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FOR RO378

6/2002

Date: 30 January 04
Project No.: 2543.02

LETTER OF TRANSMITTAL

Alameda County
FEB 03 2004
Environmental Health

Attention: Mr. Barney Chan
Company: Alameda County Health Care Services
Address: 1131 Harbor Bay Parkway, 2nd floor
Alamed, CA 94502

Subject: Xitech Product Pumps (skimmers)

We are sending you ☒ **Attached** ☐ **Under separate cover**
Via ☒ **Mail** ☐ **Federal Express** ☐ **Courier** ☐

Submittal No.	Copies	No. of Pages	Description
			Xitech Specifications

These are transmitted as checked below:

☐ **For approval** ☒ **For your use** ☒ **As requested**
☐ **For review and comment** ☐

Remarks: Barney - This is the equipment we plan to purchase for the 2855 Mandela Parkway site to remove the free-phase product.

Please call me if you have any questions

Signed:
David Kleesattel **Ext:** 541

Copy To:

Xitech MAIN Interest is Free Product Recovery

Xitech Remediation Philosophy:

Recover the most amount of Free Product from the formation in the least amount of time with the least amount of water at the lowest cost.

Xitech Resources:

Dwight L. Patterson
President of Xitech Instruments, Inc.
University of California Graduate in Mechanical Engineering
13 years of experience in designing & manufacturing Environmental Products

21 Xitech Sales Representatives
Xitech Sales Representatives are fully trained in Free Product Recovery design and installation of all Xitech products.

David Daniels
Inside Sales
David is responsible for all sales shipments, pilot study shipments, customer assistance, and representative assistance.

Xitech Web Site
Our web site provides instant access to all Xitech publications including theproduct price list. This web site is over 100 pages at this time. We have installed a quick INDEX at our home page for users to find documents quickly.

- Verification sampling
- estimate area of influence
- expanding extraction/
  collection area (additional trenches)

XITECH Instruments, Inc.

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Rev 02-2002

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Skimmer System Locations

Military Installations

IT Corporation installed 30 skimmers at Elmendorf AFB in Anchorage Alaska. **IT Corporation** has installed 8 skimmers with a Vacuum Enhancement system at the Yuma Marine Air Station in Arizona. **IT Corporation** installed mobile skimmer systems at George Air Force Base in San Bernardino, California, March AFB, and Edwards AFB. **IT Corporation** will install 30 skimmers with Vacuum Enhancement at China Lake Navel Air Station in California. **Ch2M Hill** installed skimmers at Travis AFB. **Tetra Tech Corporation** installed 13 skimmers along with a Vacuum Enhancement system at White Sands Missile Range in Southern New Mexico. **Dames & Moore** installed 10 skimmers at Nellis AFB in Nevada. **IT Corporation** installed 13 skimmers and a Vacuum Enhancement system at Dover AFB. **Dames & Moore** installed 21 skimmers and a Vacuum Enhancement system at a second location at Dover AFB. **Foster Wheeler** has replaced 20 bioslurping wells with Xitech skimmers and Vacuum Enhancement at Holloman AFB in New Mexico. **Pending Installations:** Mcguire AFB in New Jersey, Tinker AFB in Oklahoma, Offit AFB in Nebraska, Hickham AFB in Hawaii.

Oil Companies Installations

Dames & Moore installed 20 skimmers at a Chevron Refinery in Hawaii. **ERM Southwest** will install 14 skimmers at an EXXON refinery in Texas. **Harding Lawson Associates** installed 10 skimmers at the Quaker State Oil Refinery in Pennsylvania which has recovered over 130,000 gallons of product in a two year period. **IT Corporation** installed 3 mobile and 7 fixed skimmer systems at an EXXON bulk terminal in Maryland. **Dames & Moore** installed 17 skimmers on Spain's largest Oil refinery, Repsol in Cartahana, Spain. **Dames & Moore** installed three skimmers at the BP Oil Refinery in Lavera, France. **GES Environmental** has installed 6 skimmers at the Sun Oil Refinery in Pennsylvania. **IT Corporation** installed 2 more skimmers at the Sun Oil Refinery in Pennsylvania. **Pending Installations:** EXXON refinery in New Jersey, Burlington Railroad in Oaklahoma.

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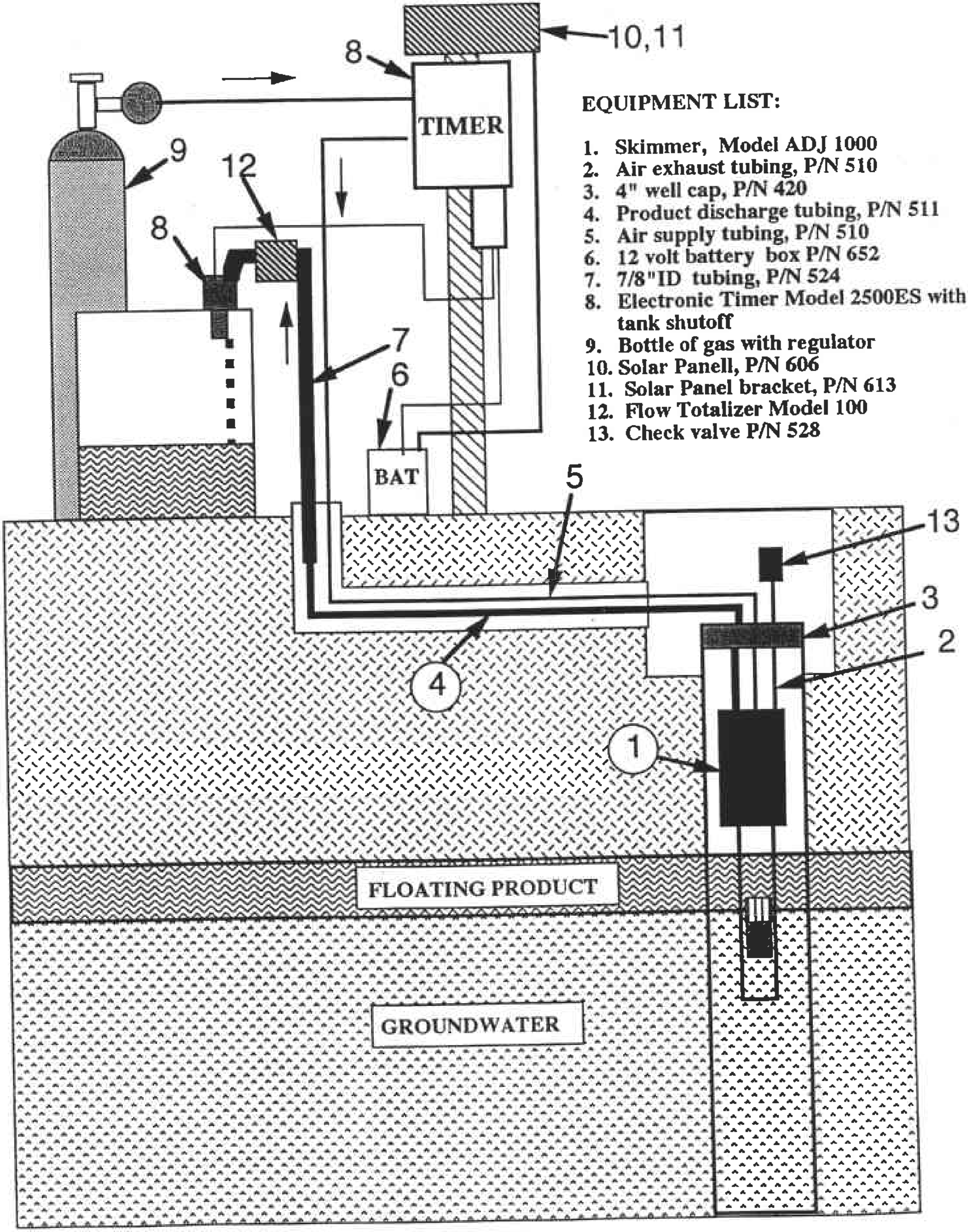
XITECH LNAPL RECOVERY SYSTEM
Without the use of AC Power



EQUIPMENT LIST:

1. Skimmer, Model ADJ 1000
2. Air exhaust tubing, P/N 510
3. 4" well cap, P/N 420
4. Product discharge tubing, P/N 511
5. Air supply tubing, P/N 510
6. 12 volt battery box P/N 652
7. 7/8"ID tubing, P/N 524
8. Electronic Timer Model 2500ES with tank shutoff
9. Bottle of gas with regulator
10. Solar Panell, P/N 606
11. Solar Panel bracket, P/N 613
12. Flow Totalizer Model 100
13. Check valve P/N 528

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XITECH ADJ 1000 Smart Skimmer Competition Comparison

Specifications	Xitech ADJ1000 Skimmer	Clean GEN/200/SOS-4 Skimmer	QED Ferret Skimmer
Maximum recovery rate:	600 gallons per day	320 gallons per day	*100 gallons per day
Pumping Range:	5-25 gallons per hour	Fixed	Fixed
Pumping controls:	Built-in	Built-in	Built-in
Pump type:	Diaphragm	Bladder	Positive displacement
Pump product isolation:	100%	100%	Air comes in contact with product
Pump inlet vacuum	160 inches of water	Unknown	Unknown
High water protection	Built-in	Optional above ground controls	Unknown
Skimmer principle:	Paper hydrophobic+direct inlet	150 mesh hydrophobic screen	Specific gravity floats
Skimming float range:	30 inches	23 inches	12 inches
Product recovery:	Sheen	Sheen	Unknown
Operating pressure:	35-125 psi	40-120 psi	50-100 psi
Maximum lift:	200 feet	200 feet	150 feet
Air consumption:	0.5 SCFM @ 125psi	*0.5 SCFM @ 80psi	0.5-1.0 SCFM @ 50psi
Minimum depth of water:	1.5 feet of water	Unknown	5 feet of water
Minimum well diameter:	4 inch	4 inch	2 inch
Weight:	11 Lbs.	9.5 Lbs.	5.75 Lbs.
Length:	48 inches	96 inches	72 inches
Product Density:	Light to Medium hydrocarbons	Light hydrocarbons	0.7-0.85 g/cc
Viscosity range:	Gasoline, diesel, jet fuel	Gasoline, diesel, jet fuel	<4 centistokes at 55°F
Solvent compatibility:	No limit	Light hydrocarbons	Not acceptable: MEK, Acetone,
Special requirements:	None	Optional high-water shut-off control	Requires special positioning kit

*Under most applications

NOTE: This information was only obtained from company literature.

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XITECH
Instruments, Inc.

BIO-VEPS Recovery of LNAPL's
Application Note #1

BIO-VEPS recovery of LNAPL's is an alternative to BIO-SLURPING. BIO-VEPS stands for Vacuum Enhanced Product Skimming With Biological Action. There are 2 good reasons to choose BIO-VEPS over BIO-Slurping. The first reason is that the BIO-VEPS technology is less expensive to purchase and operate. BIO-VEPS eliminates all above ground treatment system technology, and uses only low inches of water vacuum to enhance LNAPL recovery eliminating the need for expensive liquid ring vacuum pumps. The second reason is that the Law has recently been changed to consider natural attenuation on most L$\overset{NA}{AN}$PL sites after the liquid LNAPL is removed. This means that recovery of groundwater is no longer necessary on most sites. BIO-VEPS has retained all of the good attributes of BIO-Slurping like Insitu mass destruction of LNAPL's via Bio enhancement, large range of recovery of liquid LNAPL's to the recovery wells, and recovery of light vapor LNAPL's. A BIO-VEPS system is very easy to operate and maintain. Xitech has developed the ADJ1000(4") and ADJ200(2") Smart Skimmers for BIO-VEPS applications. These skimmers can recover liquid LNAPL's from wells operating under 160 inches of water vacuum. Teaming up our Smart Skimmers with an above ground low vacuum system is the most cost effective method for recovering LNAPLs today.

$1.9 \simeq 300$ torr
$3.7\times10^{-2} \approx 5$ psi

Current BIO-VEPS Project as of May 1999

Foster Wheeler is operating a BIO-VEPS system with 10 Skimmers at Holloman AFB in Southern New Mexico. Foster Wheeler found BIO-VEPS to be equal in recovery to Bio-Slurping on the same site. Please review Application Note #2 for further details about this site.

OHM/IT is installing a 33 well BIO-VEPS system with steam injection at North Island Navel Air station in San Diego California.

Fluor Daniel GTI/IT is operating a BIO-VEPS system at Elmendorf Air Force Base in Anchorage Alaska.

IT Corporation installed a 13 BIO-VEPS well system at Dover AFB in Delaware in 1998. **Dames & Moore** has also installed an additional 21 BIO-VEPS well system at Dover AFB in 1999.

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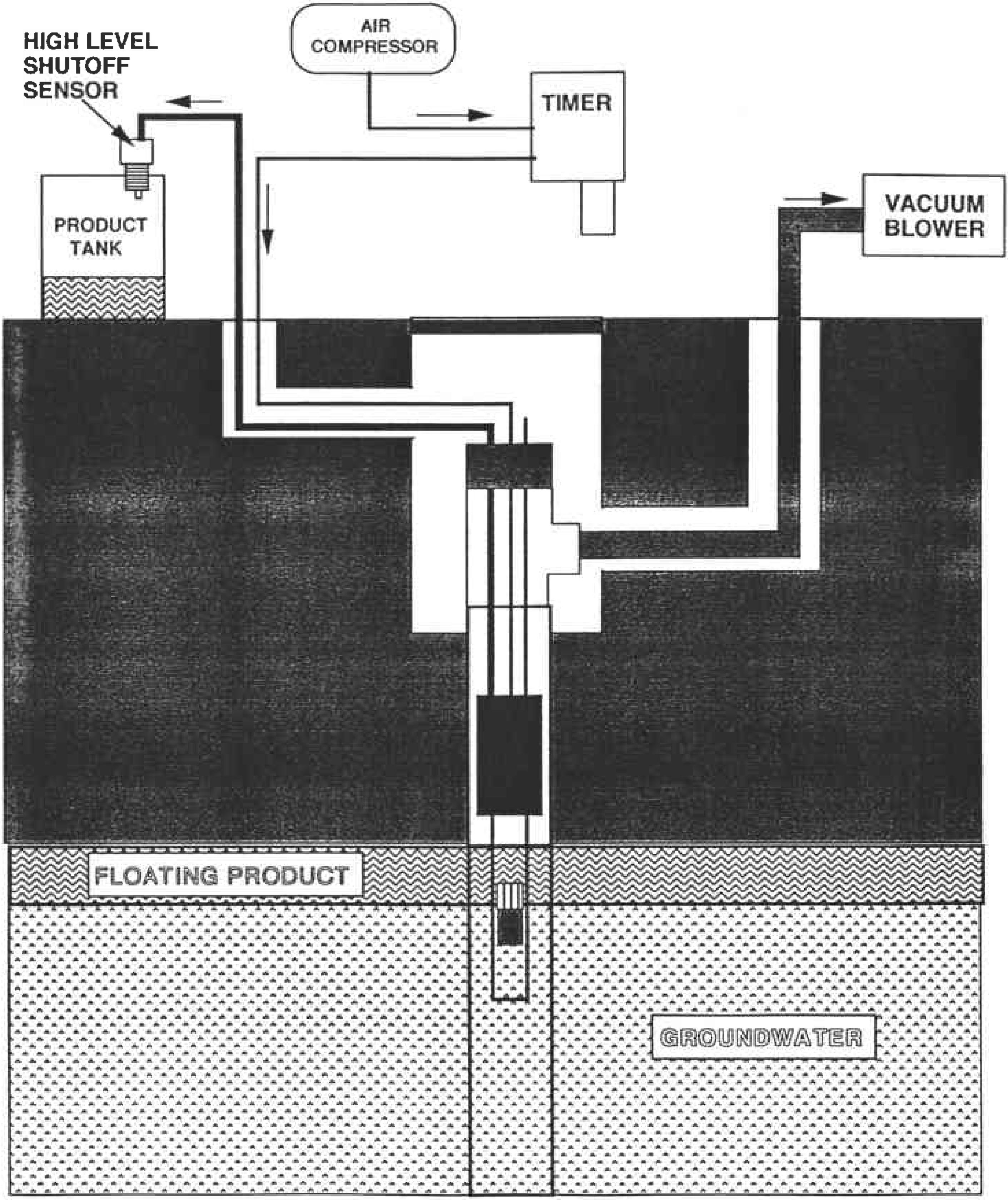
XITECH
BIO-VEPS Recovery Of LNAPL's



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Application Note #2

BIO-VEPS Recovery Of LNAPL's
At
HollomanAFB, New Mexico

The enclosed technical paper was presented at the National Defense Industrial Associates 25th Environmental Symposium & Exhibition on March 29, 1999 at Denver Colorado. This paper represents a very good example of the benefits of combining two well known technologies, Free Product Skimmers and Vacuum in the same well to increase LNAPL recovery. The Free Product Recovery Pumps mentioned in this paper were Xitech ADJ1000 Smart Skimmers. If you would like more information about this application or our products please call Xitech or visit our Web Site at www.xitechinc.com.

BIO-VEPS recovery of LNAPL's is an alternative to BIO-SLURPING. BIO-VEPS stands for Vacuum Enhanced Product Skimming With Biological Action. There are 2 good reasons to choose BIO-VEPS over BIO-Slurping. The first reason is that the BIO-VEPS technology is less expensive to purchase and operate. BIO-VEPS eliminates all above ground treatment system technology, and uses only low inches of water vacuum to enhance LNAPL recovery eliminating the need for expensive liquid ring vacuum pumps. The second reason is that the Law has recently been changed to consider natural attenuation on most LANPL sites after the liquid LNAPL is removed. This means that recovery of groundwater is no longer necessary on most sites. BIO-VEPS has retained all of the good attributes of BIO-Slurping like Insitu mass destruction of LNAPL's via Bio enhancement, large range of recovery of liquid LNAPL's to the recovery wells, and recovery of light vapor LNAPL's. A BIO-VEPS system is very easy to operate and maintain. Xitech has developed the ADJ1000(4") and ADJ200(2") Smart Skimmers for BIO-VEPS applications. These skimmers can recover liquid LNAPL's from wells operating under 160 inches of water vacuum. Teaming up our Smart Skimmers with an above ground low vacuum system is the most cost effective method for recovering LNAPLs today.

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OPTIMIZING FREE-PRODUCT (LNAPL) RECOVERIES USING INNOVATIVE BALANCING OF VER & SKIMMER TECHNOLOGIES

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ABSTRACT: A 3-month pilot study was performed to determine if down-hole hydrocarbon pumps, equipped with hydrophobic filters, can be used as an adjunct to vacuum-enhanced recovery (VER) systems for the efficient recovery of light non-aqueous phase liquid (LNAPL) hydrocarbons. Since onsite groundwater is classified as non-potable, remediation beyond the removal of any LNAPL thickness is not necessary. The study goal was to achieve a higher rate of LNAPL removal without an increase in costs (i.e., additional water treatment), to insure the greatest volume of LNAPL recovery from the subsurface per dollar spent. Application of various stepped vacuums and pumping intervals resulted in average LNAPL recharge rate increases by an approximate factor of five (5X). Increased product recoveries from 1.5 gallons (gal)/day/well in Phase I of the study to greater than 10 gal/day/well in Phase II were recorded. The dynamic wellfield management techniques tested increased pre-study LNAPL product recovery by 41 percent when compared to similar time intervals for the previous 12-month operational period of high-vacuum dual-phase extraction (HVDPE) operation alone.

INTRODUCTION

Vacuum-enhanced technologies have been demonstrated to successfully remediate hydrocarbon-impacted soil in low permeability formations. Combining technologies and realizing combined benefits, which are greater than additive without each technology's limitations (synergistic effect), are essential to moving sites toward closure sooner. In the pilot study performed, an existing HVDPE system was combined with down-hole free-product skimmer pumps.

A significant feature of VER is the induced airflow, which in turn induces LNAPL flow toward the extraction well. The pressure gradient created in the air phase results in a driving force on the LNAPL that is greater than that which can be induced by pumping the LNAPL with no induced airflow (gravity). Also of importance is the fact that airflow created by the vacuum enhances the LNAPL content surrounding the extraction well. This accumulation around the well ensures that the permeability controlling the conductivity of LNAPL is maximized. For these reasons, in addition to mass removal via soil vapor extraction, VER has the potential for removing more LNAPL and at greater rates than do other source removal mechanisms. However, the increased vacuums required to bring the recovered LNAPL to the surface from greater depths brings with it significant volumes of groundwater. Groundwater extracted during VER must be handled, treated, and discharged, which increases costs in necessary equipment and long-term operations.

Alternatively, skimmer systems withdraw little to no groundwater. The selected skimmer has a polyethylene LNAPL collection filter, a self-adjusting depth range capable of compensating for 2.5 feet (ft) of rising/falling groundwater effects, and weighted to float at the groundwater/LNAPL interface. The skimmer filter is hydrophobic and has a programmable timer, which periodically applies air pressure to the collection chamber to push accumulated

LNAPL to the surface. In general, the resulting limited pressure head (actual free-product-saturated formation thickness) provides minimal LNAPL drive toward the extraction well. This passive movement typically yields relatively low hydrocarbon recovery rates.

Objective. Determining the effect of using skimmer pumps as an adjunct to VER of LNAPL was the objective of the pilot study. The study evaluated the efficacy and feasibility of combining two existing technologies in an effort to increase LNAPL recovery, while minimizing groundwater removal, thus decreasing equipment and long-term operational costs.

Site Description. In 1991, approximately 2,000 gal of JP-8 jet fuel leaked from underground lines leading from an aboveground storage tank at the T-38 Test Cell (TC) on Holloman Air Force Base (HAFB). The base is located in southern New Mexico, 7 miles west of the city of Alamogordo. In subsequent investigations 450,000 to 485,000 gal of JP-8 LNAPL, ranging from a sheen to a maximum apparent thickness of 7.5 ft, were detected over an 11-acre area.

Groundwater occurs at 6 to 20 ft below ground surface depending on topography surrounding the TC. Hydraulic conductivities, based on slug tests, range from 7.9×10^{-5} to 2.9×10^{-4} centimeters/second. Porosities averaged 33 percent. However, effective porosities are interpreted to be significantly less than 33 percent in most cases. The gypsiferous nature of the site soil has resulted in a groundwater total dissolved solids (TDS) content in excess of 10,000 milligrams/liter in most of the basin. Groundwater beneath HAFB is classified as non-potable under the New Mexico Water Quality Control Commission Regulations. Therefore, it does not require remediation beyond the removal of any LNAPL contamination that might exist.

Shallow soil beneath the TC extending to approximately 15 ft consists of intercalated layers of alluvial sediment. Upper soil is typically tan to light brown, fine-grained, silty sand/sandy silt or silty clay/clayey silt. Underlying this layer to approximately 30 ft is reddish-brown silty clay/clayey silt with interbedded fine-grained silt and sand. Discontinuous caliche layers are also present across the site. Moisture contents of vadose zone soil ranges from 2 to 11 percent, increasing with depth. The heterogeneic character of HAFB soil, combined with the high percentage of fine-grained silt present throughout the shallow soil, results in low permeabilities. These characteristics limit the migration of the LNAPL plume, but also hinder hydrocarbon recoveries.

OPERATIONAL HISTORY

A Corrective Measures Study was performed in 1994 to establish cleanup objectives and identify and screen potential remediation alternatives. The established corrective action objects (CAO) mirrored the HAFB negotiated basewide soil remediation standards of 1000 milligrams/kilogram (mg/kg) total petroleum hydrocarbons (TPH) and 25 mg/kg benzene with the New Mexico Environment Department. At the conclusion of the CMS, HVDPE was selected as the best remedial alternative.

Interim Remediation System. A rapid response action was initiated to alleviate potential explosive vapors in the central one-acre of the LNAPL plume. Under contract to the US Army Corps of Engineers (USACE), Omaha District, a HVDPE system was designed and constructed. The system consisted of 11 extraction wells, a 5,000 standard cubic feet per minute (SCFM) thermal oxidizer unit (TOU), a 60 gal per minute water treatment system, an 8,000 gal storage tank and an 80 ft X 80 ft infiltration gallery for groundwater reinjection. A 30-hour pilot study was performed prior to construction to collect design information for the interim system. Wells were constructed of 4-inch (in.) diameter schedule-40 polyvinyl chloride (PVC) pipe and screen that were installed in a 10-in. diameter borehole. Drop tubes, located inside the well casings, were made of 2-in. diameter schedule-40 PVC pipe which allowed system operators to adjust the vacuum point elevation based on water table fluctuations and product thickness variations. The system was designed to operate at a vacuum of 16 to 20+ in. of mercury (Hg), providing 25 SCFM flow rates at individual wells, and utilizing a closed-loop oil-sealed vacuum blower.

Foster Wheeler Environmental Corporation (FWENC), was awarded a Total Environmental Restoration Contract (TERC) by the USACE in 1994 and was selected to conduct all restoration activities on HAFB, one of three Air Combat Command (ACC) anchor bases. The TERC was developed to facilitate ACC's Accelerated Cleanup Program. As such, FWENC and its subcontractor team took over the operation and maintenance of the interim system in March 1995. The interim system was operated until November 1995 when construction of the full-scale HVDPE system was initiated.

Full Scale Remediation System. In June 1996, construction of the full-scale system was completed and the system was brought on line. An additional 122 extraction wells were installed and two additional vacuum skids and vapor/liquid separators were utilized. The extraction well network, totaling 133 extraction wells, was divided into 6 sections (A through F) each comprised of 21 to 23 wells. The preexisting air and water treatment facilities were adequate for the full-scale system. Valves that allow for the operation of any combination of the six sections were strategically placed in the extraction network piping. This valving was critical to the manipulation of the LNAPL plume and allowed system operators the flexibility to adjust the number of vacuum skids utilized, vary which sections were on line, and adjust drop tube positions/elevations relative to the groundwater/free-product interface.

Previous System Configuration & Performance. System optimization efforts resulted in the use of ¾-in. diameter drop tubes raised at varying distances above the groundwater/free-product interface and each vacuum skid pulling from two sections. The benefits of such a system configuration were immediately apparent and included: (1) a manageable volume of water was being extracted while the product-fraction of the total liquid extracted increased substantially, (2) a more uniformly concentrated vapor flow reduced the occurrences of high-temperature TOU shutdowns, and (3) longer periods between maintenance activities were achieved with the reduced impact of the high TDS groundwater affecting the system.

To Date, the T-38 Remediation System has removed over 225,000 gal of JP-8. Between August 1997 and May 1998, the majority (approximately 86 percent) of the mass of hydrocarbons removed were in the vapor phase. The fraction of free-phase product removed posed the concept of a cost-effective increase in source removal utilizing other technologies as an adjunct to the existing system.

SCOPE OF PILOT STUDY

Two tests were performed to assess proposed modifications to increase system performance while reducing operation and maintenance costs. Phase I involved baseline data collection and the application of down-hole hydrophobic skimmer pumps to remove the free (mobile) phase product. Phase II included VER and the concurrent use of the hydrophobic pumps.

Phase I: Baseline Data Collection. Pilot study preparation (equipment procurement, system configuration, etc.) and collection of baseline field data including fluid-level measurements (depth to groundwater and LNAPL thickness) and baildown tests were performed in the first 4 weeks. Ten existing 4-in. recovery wells were selected for the study: five wells with the greatest observed LNAPL thickness (D-Section, best recovery potential) and five wells with the smallest observed LNAPL thickness (B-Section). Baildown tests were performed and static (no vacuum enhancement) LNAPL recovery rates were recorded.

Phase II: Vacuum Step Tests and Optimization. Incremental (low to high) vacuum pressures were applied to the test wells and LNAPL recovery rates were recorded for the remaining 8 weeks of the study period (system was not operated over the weekend). Recovered free product was collected in a 55-gal drum at each well head and was measured daily. Based on site soil and previous operational knowledge, vacuum steps were 10, 20, and 30 inches of water column (IWC). Various skimmer-pump cycle times (both interval and duration) were tested in an effort to observe the effect on LNAPL recovery.

DISCUSSION OF RESULTS

During the 3-month study period, the skimmers removed an approximate total of 7,812 pounds (lbs), or 1,260 gal of free phase LNAPL, from the subsurface and only 31 gal of water. Hydrocarbon mass removed in the aqueous (dissolved) phase was estimated based on the minimal groundwater extracted and the average concentration of total hydrocarbons detected in the monthly regulatory samples. The vapor extraction portion of the study removed approximately 9,000 lbs, or 1,452 gal, based on laboratory analytical results.

Overall, the investigation removed approximately 16,819 lbs of total hydrocarbons, or 2,713 gal, based on a laboratory tested specific gravity of 0.83 for the recovered fuel, almost half in the free phase. Table 1 summarizes the hydrocarbon recovery data.

Table 1. Summary of Hydrocarbon Recovery Data

Hydrocarbon Phase	Volume Removed (gal)	Mass Removed (lbs)	Percent of Mass Removed
Liquid (Free Phase)	1,260	7,812	46.5
Aqueous	1.2	7.4	<0.1
Gaseous	1,452	9,000	53.5
Total	2,713	16,819	100.0

Increased Recovery Rates. As illustrated in Figure 1, product recovery rates increased following vacuum application, increasing the initial recovery rates from 1.5 gal/well/day to greater than 10 gal/well/day. Approximate recharge rate increase factors ranged from 2.5 for the poorest recovery well to 10 for the greatest recovery well, averaging 5.6.

The first vacuum step was performed at 10 IWC. Vacuum-enhanced hydrocarbon recoveries increased by a factor of five (5X) and the free product was recovered with no groundwater. Properly positioned skimmer pumps (adjusted for product thickness groundwater depression) reduced the required maintenance necessary for efficient operations. At 20 IWC vacuum, additional maintenance activities were required. Recoveries were not only less than at 10 IWC, but emulsification of the LNAPL caused water to be entrained in the recovered fuel and increased required filter replacements. Similarly at 30 IWC vacuum, although recovery rates

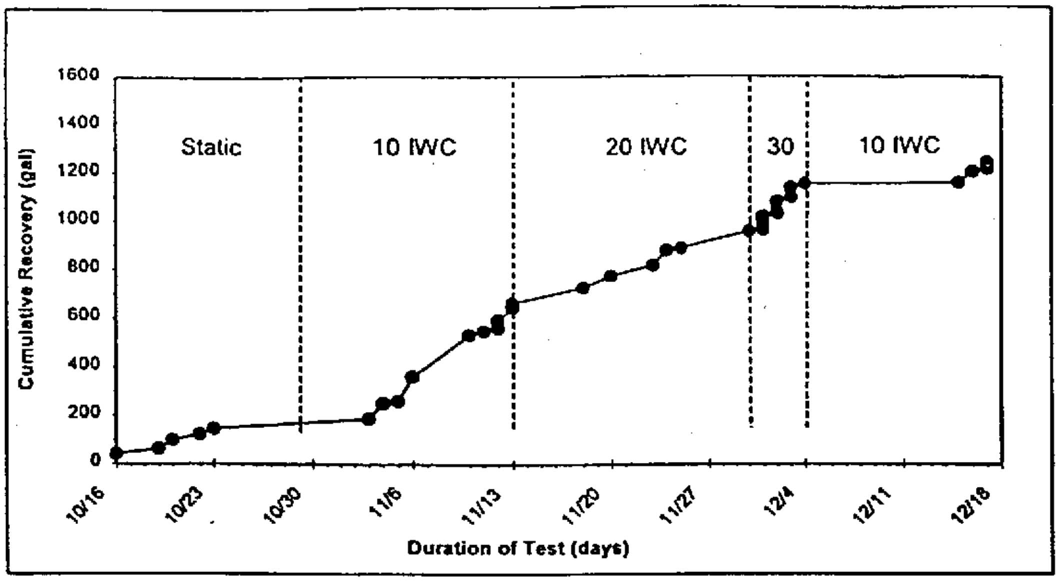

Figure 1. Free Product Recovery versus Time Throughout Pilot Study.

were temporarily higher, maintenance was required more frequently and recoveries greater than one or two well volumes were not sustainable. Product saturation in the soil surrounding each well was successfully reduced, however, long-term recovery diminished to volumes less than recoveries obtained at 10 IWC. Figure 2 illustrates the step tests and hydrocarbon recovery rates at well D-10.

Given the low permeability of the site soil, groundwater up-welling at both of the higher applied vacuums reduced the accessible LNAPL saturated formation thickness. This is of particular interest in thin product-bearing formations; since the limiting factor for product yield is that drawdown cannot exceed the saturated thickness of the product-saturated zone (assuming no induced gradient). So a balance must be obtained in that the highest achievable gradient is desired, with the least amount of induced up-welling reducing the product-bearing formation, and limiting recovery to the well.

For verification and repeatability, the final vacuum step of the study was repeated at 10 IWC. Repeating the step test provides a more accurate basis for comparing sustainable LNAPL recovery rates with other removal technologies. Similar to the first step test at 10 IWC, identical recoveries were observed in the last step.

Pump interval and duration were varied to find the effect on recovery. Pump intervals were initiated at 1.5 hours and durations of more than 10 minutes. Well recoveries however were not great enough to sustain these durations; therefore durations were decreased as recoveries were increasing ultimately using a 30-second duration at an interval of every 30 minutes. This combination of interval and duration, applying 10 IWC vacuum, was found to be the most productive in terms of the greatest LNAPL recovery rate.

Engineering Comparison. Historical HVDPE free-product recovery rates were reviewed and compared to pilot study recoveries. Results indicated the combined methodology recovered 41 percent more free-product. HVDPE, on a larger scale, concurrently achieved progress toward both CAOs, though not as efficiently or as cost effectively as the demonstrated combined methodology. The increase in source-removal rates (decrease in LNAPL thickness), with minimal increase in costs, was substantial.

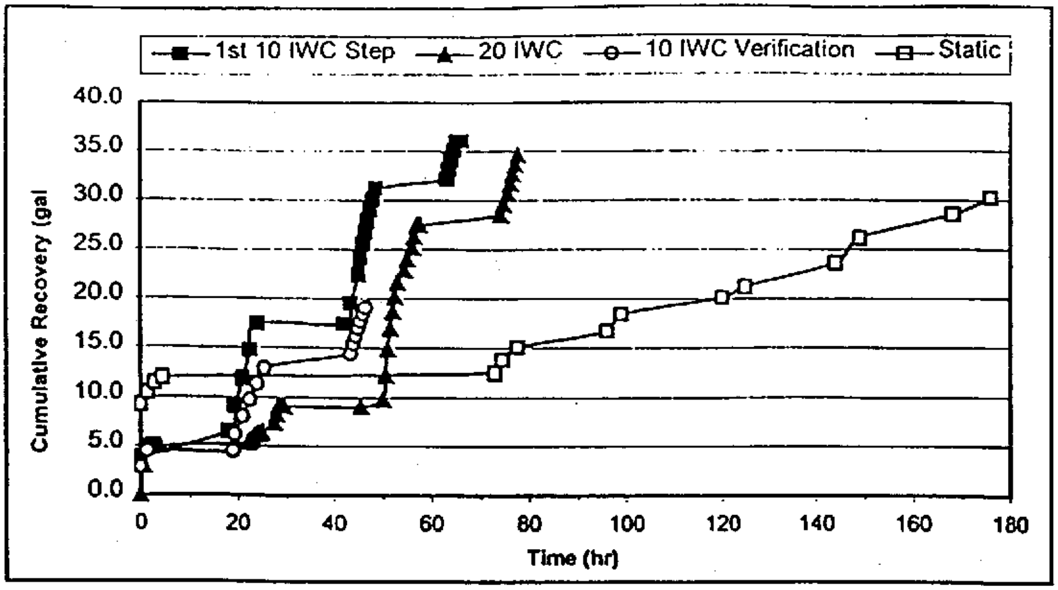

Figure 2. VER Relative to Static Recovery.

The demonstrated combined methodology proved a great adjunct to the existing system, satisfying the goal of the cost-effective collection of free-product with little to no groundwater. Additionally, the VER/Skimmer pump system can be rotated to greater free-product thickness sections/areas, increasing system flexibility. Concurrent realization of both remedial objectives will save costs, opposed to vadose zone remediation completed prior to LNAPL thickness removal due to higher mass-transfer rates in the vapor phase during HVDPE. This sequential approach is inefficient and will result in prolonging the remedial timeframe, increasing long-term costs.

CONCLUSION

Increased mass-removal rates decrease total removal costs. The investigation results demonstrated the combined extraction methodology ensured effective source removal, which will ultimately decrease long-term operation and maintenance costs. Dynamic combination of today's existing technologies, and realizing the combined benefits without each technology's limitations, is essential to moving sites toward closure sooner.

Concerns/Limitations. The following concerns/limitations warrant mentioning:

- Application of higher vacuums would be expected to produce proportionately higher yields of free product. However, groundwater up-welling (in lower permeability soil) decreases the accessible product-bearing saturated formation and, therefore, limits recovery to the well.
- Hydrophobic filters used in this study were density selective. Higher vacuums also resulted in limiting recoveries as a result of water entrainment, as the free product emulsified to the eventual point of being pumped with water.
- The increased mass-removal rates and the effectiveness of the combined technology are directly dependent on site characteristics (geologic, hydrogeologic, and contaminant characteristics, etc).
- Vacuumed-enhanced increased removal rates in higher conductivity soil must be weighed against reduced control of free-phase plume migration.

XITECH Instruments, Inc.

Well Design For LNAPL Recovery
Application Note #3

The purpose of this Application Note is to provide specific well design information that will assist Environmental Consultant in early LNAPL site closures for their clients.

Historically, LNAPL recovery wells have been designed with Total Fluids recovery in mind. The recent implementation of the RBCA regulations has caused a move away from Total Fluids recovery and placed the spotlight on Source removal. Well design for LNAPL Source removal is very different than the standard groundwater well design. The most important thing to focus on in well design for LNAPL recovery is the LNAPL pathway zone into the well. There are several design factors that impact the migration of LNAPL into a recovery well. These factors include well boring diameter, well annulus fill materials used to the at the LNAPL entrance zone, and location of slotted well casing area. Here is what we know to date about these design factors.

I. Well Boring Diameter

The LNAPL migration rate is directly proportional to the surface area in the well boring. An oversized well boring with a small well casing is the most cost effective way to increase LNAPL migration. For example a typical 4 inch recovery well casing would have a 10 inch well boring. A 4" well casing with a 14 inch well boring will significantly increase LNAPL migration. Increased well boring diameters are more expensive however, increased LNAPL migration leads to earlier site closers.

II. Well Annulus Material

Typical fill materials for the slotted well screen area for water wells has been #1 or #2 sands. These sands have done a good job of holding back silts and fine sands while providing a large pore spacing in the water/LNAPL recovery zone. Larger pore spacing materials will dramatically increase LNAPL migration with only a small amount of silt and fine sand coming into the well. The reason for only a small increase of silt and fine sands is that the LNAPL migration rate into the well is usually in low gallons per hour over a small vertical zone of a few inches.

III. Slotted Zone Location

Typical slotted zones are usually located from 50-80% below the static water level. The LNAPL vertical migration zone into a well is usually 2-6 inches at the static water level (Figure 1). A good location for the slotted casing for LNAPL recovery would be 2 feet above historical high water level down to 2 feet below historical low water level. Placing slotted well casing above the static water level allow for vacuum enhanced LNAPL recovery.

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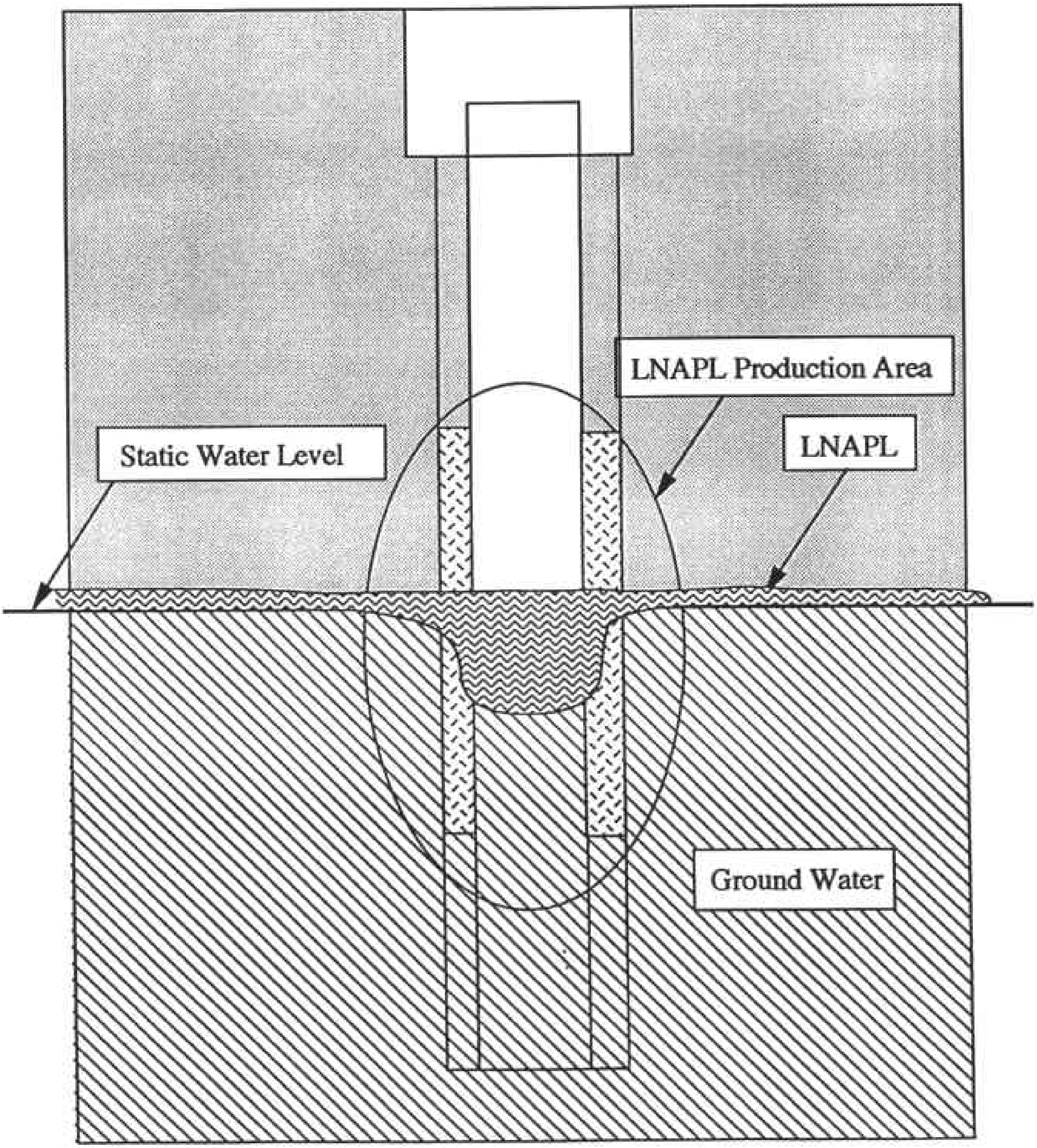
Typical Profile Of LNAPL In The Formation



XITECH
Instruments, Inc.

Application Note #7

Xitech, QED, And Clean Environment Comparison

In June of 1999 IT Corporation performed a technology comparison pilot study for the Navy at a site in California. The purpose of this pilot study was to observe how the top skimming technologies would perform under low vacuum conditions (BIO-VEPS conditions). It is Xitech's opinion that the pilot study procedures, operations, and data collection were carried out fairly for all skimmers. Section 4.8.2.3 clearly indicates that Xitech out performed the other two skimmers. Xitech skimmers were selected by IT Corporation to be installed on this site in June of 2000.

Type of Skimmers tested:
Xitech Skimmer: ADJ1000
Clean Environment Skimmer: GENIE+SPG-4 Standard
QED Skimmer: HIGH CAPACITY FERRET, Model HIWSFI12

Report Omissions:
The Xitech Skimmer operated on 1 bottle of compressed gas for the entire test period, while both the GENIE and the FERRET required an air compressor.

Xitech Conclusions:
I do not agree with the emphasis stated in 4.8.2.4 that maintenance requirement is the most important factor. The cost of hauling off water as hazardous material has been our customers' biggest concern. The FERRET recovered 66% water, the GENIE recovered 45% water, and the ADJ1000 recovered only 3.8% water. It seemed from the Report Summary that water was really an issue.

Another major concern our customers have is minimum product layer achievable by skimmers. The GENNIE's minimum product layer was 1 inch where as both the ADJ1000 and the FERRET minimum product layer was a sheen.

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