKGROUND AND PURPOSE

In January, 1992 RZA AGRA, Inc. (RZA AGRA) began a multiphase bioremediation feasibility study to determine the potential of a combined vapor extraction/biofiltration system to remove and destroy the mineral spirits in the subsurface matrix at the Northwest Airlines maintenance hangar. The study phases included: a biotreatability study to determine whether bacteria indigenous to the project site were capable of biodegrading mineral spirits; conceptual design of a vapor extraction/biofiltration treatment system for the site; and, a pilot test to determine whether the treatment system would function efficiently in the field. The system was designed to use vacuum to extract the volatile components of the used solvent from the soil and groundwater, and then treat the exhaust gas with bioremediation and a carbon adsorption polish. Previous characterization of free phase product in monitoring well EP-3 revealed that the chemical constituents in the subsurface matrix at this site were comprised of approximately 93% mineral spirits (which are easily biodegradable) and 7% chlorinated solvents (which are difficult to biodegrade). Although many chlorinated solvents can be biodegraded by cometabolism, this technology was cost prohibitive for use at a site where such small quantities of chlorinated compounds are present.

The first phase of the bioremediation study resulted in the isolation of microbes from the site with the ability to biodegrade mineral spirits. These microbes were then used to inoculate a biofilter which was installed as part of a pilot scale remediation system to be tested at this site. A pilot test was conducted during the winter of 1992/1993. The results of the field testing indicated that a relatively small amount of mineral spirits could be volatilized using the existing well configuration. Without adequate amounts of mineral spirits in the system emissions, the bacteria in the biofilter did not have an adequate food source to maintain a healthy population.

At that time, scientists and engineers at RZA AGRA evaluated modification of the vapor extraction well to increase volatilization of mineral spirits from the subsurface. The modification proposed consisted of placing a groundwater aeration unit in the well, approximately two feet below the water surface. Vacuum would be applied to the well to create the necessary pressure differential for sparging (aeration) of the groundwater in the well. The off-gas from the well was monitored on a weekly basis using field instruments. Once during the 30 day test period, an air sample was collected and evaluated for the presence of mineral spirits and chlorinated compounds using analytical chemistry methods.

2.0 RESULTS OF DOWN WELL AERATION TEST

The results of the most recent phase of the pilot test are summarized in Table 1. During the test some additional system modifications were made to increase the efficiency of system and to protect the system from damage. To reduce system back pressure from the blower, the carbon adsorption units were placed in parallel, rather than in series. Also, to reduce the possibility of pushing volatiles away form the extraction well, the aeration unit was converted from positive to negative pressure. Under these conditions the vacuum on the well from the blower supplied a force sufficient to pull air from the surrounding soil through the water in the well, and thereby aerate it.

The modified well configuration did not significantly increase the volatilization of mineral spirits. An air sample collected on 13 July, 1993 contained a concentration of approximately 44 mg/cubic meter of chlorinated solvents and about 19 mg/cubic meter of unidentified compounds in the C_6-C_{13} carbon range, most likely mineral spirits. These values are comparable to those encountered during the first field trial. Air samples taken in late November, 1992, after the pilot test was complete, contained a concentration of approximately 51 mg/cubic meter of chlorinated solvents, as well as unidentified compounds in the C_6-C_{13} range.

The ratio of chlorinated compounds to mineral spirits in the zone of influence for monitoring well EP-3 appears to have been reduced by the pilot studies conducted. At the end of the most recent test a groundwater sample was collected and analyzed for mineral spirits and chlorinated compounds. Free product on the water table was not encountered at the time of this sampling, but the water sample did contain dissolved phase contaminants consisting of 350 parts per million (ppm) mineral spirits and 23 ppm chlorinated compounds, mostly 1,1,1-trichloroethane. This constitutes a ratio of 94% mineral spirits and 6% chlorinated compounds. The ratio of these different components prior to the field tests was 93% mineral spirits, and 7% chlorinated compounds. This is important since large quantities of mineral spirits may not be able to be volatilized until the ratio of chlorinated compounds to mineral spirits is greatly reduced. This is primarily due to the fact that the partial pressures of chlorinated compounds are much greater than that of mineral spirits compounds. The significance of this point is discussed in greater detail in Appendix A, which also contains applicable calculations.

Based on the average emissions flow rate, and the contaminant loading in the off-gas, we estimate that roughly 11 pounds (lbs.) of mineral spirits and 24 lbs. of chlorinated solvents have been extracted from the subsurface over the course of the field tests. Free product is no longer present on the groundwater in well

EP-3. Vacuum extraction appears to be an effective method of removing the mineral spirits and chlorinated solvents from the subsurface. Our recommendations for scaling up the existing vacuum extraction system, and potential alternatives for treating the system exhaust gas, are presented under separate cover.

3.0 CONCLUSIONS

Based upon evaluation of the pilot test data, as well as other pertinent data for this site, we have reached the following conclusions:

1. The vacuum extraction/down well groundwater aeration system has been effective at removing used solvents from the subsurface in the vicinity of monitoring well EP-3. Roughly 35 lbs. (estimate) of solvent have been volatilized from the subsurface. Free phase product is no longer present on the groundwater in monitoring well EP-3.

2. The ratio of chlorinated solvents to mineral spirits is too high, at this time, to effect large scale volatilization of mineral spirits. Without greater amounts of mineral spirits in the system off-gas, the biofilter will not function.

3. Continued vacuum extraction/down well aeration may ultimately result in volatilization of enough chlorinated solvents to allow the petroleum mineral spirits to be removed in greater quantities. The existing system can be scaled up to remove greater quantities of waste solvents over a shorter period of time. Alternative treatment methods should be pursued for the treatment of the exhaust gas removed, at least until the ratio of chlorinated solvents to mineral spirits is sufficiently low to retest the biofilter.

4.0 CLOSURE

We appreciate the opportunity to be of continuing service to Northwest Airlines, Inc. If you have any questions regarding this project, please call us at your earliest convenience.

Respectfully submitted,
RZA AGRA, Inc.

Randy Adams, Ph.D.
Environmental Microbiologist

Carol A. Hutley, P.E.
Project Engineer

Micheal C. Moore
Associate

RHA/MCM/ch

Enclosure: Table 1. Data Summary
Appendix A, Component Ratio Calculations

Table 1: Data Summary for Down Well Groundwater Aeration Pilot Study
Northwest Airlines, Inc.
SeaTac, Washington
RZA AGRA, Inc. Project No. 11-07999-01

Date Collected	OVM (ppm)	GGI (%LEL)	Comments
17-Jun-93	320	-	System statred with positive pressure aeration and vacuum extraction
25-Jun-93	5	0	
1-Jul-93	5	0	Converted system to negative pressure aeration. Carbon units placed in parallel to reduce resistance
	11	2	Values after changes
6-Jul-93	25	3	Groundwater level had dropped to below aeration point. Readjusted system. Values taken after readjustment
8-Jul-93	5	0	Groundwater level had risen too far above aeration point to allow vacuum to provide aeration. Readjusted system
	60	8	Values after readjustment
13-Jul-93	30	1	Air samples taken for analysis: 44.1 mg/cubic meter Chlorinated Compounds 18.8 mg/cubic meter Non-Chlorinated Compounds (C6-C1
15-Jul-93	22	1	
20-Jul-93	44	1	
22-Jul-93	25	0	
12-Aug-93	-	-	Collected water sample in well: 350 ppm Mineral Spirits 23 ppm Chlorinated Solvents

Note:

OVM readings are generated by both petroleum and chlorinated solvent compounds falling within the detection limit of the instruments. The CGI only detects combustible vapors, in this case the mineral spirits/volatile petroleum fraction of the effluent gas.

4.0 CLOSURE

We appreciate the opportunity to be of continuing service to Northwest Airlines and will continue to keep you informed of the progress of this project. We would be pleased to discuss the contents of this letter, or any other aspect of this project, with you at your convenience.

Respectfully submitted,

RZA AGRA, Inc.

Randy Adams, Ph.D.
Environmental Microbiologist

for Michael C. Moore
Associate

rah/srts/clt

APPENDIX A

COMPONENT RATIO CALCULATIONS

COMPONENT RATIO CALCULATION

The major chlorinated solvent observed, to date, in air samples collected from the vapor extraction system emissions (monitoring well EP-3) is 1,1,1-trichloroethane (1,1,1-TCA, or simply TCA). TCA has a very high partial pressure; 100 mm Hg at standard temperature and pressure. Under these same conditions the average partial pressure of mineral spirits is 2 mm Hg. The estimated relative ratios of these compounds in the gaseous phase (in the system emissions) can be calculated from the partial pressures and the relative ratios in the liquid phase (dissolved phase in the groundwater). If we assume that the extraction well contains a dissolved phase chemical constituent loading of approximately 95% mineral spirits, and 5% TCA (such as the free product encountered on the water surface in monitoring well EP-3 prior to the field tests), the component ratio calculations would take the form shown below.

The expected average partial pressure of mineral spirits compounds would be:

$$2 \text{ mm Hg} \times 95\% = 1.9 \text{ mm Hg.}$$

The expected partial pressure of TCA would be:

$$100 \text{ mm Hg} \times 5\% = 5 \text{ mm Hg.}$$

The expected ratio of TCA to mineral spirit compounds in the gaseous phase would be:

$$5 \text{ mm Hg} / 1.9 \text{ mm Hg} = 2.6{:}1.$$

This ratio is very similar to the actual ratio of chlorinated solvents to nonchlorinated compounds in the most recent air sample taken from monitoring well EP-3. The concentration of chlorinated compounds and nonchlorinated compounds in the air on 13 July, 1993 was 44.1 mg/cubic meter and 18.8 mg/cubic meter, respectively (a ratio of 2.3:1 of chlorinated to nonchlorinated compounds).