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Groundwater Pump and Treat Systems

Prepared by
Department of the Navy RAO/LTMgt
Optimization Workgroup

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LANTDIV
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LIST OF ACRONYMS

AS	Air Sparging
DOD	Department of Defense
DON	Department of the Navy
EFA	Engineering Field Activity
EFD	Engineering Field Division
GAC	Granular Activated Carbon
HVOC	Halogenated Volatile Organic Compound
IR	Installation Restoration
LTM	Long Term Monitoring
MCL	Maximum Contaminant Level
MNA	Monitored Natural Attenuation
NAVFAC	Naval Facilities Engineering Command
NFESC	Naval Facilities Engineering Service Center
P&T	Pump and Treat
RITS	Remediation Innovative Technology Seminar
RAO	Remedial Action Operation
RPM	Remedial Project Manager
SVE	Soil Vapor Extraction

1.0 INTRODUCTION

The Department of the Navy (DON) Work Group on optimization of Remedial Action Operation (RAO)/ Long Term Monitoring (LTM) was tasked to collect information on the DON groundwater pump & treat systems at Installation Restoration (IR) sites. To collect the relevant information, the Work Group prepared a questionnaire and the IR Managers disseminated the questionnaire to the Naval Facilities Engineering Command (NAVFAC) Engineering Field Divisions/Activities (EFD/As). The completed questionnaires were sent to the Naval Facilities Engineering Service Center (NFESC) for data consolidation and reporting. This report presents findings from the questionnaire responses.

1.1 Background

The optimization Work Group is comprised of representatives from EFD/As, NAVFAC, Chief of Naval Operations, Headquarters Marine Corps, and NFESC. The Group developed guidance on RAO/LTM optimization in April 2001. Prior to development of this guidance, the Group conducted case studies at RAO sites for optimizing remediation systems, including five P&T system. The findings from the case studies at the P&T sites concluded that the systems were generally not making adequate progress for contaminant mass removal, and that optimization efforts based on the life cycle design concept were needed to achieve site close out within a reasonable timeframe, particularly for sites that require aquifer restoration to levels such as maximum contaminant levels (MCLs). Similar conclusions were also drawn from an earlier study (DOD IG 1998) that evaluated performance of P&T systems in the Department of Defense (DOD).

1.2 Objectives

The main objectives of the DON P&T data call were to:

- Assemble information on the operation of DON P&T systems that can assist in developing policy/guidelines for optimization of P&T operations.
- Evaluate optimization efforts currently being followed by the Remedial Project Managers (RPMs).
- Identify P&T systems that have undergone optimization efforts and have been shutdown/replaced by more effective technologies.

This report first provides an overview of results from the questionnaire responses and then makes recommendations to implement and facilitate RAO/LTM optimization efforts for P&T sites.

2.0 OVERVIEW OF RESULTS AND DISCUSSION

The P&T systems identified from the questionnaires include 29 systems currently in operation for extraction and treatment of groundwater, and 7 systems that are now shutdown/replaced by other remediation technologies. The following table lists the responses from each EFD/A for P&T systems that are operating or have been discontinued.

EFD/A	Operating	Discontinued
SOUTHWESTERN DIV	7	
SOUTHERN DIV	7	5
NORTHWEST EFA	2	
NORTHEAST EFA	7	1
ATLANTIC DIV	4	1
CHESAPEAKE EFA	2	
Total	**29**	**7**

The PACIFIC DIV provided information on one P&T system, but the system has been transferred to a local agency. Therefore, it was not included in the above list. The questionnaire responses also identified five systems that used vacuum enhancements and are primarily for free product recovery. These systems are not included in optimization discussion in this report, but may be addressed in the future along with other specific technologies. The questionnaire also asked for information on future/planned P&T systems, but only two such systems were identified. The actual number is expected to be higher and a future data calls may be necessary to identify these systems more accurately.

The questionnaire was distributed to each EFD/A, but there is a possibility that some P&T systems have not yet been identified. The actual number of operating systems may range from 40 to 50 systems; estimated from general observations such as past presentations made by RPMs/contractors on their P&T systems, and discussions during meetings, etc.

A discussion of the information from the questionnaire responses follows.

2.1 System Objectives and Remediation Goals

A majority of the operating systems, 62 percent, indicated a dual objective of containment and remediation; whereas, containment was the sole objective for the remaining 38 percent of the systems. For the systems with remediation as an objective, an overwhelming majority (88 percent) stated cleanup to MCLs or similar levels as the remediation goal. Figure 1 highlights the objectives and goals for the operating P&T systems.

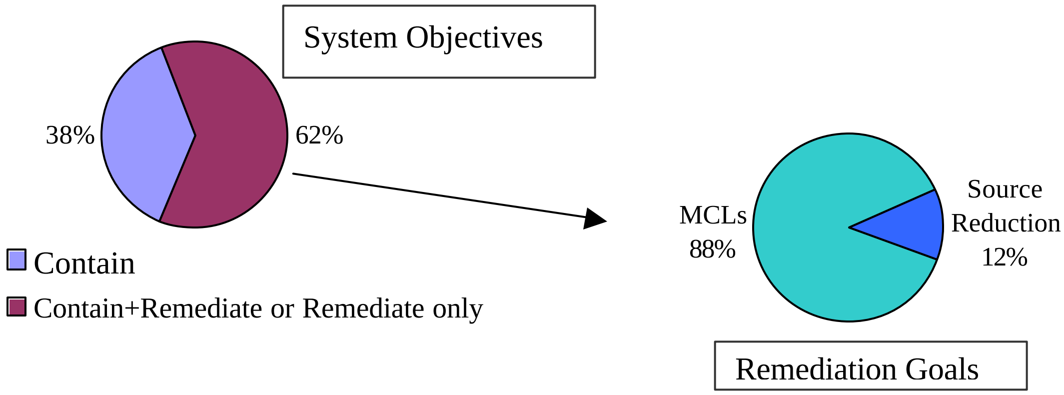

Figure 1. P&T system objectives and remediation goals.

2.2 System Start Dates and Projected Duration

Figure 2 shows the startup years for the 29 operating systems and it illustrates that a majority of the systems started operation prior to 2000. As most of these systems have been in operation for a number of years, sufficient operational and monitoring performance data should be available to evaluate system performance and to determine progress toward system objectives.

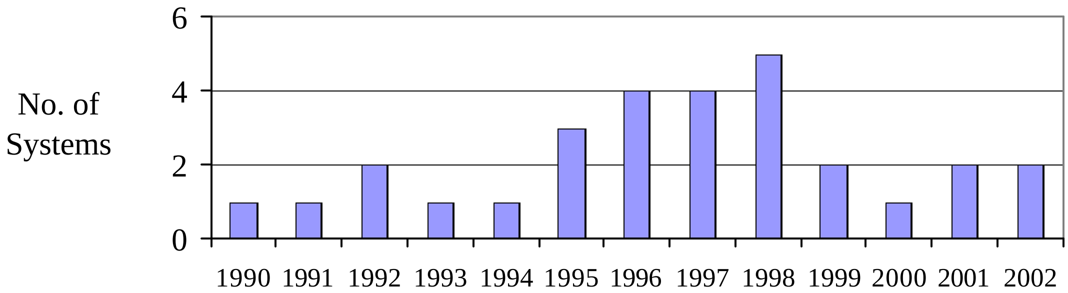

Figure 2. P&T system start up year.

Figure 3 illustrates the projected duration of the operating systems. A majority of the systems are projected to remain in operation for more than 10 years, which is typical for P&T systems.

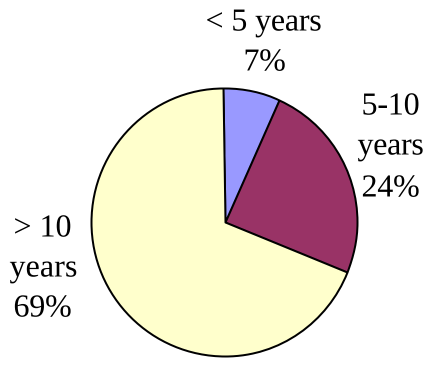

Figure 3. Projected duration to achieve objectives.

The long operating timeframe is a common limitation for P&T operations. Some of the contributing factors include aquifer heterogeneity and adsorptive partitioning of contaminants between the groundwater and aquifer materials. The result is a slowdown in contaminant mass removal, also referred to as tailing or asymptotic conditions. This phenomenon strongly limits a P&T system's ability to achieve remediation goals for aquifer restoration in a reasonable timeframe.

A majority of the systems (61 percent) are operating as final remedies and the remaining 39 percent are interim measures. Most of the interim systems have been in operation for the last 2 to 3 years, but a few have been in operation for more than five years. Several of these sites, according to the questionnaire, are now selecting final remedies.

2.3 O&M and Capital Costs

The annual O&M costs were provided for 28 systems, as displayed in Figure 4. The total annual O&M cost for the 28 systems was $11.8 million, and median and average costs were $418K and $424K, respectively.

Using the average annual cost for a system and operation duration of more than 10 years, the total O&M cost for this system is expected to be more than $4 million. However, the actual costs could potentially be higher as the P&T system may require longer operation time due to tailing/asymptotic conditions.

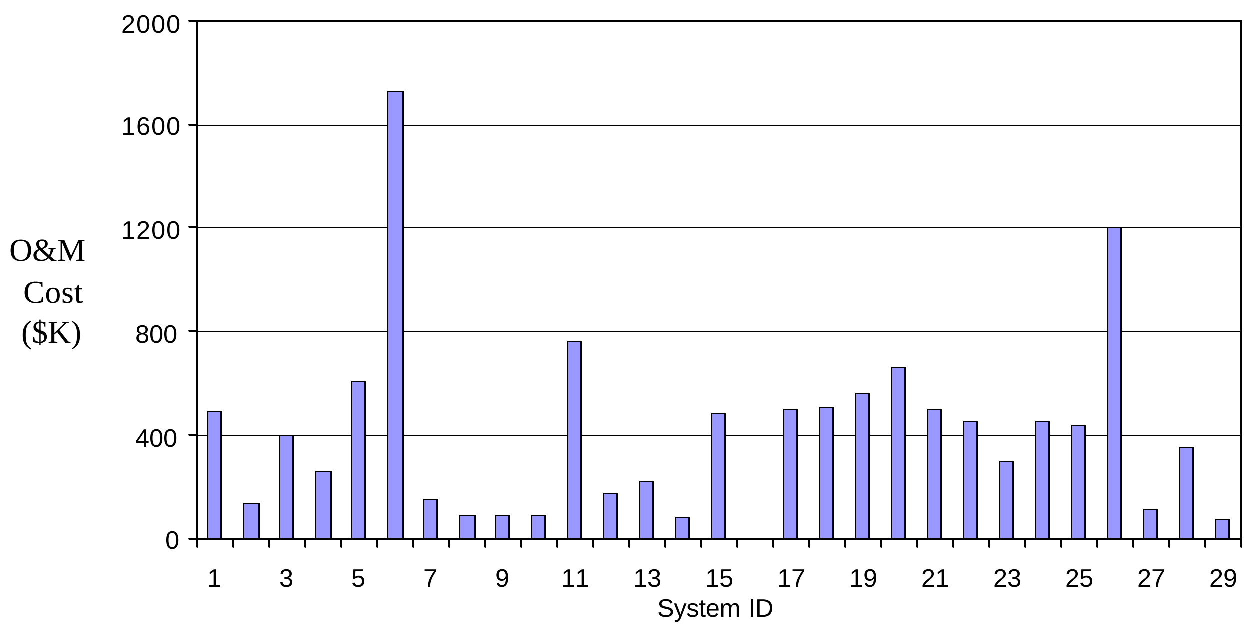

Figure 4. Operation and maintenance costs for P&T systems.

Capital costs were provided for 24 systems and are shown in Figure 5. The total capital cost for all these systems was $80.4 million. The median and average costs were $3.4 million and $2.4 million, respectively. New systems could be expected to cost considerably more as most of the reported costs were incurred several years ago and were not adjusted for cost escalation.

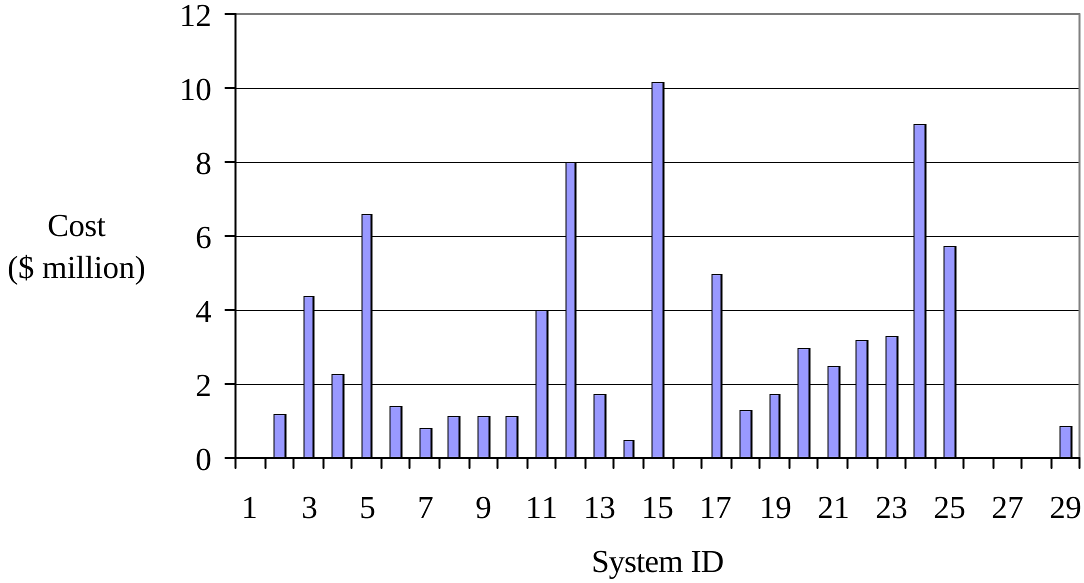

Figure 5. Capital costs for P&T systems.

2.4 Contaminants of Concern and Treatment Unit Processes

Halogenated volatile organic compounds (HVOCs) are the most common type of contaminants at DON sites and 72 percent of the P&T systems from the questionnaire are installed to address these contaminants. The remaining systems are at sites contaminated with petroleum, methyl tert-butyl ether, ordnance compounds, etc.
The treatment unit processes include air stripping (52 percent), liquid phase granular activated carbon (GAC) (26 percent), and others such as advanced oxidation and anaerobic biodegradation. Figure 6 shows distribution of treatment systems.

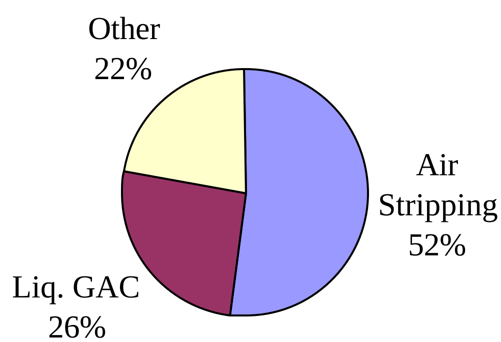

Figure 6. Treatment units for extracted groundwater.

Generally, the air stripping units are able to meet treatment requirements for HVOCs without further treatment; however, several systems have liquid phase GAC for polishing. The application of other advanced technologies for groundwater treatment at HVOC sites generally results in higher O&M costs as compared to air stripping systems.

Six percent of the systems reported to have vapor phase GAC units for off gas treatment.

2.5 System Flow Rates

Figure 7 shows the operational groundwater flow rates for the P&T systems and indicates a wide range. The median flow rate for these systems is 56 gpm, and more than 60 percent of the systems operate at less than 100 gpm.

The design flow rates ranged from 1.5 to 1,000 gpm but only a few systems were actually able to achieve the design flow rates. The operating rates were mostly lower than the design flow rates. Figure 8 shows the actual flow rate as percent of the design rate and indicates that 17 of the 29 systems are operating at less than 80 percent of the design. With lower-than-design flow rate, a system may not be able to capture the entire plume, and also may require longer than expected remediation time. However, if these systems are actually effective in plume capture or are achieving the design mass removal rates, then the original design may have been overly conservative.

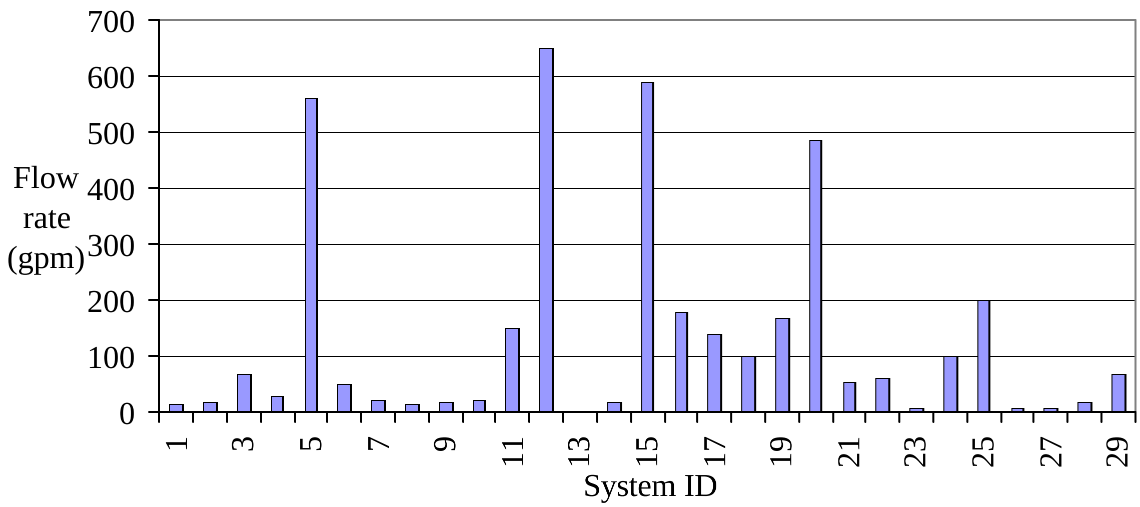

Figure 7 . P&T system groundwater flowrates.

2.6 Monitoring Programs for Groundwater Monitoring Wells

The questionnaire responses indicate that several sites practice groundwater monitoring at semi-annual or annual frequencies. However, 42 percent of the sites, as shown in Figure 9, practice quarterly monitoring for all or a portion of their monitoring wells.

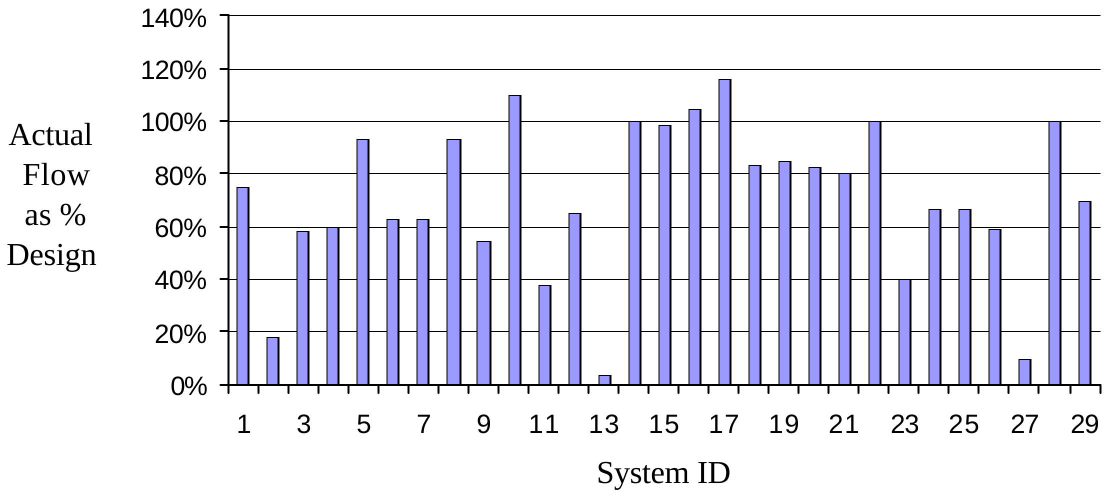

Figure 8. Actual flow rate as percent of design flow rate.

Generally, quarterly monitoring may not be necessary at most sites as the quarterly seasonal variations may not significantly impact P&T operations and plume dynamics. Quarterly monitoring may be needed for a few quarters after system startup to obtain baseline conditions.

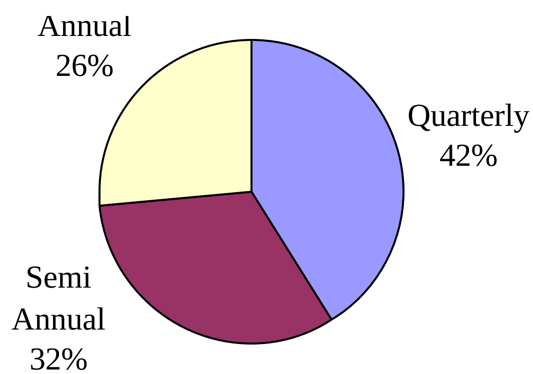

Figure 9. Monitoring frequencies for groundwater monitoring wells.

2.7 Optimization Practices

The questionnaire responses included descriptions of optimization efforts for the P&T systems. These responses varied to a great extent and the following is a summary of the reported efforts:

- Optimization efforts were conducted for several systems to enhance groundwater extraction. Four systems were mentioned to have gone through pumping optimization using groundwater modeling.

- Changes in treatment systems were mentioned for several systems. Two systems have installed air stripping units to reduce O&M costs.

- Several responses addressed optimization efforts to reduce monitoring frequency. (As discussed in an earlier section, several systems were reported to have semi- annual or annual monitoring instead of quarterly monitoring.)

- Future plans to collect data for evaluation of monitored natural attenuation (MNA) were mentioned for a few sites.

- A few systems have implemented air sparging/soil vapor extraction (AS/SVE) to address portions of the plume. Also, use of ORC®, an oxygen release compound was mentioned at three sites.

The above efforts indicate an awareness to enhance system performance. However, most of these efforts are focusing on long term operation of P&T systems and may not be adequately addressing the issue of contaminant tailing/asymptotic conditions that severely limits P&T technology's ability for aquifer remediation. Without adopting an iterative optimization program, these systems are expected to be in operation for tens of years for many of the sites.

2.8 Discontinued P&T Systems

Seven questionnaire responses provided information on P&T systems that have been discontinued. The contaminants of concern included HVOCs at 3 sites, HVOCs and petroleum at 3 sites, and petroleum only at 1 site. P&T duration ranged from 2 to 10 years. The optimization/site closeout approaches that have enabled shutdown of active P&T at these sites include:

- Chemical oxidation to reduce source area contamination, followed by MNA for polishing to achieve cleanup goals.
- Monitoring to meet State requirement for no further action.
- Vacuum enhanced recovery to replace P&T for petroleum contamination.
- Analysis of flow and contaminant distribution to show P&T is no longer necessary.

The actions taken by the RPMs at these sites indicate application of the life cycle design approach to replace P&T by more appropriate technologies that address changes in the plume concentration or site conditions.

3.0 RECOMMENDATIONS

The P&T systems require long remediation time, perhaps decades, to achieve cleanup goals. Therefore, site closeout costs for these sites using P&T are expected to be very high as these systems are O&M cost intensive. The following recommendations are provided to facilitate implementation of optimization efforts for effective site closeout. These recommendations are based on the questionnaire results and P&T system case studies conducted by the RAO/LTM Optimization Work Group.

- A Navy-wide policy may be developed to consistently apply a systematic and iterative process to make optimization a regular practice.

- Provide training to RPMs through CECOS courses, NFESC Remediation Innovative Technology Seminars (RITS), and other technology transfer mechanisms.

- Implement the RAO optimization process provided in the guidance developed by the Work Group (DoD RAO/LTM April 2001).

- Implement the monitoring optimization process provided in the guidance developed by the Work Group (DoD RAO/LTM January 2000).

- Detailed annual evaluations should be performed to review progress toward remediation goals, to identify optimization opportunities, and to evaluate site closeout strategies.

- Data analysis including time series plots, cost and performance plots, and plume contour maps should be regularly developed to track progress. These data along with analyses of the data should be included in regular operation and monitoring reports.

- Lessons learned from the P&T systems that have been shutdown should be shared with other RPMs.

- Similar questionnaires should be developed for other remediation technologies to provide a more comprehensive assessment of optimization efforts.

4.0 REFERENCES

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