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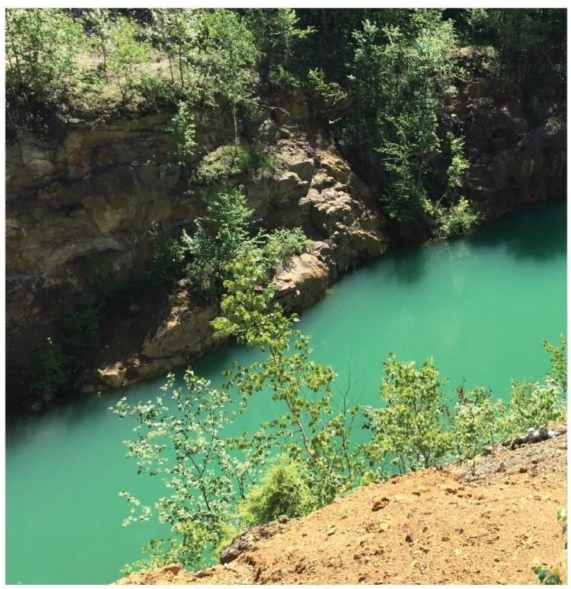
Superfund Optimization Progress Report 2011 – 2015



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AVAILABLE SEPARATELY

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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) is continuing to make progress on (1) implementing recommendations for individual optimization events, (2) conducting site-specific technical support, and (3) implementing the elements of the 2012 *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion* ("the Strategy"). Status updates are provided in this report for (1) optimization recommendations for 41 new optimization events conducted during Fiscal Years (FY) 2011 through FY 2015, for (2) 20 optimization events with outstanding recommendations recorded in previous progress reports, and for (3) 25 technical support projects conducted during FY 2011 through FY 2015. Project highlights are provided for both optimization and technical support events.

The Strategy instituted changes to the Superfund remedial program business processes to take advantage of newer tools and strategies that promote more effective and efficient cleanups. Under the Strategy, EPA expanded the optimization program to support nearly 50 ongoing optimization events in a typical year and complete about 20 optimization events per year. By expanding the optimization program, EPA has realized benefits from optimization at a larger number of sites, such as increasing remedy effectiveness, improving technical performance, reducing costs, moving sites to completion, and lowering the environmental footprint of remediation activities. In addition, optimization and technical support events are being conducted across all phases of the Superfund pipeline from site assessment through site completion, with the goal of improving the approaches to characterization, design, remediation, and operation and maintenance of Superfund sites. Approximately 35 percent of the optimization events included in the report were conducted in pre-remedial phases of the Superfund pipeline, 51 percent during remedial action phases, and 14 percent during operation and maintenance.

In FY 2015, EPA collected information from Remedial Project Managers on the status of the optimization recommendations from the reviews of 61 sites. Overall, 64 percent of optimization recommendations were implemented, are in progress, or are planned. Another 15 percent are still under consideration and only 16 percent were declined. A small number of recommendations (4 percent) were deferred to the state or Potentially Responsible Party for action; 1 percent do not have status information available.

EPA conducted a more detailed analysis of the various tools and techniques included in optimization recommendations and of the beneficial outcomes achieved by implementing them. EPA noted use of the following tools and techniques as a result of the optimization reviews and technical support events: (1) 68 percent of the sites had improvements to the conceptual site model, (2) 60 percent of the sites had streamlined or improved monitoring, (3) 39 percent of the sites had improved system engineering, and (4) 36 percent of the sites had a change in the remedial approach.

Technical support was completed for 25 events. Three of these events are highlighted in the report and include support in conducting high-resolution site characterization, developing an environmental footprint analysis, and developing conceptual site models.

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has been conducting optimization activities at Superfund sites since 1997 and periodically reporting on the progress of implementing optimization recommendations (EPA, 2012a). EPA began its optimization efforts as a pilot program focused on groundwater pump and treat (P&T) remedies at Superfund (Fund-lead) sites by conducting remediation system evaluations and long-term monitoring optimizations. In August 2004, EPA developed the *Action Plan for Ground Water Remedy Optimization* ("Action Plan") (EPA, 2004) to further implement important lessons learned from the pilot phase and fully integrate optimization into the Superfund cleanup process, where appropriate. As the program matured, further recognition of the benefits of optimization prompted EPA to expand and formalize its optimization program. In 2012, EPA issued the *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion* ("the Strategy") (EPA, 2012b). Under the Strategy, optimization activities are conducted at every phase of the Superfund pipeline, from site assessment to site completion. This *Superfund Optimization Progress Report 2011 – 2015* summarizes EPA's progress on implementing optimization recommendations for individual optimization events, conducting technical support, and implementing the elements of the overall Strategy.

The four main sections of this report are: Introduction (Section 1.0), including a discussion of the purpose of the report and background on the history of the optimization program and optimization strategy; Summary of Implementation Progress (Section 2.0), including a summary of EPA's progress in implementing optimization recommendations at sites that were reviewed and information on technical support events; Summary of Progress on Implementing the National Optimization Strategy (Section 3.0), summarizing EPA's progress in implementing this strategy; and References (Section 4.0). Appendix A provides a detailed discussion of EPA's progress on implementing the National Optimization Strategy. Appendix B lists the optimization and technical support events completed through FY 2015.

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1.1 Purpose and Scope

The purpose of this report is twofold: (1) to provide a summary and analysis of the status of implementation of the site-specific recommendations resulting from independent optimization reviews at Superfund sites and to discuss and highlight technical support activities; and (2) to summarize EPA's progress on implementing the four main elements of the Strategy. The elements include:

- Element 1: Planning and Outreach.
- Element 2: Integration and Training.
- Element 3: Implementation.
- Element 4: Measurement and Reporting.

Optimization reviews result in site-specific reports with recommendations that fall within one of five standard recommendation categories: remedy effectiveness, cost reduction, technical improvement, site closure, and green remediation. Starting one year after completing the optimization review, the optimization team follows up with the Remedial Project Manager (RPM) for the site to determine the status of implementing the recommendations at the site. The implementation status of the recommendations is then tracked, and follow-up continues until all recommendations have been implemented, declined, or in some cases, deferred to the state.

Technical support projects generally result in providing site support for specific activities such as developing a strategic sampling approach, conducting systematic project planning, conducting a focused technical review of a specific aspect of a site, and visualizing and analyzing data to help identify data gaps in the conceptual site model (CSM). Technical support projects do not generally result in a report with recommendations that are tracked, although EPA does track the start and completion dates of these projects.

Successful strategies for implementing optimization recommendations, opportunities for improvement, barriers to implementation, and changes in project costs as a result of optimization are also a focus of this report. In addition, project highlights showcasing specific sites where optimization activities have had positive impacts are presented. Summaries and highlights of technical support projects whose positive results and lessons learned may be beneficial to other sites are also included.

This report covers the implementation of optimization recommendations during fiscal year (FY) 2011 through FY 2015 from 61 optimization events that are subject to tracking. It should be noted that not all optimization events completed in FY 2015 are included in this report; only those completed early in FY 2015 and where updated information was available are addressed. Information is provided on the implementation of recommendations for 41 events where an optimization was performed since the last progress report and which are being reported on for the first time (Table 1). Information is also provided for 20 events where implementation of recommendations has continued since the last progress report (Table 2). Most reviews were conducted at sites on the National Priorities List (NPL); some were conducted at non-NPL sites such as sites from the Brownfields and Underground Storage Tank programs.

Table 1: New Optimization Events Included in this Progress Report

State	Optimization Event	FY Complete	Optimization Focus	Total Optimization Events
Region 1				**6**
MA	Baird & McGuire	2013	R	
ME	Eastern Surplus	2012	R	
MA	Groveland Wells No. 1 & 2	2013	L	
MA	Groveland Wells No. 1 & 2	2014	L	
NH	Ottati & Goss/Kingston Steel Drum	2014	R, L	
MA	Baird & McGuire	2013	R	
Region 2				**3**
NJ	MetalTec/Aerosystems	2012	L	
NY	Richardson Hill Road Landfill/Pond and Sidney Landfill Site	2012	I, R	
NJ	Rockaway Borough Well Field, OU 2	2012	L	
Region 3				**3**
PA	Fischer & Porter Co.	2014	R	
PA	North Penn – Area 6	2012	R	
VA	Peck Iron and Metal	2013	I	
Region 6				**6**
TX	East 67th Street Ground Water Plume	2012	D	
NM	Homestake Mining Co.	2011	R	
TX	Jones Road Ground Water Plume	2014	D	
TX	Sandy Beach Road Ground Water Plume	2014	D	
TX	State Road 114 Groundwater Plume	2014	R	
OK	Tar Creek (Ottawa County), OU 4	2014	R	
Region 7				**5**
IA	Fairfield Coal Gasification Plant	2012	L	
NE	Hastings Ground Water Contamination	2013	R	
MO	Lee Chemical	2012	L	
IA	Railroad Avenue Groundwater Contamination	2014	R	
MO	Valley Park TCE	2013	I, L	
Region 8				**8**
SD	Batesland (Former Mobil Gas Station)	2013	I, D	
MT	Burlington Northern (Somers Plant) (BNSF Railway)	2015	R	
UT	Former Old Hilltop	2013	I, D	
SD	Gilt Edge Mine	2013	R	
UT	Intermountain Waste Oil Refinery (IWOR)	2011	R	

State	Optimization Event	FY Complete	Optimization Focus	Total Optimization Events
MT	Lockwood Solvent Ground Water Plume, OU 2	2014	I, D	
SD	Pine Ridge Oil	2013	I, D, R	
CO	Standard Mine	2014	D	
Region 9				**6**
AZ	Davis Chevrolet/Nav 185 Site	2013	I, D, R	
CA	Intel Magnetics	2013	L	
CA	Middlefield-Ellis-Whisman (MEW) Study Area	2012	D	
AZ	Painted Desert Inn/Nav 049 Site	2013	I, D, R	
CA	Sulphur Bank Mercury Mine	2015	R	
AZ	Telles Ranch/CRIT 002	2013	D, R	
Region 10				**4**
OR	Black Butte Mine	2012	I	
ID	Bunker Hill Mining & Metallurgical Complex, OU 2	2013	R	
WA	Moses Lake Wellfield Contamination	2015	I	
WA	Palermo Well Field Ground Water Contamination	2012	R	
TOTAL				**41**

- FY Complete indicates the Fiscal Year of the final optimization report.
- I = Investigation, D = Design, R = Remedy, L = Long-Term Monitoring; a single event may have recommendations that fall into more than one focus area.

Table 2: Updated Sites Included in this Progress Report

State	Optimization Event	FY Complete	Optimization Focus	Total Optimization Events
Region 2				**3**
NY	GCL Tie and Treating Inc.	2007	R	
VI	Tutu Wellfield	2012	R	
NJ	Vineland Chemical Co., Inc.	2012	R	
Region 3				**1**
PA	Mill Creek Dump	2010	R, L	
Region 4				**3**
FL	Alaric Area GW Plume	2010	R	
FL	American Creosote Works, Inc. (Pensacola Plant)	2006	R	
NC	Benfield Industries, Inc.	2007	R	
Region 5				**5**
MN	Baytown Township Ground Water Plume	2011	R	
WI	Moss-American Co., Inc. (Kerr-McGee Oil Co.)	2011	R	
MI	Ott/Story/Cordova Chemical Co.	2002	R	
MI	Wash King Laundry	2011	R	
IN	Reilly Tar & Chemical Corp. (Indianapolis Plant)	2004	R	
Region 7				**2**
NE	10Th Street Site	2010	R	
KS	57th and North Broadway Streets Site	2006	R	
Region 8				**1**
CO	Central City, Clear Creek	2007	R	
Region 9				**2**
CA	Modesto Ground Water Contamination	2002	R	
CA	Pemaco Maywood	2011	R	
Region 10				**3**
WA	Boomsnub/Airco	2002	R	
WA	Colbert Landfill	2011	R	
OR	Northwest Pipe and Casing/Hall Process Company	2007	R	
TOTAL				**20**

- FY Complete indicates the Fiscal Year of the final optimization report.
- I = Investigation, D = Design, R = Remedy, L = Long-Term Monitoring; a single event may have recommendations that fall into more than one focus area.

1.2 Project Background

EPA's Office of Land and Emergency Management (OLEM), formerly the Office of Solid Waste and Emergency Response (OSWER), developed the pilot Fund-lead P&T optimization initiative as part of the *FY 2000-FY 2001 Superfund Reforms Strategy* (EPA, 2000). Optimization is intended to facilitate systematic review and modification of planned and operating remediation systems to promote continuous improvement and to ensure overall remedy protectiveness and cost effectiveness. In the Superfund program, many optimization evaluations utilize the Remediation System Evaluation process, a tool developed by the U.S. Army Corps of Engineers (USACE) that EPA has further refined through application at Superfund sites.

The pilot phase of the optimization initiative demonstrated that optimization reviews offered measurable benefits in the form of cost savings and improved remediation system performance (EPA, 2005). In August 2004, EPA developed the Action Plan (EPA, 2004) to further implement important lessons learned from the pilot phase and fully integrate optimization into the Superfund cleanup process, where appropriate. Among other actions, this plan envisioned the development of routine progress reports concerning the implementation of recommended system changes.

Since the creation of the Action Plan, the Superfund program has consistently developed best practice tools and approaches that apply optimization concepts to sites earlier in the investigation and cleanup process. In late 2010, EPA initiated the development of the Strategy to increase the capacity for conducting optimizations and to extend optimization to all phases of the Superfund pipeline. The Strategy, issued in September 2012 (EPA, 2012b), expands and formalizes optimization practices from site assessment to site completion as an operating business model for the Superfund program. Widespread implementation of optimization review recommendations and best practices could assist EPA in achieving the goals of the *Superfund Remedial Program Review (SPR) Action Plan* (EPA, 2013a). Optimization reviews contribute to the following SPR Action Plan goals:

- More efficient use of constrained budgetary resources.
- Integrating remedial design and remedial action.
- Integrating adaptive management throughout the remedial process.
- Streamlining processes.
- Leveraging resources.

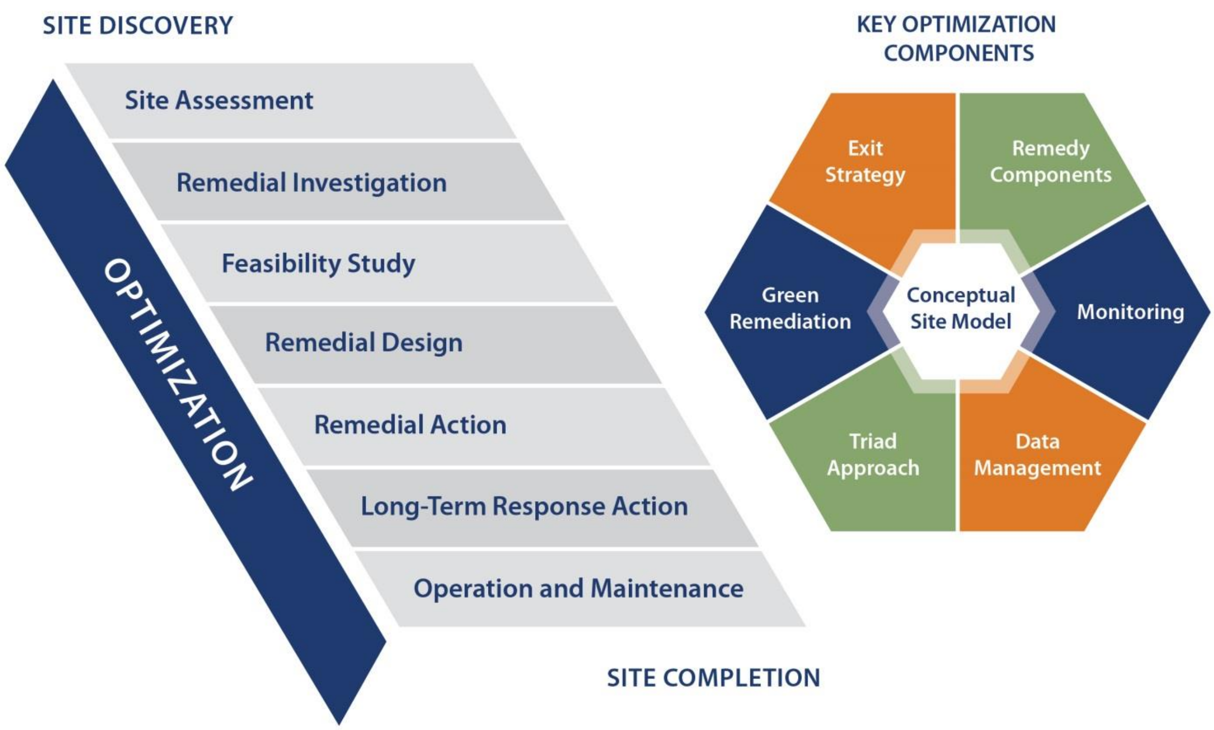
The Strategy encourages overarching process changes in program management and implementation, as well as site-level project management. These changes are intended to instill routine and frequent assessment of site cleanup progress, improve technical performance, reduce costs, and refine business practices including acquisition strategies and contracts management. The Strategy emphasizes incorporating optimization principles throughout the cleanup process from site assessment through site completion. Progress on the implementation of the Strategy is summarized in Section 3.0 and discussed in more detail in Appendix A of this report.

Sites are selected for optimization reviews collaboratively, based on input from EPA Headquarters (EPA HQ), RPMs, regional management, Regional Optimization Liaisons (ROLs), and stakeholders.

The optimization teams consist of an EPA HQ lead, the ROL, and a team of technically qualified individuals from within EPA, USACE, or one of EPA's pool of contractors with the qualifications necessary to conduct the optimization review. The site team consists of the RPM, regional technical support staff such as a hydrogeologist, state personnel, tribes, potentially responsible parties (PRPs), contractors, and other stakeholders such as community representatives. The reasons for conducting an optimization review vary and can include the following: (1) uncertainty regarding the current CSM; (2) highly complex site conditions with multiple sources, multiple contaminant plumes, or significant subsurface heterogeneity; (3) increasing investigative costs or expanding the scope of the investigation; (4) lack of progression to the next phase in the Superfund pipeline; (5) concerns regarding planned or existing remedy performance, effectiveness, or cost; (6) need to obtain an independent assessment of a remedial design; (7) interest in applying innovative strategies or technologies; (8) not achieving the goals of the remedy as anticipated; (9) exploring the opportunity to reduce monitoring points and costs; (10) a need to expedite the time frame for property redevelopment; (11) a need to reduce energy and effort and enhance efficiency; and (12) a need to develop or refine the completion strategy.

Figure 1 depicts the key components of optimization and the remedial pipeline phases at which optimization can be applied.[1,2]

Figure 1: Key Optimization Components and Superfund Pipeline Activities



Source: Adapted from EPA 2012b.

[1] See CFR, title 40, sec 300, Subpart E, for details regarding the phases of the Superfund pipeline

[2] Information about the seven key components can be found at www.epa.gov/superfund/cleanup-optimization-superfund-sites

Early in the optimization program, the reviews centered on Fund-lead groundwater P&T remedies and primarily focused on the constructed remedy and long-term monitoring. In more recent years EPA has found that, consistent with the goals of the Strategy, optimization reviews are conducted at any phase of the Superfund pipeline. In general, the recommendations made in an optimization review cover one of four optimization focus areas: investigation, design, remedy and long-term monitoring.[3] Optimization review teams usually include an evaluation of the CSM for each site, and make recommendations related to investigation activities when needed. This practice continues as EPA has learned that a continual focus on CSMs is valuable in assisting site teams in improving site remedy performance and progress, no matter the phase of the Superfund pipeline or the focus of the optimization review of the site.[4]

EPA has conducted a total of 194 optimization and technical support events from FY 1997 through FY 2015 (Table 3). A list of these optimization and technical support events is provided in Appendix B. From FY 1997 through FY 2010, EPA completed 94 optimization and technical support events, averaging seven events per year. From FY 2011 through FY 2015, with the implementation of the Strategy, EPA completed 100 optimization and technical support events, averaging 20 events per year. Through implementation of the Strategy, EPA has nearly tripled the number of optimization reviews and technical support projects it completes each year. Accordingly, EPA has expanded the benefits from optimization and technical support to a much larger universe of sites.

Table 3: Completed Optimization and Technical Support Events FY 1997 - FY 2015

Region	Number of Events 1997 - 2010	Number of Events 2011 –2015	Total Events 1997 –2015	% per Region
1	10	7	17	9%
2	12	12	24	12%
3	18	6	24	12%
4	11	1	12	6%
5	12	4	16	8%
6	5	11	16	8%
7	6	13	19	10%
8	4	12	16	8%
9	6	20	26	13%
10	10	14	24	12%
TOTAL	**94**	**100**	**194**	**100%**

In addition to expanding the program, EPA has implemented innovative approaches to optimization, such as reviewing a portfolio of sites located in a common geographic area. Coordinating site visits reduces costs associated with travel and deployments of personnel. EPA has also targeted

[3] Note the focus area of the optimization review does not necessarily line up with the Superfund pipeline phase. An optimization may be characterized as a remedy review even if the site is in O&M if the recommendations focus on the operating remedy.

[4] See factsheet: *Environmental Cleanup Best Management Practices: Effective use of the Project Lifecycle Conceptual Site Model* (EPA, 2011)

optimization and technical support activities at certain types of sites, with the most recent example being the mining site optimization pilot. This focused pilot effort was initiated based on the recognition that mining sites constitute some of the largest, costliest, most complex and longest-duration cleanups and can benefit from optimization. The treatment of mining influenced waters (MIW) is required at many mining sites and can be costly, making these sites good candidates for optimization and technical support projects.

EPA has continued to make improvements to the optimization program. These improvements are discussed in Section 3.0, Summary of Progress on Implementing the National Optimization Strategy.

2.0 SUMMARY OF RECOMMENDATION IMPLEMENTATION PROGRESS

Implementing recommendations from optimization reviews can result in improved: (1) understanding of the site conditions, (2) designs for remedies, or (3) operations of remediation systems, depending on the type of optimization review conducted and the phase of the Superfund pipeline. Optimization reviews typically identify a number of opportunities for improvements. These improvements are organized into five recommendation types; some recommendations are categorized into more than one recommendation type. The recommendation types and the total number of recommendations for each type are as follows:

- Remedy effectiveness – 273 recommendations.
- Cost reduction – 152 recommendations.
- Technical improvement – 158 recommendations.
- Site closure – 107 recommendations.
- Green remediation – 32 recommendations.

A total of 61 optimization events are included in this report—41 new optimization events (Table 1) and 20 optimization update events from previous years (Table 2). EPA worked closely with regional staff including RPMs and ROLs to collect information on the status of the recommendations for each of the 61 optimization reviews. Sources of information for this report included information from RPMs, site-specific optimization reports, optimization recommendation follow-up recorded in past annual reports, and follow-up information provided in the most recent data collection effort.

Section 2.1 summarizes the overall progress in implementing each of the recommendations by category without regard to the optimization focus area; provides the status of implementation for each of the five recommendation categories; presents specific project highlights for the five recommendation categories; and examines the tools and techniques recommended in optimization reviews that have led to positive outcomes. Section 2.2 summarizes investigation type, design type, remedy type and long-term monitoring (LTM) type recommendations and presents specific project highlights. Section 2.3 presents the list of events and sites that are no longer subject to follow up. Section 2.4 presents specific project highlights for technical support events.

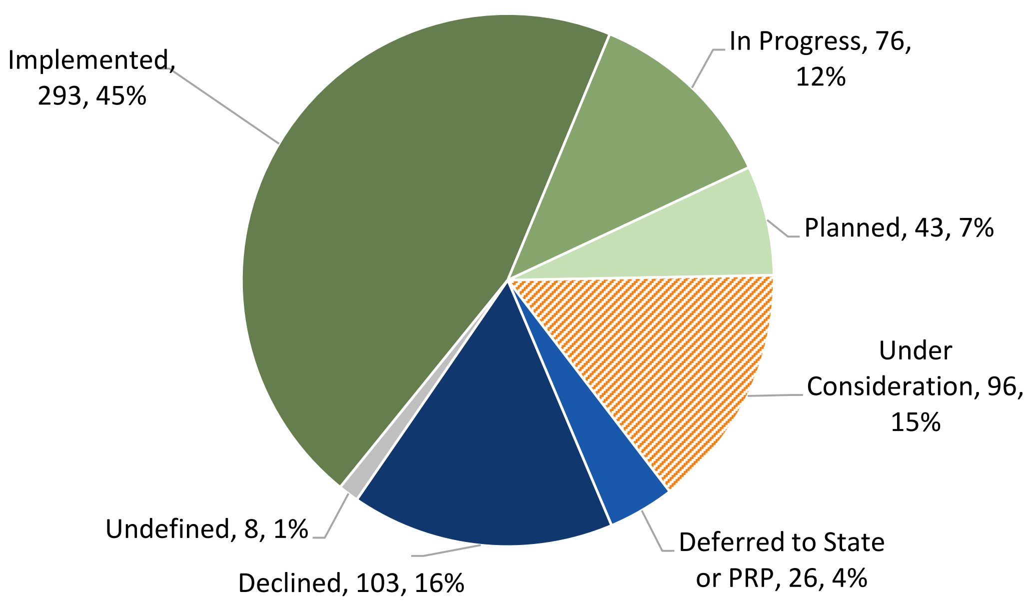
2.1 Overview of Progress

As shown in Figure 2, completed optimization reviews for the 61 optimization events included in this report identified a total of 645 optimization recommendations.

Overall, 64 percent of optimization recommendations have been implemented, are in progress, or are planned, and another 15 percent are under consideration. Only 16 percent of optimization recommendations were declined. Recommendations can be declined for a number of reasons including changed site conditions or selection of one option when several are offered. A small number of recommendations (4 percent) were deferred to the state or PRP for action. Recommendations are deferred to the state or PRP when site activities are their responsibility and the remedy is protective. In these cases the recommendations are provided as suggestions for improvements to be addressed at the discretion of the state or PRP. No information was provided for one percent of the recommendations, labeled as undefined. These results demonstrate that optimization review teams continue to evaluate site conditions and put forth reasonable recommendations for making improvements and that site teams are open to suggestions for improvement.

Figure 2: Overall Status of all Optimization Recommendations

Total Number of Recommendations = 645



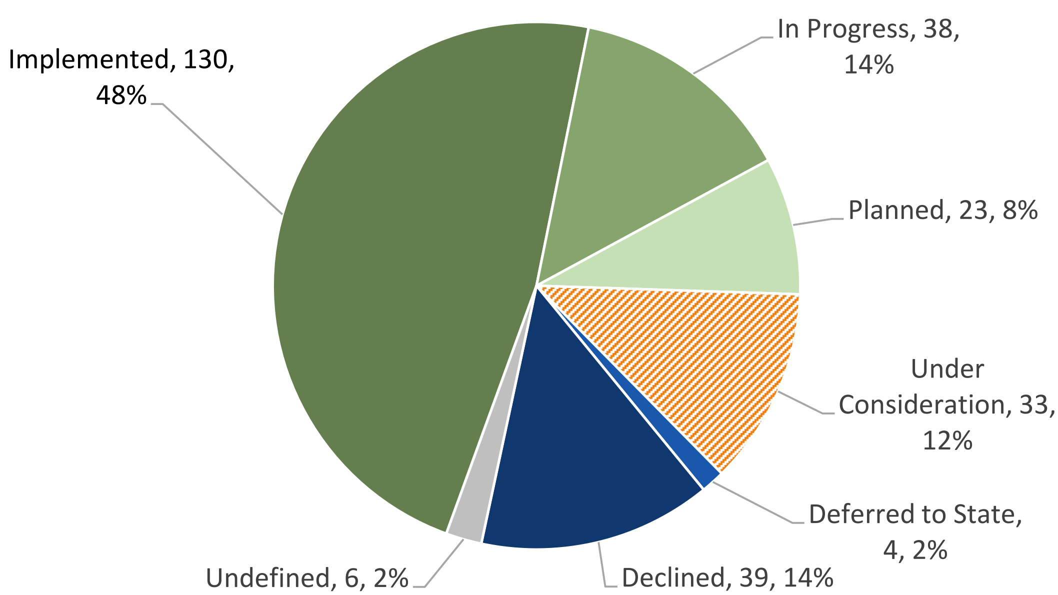
Information about the overall progress for each recommendation type, remedy effectiveness, cost reduction, technical improvement, site closure, and green remediation is presented in Sections 2.1.1 through 2.1.5. For each recommendation type, specific project examples are included that highlight progress. Information about how various tools and techniques were recommended as part of optimization events and how beneficial outcomes were achieved by implementing the optimization recommendations is summarized in Section 2.1.6.

2.1.1 Remedy Effectiveness

The majority of optimization recommendations (273 of the 645) fall into the remedy effectiveness category. As shown in Figure 3, 70 percent of the recommendations for remedy effectiveness have been implemented, are in progress, or are planned, and another 12 percent are still under consideration. Only 14 percent of optimization recommendations in the remedy effectiveness category were declined.

Figure 3: Remedy Effectiveness Implementation Status

Total Number of Recommendations = 273



Examples of remedy effectiveness recommendations include the following:

- Improvements in the CSM through additional characterization of sources and environmental media.
- Changes in remedial approach to address subsurface contamination.
- Changes in management approach.
- Improvements to the performance of an existing system.
- Identification and reduction of risk.

Highlights 1 and 2 for Baytown Township and Benfield Industries, Inc. provide examples of remedy effectiveness recommendations.

Highlight 1: Remedy Effectiveness

Baytown Township Ground Water Plume Site, Lake Elmo, Minnesota

KEY CHALLENGES

- Contaminant mass in subsurface not adequately addressed by P&T
- Source not adequately characterized
- Sampling groundwater by pumping expensive to implement
- Data not easily retrievable

PRIMARY RECOMMENDATIONS

- Consider implementing technologies to remove contaminant mass in subsurface
- Use Membrane Interface Probe (MIP) to assess the source mass distribution
- Consider use of passive methods to collect groundwater samples where appropriate
- Use existing electronic data management system to improve data retrieval

IMPLEMENTATION OUTCOMES

- Changed remedial approach for groundwater by adopting in situ chemical oxidation (ISCO) followed by in situ bioremediation (ISB) using Enhanced Reductive Dechlorination (ERD)
- Performed MIP assessment of source zone in 2012
- Using electronic database software to store and retrieve data

The Baytown Superfund site involves groundwater contamination with trichloroethene (TCE) attributed to a former metal working facility. The selected remedy initially included a groundwater P&T system, granular activated carbon (GAC) units for affected private wells, and a long-term monitoring program to assess the effectiveness of the P&T system. A pilot test for ISCO conducted before the optimization review showed promising results for reducing subsurface contaminant concentrations in the source area. The pilot study was conducted in recognition that P&T alone would take a long time to reach Remedial Action Objectives (RAOs) if the source zone remained untreated.

The optimization review, completed in FY 2011, recommended additional source characterization, full-scale implementation of ISCO in the source area with continued operation of the P&T system, and consideration of ISB using ERD. The optimization review also recommended improvements to monitoring such as using passive sampling techniques for collecting groundwater samples and improving data management. ISCO and ERD have been implemented at the site to address the subsurface source zone and groundwater contamination, and data and chain-of-custody are managed electronically.

Highlight 2: Remedy Effectiveness

Benfield Industries, Inc. Site, Waynesville, North Carolina

KEY CHALLENGES

- Several carcinogenic polycyclic aromatic hydrocarbons (PAHs) have been detected above cleanup levels in one monitoring well

PRIMARY RECOMMENDATIONS

- Identify additional areas of PAH contamination and consider use of ISCO and in situ enhanced bioremediation (ISEB)
- Consider Monitored Natural Attenuation (MNA) as a groundwater remedial strategy rather than the existing groundwater system
- Document the rationale for eliminating metals analysis; conduct a background study if needed

IMPLEMENTATION OUTCOMES

- Changed remedial strategy from P&T to in situ treatment of source contamination documented in a Record of Decision Amendment (ROD Amendment) in FY 2015
- Planning for additional confirmatory sampling and documentation of rationale for stopping metals analysis

The Benfield Industries site occupies a 6-acre parcel in Waynesville, North Carolina, that was once used as a bulk chemical mixing and packaging facility. A fire destroyed the facility in 1982. Site investigations conducted after the fire identified soil and groundwater contamination. The specified soil remedy included excavation, ex-situ physical and biological treatment, and on-site backfill. For groundwater, the specified remedy was hydraulic containment and plume remediation by groundwater extraction, with discharge of untreated groundwater to the Waynesville publicly owned treatment works (POTW). The soil remedy was implemented between 1997 and 2000. The groundwater extraction system began operating in April 2001. The extraction system was shut down on June 1, 2007 and has not been restarted.

The optimization review completed in FY 2007 recommended consideration of MNA as the groundwater remedy, additional source characterization, and possible implementation of ISCO in the source area with ISEB for polishing. MNA was evaluated and additional site investigations were conducted. These studies resulted in ISCO in combination with ISEB being selected in the September 2015 ROD Amendment as the recommended remedy. EPA has stated that an anticipated benefit of remediating the residual soil contamination is that the injected oxidant will also destroy the contaminants that have already migrated into the groundwater. Therefore, it is expected that with the successful treatment of this residual soil contamination, neither an active groundwater remedy nor MNA will be necessary for this site. Additional sampling will be conducted to confirm that metals analysis is no longer required.

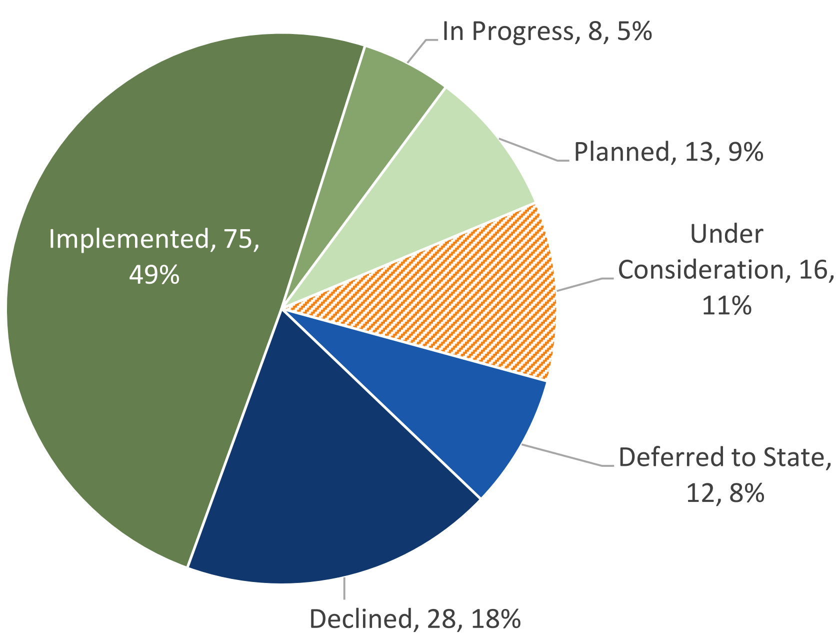
2.1.2 Cost Reduction

Optimization recommendations pertaining to cost reduction may cover many aspects of system operation, including the use of specific treatment technologies, operator and laboratory labor, reporting, and project management. More than 60 percent of optimization recommendations for cost reduction have been implemented, are in progress, or are planned, and another 11 percent are still under consideration (Figure 4). Only 18 percent of optimization recommendations in the cost reduction category were declined.

Cost savings for this report were estimated as one-time cost savings or multiple year annual cost savings. It should be noted that a short-term investment may be required to realize longer-term cost savings. In addition, cost savings in the form of cost avoidance are often realized but are difficult to quantify. Optimization reviews continue to identify many opportunities to reduce on-site labor without affecting remedy performance. Such reductions may be possible following system shakedown, when a remedy is designated as operational and functional. Furthermore, some treatment components may become inefficient or unnecessary as a result of changing site conditions or overly conservative estimates used during the design phase. Simplifying a treatment system under such conditions has resulted in cost savings associated with reduced material costs, decreased energy usage, and reduced labor cost for maintaining or improving remedy performance.

Figure 4: Cost Reduction Implementation Status

Total Number of Recommendations = 152



Examples of cost reduction recommendations include the following:

- Automate systems to reduce labor costs.
- Streamline monitoring to reduce laboratory and reporting costs.
- Simplify treatment systems to reduce operating costs.

Highlights 3 and 4 for State Road 114 Groundwater Plume and Wash King Laundry provide examples of cost reduction recommendations.

Highlight 3: Cost Reduction

State Road 114 Groundwater Plume Site, Levelland, Texas

KEY CHALLENGES

- Groundwater system operates at high cost and high energy usage
- Significant amount of treated water is recaptured, increasing the volume extracted
- On-site extraction wells pump less volume than designed because of significant fouling issues

PRIMARY RECOMMENDATIONS

- Eliminate the use of cryogenic-cooling and compression (C3) units
- Streamline groundwater monitoring
- Eliminate the use of on-site extraction wells
- Consider use of passive methods to collect groundwater samples

IMPLEMENTATION OUTCOMES

- Eliminated C3 units for a savings of approximately $1.8 million/year
- Reduced monitoring by eliminating wells for a savings of $84,000/year
- Reduced rehabilitation costs by eliminating on-site extraction wells for a savings of $91,500/year
- Significantly reduced environmental footprint (86-95 percent reduction)
- Reduced reporting costs by $24,000/year

The State Road 114 Groundwater Plume Superfund site is located west of the City of Levelland in Hockley County, Texas. The site consists of a groundwater plume more than a mile long primarily consisting of 1,2-dichloroethane and benzene contamination. The source of the groundwater contamination is a former petroleum products refinery. The selected remedy included a groundwater P&T system, air stripping and GAC units for off-gas treatment. A soil vapor extraction (SVE) system is in place in the defined light non-aqueous phase liquid (LNAPL) area. The C3 unit is used for compression, cooling and condensing vapors from the SVE system to capture volatile organic compounds (VOCs) as NAPL.

The optimization review completed in FY 2014 confirmed the site team's suggestion to shut down the shallow SVE system eliminating one of the C3 units. Other recommendations that were implemented included treating the air-stripper off-gas with vapor GAC, eliminating the need for the Munster concentrator and another of the C3 units, and replacing the remaining three C3 units for treatment of the deep SVE vapors with a regenerative thermal oxidizer resulting in lower costs and energy usage. Elimination of the C3 units reduced: (1) global warming potential footprint from 1,969 tons to 270 tons (86 percent reduction); (2) total energy use from 41,726 million British thermal units (MMBtu) to 3,639 MMBtus (91 percent reduction); and (3) total nitrogen oxides, sulfur oxides, and particulate matter emissions footprint from 35,965 pounds to 1,673 pounds (95 percent reduction). Strategic sampling is employed as recommended through the reduction of metals sampling, which allows for all VOC sampling at monitoring wells to be conducted with passive diffusion bags, except for infrequent events where other sampling approaches can be employed. Costs were further reduced by eliminating the need for rehabilitation of the extraction wells taken out of service and decreasing reporting. Implementation of additional recommendations is planned which will further reduce costs including reducing the level of effort for the plant operator and operating with only one air stripper.

Highlight 4: Cost Reduction

Wash King Laundry Site, Pleasant Plains Township, Michigan

KEY CHALLENGES

- Reducing costs of operation of groundwater treatment system and monitoring program
- Identifying additional source areas

PRIMARY RECOMMENDATIONS

- Consider modifying groundwater monitoring program; reduce or eliminate metals analysis
- Discontinue pumping at extraction well EW-4
- Investigate sources in the lagoon area

IMPLEMENTATION OUTCOMES

- Reduced costs $30,000/year by modifying the groundwater monitoring program
- Discontinued pumping at EW-4
- Achieved progress on identifying sources in the lagoon area

The Wash King Laundry site is located south of the city of Baldwin in Pleasant Plains Township, Lake County, Michigan. As part of the laundry operations/services, dry cleaning was conducted, which included the use of the solvent tetrachloroethene (PCE). The optimization review completed in FY 2011 focused on all aspects of site remediation including the P&T system, SVE system, in situ bioremediation, and site-wide monitoring program.

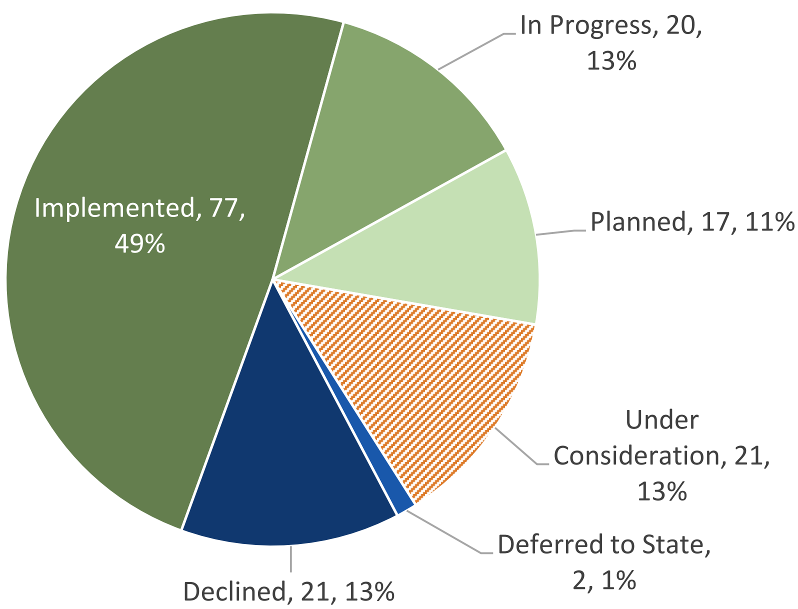
On recommendation of the optimization review, pumping at extraction well EW-4 was discontinued. Extraction well EW-1 appears to have successfully captured much of the contamination that would migrate to EW-4, and the VOC concentrations at EW-4 and nearby monitoring wells MW-301S and MW-301D are routinely below cleanup levels. In addition, as recommended, the monitoring program was restructured to allow strategic sampling to fully track the progress of the remediation while reducing the number of sampling locations and frequency as appropriate. Progress has been made in identifying the additional source areas by conducting additional investigation as recommended in the optimization review.

2.1.3 Technical Improvement

Technical improvement recommendations cover a wide range of items to improve overall site operations and usually relate to improving existing systems. These recommendations are generally easy to implement, require minimal funding, and are not typically contingent on other recommendations. More than 70 percent of optimization recommendations for technical improvement have been implemented, are in progress, or are planned, and another 13 percent are under consideration (Figure 5). Only 13 percent of optimization recommendations in the technical improvement category were declined. Some recommendations for technical improvement were not implemented because they addressed an existing component that was likely going to be changed based on remedy effectiveness recommendations.

Figure 5: Technical Improvement Implementation Status

Total Number of Recommendations = 158



Examples of technical improvement recommendations include the following:

- Reconfigure components of the treatment train.
- Inspect and then clean, repair, or replace faulty equipment.
- Rehabilitate fouled extraction or injection wells.
- Consider more efficient pumps and blowers.

Highlights 5 and 6 for Sandy Beach Groundwater Plume and Gilt Edge Mine provide examples of technical improvement recommendations.

Highlight 5: Technical Improvement

Sandy Beach Ground Water Plume Site, Pelican Bay, Texas

KEY CHALLENGES

- Multiple data gaps affecting the CSM and design of the source remedies including:
  - Uncertainty about materials remaining in the source area
  - Distribution of TCE in shallow and saturated soils of varying porosity
  - Impact of ISB treatments on water quality
  - Effect of back-diffusion from low permeability deposits on the dissolved phase plume

PRIMARY RECOMMENDATIONS

- Conduct additional ISB pilot test to evaluate effectiveness as a source area remedy and secondary impacts to water quality
- Implement remedy performance monitoring

IMPLEMENTATION OUTCOMES

- ISB pilot test completed during the remedial design
- Implementation of ongoing remedy performance monitoring

The Sandy Beach Ground Water Plume Superfund site involves groundwater contamination with TCE attributed to a former unpermitted landfill. The selected remedy included a groundwater P&T system, installation of filtration units for affected residential wells or replacement with municipal water supply connections, SVE, and ISB.

The optimization review completed in FY 2014 recommended prioritizing and sequencing remedial activities, additional source characterization, an additional ISB pilot test, modifying the scale and design of the P&T system to improve the efficacy of plume hydraulic control, and long-term monitoring program to confirm control of the plume and the performance of aggressive source remediation.

Remediation of the source area was prioritized and began in September 2015. Trenching and sampling in the area of the site slated for SVE was conducted to determine if there was another potential source in that area. Source area saturated zone soils were characterized using a photoionization detector on rotosonic cores. The ISB pilot test was completed during the remedial design and the full-scale implementation of ISB was scheduled to begin January 2016. Remedy performance monitoring is ongoing and includes collection of vapor samples from individual SVE wells, groundwater samples from SVE wells, and performance monitoring of the system.

Highlight 6: Technical Improvement

Gilt Edge Mine Site, Northern Black Hills, South Dakota

KEY CHALLENGES

- High labor costs for monitoring Hoodoo Gulch Collection Facility
- Need alternatives for addressing high sulfate water
- Various minor issues related to source control such as uncaptured seeps

PRIMARY RECOMMENDATIONS

- Upgrade the Hoodoo Gulch Collection Facility
- Operate the water treatment plant (WTP) in batch mode to reduce staffing and vehicle leases
- Implement minor WTP changes:
  - Consider feeding lime only at one location to simplify the control of the WTP and to optimize lime dosing
  - Install orifice plates in the influent lines to each filter to control rates
  - Install a backup filter feed pump
- Implement planned Operable Unit (OU) 01 source control remedy to address other challenges after upgrade to Hoodoo Gulch Facility

IMPLEMENTATION OUTCOMES

- Communication and remote monitoring systems are being added to Hoodoo Gulch
- Automation upgrades are in process
- Modified WTP flow rate for more effective removal of sulfate in clarifier
- Installed the backup filter feed pump and upgraded filter valves to prepare for automated operation

Mining activities at the Gilt Edge Mine resulted in the contamination of surface water, groundwater, soil and sediment at the site. The surface water and groundwater remedy consists of the WTP, which treats acid rock drainage collected at the site. The selected remedy in the 2001 Interim Record of Decision (ROD) for OU 02 included collecting and conveying the acid rock drainage seep and surface water flow to the WTP, and treating acid rock drainage at the WTP with a lime-based precipitation process. An additional purpose of the Interim ROD actions was to reduce WTP operating costs.

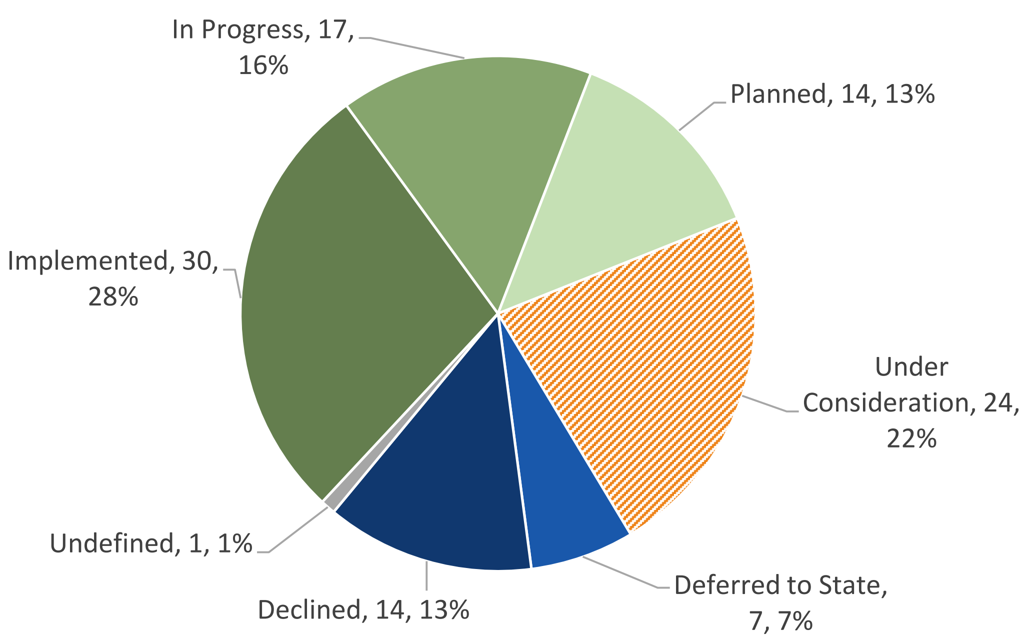
The optimization review completed in FY 2013 recommended the consideration of alternative treatment options for the remaining high-sulfate acid rock drainage, upgrading the Hoodoo Gulch collection facility and other collection and WTP facilities prior to implementation of the OU 01 remedy, reducing the labor force, eliminating overnight staffing and operating the WTP in batch mode, implementing minor WTP changes and not rebuilding or relocating the WTP. The optimization review triggered modifications to the WTP flow rate which allowed for the more effective removal of sulfate in the clarifier. The backup filter feed pump and upgraded filter valves were installed to prepare for automated operation. Automation upgrades at the WTP are in progress, which will allow for the elimination of nighttime staffing, while still allowing the WTP to run full-time during wet years and run in batch mode during dry periods.

2.1.4 Site Closure

Optimization reviews continue to identify opportunities to accelerate progress toward achieving final cleanup goals and eventual site completion or closure. These recommendations most commonly involve developing a clear and comprehensive completion strategy and evaluating changes in the remedial approach in situations where the current remedy may no longer be the most effective approach. Nearly 60 percent of optimization recommendations for site closure have been implemented, are in progress, or are planned, and another 22 percent are still under consideration (Figure 6). Only 13 percent of optimization recommendations in the site closure category were declined.

Figure 6: Site Closure Recommendation Implementation Status

Total Number of Recommendations = 107



When considering site closure for groundwater sites, EPA's *Groundwater Remedy Completion Strategy* (EPA, 2014) and related guidance documents provide an approach and statistical tool for assessing when monitoring results indicate that cleanup levels are achieved and aquifer restoration is accomplished. A completion strategy "…is a recommended site-specific course of actions and decision-making processes to achieve groundwater RAOs and associated cleanup levels using an updated conceptual site model, performance metrics and data derived from site-specific remedy evaluations" (EPA, 2014). Using the completion strategy decision-making process will allow for the assessment of remedial performance and evaluation of whether a remedial action is working as anticipated or if the remedy selected in the decision document may need to be modified to achieve RAOs and associated cleanup levels. Such modifications have often included addressing additional source material or residual subsurface contamination.

Examples of site closure recommendations include the following:

- Further characterization of sources.

- Targeted treatment of remaining sources.
- Development of an exit strategy including performance metrics for determining achievement of RAOs.

Highlight 7 for Groveland Wells No. 1 & 2 provides an example of site closure recommendations.

Highlight 7: Site Closure

Groveland Wells No. 1 & 2 Site, Groveland, Massachusetts

KEY CHALLENGES

- Subsurface contamination difficult to remediate with P&T and SVE
- P&T would be required for a long period of time if subsurface source material remains untreated

PRIMARY RECOMMENDATIONS

- Additional characterization of sources and groundwater
- More aggressive treatment of sources
- Close monitoring of groundwater P&T system after source treatment
- Develop P&T shutdown and restart criteria

IMPLEMENTATION OUTCOMES

- In situ thermal (IST) remedy implemented in subsurface source area
- P&T system monitored monthly for one year after IST implementation
- Shutdown and restart criteria developed for P&T system
- Increased groundwater monitoring demonstrated no rebound of TCE
- P&T system shut down in April 2014 and restart criteria have not been exceeded to date

Municipal supply wells in Groveland were contaminated by TCE in the late 1970s. The contamination was attributed to nearby Valley Manufactured Products. The PRP implemented an interim P&T remedy and used SVE in the source area from 1992–2002, which was unsuccessful. The PRP subsequently filed for bankruptcy and the site became a Fund-lead project. EPA and the State of Massachusetts operated the P&T system until 2014.

Several optimization reviews were conducted for the site. An optimization review conducted in 2002 led to additional source investigations, pilot testing, and a feasibility study (FS) which ultimately led to the selection and implementation of IST from 2010–2011 in the source area. An additional optimization review was conducted in 2012 before the P&T system was transferred to the state. The FY 2013 review recommended more frequent monitoring of the P&T system performance and monitoring network for one year to fully evaluate the impact of IST. An optimization review in FY 2014 recommended the development of P&T shutdown and restart criteria based on the effectiveness of IST and those recommendations were adopted. The P&T system was shut down in 2014 based on the shutdown criteria. The restart criteria have not been exceeded since the system was shut down.

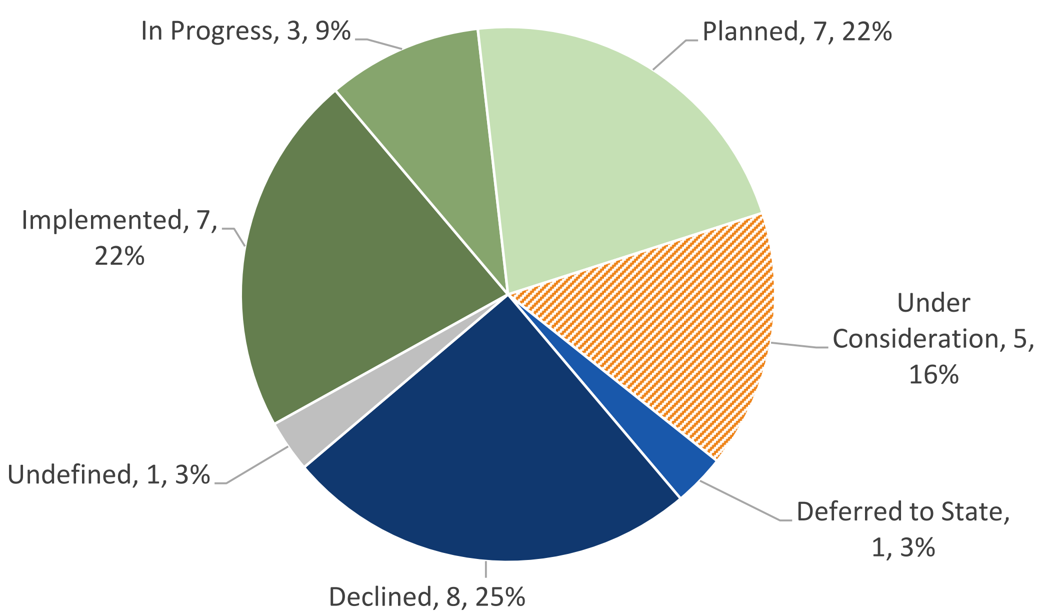
2.1.5 Green Remediation

Optimization reviews continue to identify opportunities to accelerate progress toward achieving green remediation and reductions in environmental footprints. Over 50 percent of optimization recommendations for green remediation have been implemented, are in progress, or are planned, and another 16 percent are still under consideration (Figure 7). A total of 25 percent of optimization recommendations in the green remediation category were declined.

It should be noted that recommendations for other optimization categories—remedy effectiveness, cost reduction, and technical improvement—often include opportunities for reductions in environmental footprint. EPA is also conducting environmental footprint analyses during the design-phase as technical support projects (see Section 2.4) to identify green remediation best management practices and to ensure remedy components are right-sized when implemented.

Figure 7: Green Remediation Recommendation Implementation Status

Total Number of Recommendations = 32



Examples of green remediation recommendations include the following:

- Utilize local labor for site management and sampling to avoid air emissions associated with travel.
- Consider opportunities for renewable energy such as solar, wind, or renewable energy credits.
- Streamline the treatment train.
- Downsize pumps and blowers.

Highlight 8 for Pemaco Maywood provides an example of green remediation recommendations.

Highlight 8: Green Remediation

Pemaco Maywood Site, Maywood, California

KEY CHALLENGES

- Modify remediation system now that significant mass reduction has occurred to address operational costs and energy use

PRIMARY RECOMMENDATIONS

- Reduce groundwater monitoring
- Shut down 6 of 8 dual phase extraction and SVE wells
- Remove one blower and replace other blower with a regenerative blower
- Remove the cooling tower, water softener, and water pressure booster

IMPLEMENTATION OUTCOMES

- Reduced electricity usage by reducing the operation of the system to one blower and by installing a variable frequency drive on the operating blower to reduce power consumption
- Reused equipment taken off-line for other projects and sold some equipment
- Reduced costs from $58,000/month to $25,000/month by modifying the groundwater monitoring program

The Pemaco Maywood site operated as a chemical blending and distribution facility from the late 1940s until June 1991. The site soils and groundwater were impacted by aromatic and chlorinated solvents, flammable liquids, specialty chemicals, and oils used and stored at the site. Hot spot removal and soil capping was conducted. A SVE, high-vacuum dual-phase extraction, and a groundwater extraction system were still in operation at the time of the optimization. Electric resistive heating had been conducted between September 2007 and April 2008.

All recommendations from the FY 2011 optimization review were implemented resulting in a reduced environmental footprint for the remediation system. The smaller environmental footprint resulted from reductions in electricity usage and air emissions by shutting down SVE wells and a blower, removing equipment, and fitting the operating blower with a variable frequency drive; reductions in energy use and air emissions associated with laboratory analysis from a decrease in groundwater and process monitoring; and reductions in fuel usage and air emissions from a decrease in operator labor and the number of visits per week.

2.1.6 Tools and Techniques Leading to Beneficial Outcomes

EPA conducted a more detailed analysis of the various tools and techniques included in optimization recommendations and of the beneficial outcomes achieved by implementing them. The tools and techniques identified by EPA, were grouped into seven categories as described in Table 4, with references to highlights that provide examples of sites where those tools and techniques are being implemented. These tools and techniques may be used separately; however, many are inter-related and are often used together. The outcomes from the tools and techniques include improving remedy effectiveness, reducing costs, adding technical improvements to the remedy, accelerating the progress to site closure, and reducing the environmental footprint of remediation and operations.

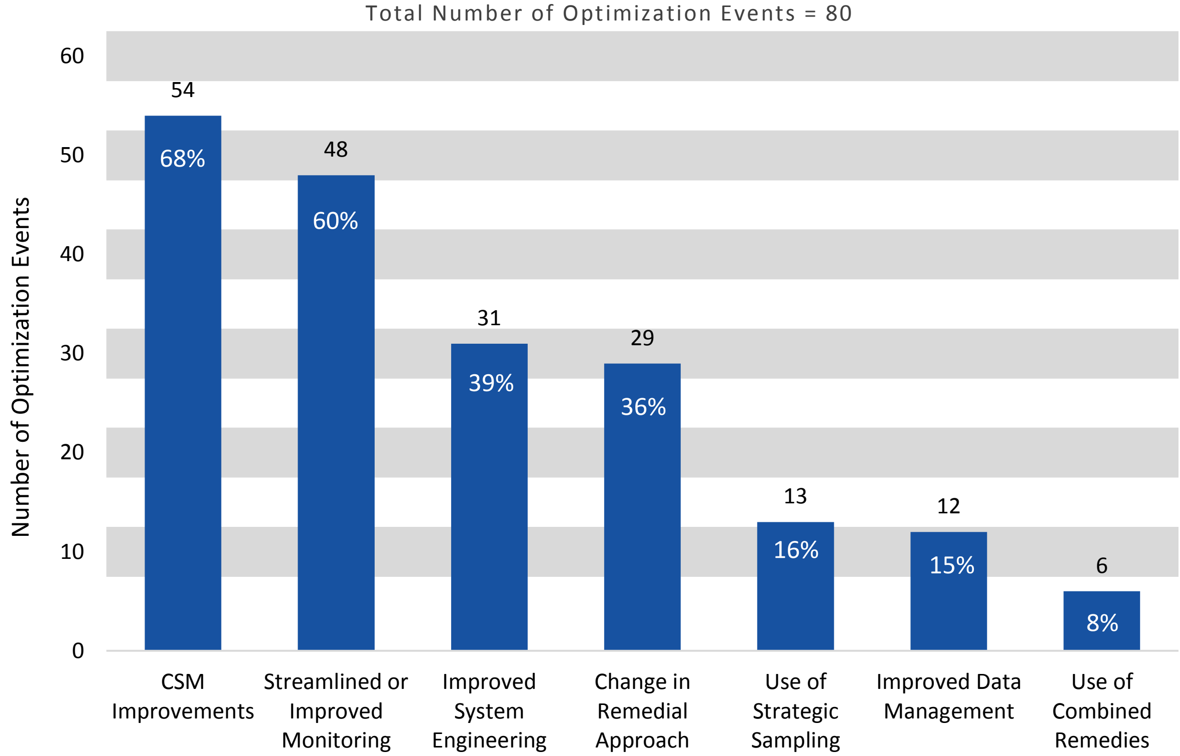
Table 4: Recommended Tools and Techniques Leading to Beneficial Outcomes

Recommended Tools and Techniques	Description	Highlight References
Use of Strategic Sampling Approaches	Specific strategic sampling approaches apply to several types of characterization activities conducted on various environmental media and help improve the technical understanding of site conditions. These approaches include high-resolution site characterization for groundwater and incremental sampling for contaminated soil for improved characterization of source volumes and locations. Strategic sampling approaches can often lead to other beneficial results such as CSM improvements, the use of combined remedies, and right-sizing remedies.	1, 9, 18, 21
CSM Improvements	Improving the CSM can be achieved through additional characterization of sources and environmental media, such as groundwater, or by analyzing existing data with new tools, such as 3-dimensional visualization and analysis (3DVA). CSM improvements are best achieved through smart scoping and the use of strategic sampling approaches and incorporate improved data management.	1, 2, 4, 5, 7, 9, 10, 11, 12, 14, 15, 16, 19, 20, 21
Improved Data Management	Aspects of improved data management include improving data management planning, data acquisition, data processing, data analysis (using 3DVA), data preservation and storage, and data publication and sharing.	1, 21
Improved System Engineering	Improved system engineering includes modifying one or more engineered components of a remedial system to improve overall system performance. Improved system engineering can include right-sizing remedies which involves using a more targeted approach that applies technologies to a specific and well-defined area. Smart scoping, strategic sampling approaches, CSM improvement, and improved data management can facilitate right-sizing remedies.	3, 6, 8, 10, 11, 19
Change in Remedial Approach	Changes in remedial approach include adding or changing remedies to better address remaining contamination or newly identified areas of contamination. The recommendations provide improvements in remedy effectiveness, cost reductions, and the achievement of site closure in a shorter period of time.	1, 2, 4, 5, 7, 10, 13, 14, 15, 16, 19, 20
Use of Combined Remedies	Combined remedies include the concurrent use of more than one technology for different portions of contaminated media and the use of multiple technologies to address contaminated media at different points in time. Smart scoping, strategic sampling approaches, CSM improvements, and improved data management can facilitate the use of combined remedies.	1, 7, 12, 13, 19
Streamlined or Improved Monitoring	Streamlined or improved monitoring involves adjustments to monitoring frequency, monitoring locations, chemicals of concern analyzed, as well as the analysis of monitoring results over time. Streamlined or improved monitoring also addresses data management practices.	1, 2, 3, 4, 5, 8, 14, 17, 18

Figure 8 presents the number and percentage of events that implemented one or more of the tools and techniques by category. The categories that were implemented for the largest number of optimization events include: (1) CSM improvements, (2) streamlined or improved monitoring, (3) improved system engineering, and (4) change in remedial approach. As mentioned above, these tools and techniques may be used separately or in combination at a site.

Figure 8: Number of Implemented Tools and Techniques

Total Number of Optimization Events = 80



2.2 Recommendations by Optimization Focus

In addition to the five optimization categories based on overall outcome of the effort, recommendations can also be classified by optimization focus—investigation, design, remedy and long-term monitoring. To better understand the common findings and outcomes of optimization reviews and communicate lessons learned, EPA discusses recommendation implementation by these optimization focus areas in Sections 2.2.1 through 2.2.4. While the focus areas are related to the phases of the Superfund pipeline, an optimization focus may not align exactly with the Superfund pipeline. For example, an LTM-focused optimization may be done during the remedy phase of the Superfund pipeline to prepare for LTM.

2.2.1 Investigation Recommendations

An investigation-focused optimization involves translating the site data gaps and uncertainties into a sampling strategy with the goal of refining the CSM to allow for remedy selection. Accordingly, the investigation optimization review examines the collection of the data necessary to understand exposure pathways, exposure point concentrations for site receptors and information to aid the evaluation and selection of potential remedies, and to the extent possible, the design data requirements of likely site remedies. An effective investigation optimization review considers the regulatory framework of the project, human and ecologic exposure points, potential RAOs, the perspectives of the various site stakeholders, and the available site-specific technical information. Investigation best practices are emphasized in the optimization review to ensure that an effective, efficient characterization is performed. Investigation optimization reviews can be conducted during any phase of the Superfund pipeline whenever additional site characterization activities may be necessary. The remedial design phase of the Superfund pipeline frequently involves site characterization activities to accurately estimate treatment and disposal volumes and to delineate a more accurate footprint for the application of various in situ technologies. The remedial action and long-term response action (LTRA) phases of the Superfund pipeline can also involve site characterization to reconcile data gaps in the CSM that are indicated by performance issues with the constructed remedy. For example, a groundwater remedy that is not performing as expected (that is not reducing contaminant concentrations in the groundwater as predicted) may be an indication of an undiscovered source of contamination and additional characterization may be required to determine if other source areas exist.

Remedy effectiveness was the main category of recommendation made for investigation optimizations, followed by technical improvement and site closure (Table 5). The fewest number of recommendations were made for cost reduction and green remediation.

Table 5: Types of Investigation Recommendations

Types of Recommendations	Total
Remedy Effectiveness	64
Cost Reduction	14
Technical Improvement	36
Site Closure	32
Green Remediation	4
All Recommendation Types	**150**

At the Black Butte Mine site (Highlight 9), an optimization review of the remedial investigation was conducted after a removal action. The optimization review team first identified data gaps and missing components of the CSM of this large site with a long history of mercury mining. They leveraged existing data to complete the CSM and identify area-specific data gaps to address numerous study questions. To maximize information and resources, the optimization team recommended sequenced field investigations that utilized real-time measurement technologies and incremental sampling. The decision logic for sequencing field activities was developed as part of the optimization.

Investigation optimizations may also help distinguish the most effective combination of remedial actions. At the Sulphur Bank Mercury Mine site (Highlight 10), a FS contained alternatives that involved either long-term P&T or short-term P&T in conjunction with the replacement of an existing waste rock dam. The state and EPA each favored different alternatives as the preferred approach. The optimization review team recommended a hybrid of the two alternatives that included components of both the EPA and state’s preferences. The team utilized investigation data to provide an innovative approach to the site by using a slurry wall and subaqueous cap in combination with a permeable treatment conduit within the waste rock dam. Both the EPA and state have agreed to consider this hybrid alternative and plan to propose it as the preferred remedy. The Sulphur Bank Mercury Mine site, conducted as part of the mining site optimization pilot, demonstrates how an optimization review can help develop effective and lower cost actions for MIW management.

Highlight 9: Investigation Recommendations

Black Butte Mine Site, Lane County, Oregon

KEY CHALLENGES

- Incomplete CSM
- Numerous data gaps
- Large site with long history of mercury mining

PRIMARY RECOMMENDATIONS

- Identify data gaps for specific areas to streamline study questions
- Sequence activities focusing on source control first
- Use real-time measurement technologies and incremental sampling
- Conduct strategic sampling for storm/non-storm events, groundwater—surface water interactions, and mercury methylation rates

IMPLEMENTATION OUTCOMES

- Leveraged existing data to build CSM
- Identified data gaps for each area to focus study
- Developed decision logic for conducting sequenced activities

The Black Butte Mine site contains numerous on-site sources that affect nearby surface water bodies that eventually lead to the Cottage Grove Reservoir located 10 miles downstream from the site. Contaminants include dissolved and particulate mercury, which is converted to methylmercury in the reservoir, resulting in high levels of mercury in fish tissue and potential ecological and human health exposures. A removal action was conducted at the site and the optimization review was conducted to assist with planning of the remedial investigation.

The optimization review team used existing data to identify important data gaps for the specific areas throughout the mine and for surface water bodies leading from the mine to the reservoir downstream. The data gaps were then used to prioritize and identify data collection activities to be conducted in sequence, with continuing mercury sources to be addressed first. Decision logic for conducting the sequence of investigation activities was developed. The recommended use of real-time measurement technologies and, when appropriate, incremental sampling design was implemented. In addition, the site team implemented real-time measurement technologies, strategic sampling for storm/non-storm events, groundwater–surface water interactions, and mercury methylation rates in reservoir sediments and the water column.

Highlight 10: Investigation Recommendations

Sulphur Bank Mercury Mine Site, Clear Lake, California

KEY CHALLENGES

- Large site with long history of sulfur and mercury mining
- Draft FS contained alternatives that required either long-term surface water management or extensive replacement of existing waste rock dam to protect Clear Lake from contaminated water in Herman Impoundment
- EPA and the state favored different alternatives as the potential preferred alternative

PRIMARY RECOMMENDATIONS

- Consider hybrid alternative that:
  - Includes aspects of the EPA- and state-favored alternatives for mine waste and mining influenced water management
  - Eliminates P&T of Herman Impoundment by using innovative isolation techniques and treatment technologies

IMPLEMENTATION OUTCOMES

- Steps being taken to fully evaluate a hybrid alternative in a focused feasibility study (FFS)
- Hybrid alternative satisfies both EPA and state objectives while eliminating perpetual P&T of Herman Impoundment and extensive replacement of waste rock dam

The Sulphur Bank Mercury Mine site operated as a sulfur mine and then as a mercury mine from 1856 to 1957. Open pit mercury mining left a large flooded open pit, called the Herman Impoundment, which is filled with contaminated water that leaches mercury into nearby Clear Lake. In addition, there are 2 million cubic yards of mine wastes and tailings on the site.

EPA completed a FS for OU 01 that addressed Herman Impoundment and mining wastes and tailings. However, EPA and the state both identified concerns with the alternatives analyzed for OU 01. EPA identified concerns related to the potential for mercury leaching into Clear Lake, and preferred to include long-term P&T of Herman Impoundment to lower the level. The state raised concerns over the feasibility of long-term P&T and preferred to include short-term P&T of Herman Impoundment and extensive replacement of the existing waste rock dam. The optimization review team proposed a hybrid alternative that includes elements of the EPA and state's preferences for the mine wastes and tailings and that provides an innovative approach to Herman Impoundment by using isolation techniques (slurry wall on the impoundment side and subaqueous cap on the Clear Lake side of waste rock dam) in combination with a permeable treatment conduit within the waste rock dam. EPA and the state have agreed to consider the hybrid alternative in a FFS and will use a comparative analysis to propose a preferred alternative that incorporates components of the optimization review.

2.2.2 Design Recommendations

A design-focused optimization is typically conducted before completion of the design of the selected remedy. The design generally involves developing specific performance objectives, outlining a clear remedial strategy, developing the technical specifications of a remedy, preparing a monitoring program to monitor the effectiveness of the remedy, and formulating an effective remedy completion strategy. Optimization during pre-design, design or redesign evaluates the selected remedy prior to implementation and operation. It considers the goals of the remedy, CSM, available site data, performance considerations, effectiveness, cost-effectiveness and closure strategy. Design optimization reviews may add greater certainty to the selected remedy and ensure streamlined operations from the start of the project. An effective design optimization review should also address costs for implementation and long-term operation, maintenance and monitoring, including designing and implementing a remedy in phases, and allowing additional information from initial phases to guide later phases of design.

Remedy effectiveness is the main type of recommendation in the design stage, followed by site closure, technical improvement, and cost reduction (Table 6). Although green remediation had the fewest recommendations, they are most frequently made during design and remedy-focused optimizations. Green remediation and environmental footprint evaluations are also done as technical support efforts (see Section 2.4) rather than optimization reviews.

Table 6: Types of Design Recommendations

Types of Recommendations	Total
Remedy Effectiveness	73
Cost Reduction	27
Technical Improvement	38
Site Closure	39
Green Remediation	15
All Recommendation Types	**192**

Design optimizations are often requested when uncertainties exist surrounding the CSM and characterization of contamination at a site. For the Lockwood Solvent Ground Water Plume site, OU 02 (Highlight 11), the optimization review included several recommendations for additional site characterization activities to reduce source and plume uncertainties. As a result of implementing the optimization team's recommendations, source remediation was expanded to more fully address all subsurface sources and the groundwater plume morphology was characterized. At the Jones Road Ground Water Plume site (Highlight 12), vapor intrusion impacts were not fully characterized and contamination in the unsaturated zone was not fully identified. The optimization review recommended further refining the CSM and developing a vapor intrusion indoor air sampling program. At the East 67th Street Ground Water Plume site (Highlight 13), there were uncertainties regarding the response of the mass contamination to SVE, extent of dissolved contamination in the aquifer, and time required for restoration. The optimization review recommended pilot testing the SVE system and prioritizing the remediation of one aquifer at the site. The optimization also recommended using the extracted groundwater for ISB substrate blending and delivery.

Concerns regarding planned remedy performance, effectiveness or cost are other reasons to conduct a design-stage optimization review. At the Jones Road Ground Water Plume site, there was concern that the selected remedy of an extensive P&T system may not provide an optimal approach to address contamination at the site. The optimization review team recommended further refining the CSM through delineation of the shallow groundwater plume and initiating ISB in high-concentration areas of the plume. Now the shallow groundwater plume has been fully delineated and there is a plan in place to scale up the use of ISB for source areas and the downgradient plume if the source remedy alone does not adequately address the plume. In addition, the review recommended the development and support of electronic data management and visualization tools to document and communicate remedy performance more rapidly and effectively.

Design optimization reviews may also recommend implementing the site remedy in phases as a method of improving remedy effectiveness. At the Lockwood Solvent Ground Water Plume site OU 02 (Highlight 11), a phased approach to the remedial components was implemented and aggressive action on the plume was delayed to first assess the impacts of source remediation on groundwater. The optimization review may also make suggestions for technical improvements and identify alternative strategies or technologies for implementing a selected remedy, such as carefully designed injection wells instead of using direct-push technology for injections, pre-fabricated systems instead of on-site construction of the systems, treatment and reinjection instead of discharge to a POTW, and use of extracted groundwater instead of potable water for reagent blending, injection, and circulation to improve remedy effectiveness and reduce costs (Highlight 13, East 67th Street Ground Water Plume site).

Highlight 11: Design Recommendations

Lockwood Solvent Ground Water Plume Site OU 02, Billings, Montana

KEY CHALLENGES

- Source uncertainties—identification of all source areas, vertical contaminant distribution, soil heterogeneity
- Plume uncertainties—long well screens confound vertical characterization, effect of pumping wells to west, effect of sewer installation, impact of source remediation on dissolved plume

PRIMARY RECOMMENDATIONS

- Rotosonic drilling to obtain cores and develop cross-sections
- New nested wells with short well screens
- Monitor downgradient plume for stability
- Use Membrane Interface Probe to delineate shallow sources in fine-grained zone and guide excavation of shallow sources

IMPLEMENTATION OUTCOMES

- Source areas delineated and source excavation expanded to address mass stored in fine-grained zone
- Dissolved plume delineated
    - Identified plume morphology
    - Monitoring being conducted to determine effects of source removal on groundwater plume before aggressive action on the plume

The Lockwood Solvent Ground Water Plume site consists of two operable units. OU 01 and OU 02 address separate contaminant sources and associated groundwater plumes. OU 02 contaminants of concern include PCE, TCE, cis-1,2-dichloroethene (cis-1,2 DCE) and vinyl chloride. The selected remedy for OU 02 includes a number of source and groundwater treatment options. The optimization review was conducted while the OU 02 remedy was being designed and focused on remedy design considerations. The optimization review included recommendations for designing a remedy to address contamination in soil and groundwater to achieve maximum effectiveness while improving remedy cost and energy efficiency and minimizing the time required to achieve cleanup goals.

The optimization review recommended reducing CSM uncertainties associated with OU 02 sources and the OU 02 plume. Recommendations for additional characterization work included: (1) more thorough identification of the source contaminant footprints, (2) obtaining a vertical profile of contaminant distribution in the subsurface especially at it relates to soil heterogeneity, (3) identifying plume morphology, (4) assessing impact of pumping wells and sewer installation, and (5) understanding how source remediation may impact groundwater contamination. The optimization review recommendations were implemented and additional characterization of both sources and groundwater was conducted. Source remediation was expanded to more fully address all subsurface sources and the groundwater plume morphology was characterized. Action on the plume delineation was delayed to determine the impact of more thorough source remediation made possible by the additional source characterization work.

Highlight 12: Design Recommendations

Jones Road Ground Water Plume Site, Harris County, Texas

KEY CHALLENGES

- Selected remedy of extensive P&T system may not provide an optimal approach to address site groundwater contamination
- Vapor intrusion impacts not fully characterized
- Unsaturated zone contamination not fully identified

PRIMARY RECOMMENDATIONS

- Install SVE system in the Unsaturated Chicot sand unit (to be initiated by a ROD Amendment)
- Perform SVE pilot for the shallow soil and, if successful, install a full SVE system in the shallow soil to address the primary source of contaminant mass
- Develop an indoor air sampling protocol to assess vapor intrusion
- Initiate ISB in high-concentration areas of shallow water bearing zone (WBZ)
- Limited groundwater P&T system is recommended for the Lower Chicot and possibly the shallow WBZ near the source area to control plume migration only after the SVE and ISB systems have been operating for the time necessary to evaluate the effectiveness of source reduction on groundwater
- Use electronic data management and visualization tools for documentation

IMPLEMENTATION OUTCOMES

- Delineated shallow groundwater plume
- Installed nested wells to delineate contamination vertically
- Plan to scale up use of ISB for source and downgradient plume if source remedy alone does not adequately address the plume

The Jones Road Ground Water Plume Superfund site is located just outside of the city limits of Houston, Texas. Releases of chlorinated VOCs from improper disposal of dry cleaning solvents migrated downward through the unsaturated zone to perched water and to lower aquifers, where multiple private water supply wells were and are presently located. The remedy selected in the ROD includes an extensive groundwater extraction and treatment system and extending municipal water supplies to properties with affected private water supply wells. Subsequent site data collection and cost estimates indicated that the P&T system may not provide an optimal approach to address site contamination. The optimization review team recommended the site remedial design include aggressive source treatment to reduce or eliminate the need for P&T and reduce or eliminate mass discharge to the aquifer.

The optimization review completed in FY 2014 provided recommendations for further refining the CSM and treating the contaminant source. The shallow WBZ plume has now been fully delineated and ISB treatment of the shallow WBZ is underway. The groundwater sampling in the Lower Chicot WBZ is being conducted at the existing wells to establish a baseline prior to potential source treatment with SVE. The optimization review recommended the use of electronic data management and visualization tools to document and communicate remedy performance more rapidly and effectively; these improvements are also already underway.

Highlight 13: Design Recommendations

East 67th Street Ground Water Plume Site, Odessa, Texas

KEY CHALLENGES

- Several data gaps were identified in the CSM relevant to remedial design, including:
  - Quantity of mass remaining in the vadose zone soils and its potential response to SVE treatment
  - Extent of dissolved contamination in the US2 plume
  - Potential effect of active ISB on secondary water quality issues
  - Extent of contaminant migration and time frame for aquifer restoration

PRIMARY RECOMMENDATIONS

- Eliminate exposure pathways and vertical migration by replacing specific private water supply wells that may function as conduits to the lower sand number 1 (LS1) layer of the Trinity Sands
- Improve plume monitoring by installing new groundwater monitoring wells
- Increase priority of US2 ISB remedy
- Use extracted groundwater for ISB substrate blending and delivery
- Conduct small-scale SVE pilot test in source area to improve characterization of contaminant mass remaining in the vadose
- Evaluate the need for active remediation in LS1 after plugging supply wells that appear to be contaminant transport conduits to the lower unit
- Implement remedy performance monitoring
- Establish completion criteria for each remedy component

IMPLEMENTATION OUTCOMES

- Extracted groundwater is used for ISB substrate blending
- Two ISB treatment zones were installed in the US2 aquifer zone
- SVE pilot test is planned for the next remedial design

The East 67th Street Ground Water Plume Superfund site involves groundwater contamination resulting from a 1985 release of alcohols, naphtha-based solvents and PCE from above ground tanks. The primary contaminants of concern are PCE, TCE and cis-1,2 DCE. The selected remedy included a groundwater P&T system, the installation of a municipal water supply line, ISB treatment zones, SVE, well abandonment, and institutional controls.

The optimization review completed in FY 2014 recommended plugging, abandoning and replacing key water supply wells, installing additional monitoring wells in US2 and LS1, increasing the priority of the US2 ISB remedy, using extracted groundwater for ISB substrate blending and delivery, conducting a small-scale SVE pilot test in the source area, implementing remedy performance monitoring, and establishing exit criteria for each remedy component. The optimization review also recommended evaluating LS1 after well plugging and US2 remediation to determine the need for active remediation of LS1. Use of ISB was expanded, extracted groundwater is used for ISB substrate blending, and an SVE pilot test is planned. Monitoring of remedy performance and develop completion criteria for each remedy component is also planned.

2.2.3 Remedy Recommendations

Remedy-focused optimization reviews include recommendations for reducing costs and improving the operation of the engineered systems that are in place. Remedy optimization is still the most frequent type of optimization review, and is conducted on remedies that have been constructed and are currently operating. During the remedy phase of the Superfund pipeline, new information may become available and site conditions may change as additional data is collected in the course of operating the remedy. Remedies can be adjusted over time to adapt to this new information and these changing conditions. As a result, it is helpful to review progress towards RAOs specified in the site decision documents, performance objectives specified during design, overall remedial strategy, current conditions relative to original design assumptions, and the monitoring program. An effective remedy optimization review considers the regulatory framework of the project, the RAOs, the perspectives of the various site stakeholders, and the available site-specific technical information. Reviews should also address costs for implementation and long-term operation, maintenance and monitoring.

Remedy optimization reviews may identify the need for changes to the remedial strategy. At North Penn – Area 6 site (Highlight 14), additional areas of contamination in the unsaturated zone would not be addressed by the current P&T system used for the deeper groundwater contamination. SVE and zero-valent iron (ZVI) injections were tested as treatment options for the newly discovered areas of contamination.

Many of the remedy optimization events were conducted at sites with remedy components common in the 1980s, 1990s, and early 2000s such as P&T and SVE systems. Many of the sites also noted the presence of NAPL. More than 40 percent of optimization events in this report provided recommendations that would change remedial approaches in response to the optimization review and in some of those cases adopted remedy components for more aggressive source treatment and in situ treatment of groundwater contamination as a replacement for or a supplement to existing P&T systems. This is consistent with more recent trends showing that in situ remedies for groundwater, in combination with targeted P&T, are being selected with increasing frequency (EPA, 2013b). When remedy changes are recommended by the optimization team, and accepted by the site team, the team must follow all Superfund procedures for remedy selection in a decision document, ultimately issuing a ROD Amendment or Explanation of Significant Difference if necessary. The additional data gathered and evaluated as a result of the optimization recommendations and CSM refinement help provide the basis for the remedy decision. In this way, optimizations may inform decision documents.

Remedy effectiveness is the main type of recommendation in the remedy-focused optimization reviews, followed by cost reduction and technical improvement, with site closure and green remediation having the fewest recommendations (Table 7).

Table 7: Types of Remedy Recommendations

Types of Recommendations	Total
Remedy Effectiveness	177
Cost Reduction	118
Technical Improvement	101
Site Closure	52
Green Remediation	15
All Recommendation Types	**463**

A remedy optimization review evaluates existing remedial systems and will also assess the completeness of the CSM and the completion strategy for the site. The need for CSM improvements are usually indicated when existing remedial systems are not meeting performance goals or progressing towards achieving cleanup levels as expected. At North Penn – Area 6 site (Highlight 14), the optimization team identified the need for CSM improvements to identify additional source areas and fully delineate the groundwater plumes. Optimization recommendations were implemented; the additional characterization work identified significant source zones in the unsaturated zone and both the shallow and deeper plumes were fully delineated. At the Palermo Well Field Ground Water Contamination site (Highlight 15), additional sampling was required to define and delineate the plumes. It was recommended that the sampling results be used to inform the capture zone analysis.

At Palermo, improvements to the P&T system, French drain system, and water sampling scheme were suggested. Remedy optimizations may also include new strategies for improved effectiveness such as the implemented changes to the structure of the project team by engaging Tribal Nations at Tar Creek (Ottawa County), OU 04 (Highlight 16). Full engagement by all stakeholders can save time, money and ensure that all concerns at the site are addressed. Also at Tar Creek, the optimization improved the effectiveness of the remedy by shifting the focus to prioritize activities based on contaminant of concern (COC) loading rates, improving watershed remediation, and protection.

Highlight 14: Remedy Recommendations

North Penn – Area 6 Site, Landsdale, Pennsylvania

KEY CHALLENGES

- Large PCE and TCE plume with many sources
- Complicated hydrogeology—weathered and fractured bedrock
- CSM uncertainties—sources, shallow groundwater contamination, hydraulic information
- Remedy effectiveness concerns—potential contaminant mass in unsaturated zone and in shallow groundwater that is not addressed by P&T in deeper groundwater, uncertainty regarding capture zone of P&T system, vapor intrusion potential

PRIMARY RECOMMENDATIONS

- Additional source characterization beneath previous excavations and buildings
- Additional shallow groundwater characterization
- Further delineation of groundwater plumes
- Test efficacy of SVE for shallow sources and potential expansion of SVE
- Investigate vapor intrusion pathway

IMPLEMENTATION OUTCOMES

- Source characterization conducted and significant unsaturated zone contamination found in several areas and confirmed to be absent in other areas
- Shallow groundwater contamination characterized and groundwater plumes better delineated
- SVE and ZVI injections tested—SVE difficult because of geology, ZVI injections hold promise of reducing subsurface contamination
- Synoptic water level measurements conducted
- Vapor intrusion pathway evaluated

The North Penn – Area 6 site addresses multiple sources of contamination by PCE, TCE, and their breakdown products. The sources have resulted in a large contaminant plume within shallow and deeper bedrock units beneath large portions of Lansdale, Pennsylvania. The optimization review focused on five source areas being addressed by EPA with P&T systems. Previous actions included excavation of contaminant sources. The optimization review identified several uncertainties and recommendations were provided to reduce the uncertainty associated with remaining contaminant sources, shallow groundwater contamination, and effectiveness of the deeper groundwater P&T systems.

Optimization recommendations were implemented and the additional characterization work identified significant source zones in the unsaturated zone and confirmed that sources were absent in other areas. Both the shallow and deeper groundwater contamination was further delineated and ZVI injections are being tested to reduce subsurface contamination. In addition, the vapor intrusion pathway is being evaluated.

Highlight 15: Remedy Recommendations

Palermo Well Field Ground Water Contamination Site, Palermo, Washington

KEY CHALLENGES

- CSM issues—limited TCE plume resolution and connection to source areas, plume not delineated
- Remedy performance issues—cannot assess plume capture by existing P&T via city wellfield, source area SVE shut down, French drain system for vapor intrusion not meeting ROD goals
- Uncertainty in roles and responsibility

PRIMARY RECOMMENDATIONS

- Expand groundwater sampling by locating and using historical wells to delineate and define plume, use information to inform capture zone analysis
- Fill vapor intrusion data gaps by sampling residential indoor air
- Consider options for lowering water table to address vapor intrusion
- Assess vapor intrusion, evaluate SVE effectiveness, and implement institutional controls at dry cleaner source area
- Seek agreement to have municipal wellfield operated in a manner to ensure capture
- Reduce sampling frequency in monitoring well network

IMPLEMENTATION OUTCOMES

- Agreement was reached on defined roles and responsibilities for a clear resolution and path forward on
  - Vapor intrusion assessment and mitigation
  - Plume capture evaluation
  - French drain and groundwater to surface water pathway
  - Groundwater sampling scheme
  - SVE and vapor intrusion assessment at dry cleaner source area
- Third party evaluation provided venue for CSM refinement and agreement of future efforts

An optimization review was conducted on the existing Palermo Well Field remedy, which consisted of P&T using the existing wellfield, a French drain to address vapor intrusion in a nearby residential area, and an SVE system at a source area. The optimization review confirmed the CSM and remedy issues that had been identified by the site team. The optimization review recommended expanding the groundwater sampling using existing wells to better delineate and define the plume and to provide information for a capture zone analysis. Additional source characterization work was recommended for the two sources, a Washington Department of Transportation facility and a dry cleaner. Recommendations also addressed adjustments to P&T system using the existing wellfield, improving performance of the French drain, improving the groundwater sampling scheme, and assessing effectiveness of SVE. All parties are engaged in the source area investigation and remedy, and the site team achieved a better understanding of site conditions leading to improved and documented remedy performance.

Highlight 16: Remedy Recommendations

Tar Creek (Ottawa County) Site, OU 04, Ottawa County, Oklahoma

KEY CHALLENGES

- Large and complex former lead and zinc mining site
- Numerous stakeholders with diverse perspectives
- Mining wastes located in many areas, often adjacent to creeks and rivers
- Impacts to numerous surface water bodies affecting two watersheds

PRIMARY RECOMMENDATIONS

- Prioritize remedial activities based on COC loading rates
- Shift primary focus to watershed remediation and protection, specifically in affected riparian areas
- Ensure remedial activities minimize potential impacts to Roubidoux aquifer and Grand Lake
- Leverage potential synergies with project team structure, roles and responsibilities
- Develop coordinated tactical plans and project controls

IMPLEMENTATION OUTCOMES

- Implemented watershed and riparian area approach by aligning tactical plans of the project with larger watershed issues
- Implemented changes to structure of project team by engaging Tribal Nations under OU 05; and the Quapaw Tribe of Oklahoma (Quapaw Tribe), and the Oklahoma Department of Environmental Quality (ODEQ) to perform the remedial actions at distal areas under OU 04
- Provide funding to the Quapaw Tribe (for OU 04) and ODEQ (for OU 02 and OU 04) through remedial action cooperative agreements with the EPA
- Continue to provide technical support to the Quapaw Tribe and ODEQ, while they continue to develop technical capacity to implement the remedial actions
- Continue to involve the Bureau of Indian Affairs when coordinating with the Quapaw Tribe Realty Department on chat sales of tribal-owned chat

The Tar Creek Superfund site is a large and complex site with numerous former lead and zinc mines. The site is being investigated and remediated in operable units. OU 04 covers 40 square miles and addresses source materials including numerous types of mine wastes. The initial focus of activities was to mitigate threats to human health and the environment through residential yard remediation, relocation, and by consolidating, disposing of, and reusing source materials. In response to challenges that occurred during the consolidation and disposal of the source materials, an optimization review was requested. Two of the optimization review recommendations included shifting the focus of the next phase of work to prioritize activities based on COC loading rates, watershed remediation and protection in riparian areas, and leveraging the project team structure. The optimization review recommendations have largely been implemented leading to increased watershed and riparian remediation and protection and full engagement of the stakeholders in implementing the remedial activities for OU 02, OU 04, and OU 05.

2.2.4 Long-Term Monitoring Recommendations

An LTM-focused optimization review most commonly takes place during the remedial action phase or O&M phase of the Superfund pipeline and involves preparing for site reuse and closure, preparing a monitoring program to evaluate the attainment of remedial goals or evaluating an existing monitoring program and developing an effective remedy completion (exit) strategy. An effective LTM optimization review considers the regulatory framework of the project, the RAOs, the perspectives of the various site stakeholders, and the available site-specific technical information and long-term goals for property reuse. An LTM optimization review may include an evaluation of remedy effectiveness and consequences of a remedy not progressing as expected.

LTM optimization was performed less frequently than any of the other optimization stage reviews. However, some LTM reviews fall under the category of technical support because they do not result in an optimization review report with the typical list of recommendations that fit into the five recommendation types (see Section 2.4). As shown in Table 8, most LTM recommendations fall into the remedy effectiveness category with cost reduction and technical improvement categories being the next most common.

Table 8: Types of Long-Term Monitoring Recommendations

Types of Recommendations	Total
Remedy Effectiveness	33
Cost Reduction	21
Technical Improvement	22
Site Closure	13
Green Remediation	4
All Recommendation Types	**93**

An LTM optimization review is often requested when a remedy is not achieving its goals as anticipated or there is an opportunity to reduce monitoring points and costs. At the Middlefield-Ellis-Whisman (MEW) Study Area (Highlight 17), a “regional” groundwater extraction system to address the combined plumes was initiated in the late 1990s. The site’s monitoring program is extensive and it is expected to take a long time to reach RAOs. Based on an optimization assessment conducted in FY 2015, the plan is to reduce annual sampling of 400 wells to biennial sampling, and semi-annual water level gauging to annual water level gauging for 650 wells, which will result in a cost-savings without impacting the effectiveness of the performance monitoring. At the MetalTec/Aerosystems site (Highlight 18) the groundwater monitoring program includes quarterly sampling of numerous analytes to assess the performance of the remedial P&T system. Based on their review, the optimization team recommended decreasing sampling frequency and the number of analytes included for analysis.

An LTM optimization may also be conducted when there is uncertainty about the effectiveness of a selected remedy. For example, the stability of the plume at the MetalTec/Aerosystems site was unknown because of the site’s complicated geology. The optimization review was able to confirm that the plume is stable or decreasing using two different software packages.

LTM optimization reviews often recommend remedy system and component improvements, including operational improvements and maintenance and optimizing monitoring. At both the MEW Study Area and the MetalTec/Aerosystems site, the optimization review recommended using passive methods, rather than active methods, to collect groundwater samples. A long-term monitoring optimization assessment was recommended at the MEW Study Area, including the network and monitoring frequency, resulting in a significant reduction in sampling frequency.

Highlight 17: Long-Term Monitoring Recommendations

MEW Study Area, Mountain View and Moffett Field, California

KEY CHALLENGES

- Long time period expected to reach RAOs
- Monitoring program is extensive

PRIMARY RECOMMENDATIONS

- Consider further long-term monitoring optimization assessment
- Consider use of passive methods to collect groundwater samples

IMPLEMENTATION OUTCOMES

- Trial reduction of annual chemical sampling of over 400 wells to sampling every two years
- Trial reduction of water level gauging frequency of over 650 wells from twice per year to once per year
- Consolidation of treatment systems
- Implementation of passive methods to collect groundwater samples

The MEW Study Area is located in Mountain View, California. The site includes multiple sources of chlorinated volatile organic compounds (CVOCs), primarily TCE, creating a groundwater plume that is 11,000 feet in length impacting several water-bearing stratigraphic units. Source areas have generally been addressed by soil excavation, groundwater extraction, and slurry wall construction around the larger sources. Two “regional” groundwater extraction systems to address the co-mingled contaminant plumes and nine facility-specific treatment systems for source areas were initiated in the 1990s in accordance with the ROD. Currently eight plants treat groundwater from various extraction wells screened in multiple aquifer units.

The optimization review recommended further analysis of the potential for optimization of the long-term monitoring program, including the network and the monitoring frequency. In FY 2015, a trial reduction of annual chemical sampling of over 400 wells was implemented, reducing it to biennial sampling and reducing semi-annual water level gauging to annual water level gauging for over 650 wells. This reduction in sampling and water level gauging will result in a cost-savings without impacting the effectiveness of the performance monitoring. A footprint analysis for the MEW Study Area was also conducted in FY 2012.

Highlight 18: Long-Term Monitoring Recommendations

MetalTec/Aerosystems Site, Franklin Borough, New Jersey

KEY CHALLENGES

- Stability of plume unknown
- Sampling conducted quarterly
- Sampling includes numerous analytes and MNA parameters

PRIMARY RECOMMENDATIONS

- Reduce sampling frequency to annually
- Reduce analytes list to VOCs of interest
- Reduce testing for MNA parameters
- Consider use of passive sampling rather than grab sampling where appropriate

IMPLEMENTATION OUTCOMES

- Plume stability confirmed through optimization team analysis
- Sampling frequency reduced to annually
- Analytes list reduced to VOCs of concern
- MNA sampling frequency reduced to every five years
- Passive sampling to be adopted in future

The MetalTec/Aerosystems site is located in complicated geology including overburden, granite bedrock, and dolomite bedrock. Groundwater at the site is contaminated with VOCs. The remedial system includes P&T in the granite bedrock formation with groundwater monitoring to assess performance of the remedial system. The monitoring program was assessed by the optimization team to determine if adjustments could be made that would reduce costs without reducing the quality of the information and effectiveness of the monitoring program.

The optimization review confirmed that the plume is stable or decreasing using the Monitoring and Remediation Optimization System (MAROS) and 3-Tiered Monitoring Optimization (3TMO) Tool software packages. Additional analyses led to recommendations to decrease sampling frequency, decrease the number of analytes included for analysis, and change the approach to sample collection. If sampling is focused on the VOCs, alternative sampling methods that require less labor and provide equally valid results can be considered, such as the use of passive-diffusion bag (PDB) samples. For those few rounds where the other parameters (that are not amenable to PDBs) are required, grab samples may be obtained using no-purge sampling devices. Note, it was recommended that artesian (i.e., naturally flowing) wells continue to be sampled by purging (under natural flow) and sampling, as it may be difficult to place and secure the PDBs and the natural flow would be adequate to obtain a sample without a pump. Many of the optimization review recommendations have been implemented, while others are in the process of being implemented.

2.3 Events and Sites Requiring No Further Follow-Up

RPMs continue to demonstrate a commitment to the implementation of optimization recommendations. The optimization process is now complete at a number of sites as a result of the successful implementation or thorough consideration of all optimization recommendations. EPA is no longer conducting annual follow-up discussions for the following events and sites, though assistance is still available to site managers in the event that any optimization-related issues arise:

- 10th Street Site, 2010 Event.
- American Creosote Works, Inc. (Pensacola Plant).
- Boomsnub/Airco.
- Bunker Hill Mining & Metallurgical Complex, OU 02, 2013 Event.
- Burlington Northern (Somers Plant).
- Colbert Landfill.
- Eastern Surplus.
- Groveland Wells No. 1 & 2, 2013 Event.
- Groveland Wells No. 1 & 2, 2014 Event.
- Intel Magnetics.
- Intermountain Waste Oil Refinery.
- Northwest Pipe & Casing/Hall Process Company.
- Old Hilltop (Hilltop Station).
- Ott/Story/Cordova Chemical Co.
- Pemaco Maywood.
- Pine Ridge Oil Underground Storage Tank Site.
- Railroad Avenue Groundwater Contamination.
- Tutu Wellfield.

Previous progress reports identified 32 events and sites that no longer require implementation tracking, for a total of 50 events and sites that have successfully completed the follow up process since it began as a result of the Action Plan in 2004.

2.4 Technical Support Highlights

In addition to formal optimization reviews, EPA provides technical support that results in optimization principles being applied more broadly. Technical support activities can include a broad range of support such as providing environmental footprint analysis, providing assistance with strategic sampling using incremental sampling, using 3DVA, conducting High-Resolution Site Characterization (HRSC), developing a CSM, developing a decision framework for shutdown, reviewing technical documents such as engineering specifications, or providing cost estimates.

Table 9 lists the technical support projects completed from FY 2011 through FY 2015. The majority of technical support projects were conducted as investigation optimizations.

Table 9: Completed Technical Support Projects FY 2011 – FY 2015

State	Optimization Event	FY Complete	Optimization Focus	Total Optimization Events
Region 1				**2**
MA	Fairmont Line – Modern Electroplating	2013	R	
MA	Groveland Wells No. 1 & 2	2014	L	
Region 2				**4**
NY	Fulton Avenue	2013	I	
NJ	King of Prussia	2012	R	
NJ	Passaic River-Diamond Alkali	2011	I	
NY	South Buffalo Brownfields Opportunity Area	2012	I	
Region 3				**2**
PA	Clearview Landfill OU 03	2014	I	
VA	Fort Eustis (US Army)	2013	Not Defined	
Region 7				**3**
MO	Missouri Dioxin Reassessments	2014	Not Defined	
MO	Rt. 66 Park (Under MO Dioxin Reassessment Site)	2014	Not Defined	
MO	Strecker Dioxin Site (Under MO Dioxin Reassessment)	2014	Not Defined	
Region 8				**3**
MT	Lockwood Solvent Ground Water Plume (OU 02)	2014	D	
UT	Ogden Railroad Yard	2013	L	
CO	Standard Mine	2014	D	
Region 9				**5**
CA	Hunter's Point	2013	Not Defined	
AZ	Iron King Mine	2013	I	
CA	McCormick & Baxter	2014	I	
CA	MEW Superfund Study Area	2012	I	
CA	Newmark Groundwater Site Event 3	2014	I	
Region 10				**6**
ID	Bunker Hill Mining & Metallurgical Complex OU 03	2014	I	
WA	Hamilton/Labree Roads GW Contamination Site	2015	D	
OR	Northridge Estates	2015	D	
OR	Portland Harbor/Rhone Poulenc	2011	I	
WA	Upper Columbia River	2013	Not Defined	
WA	Wyckoff Co./Eagle Harbor	2014	I	
TOTAL				**25**

- I = Investigation, D = Design, R = Remedy, L = Long-Term Monitoring; a single event may have recommendations that fall into more than one focus area.

Technical support includes both planning and implementation activities and frequently results in products including work plans, quality assurance project plans, mapping and 3DVA products, and contaminant results that are used directly by the site teams. In many cases, EPA's technical support helps move a project forward and can help improve site decision-making. EPA has expanded its support services for environmental footprint analysis as well as 3DVA. Several technical support projects, including Hunter's Point, MEW, and Northridge Estates involved activities associated with green remediation and environmental footprint analysis. During this reporting time frame, six 3DVA technical support projects were completed. EPA considers 3DVA to be a best practice for completing site characterizations, transitioning site activities from RI to FS, evaluating remedy effectiveness, and monitoring remedy progress. Project Highlights 19, 20 and 21 below show the variety of activities for which EPA provides technical support.

Highlight 19: Technical Support

Hamilton/Labree Roads GW Contamination Site, Hamilton Road Impact Area, OU 01, Chehalis, Washington

As part of the design phase of the project, technical support was provided for the Hamilton Road Impact Area (HRIA) of the Hamilton/Labree Roads GW Contamination site to plan and conduct a dynamic field investigation. Soil, sediment, and groundwater are contaminated with PCE from suspected illegal dumping in the past. The selected remedy includes in situ thermal treatment of soil and sediment, excavation and disposal of contaminated soil and sediment, and in situ bioremediation of contaminated groundwater. The technical support project was designed to identify the footprint of each of the components of the selected remedy. Real-time measurement technologies in combination with 3DVA mapping of results were used to define the various contamination zones at HRIA. Real-time results from each day's investigative efforts were processed in 3DVA software and the visualizations were then used to help guide the investigative efforts to be conducted on the following days. The results of the effort are being used in the design of the multi-component remedy.

Highlight 20: Technical Support

Wyckoff Co./Eagle Harbor Site, Seattle, Washington

The technical support for the Wyckoff Co./Eagle Harbor site involved conducting 3DVA using existing data for the source area. The contamination at the site includes subsurface soil and groundwater contamination with creosote from many years of wood treating operations at the facility. A large amount of existing data was available for the site. The existing data consisted of historical contaminant data as well as real-time data from the use of laser-induced fluorescence (LIF) direct push borings in the source zone. The 3DVA specialty contractor developed a methodology for using the LIF data without data reduction and potential corresponding loss of source definition. The 3DVA results helped to identify the various zones of contamination within the source area and assisted with calculation of the source volume in the subsurface. The technical support helped to move the project from the investigative phase into the remedy selection and design phases.

Highlight 21: Technical Support

Colorado Smelter Site, Pueblo, Colorado

Historical operations at the Colorado Smelter site have resulted in lead and arsenic contamination of site soil and the soil of residences near the site. The technical support for the Colorado Smelter site involved planning and implementing soil sampling using X-ray fluorescence (XRF) in combination with an incremental sampling strategy for residences near the site. The project required planning support as well as design and execution of a Demonstration of Methods Applicability (DMA) study to ensure samples were collected, processed, and analyzed properly. A field soil laboratory was also established to ensure proper sample preparation and analysis. The XRF was used with a high level of quality control (QC) during the project, establishing a rigorous QC program and data from the XRF are continually evaluated against fixed laboratory methods for a subset of analytical samples. The DMA study also included a comparison of the 5-point composite sample currently in EPA's lead handbook with a 30-point incremental composite sample. The results of the technical support project concluded that the XRF did provide reliable results suitable for decision-making when used with proper sample processing support and careful QC. The comparison of the 5-point and 30-point composite sampling showed that the 30-point composite sampling strategy resulted in slightly fewer decision errors than 5-point composite sampling strategy. Though empirical evidence gathered from incremental sampling at a variety of sites has indicated that the 30-point strategy is usually necessary, at this site the 5-point approach adequately addressed matrix heterogeneity and provided acceptable decision error rates. The project also verified that careful decision unit selection, sample processing, subsampling, and analytical procedures were required for either strategy.

3.0 SUMMARY OF PROGRESS ON IMPLEMENTING THE NATIONAL OPTIMIZATION STRATEGY

EPA has continued to successfully implement the Strategy and expand the optimization program and its many benefits to reach a larger number of sites, across all stages of optimization, and all stages in the Superfund pipeline. The four main elements of the Strategy form the basis of development and implementation of the Strategy. They include:

- Element 1: Planning and Outreach.
- Element 2: Integration and Training.
- Element 3: Implementation.
- Element 4: Measurement and Reporting.

3.1 Planning and Outreach

EPA has continued to increase its success in planning and outreach, through a collaborative process between EPA HQ and the Regions, facilitated by ROLs and Superfund and Technology Liaisons (STLs), to continuously identify sites or site projects that would benefit from an optimization review. This includes Regions identifying sites that may benefit from an independent optimization review and requesting support from the EPA HQ team. Other government stakeholders (such as states, tribes and local governments) and communities are also requesting optimization technical support through their respective EPA Regions. In addition, an increasing number of requests are being generated from the optimization material presented at CERCLA Education Center (CEC) and National Association of Remedial Project Managers (NARPM) Training Program courses and EPA HQ and regional presentations at outside conferences and training programs. Support may be provided by EPA HQ, Regions, or resources from other EPA offices such as the Office of Research and Development (ORD).

The use of optimization practices helps to address stakeholder concerns and provide information on the protectiveness and efficacy of remedies and may instill more confidence to communities that remedies are and will remain protective. EPA's optimization website www.epa.gov/superfund/cleanup-optimization-superfund-sites contains detailed information on the optimization program and is accessible to the public.

3.2 Integration and Training

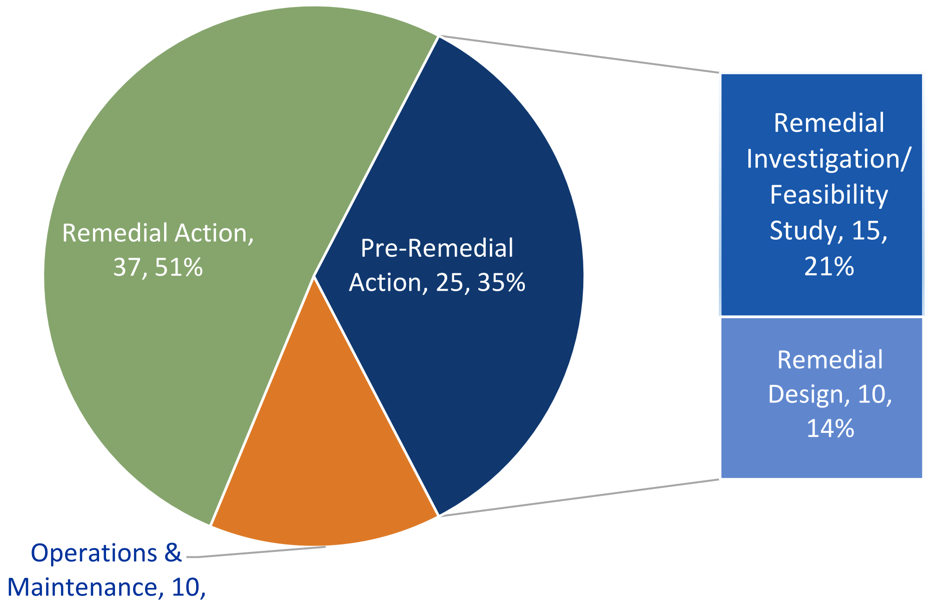
EPA continues to collect, synthesize and share optimization lessons learned through: (1) CEC and Environmental Response Training Program (ERTP) training courses; (2) NARPM and On-Scene Coordinator (OSC) Academy training programs; (3) periodic meetings of the National Optimization Team composed of EPA HQ staff, ROLs, and STLs; and (4) presentations at conferences and training programs sponsored by other entities within EPA (Brownfields, Federal Facilities and Resource Conservation and Recovery Act corrective action programs) and outside of EPA (such as Battelle conferences, Northeast Waste Management Officials' Association conferences, and Association of State and Territorial Solid Waste Management Officials events). EPA is in the process of developing and issuing three technical guides on topics related to optimization that were identified in the SPR Action Plan: smart scoping, strategic sampling approaches, and data management. EPA has also developed standard operating procedures such as project engagement forms, checklists and documentation to facilitate the scoping and conduct of optimization reviews.

3.3 Implementation

The primary goals of implementation are to extend optimization to all phases of the Superfund pipeline and to build capacity for integrating optimization concepts throughout the pipeline. EPA accomplishes this goal not only by executing training and integration efforts, but also by increasing the amount of optimization reviews conducted with site teams in all regions, introducing site team members to optimization concepts that then become incorporated as standard operating practice. Initially all optimizations were done for sites in the remedial action or O&M phase of the Superfund pipeline. Since implementing the Strategy, 35 percent of all optimizations are done in pre-remedial action phases including remedial investigation/feasibility study and remedial design phases (Figure 9).

Figure 9: Superfund Phase of Optimization Events

Number of Superfund Optimization Reviews and Technical Support Events = 72



- Total Optimization Events included in the report = 86 (61 optimization reviews and 25 technical support efforts); 14 events were not at Superfund sites and are not included in the analysis.

Prior to implementing the Strategy, EPA completed approximately seven optimizations per year. In late 2010, EPA initiated the development of the Strategy to increase the capacity for conducting optimizations and extending optimization to all phases of the Superfund pipeline. Since implementing the Strategy, EPA now completes 20 optimizations per year on average (Table 3, Section 1.2). In addition to the number of completions per year, the capacity to support ongoing optimization events has increased to an average of nearly 50 optimizations per year, with 68 events supported in FY 2016 (Table 10).

Table 10: EPA Optimization Support

Fiscal Year	Started	Ongoing	Completed	Number of Optimization Events and Technical Support Projects Supported by OSRTI*
2011	19	16	11	35
2012	21	24	18	45
2013	27	27	27	54
2014	18	27	29	45
2015	28	16	15	44
2016	39	29	30	68

* This column represents the number of events started each fiscal year combined with the number of events ongoing from the previous fiscal years.

3.4 Measurement and Reporting

In order to more accurately track optimizations and be able to provide data and information regarding the program, EPA uses two tracking tables: the Optimization Project Log (OPL) and the Optimization Report Inventory and Tracking Tool (ORITT). In OPL, EPA lists all optimization events (technical support events and optimization review events) by site name and records key information about each event including:

- Event type (technical support or optimization review).
- Project lead, regional contact, and contractor support.
- Site type, media, and contaminant groups addressed.
- Current project status (anticipated, in progress or complete).
- Major project milestone dates (scoping call, kickoff call, site visit, drafts, and final reports).
- FY start and completion dates.

OPL is updated each month. Summary reports on the current status of all events supported during the current fiscal year are provided to EPA management. ORITT houses recommendation data from all optimization reviews that have been completed to date. EPA records the names and type of recommendations, the optimization focus of recommendations, and the implementation status of the recommendations. ORITT also includes the potential costs and savings projected by the optimization team for implementing each recommendation and can also include actual cost data when available.

Further details on meeting the goals of the Strategy are included in Appendix A.

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APPENDIX A

Progress on Implementing the National Optimization Strategy

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EPA has been successful in implementing the Strategy and expanding the optimization program, extending the benefits of optimization to a larger number of sites and across all stages of optimization and the Superfund pipeline from site assessment to site completion. This section presents a discussion of the successes and challenges EPA experienced while implementing the Strategy.

The Strategy instituted changes to the Superfund remedial program business processes to take advantage of newer tools and strategies that promote more effective and efficient cleanups. The Strategy identified several objectives to achieve verifiably protective site cleanups faster, cleaner, greener and cheaper. The Strategy envisions iterative efforts by Regions to pursue cost-effective expenditure of Superfund dollars, lower energy use, reduced carbon footprint, improved remedy effectiveness, improved project and site decision making, and accelerated project and site completion by deploying newer tools and strategies for site evaluation and remediation throughout the life cycle of the site cleanup.

Optimization in the context of the Strategy is defined as:

> "Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness." (EPA, 2012b)

The Strategy is built on the success of existing strategies, coordination with similar optimization technical support efforts, and the expansion of optimization reviews to more sites and to all phases of the remedial pipeline. Four elements form the basis of development and implementation of the Strategy, as discussed in the following subsections:

- Section A.1 - Element 1: Planning and Outreach.
- Section A.2 - Element 2: Integration and Training.
- Section A.3 - Element 3: Implementation.
- Section A.4 - Element 4: Measurement and Reporting.

A.1 Progress on Implementing Element 1: Planning and Outreach

Element 1 involves a series of planning and outreach efforts to document Strategy goals, apply optimization to improve community engagement, nominate sites for optimization and coordinate with related efforts. Element 1 is divided into four sub-elements. EPA's progress on each sub-element under Element 1 is discussed below.

Element 1.1: Establish Strategy Goals: The Strategy established the following overarching goals:

- Incorporate optimization experience and principles in remedial program business practices including:
  - Assessment of site cleanup progress, site technical performance and costs;
  - Regional/EPA HQ work planning and reviews; and
  - Implementation of acquisition strategies and contracts management practices;
- Collect, synthesize and share optimization lessons learned;
- Apply optimization practices earlier and throughout the remedial pipeline;
- Increase the number of optimization reviews supported by EPA to 20 to 30 sites annually; and
- Measure optimization outcomes and report results.

EPA has successfully achieved or is in the process of achieving the overarching goals of Element 1.1. EPA has incorporated optimization experience and principles in remedial program business practices by continuing to assess site cleanup progress, technical performance and costs and documenting those in optimization reports and technical memos. Regions and EPA HQ work planning and reviews include an optimization component and all but one Region has identified a Regional Optimization Liaison (ROL) to facilitate optimization efforts at the regional level. In addition, Superfund and Technology Liaisons (STL) in all Regions are also participating in and facilitating Regional optimization activities. The EPA Superfund remedial program is in the process of replacing regional remedial contracts with a suite of national contracts to execute Superfund remedial work. Under these contracts, EPA will have the ability to incorporate optimization into task order requirements.

EPA continues to collect, synthesize and share optimization lessons learned through (1) CERCLA Education Center (CEC) and Environmental Response Training Program (ERTP) training courses, (2) National Association of Remedial Project Managers (NARPM) and On-Scene Coordinator (OSC) Academy training programs, (3) periodic meetings of the National Optimization Team composed of EPA HQ staff, ROLs, and STLs, and (4) presentations at conferences and training programs sponsored by other entities within EPA (Brownfields, Federal Facilities and Resource Conservation and Recovery Act corrective action programs) and outside of EPA (such as Battelle conference, Northeast Waste Management Officials' Association conference, and Association of State and Territorial Solid Waste Management Officials events).

EPA has applied optimization practices earlier and throughout the remedial pipeline, as evidenced in Figure 9 (Section 3 of main report). Figure 9 shows the Superfund stage of completed optimization events and technical support projects from FY 2011 through FY 2015. EPA currently has a number of additional ongoing optimization reviews and technical support projects underway, as shown in Table A-1. This table lists the number of initiated, ongoing, and completed events supported by EPA each year from FY 2011 through FY 2016. EPA has increased the number of optimization reviews and technical support projects it supports and has exceeded the goal of supporting 20 to 30 optimization reviews annually. EPA continues to measure optimization outcomes and is reporting on the results with this optimization progress report.

Table A-1: EPA Support of Optimization

Fiscal Year	Started	Ongoing	Completed	Number of Optimization Events and Technical Support Projects Supported by OSRTI*
2011	19	16	11	35
2012	21	24	18	45
2013	27	27	27	54
2014	18	27	29	45
2015	28	16	15	44
2016	39	29	30	68

* This column represents the number of events started each fiscal year combined with the number of events ongoing from the previous fiscal years.

Element 1.2: Apply Optimization as a Means to Improve Community Engagement: The Strategy identifies how optimization can be instrumental in providing structure and tools to improve communication with communities, local stakeholders, regulatory agencies, tribes and Potentially Responsible Parties (PRPs). Below are examples of how optimization was used during FY 2011 through FY 2015 to facilitate or improve community involvement and communication:

1.2.1 *Triad Approach*. The Triad is an innovative approach to decision-making for hazardous waste site characterization and remediation. The Triad approach proactively exploits new characterization and treatment tools using innovative work strategies. The Triad refers to three primary components: systematic planning, dynamic work strategies, and real-time measurement systems. Efforts to advance site management strategies that help to more fully characterize sites and to increase confidence in the understanding of the extent, location and behavior of contamination can help communicate site conditions and progress to stakeholders. EPA recently updated its Triad training with revision of the CEC course, "Best Practices for Site Characterization Throughout the Remediation Process," by clearly identifying the best practices, updating the case studies with recent examples, and developing exercises that give participants the opportunity to apply the Triad concepts covered in the course.

1.2.2 *Remediation System Evaluations* (RSE) and *Long-Term Monitoring Optimization* (LTMO). EPA continued to conduct RSEs and LTMOs as part of remedy and LTM optimization reviews. The use of these and other optimization practices help to address stakeholder concerns and provide information on the protectiveness and efficacy of remedies and may instill more confidence to communities that remedies are and remain protective. The website www.epa.gov/superfund/cleanup-optimization-superfund-sites contains detailed information on the optimization program and is accessible to the public.

1.2.3 *Green Remediation*. EPA has continued its effort to reduce the environmental footprint of remedies through environmental footprint reviews and has developed technical resources and training to assist project teams with site-specific efforts. These efforts help stakeholders understand the potential effects of remedies on their environment and project teams to understand and minimize those effects. The website www.epa.gov/superfund/superfund-green-remediation contains more information, technical resources, and available training sessions and is accessible to the public.

1.2.4 *Knowledge Transfer.* Current information resources and infrastructure, provided through www.epa.gov/superfund and www.epa.gov/superfund/superfund-training-and-learning-center and the Technology Innovation and Field Services Division's (TIFSD) internet seminars, provide a great deal of readily available and accessible information to stakeholders. In addition, EPA HQ, Regions and ORD subject matter experts have assisted regions with community meetings related to site characterization and cleanup.

1.2.5 *Training.* EPA's CEC and ERTP provided training for the EPA and state regulators, tribes, other government stakeholders, and private industry that has been updated and revised to integrate both optimization and stakeholder engagement concepts. CEC and ERTP training courses are described on the website www.trainex.org/, which is also used for course registration.

Element 1.3: Identify Projects and Sites for Optimization: A collaborative process between EPA HQ and the Regions, facilitated by ROLs and STLs, is being used to identify sites or site projects that would benefit from an optimization review. Regions determine which sites may warrant an independent optimization review and, as applicable, request optimization support from the EPA HQ team. Support can be provided by EPA HQ, Regional or ORD resources. In addition, an increasing number of requests are being generated from the optimization material presented at CEC and NARPM Training Program courses and EPA HQ and regional presentations at outside conferences and training programs.

Other government stakeholders (such as states, tribes and local governments) and communities may also seek optimization technical support through their respective EPA regions and these requests are also frequently triggered after CEC course deliveries. Based on regional determination and available resources, EPA HQ, ORD, and Regions have provided stakeholders the requested technical support.

Element 1.4: Coordinate with Complementary Technical Support Efforts: Optimization efforts continue to support established remedial program goals. Optimization reviews and technical support projects collaterally support the National Remedy Review Board, Contaminated Sediments Technical Advisory Group, and Value Engineering efforts, five-year reviews and transfer of sites from LTRA to O&M. Optimization efforts also facilitate progress towards achievement of program measures such as construction completion, site-wide ready for anticipated use, human exposure under control, and groundwater migration under control.

Under this element the National Optimization Program coordinates with key related EPA workgroups to connect with optimization and avoid conflicts with their efforts. Key workgroups include the subgroups of the Technical Review Workgroup, the forums under EPA's Technical Support Program, including NARPM and the Ground Water Forum, Engineering Forum, and Federal Facilities Forum.

A.2 Progress on Implementing Element 2: Integration and Training

EPA has integrated optimization into program operations by creating technical resources to supplement existing guidance documents (as appropriate) and integrating optimization into its training programs. EPA is in the process of evaluating current incentives for optimization, addressing optimization in new guidance, and incorporating optimization language into contracts. Element 2 of the Strategy has three sub-elements which are discussed below.

Element 2.1: Create Technical Resources to Supplement Existing Guidance and Policy, and Address Optimization in New Guidance: EPA organized existing optimization-related resources on the website www.epa.gov/superfund/cleanup-optimization-superfund-sites, to provide easy access for a broad spectrum of stakeholders. Written resources include report templates, technical Triad resources, and completed optimization review reports. In addition, EPA technical staff with expertise in optimization (EPA HQ and regional ROLs and STLs) are identified on the optimization website. These resources describe how optimization principles, practices and techniques can be utilized with current programmatic guidance. Existing guidance has been and continues to be supplemented by directives, technical bulletins, fact sheets and other technical materials to explain how optimization applies at various stages of cleanup. For example, EPA is in the process of developing and issuing three technical guides on topics related to optimization: smart scoping, strategic sampling approaches, and data management. These technical guides were identified in the Superfund Remedial Program Review Action Plan. EPA has also developed standard operating procedures such as project engagement forms, checklists and documentation to facilitate the scoping and conduct of optimization reviews.

Element 2.2: Adopt Lessons Learned into Business Practices: On a routine basis, optimization lessons learned are collected, summarized and discussed by EPA and regional program and project staff to determine how business practices, including contracting, can benefit from these lessons learned. The National Optimization Team meets regularly to identify these lessons learned and create strategies to ensure they are distributed broadly across the Superfund program. The EPA Superfund remedial program is in the process of replacing regional remedial contracts with a suite of national contracts to execute Superfund remedial work. Under these contracts, EPA will have the ability to incorporate optimization into task order requirements.

Element 2.3: Formalize an Optimization Training Program: EPA made significant progress on this element of the Strategy through in-person classroom training events and internet-based training events, and by presenting optimization findings at numerous national conferences. EPA focused its training efforts on Remedial Project Managers (RPMs) and technical staff by participating in and developing training courses for the CEC, NARPM training program and Technical Support Project Forum meetings. All existing CEC courses have been revised and updated to include optimization concepts and promote optimization efforts. EPA developed two technical groundwater courses on High-Resolution Site Characterization (HRSC) for unconsolidated environments and fractured sedimentary bedrock environments and has been delivering these courses since 2012. Groundwater HRSC optimizes the characterization of contamination in groundwater which leads to targeted actions and combined remedies that facilitate restoration and site completion. In addition, significant revisions were made to the CEC's "Best Practices for Site Characterization Throughout the Remediation Process" to clearly identify the set of best practices for investigation-focused optimization activities and to include recent case studies. EPA continues to review optimization training needs, consolidate existing training material, and develop new training as needed. New training will be delivered to RPMs and other project managers and technical staff using the CEC, ERTP, and internet-based training events.

Optimization training supplements guidance and other technical resources and provides a number of benefits, including, but not limited to:

- Increased knowledge of optimization practices and tools for all participants;
- National consistency in the quality of, approach to and outcomes of optimization efforts;
- An increase in the number of sites that are recommended for optimization; and
- Expansion of region-led optimization efforts.

A.3 Progress on Implementing Element 3: Implementation

Element 3 involves implementing the Strategy based on the goals established through the planning process. Implementation involves conducting optimization reviews at all stages of the project pipeline beginning with site assessment; incorporating Triad, Green Remediation and other best practices; providing access to a pool of qualified optimization contractors; developing the capabilities of regions and other stakeholders; and advancing the application of innovative optimization strategies. EPA's progress on implementing the seven sub-elements of Element 3 are described below.

Element 3.1: Conduct Optimization Reviews at all Stages of the Project Pipeline Beginning with Site Assessment: EPA has achieved its goal of supporting 20 to 30 optimization reviews and technical support projects as shown in Exhibit A-1 above. Investigation-focused optimization reviews and technical support projects are being conducted at a steady pace. EPA is currently supporting two technical support projects in the site assessment phase (before listing of the sites on the National Priority List) with 3-dimentional visualization and analysis (3DVA) of existing data to supplement the Hazard Ranking System packages for those projects.

Element 3.2: Expand Optimization to Earlier Project Pipeline Stages and Incorporate Triad, Green Remediation and Other Best Practices: In accordance with the Strategy, EPA has expanded optimization to sites earlier in the Superfund project pipeline, including site assessment, RI, FS and RD as demonstrated in Figure 9, in Section 3 of this report. Site characterization best practices are stressed in investigation-focused optimization reviews and technical support projects, regardless of which phase of the remedial pipeline site characterization activities are being conducted. EPA has expanded the use of 3DVA (characterization best practice) by supporting projects in all phases, from site assessment to the remedial action phase. EPA is currently providing technical site support for conducting HRSC for groundwater and incremental sampling using x-ray fluorescence for soil, both of which are considered to be strategic sampling approaches and best practices for site characterization. In addition, green remediation is addressed during every optimization review conducted by EPA. EPA also provides technical support for conducting environmental footprint analyses and implementing green remediation best management practices.

Element 3.3: Independent Party Optimization Review Steps: EPA developed several documents to establish a consistent and standardized approached to implementing optimization reviews. These documents facilitate the tracking of optimization and technical support events from team development to issuance of a final report or technical support product and ease the identification and tracking of optimization recommendations from optimization review reports. As the number of different parties conducting optimization reviews and technical support has increased, it is even more important that everyone adhere to standard operating procedures. Without consistency, both the tracking of the optimization reviews and technical support projects and the identification and tracking of optimization recommendations is more difficult. Moving forward, EPA will be able to update these documents as any procedures or tracking requirements change. These documents are made available in electronic format to optimization team members and include:

- An optimization standard operating procedure;
- An optimization primer and overview;
- An optimization engagement form;
- Management notification emails; and
- A template optimization report.

Element 3.4: Provide Access to a Pool of Qualified, Independent Contractors: Optimization involves the synthesis and analysis of a significant quantity of data in a limited time frame and budget. To accomplish optimization objectives, EPA must have access to a pool of highly-qualified technical experts with the demonstrated qualifications to provide the capacity to accomplish these goals on highly challenging, unique, and complex sites across the country. EPA expanded the number of these technical experts in various organizations including in EPA HQ (TIFSD), Environmental Response Team (ERT), and Assessment and Remediation Division, ORD, Argonne National Laboratory, the U.S. Army Corps of Engineers (USACE), and EPA contractors. EPA will continue to look for ways to increase this pool of qualified experts, including through training of staff and accessing additional expertise through EPA contracts such as the new Remedial Action Framework national contracts.

Element 3.5: Develop Regional Optimization Capabilities: To fully integrate optimization into the remedial program, regional offices are involved in planning and implementing optimization at all stages of the remedial process. All Regions but one have assigned an ROL to facilitate the expansion of regional optimization capabilities. STLs in every region are also helping to identify optimization opportunities and facilitate optimization reviews and technical support activities. ROLs and STLs are assisting with implementation of the Strategy.

Element 3.6: Develop Other Stakeholders' Capabilities: A wide range of stakeholders, including state project managers and tribal nations are included at the outset of optimization reviews, during implementation, and during follow-up tracking. EPA continues to build the capabilities of stakeholders through its various training programs which integrate optimization concepts with other technical content related to Superfund. Many state and tribal stakeholders have already taken or are planning to participate in these trainings.

Element 3.7: Advance Application of Innovative Optimization Strategies: EPA has continued to advance innovation in the optimization arena by participating in ongoing research projects (for example, ORD, Department of Defense's Strategic Environmental Research and Development Program and Environmental Security Technology Certification Program, National Institute of Environmental Health Sciences Superfund Research Program, Interstate Technology and Regulatory Council, national laboratories and universities), performing general tracking of developments by other agencies or the private sector, and encouraging and deploying innovative approaches at Superfund sites.

A.4 Progress on Implementing Element 4: Measurement and Reporting

Element 4 involves tracking progress of optimization, measuring outcomes and accounting for related costs. Element 4 has three sub-elements which are discussed below.

Element 4.1: Track Implementation of Recommendations: EPA tracks the implementation of all optimization review recommendations provided in optimization reports. The Superfund Optimization Progress Report is EPA's primary vehicle for reporting on the progress of optimization recommendation implementation, with this current version providing an update on progress during FY 2011 through FY 2015. EPA has focused its optimization resources on scaling up the program to cover activities across all focus areas of the optimization process and all phases of the Superfund pipeline and to increasing the number of optimization reviews and technical support projects. Currently, EPA collects the following information for optimization reviews:

- Status of each optimization recommendation (implemented, alternative implemented, in progress, planned, under consideration, deferred to state/PRP, and declined)—the collection of this information is facilitated by use of a menu of choices that can then be easily tracked;
- Cost impacts of each optimization recommendation (capital costs, O&M costs, and cost savings)—the collection of cost savings has been difficult and could be improved;
- Benefits that resulted from implementation—recommendations are put into five categories which describe five broad benefits. Collecting more detailed information on the benefits, such as the use of best practices and strategic sampling approaches and improved data management can only be discovered by reading each recommendation follow-up narrative. The reporting process would benefit from the development of a drop down list from which specific benefits could be chosen; and
- Obstacles encountered during implementation are recorded by narrative provided by the project manager for each recommendation. The reporting process would benefit from having a specific question regarding obstacles encountered.

Element 4.2: Measure Optimization Outcomes and Report Results: The analyses performed for the Superfund Optimization Progress Report included measuring the optimization outcomes using the available data and information collected for the report. EPA is improving its processes for collecting optimization data and information, including identifying ways to streamline data collection. For example, EPA is making the process of collecting follow-up information on the implementation of optimization recommendation easier and more frequent.

Element 4.3: Monitor Cost Accounting: EPA tracks and reports on the costs of conducting individual optimization reviews and implementing the Strategy. In addition, the optimization team's estimates of potential costs and savings of implementing individual recommendations are included as part of an optimization review. However, the availability of actual cost information on the implementation of optimization recommendations has been limited, with these data often difficult to obtain. Reasons cited include time constraints on remedial staff and difficulty in quantifying actual cost savings. For example, as optimizations are implemented earlier in the Superfund pipeline, improving site characterization and having more complete conceptual site models are intended to lead to better remedy selection and design, leading to rapid achievement of RAOs and site closure. However, quantifying the difficulties and "avoided costs" that could have resulted from not conducting optimization early on, can be difficult to estimate. EPA is continuing to work on improving cost data.

APPENDIX B

List of Completed Optimization and Technical Support Events FY 1997 – FY 2015*

*Not all FY 2015's were completed in time to be included in the progress report.

State	Site	Fiscal Year Complete	Total Optimization Events
Region 1			**17**
MA	Baird & McGuire - Event 1	2002	
MA	Baird & McGuire - Event 2	2013	
NY	BCF Oil Refining, Inc.	2009	
ME	Eastern Surplus	2012	
MA	Engelhard Corporation Facility	2005	
MA	Fairmont Line- Modern Electroplating	2013	
MA	Groveland Wells No. 1 & 2 - Event 1	2002	
MA	Groveland Wells No. 1 & 2 - Event 2	2013	
MA	Groveland Wells No. 1 & 2 - Event 3	2014	
NH	Kearsarge Metallurgical Corp.	2010	
NH	Ottati & Goss/Kingston Steel Drum	2014	
CT	Ridson Corporation	2004	
NH	Savage Municipal Water Supply	2001	
MA	Silresim Chemical Corp. - Event 1	2002	
MA	Silresim Chemical Corp. - Event 2	2014	
NH	Somersworth Sanitary Landfill - Event 1	2009	
NH	Sylvester	2009	
Region 2			**24**
NJ	A-Z Automotive	2004	
NJ	Bog Creek Farm	2002	
NY	Brewster Well Field	2002	
NJ	Ciba-Giegy Corp.	2012	
NY	Circuitron Corp.	2005	
NY	Claremont Polychemical	2002	
NJ	Ellis Property	2006	
NY	Fulton Avenue	2013	
NY	GCL Tie and Treating Inc.	2007	
NJ	Higgins Farm	2004	
NJ	King of Prussia	2012	
NY	Mattiace Petrochemical Co., Inc.	2001	
NJ	MetalTec/Aerosystems - Event 1	2012	
NJ	MetalTec/Aerosystems - Event 2	2015	
NY	Morgan Terminal	2004	
NJ	Passaic River- Diamond Alkali	2011	
NY	Richardson Hill Road Landfill/Pond	2012	
NJ	Rockaway Borough Well Field, OU 02	2014	

State	Site	Fiscal Year Complete	Total Optimization Events
NJ	Shorco South	2004	
NY	Sidney Landfill	2012	
NY	SMS Instruments, Inc.	2004	
NY	South Buffalo Brownfields Opportunity Area	2012	
VI	Tutu Wellfield	2011	
NJ	Vineland Chemical Co., Inc.	2011	
NJ	A-Z Automotive	2004	
Region 3			**24**
PA	A.I. W. Frank/Mid-County Mustang	2006	
PA	Butz Landfill	2006	
PA	Clearview Landfill - OU 03	2014	
PA	Crossley Farm	2006	
PA	Croydon TCE	2006	
PA	Cryochem, Inc.	2006	
DE	Dover Gas Light Co., OU 02	2015	
PA	Fischer & Porter Co.	2014	
PA	Former Honeywell Facility	2003	
VA	Fort Eustis (US Army)	2013	
VA	Greenwood Chemical Co. - Event 1	2004	
VA	Greenwood Chemical Co. - Event 2	2006	
PA	Havertown PCP - Event 1	2004	
PA	Havertown PCP - Event 2	2006	
PA	Hellertown Manufacturing Co. - Event 1	2002	
PA	Hellertown Manufacturing Co. - Event 2	2006	
PA	Mill Creek Dump	2010	
PA	North Penn - Area 1	2006	
PA	North Penn - Area 6	2012	
VA	Peck Iron and Metal	2013	
PA	Raymark - Event 1	2002	
PA	Raymark - Event 2	2006	
VA	Saunders Supply Co. - Event 1	2006	
DE	Standard Chlorine of Delaware, Inc.	2007	
Region 4			**12**
FL	Alaric Area GW Plume	2010	
FL	American Creosote Works, Inc. (Pensacola Plant)	2006	
NC	Benfield Industries, Inc.	2007	
NC	Cape Fear Wood Preserving	2005	

State	Site	Fiscal Year Complete	Total Optimization Events
NC	Celanese Corp. (Shelby Fiber Operations)	2009	
FL	Chemko Technical Services, Inc. Facility	2005	
SC	Eliskim Facility	2004	
SC	Elmore Waste Disposal	2001	
NC	FCX, Inc. (Statesville Plant)	2002	
FL	Taylor Road Landfill	2007	
TN	Velsicol Chemical Corp. (Hardeman County)	2013	
GA	Woolfolk Chemical Works, Inc.	2008	
Region 5			**16**
MN	Baytown Township Ground Water Plume	2011	
MI	Clare Water Supply - Event 1	2007	
MI	Clare Water Supply - Event 2	2007	
OH	Delphi VOC Site	2003	
IN	Douglass Road/Uniroyal, Inc. Landfill	2004	
OH	Lincoln Fields Co-Op Water Assn Duke Well	2015	
MN	MacGillis & Gibbs Co./Bell Lumber & Pole Co.	2001	
WI	Moss-American Co., Inc. (Kerr-McGee Oil Co.)	2011	
WI	Oconomowoc Electroplating Co., Inc.	1997	
MI	Ott/Story/Cordova Chemical Co. - Event 1	2002	
MI	Peerless Plating Co.	2006	
WI	Penta Wood Products	2006	
IN	Reilly Tar & Chemical Corp. (Indianapolis Plant)	2004	
WI	Stoughton City Landfill	2008	
MI	Wash King Laundry - Event 1	2006	
MI	Wash King Laundry - Event 2	2011	
Region 6			**16**
LA	American Creosote Works, Inc. (Winnfield Plant)	2008	
LA	Bayou Bonfouca	2001	
TX	Conroe Creosoting Co.	2015	
LA	Delatte Metals	2009	
TX	East 67th Street Ground Water Plume	2014	
NM	Grants Chlorinated Solvents	2008	
NM	Homestake Mining Co.	2011	
TX	Jones Road Ground Water Plume	2014	
NM	McGaffey & Main Groundwater Plume - Event 1, OU 02	2012	
NM	McGaffey & Main Groundwater Plume - Event 2, OU 03	2015	
AR	Midland Products	2001	

State	Site	Fiscal Year Complete	Total Optimization Events
NM	North Railroad Avenue Plume	2015	
AR	Ouachita Nevada Wood Treater	2015	
TX	Sandy Beach Road Ground Water Plume	2014	
TX	State Road 114 Groundwater Plume	2014	
OK	Tar Creek (Ottawa County) - Event 1–OU 04	2014	
Region 7			**19**
NE	10th Street Site - Event 1	2010	
NE	10th Street Site - Event 2	2014	
KS	57th and North Broadway Streets Site	2006	
KS	Ace Services - Event 1	2007	
KS	Ace Services - Event 2	2013	
NE	Cleburn Street Well	2001	
NE	Eaton Corp-Kearney	2006	
IA	Fairfield Coal Gasification Plant	2012	
IA	General Motors S.C.	2012	
NE	Hastings Ground Water Contamination	2013	
MO	Lee Chemical	2012	
MO	Missouri Dioxin Reassessments	2014	
MO	Missouri Tannery Sludge	2010	
IA	Nichols Groundwater Contamination, (Cropmate)	2014	
NE	Ogallala Ground Water Contamination	2013	
IA	Railroad Avenue Groundwater Contamination	2014	
MO	Rt. 66 Park (Under MO Dioxin Reassessment site)	2014	
MO	Strecker Dioxin Site (Under MO Dioxin Reassessment)	2014	
MO	Valley Park TCE	2013	
Region 8			**3**
SD	Batesland (Former Mobil Gas Station)	2013	
MT	Burlington Northern (Somers Plant) (BNSF Railway)	2015	
CO	Central City, Clear Creek	2007	
UT	Former Old Hilltop (Hilltop Station)	2013	
CO	French Gulch	2013	
SD	Gilt Edge Mine	2013	
MT	Idaho Pole Co. - Event 1	2009	
MT	Idaho Pole Co. - Event 2	2015	
UT	Intermountain Waste Oil Refinery (IWOR)	2011	
UT	Jacobs Smelter	2010	
MT	Lockwood Solvent Ground Water Plume - Event 1, (OU 01)	2014	

State	Site	Fiscal Year Complete	Total Optimization Events
MT	Lockwood Solvent Ground Water Plume - Event 2, (OU 02)	2014	
UT	Ogden Railroad Yard	2013	
SD	Pine Ridge Oil	2013	
CO	Standard Mine - Event 1	2014	
CO	Summitville Mine - Event 1	2002	
Region 9			**26**
CA	Applied Materials	2012	
NM	Bond & Bond/Nav 046 Site	2013	
CA	BP Carson Refinery	2006	
NV	Carson River Mercury Site Event 1, OU 02	2014	
AZ	Davis Chevrolet/Nav 185 Site	2013	
CA	Hunter's Point	2013	
CA	Intel Magnetics	2013	
AZ	Iron King Mine - Humboldt Smelter - Event 1	2014	
AZ	Iron King Mine - Humboldt Smelter - Event 2	2014	
AZ	Iron King Mine - Humboldt Smelter - Event 3	2013	
CA	Klau/Buena Vista Mine - Event 1	2010	
CA	Lava Cap Mine (OU 03) - Event 1	2014	
CA	McCormick & Baxter Creosoting Co. - Event 1	2014	
CA	Middlefield – Ellis – Whisman (MEW) Study Area - Footprint Analysis	2012	
CA	Middlefield – Ellis – Whisman (MEW) Study Area - Optimization Report	2012	
CA	Modesto Ground Water Contamination	2002	
CA	Newmark Ground Water Contamination - Event 1 (First MAROS)	2007	
CA	Newmark Ground Water Contamination - Event 2 (Second MAROS)	2009	
CA	Newmark Ground Water Contamination - Event 3 (First 3DVA)	2014	
CA	Newmark Ground Water Contamination - Event 4 (Third MAROS)	2015	
AZ	Painted Desert Inn/Nav 049 Site	2013	
CA	Pemaco Maywood	2011	
CA	San Fernando Valley (Area 1)	2012	
CA	Selma Treating Co. - Event 1	2002	
CA	Sulphur Bank Mercury Mine	2015	
AZ	Telles Ranch/CRIT 002	2013	

State	Site	Fiscal Year Complete	Total Optimization Events
Region 10			**24**
OR	Black Butte Mine	2012	
WA	Boomsnub/Airco	2002	
ID	Bunker Hill Mining & Metallurgical Complex - Event 1	2006	
ID	Bunker Hill Mining & Metallurgical Complex - Event 2, OU 02 (CTP)	2013	
ID	Bunker Hill Mining & Metallurgical Complex - Event 3, OU 03	2014	
WA	Colbert Landfill	2011	
WA	Commencement Bay, South Tacoma Channel - Event 1	2002	
WA	Commencement Bay, South Tacoma Channel - Event 2	2008	
WA	Frontier Hard Chrome, Inc.	2008	
WA	Hamilton/Labree Roads GW Contamination (HRIA) - Event 1	2010	
WA	Hamilton/Labree Roads GW Contamination (HRIA) - Event 2	2015	
WA	Keyport (Official name: Naval Undersea Warfare Engineering Station (4 Waste Areas)), Operable Unit 1/Area 1– Keyport Landfill, WA	2013	
AK	Kodiak USCG Integrated Support Command Base	2015	
OR	McCormick & Baxter Creosoting Co. (Portland Plant)	2002	
WA	Moses Lake Wellfield Contamination	2015	
	Northridge Estates	2015	
OR	Northwest Pipe and Casing/Hall Process Company - Event 1	2007	
WA	Occidental Chemical Corporation	2004	
WA	Palermo Well Field Ground Water Contamination	2012	
OR	Portland Harbor	2011	
WA	Upper Columbia River	2013	
WA	US Navy Whidbey Island Naval Air Station, (Ault Field/OU 1)	2014	
WA	Wyckoff Co./Eagle Harbor - Event 1	2005	
WA	Wyckoff Co./Eagle Harbor - Event 2	2014	
TOTAL			**194**