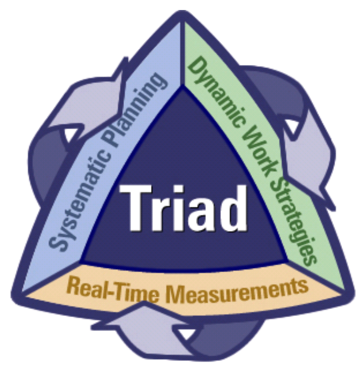
Best Management Practices: Use of Systematic Project Planning Under a Triad Approach for Site Assessment and Cleanup

September 2010

AUDIENCE AND PURPOSE

This U.S. Environmental Protection Agency (EPA) technical publication is intended for environmental practitioners engaged in the investigation, design, remediation, and closure or reuse of contaminated sites. It may be of particular interest to project managers, senior technical advisors, stakeholders and others who are responsible for project planning, management and technical execution; as well as non-technical individuals engaged in project participation. This technology bulletin explains how systematic project planning (SPP), a comprehensive planning process for environmental cleanup projects, can be used to plan and execute projects more effectively to achieve the often diverse strategic objectives of all stakeholders, while satisfying the specific technical and quality objectives required for each stage of a project's life cycle. Derived as a best management practice (BMP) under the Triad Approach to Site Assessment and Cleanup, SPP has been successfully implemented in each of the primary regulatory frameworks, including Brownfields, Superfund, Resource Conservation and Recovery Act (RCRA), underground storage tanks (UST), and numerous states' voluntary cleanup programs. It has also been used in integrated regulatory program frameworks.

THE TRIAD APPROACH



The Triad Approach (a.k.a., Triad), is a three-pronged approach for managing all forms of project uncertainty to improve decision-making and streamline environmental cleanup projects. Triad draws on science and technology advancements and practitioner experience to develop strategies for making site work more scientifically-defensible, resource-effective, adaptive to changing project needs, and responsive to stakeholder concerns.

The three integrated BMPs of the Triad Approach are:

- **<u>Systematic project planning (SPP)</u>: An efficient method for comprehensive planning, design, and implementation for all stages of hazardous waste site investigation and cleanup projects. Generally recognized to be common practice for all projects, SPP is uniquely applied and critical to the successful design and execution of a Triad-based project.**
- <u>Dynamic work strategies (DWS)</u>: A sequence of dynamic data collection activities that efficiently addresses identified project concerns, which are implemented and managed in the field using real-time information to target and manage data and decision uncertainty. Streamlined workplans, developed in the context of a project's regulatory framework, are used to document DWS.
- <u>Real-time measurement technologies</u>: Any data generation that enables reliable measurement or collection and analysis of environmental media in a time frame that facilitates execution of a DWS. These measurements typically result in a much greater density of information and are available to direct field activities in time frames shorter than those commonly achieved with conventional sampling and analytical methods. Together with the DWS, real-time measurement technologies are used to focus when and where collaborative sampling and analyses can provide the greatest benefit.

The Triad Approach can be used to significantly reduce data collection costs, expedite project schedules, enhance stakeholder communication, and improve the quality of project and site decisions.

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SYSTEMATIC PROJECT PLANNING

Systematic Project Planning is a rigorous project planning process that lays a scientifically defensible foundation for proposed project activities. SPP under Triad builds off of existing federal standards and guidance for environmental cleanup project planning and emphasizes that all data collected satisfy a defined need. It involves planning for known decisions and building in contingencies to accommodate changes in project conditions so that stakeholders are able to facilitate the project through all key decision-making stages.

As part of the Data Quality Objectives (DQO) process, EPA guidance requires that all projects use SPP to develop data acceptance and other project performance criteria for incorporation in project quality assurance project plans (QAPPs). As the most critical element for successful planning and implementation of a Triad-based project, SPP is a natural extension of EPA's DQO process as it incorporates data quality with non-scientific elements, such as social or economic factors. SPP also places a strong emphasis on using a CSM as the basis for the planning of all phases of the project life cycle, from investigation through remediation (cleanup or mitigation) and site closure (regulatory satisfaction that site risks have been removed or mitigated). The CSM is used during SPP to identify data needs, design the DWS, and drive the selection of appropriate data collection, analysis, and use methodologies. Inherent to DWS design is an explicit recognition that spatial heterogeneity is the primary source of uncertainty affecting confident site decision-making. Therefore, SPP de-emphasizes determining exact numbers of samples to be collected and analyzed and focuses more on the dynamic generation of a variety of collaborative data sets.

Systematic Project Planning Process

Preparation activities:

- Organize the project team of stakeholders and technical resources
- Summarize site information in a Preliminary Conceptual Site Model (CSM)
- Research potential investigation and remedial technologies
- Submit Preliminary CSM and other information to SPP participants in advance of meeting

Meeting activities:

- Introduce and confirm roles and authorities of participants
- Define site reuse goals and project exit strategy
- Identify key site decisions, decision-making processes, tools and rules
- Create a Baseline CSM based on refinement of Preliminary CSM
- Use Baseline CSM to identify key data gaps
- Identify and quantify acceptable levels of uncertainty
- Identify real-time technologies and collaborative data needs
- Plan for real-time data management, assessment, visualization and communication
- Develop detailed DWS outline, decision logic diagrams and activity sequencing plan

In addition to addressing scientific issues, SPP also considers financial, contractual, stakeholder, legal, and regulatory issues of a site cleanup, such as budgets, contracts, stakeholder concerns, site reuse, and legal and regulatory issues. While SPP efforts are critical for early project stages, the BMPs associated with planning can be used with equal effectiveness during subsequent phases to optimize a project throughout its life cycle.

Effective SPP efforts should address the following key considerations:

- Building social capital among project stakeholders.
- Evaluating reuse options and exit strategies.
- Achieving stakeholder consensus on the CSM and data gaps.
- Identifying life cycle project data and resource needs.

DQO Guidance Documents that Support SPP

EPA Quality Manual for Environmental Programs. (EPA 2000, May).

Guidance on Systematic Planning Using the Data Quality Objectives Process. (EPA 2006, February).

Guidance for Developing Quality Assurance Project Plans. (EPA 2002, December).

Uniform Federal Policy for Quality Assurance Project Plans (Manual). (EPA 2005, March).

Workbook for Uniform Federal Policy for Quality Assurance Project Plans (Worksheets*). (EPA 2005, March).*

- Identifying clear project objectives, timelines and other constraints.
- Developing the basic elements of the DWS and establishing performance metrics.
- Evaluating and planning for managing risk-related uncertainties.
- Other integral considerations, such as green remediation, sustainable reuse and Environmental Justice and Community Involvement.

More information on SPP may be found at: www.triadcentral.org/mgmt/splan/
More information about SPP technical tools and components: www.triadcentral.org/tech/dsp_sub.cfm?id=1

Building social capital among project stakeholders
SPP involves many activities, including identifying stakeholders, articulating objectives, evaluating re-use goals, building CSM consensus, addressing constraints, identifying regulatory drivers, and specifying project sequencing to maximize the use of available resources. SPP also includes building 'social capital' between stakeholders, using a team approach to support consensus-based decision-making; identifying areas of contention; and facilitating stakeholder involvement, investment and accountability.

Social Capital

Social Capital is anything that facilitates individual or collective action, generated by networks of relationships, reciprocity, trust, and social norms (Coleman, 1988). Unlike traditional forms of capital, social capital is not depleted by use, but in fact depleted by non-use. As social capital lowers the transaction costs of working together, it facilitates cooperation. People have the confidence to invest in collective activities, knowing that others will also do so. Four features are important: relations of trust; reciprocity and exchanges; common rules, norms, and sanctions; and connectedness in networks and groups (Pretty, 2003).

Stakeholders typically include property owners, responsible parties, regulatory agencies, local interest groups or organizations ('community' representation), and technical experts. The breadth of participation, degree of involvement, and timing of input from stakeholders will vary based on project-specific conditions and regulatory framework. For teams to be successful, participants must be committed to working through technical and non-technical issues in a collaborative, non-adversarial manner. While disagreements among stakeholders are not uncommon, SPP under Triad provides a process whereby those disagreements can be resolved to the satisfaction of all interested stakeholders.

Triad Functional Teams

Stakeholders – Persons from involved organizations with final decision-making authority.
Core Technical Team – Senior technical experts who design and manage the project.
Field Team – Middle and junior-level staff who perform onsite technical activities.

Project teams that have membership continuity over the life cycle of a project tend to be successful because the teams will embody a collective understanding of the technical, economic, and political basis for work done to date and work proposed for the future. Because such team continuity is not always feasible, new personnel are commonly required to climb a steep, labor-intensive learning curve based on personal review of large quantities of background documents and other information. SPP efforts ensure faster and more cost-effective personnel transitions through the use of a robust CSM and quality documentation of decisions and work completed to date.

Triad advocates and project managers should facilitate stakeholder involvement and commitment throughout the project life cycle, particularly during field activities, so that concerns can be managed and addressed in real time. The role of the project manager in SPP is to encourage stakeholders to engage in the following activities:

- Share knowledge and insights.
- Test assumptions, beliefs and perspectives.
- Evaluate legal, budgetary and technical constraints.
- Achieve clarity over different viewpoints.
- Resolve important concerns and interests.

Involving stakeholders in the project planning process and during project execution is particularly critical under Triad in order to avoid misunderstandings, disagreements, and potential 'last minute surprises' associated with stakeholder concerns. Continual stakeholder involvement ensures that all uncertainties and differing viewpoints regarding the CSM are addressed and that site decision consensus is maintained among the stakeholders. In addition, stakeholder involvement helps mitigate concerns regarding unfamiliar data collection technologies and the decision-making process to be used at the site. Increased involvement of senior resources at critical times or delegating greater decision-making power to the field team increases stakeholder confidence in field-based decisions, ensures quality, and optimizes project efficiency.

Identifying clear project objectives, timelines and other constraints

It is critically important that project stakeholders agree on project objectives or goals, timelines, and other primary constraints before working together to develop a DWS or other project plan. For example, the following are typical questions that parties seeking a Brownfield redevelopment grant should be prepared to answer prior to conducting an SPP effort:

- What is the site's planned reuse?
- What is the economic viability of cleanup?
- Who is responsible for cleanup of the site?
- What is the estimated cost for redevelopment of the site?
- What plans are there for meaningful community involvement?
- Are there environmental justice issues associated with the site?
- Are remedial action objectives (RAOs) specified?

Projects being performed under other regulatory programs, such as Superfund or RCRA, may also benefit from these advanced considerations, as well as others specific to those programs. An example of this might be evaluating procurement strategies in the context of the contractual requirements and funding constraints applicable to the project environment. The following are examples of questions that are typically considered during SPP under Triad:

- What are the site's main environmental issues?
- What media and receptors may be affected?
- What is the nature and extent of contamination?
- What is the fate and transport of contaminants?
- Are exposure pathways complete?
- What are the site's appropriate cleanup levels?
- What data are needed to support implementation of potential cleanup remedies?
- Will data be sufficient to support cleanup objectives?
- What real-time measurement technologies exist for acquiring those data?
- How can the sequencing of project field activities be optimized to maximize real-time data use and CSM refinement, while minimizing mobilizations?
- Do viable treatment or containment technologies or other alternatives exist?
- What is the preferred remedial alternative?
- What data are needed to evaluate remedy effectiveness?
- What metrics will be used to evaluate remedy performance?
- How can system performance be optimized and operating costs reduced?
- How can site closure be documented?
- What is the stakeholder comfort level with the expected performance of real-time technologies?
- What innovative tools and strategies are potentially applicable?
- Is a demonstration of methods applicability (DMA) needed?
- Which uncertainties pose the greatest threat to project success and how will they be managed?

Answers to these questions or other critical project elements identified during SPP serve as the basis for developing technical planning documents such as QAPPs, field sampling plans (FSPs), and construction work plans. Clear definitions of team member roles and responsibilities, critical project components, short-, mid-, and long-term milestones, and key decision points requiring timely stakeholder input help ensure project efficiency.

Developing and evolving a CSM to identify life cycle project data and resource needs

In addition to supporting the identification of data and resource needs, the CSM is an effective BMP for facilitating technical team communication, maintaining stakeholder consensus, and supporting public information presentations. Under Triad-based projects, the CSM is the basis for defining data needs and strategies for uncertainty management and managing them throughout the project's life cycle. Simplified renderings and more complex visualization tools are used to capture, communicate, and exploit all existing information, while enhancing stakeholder understanding of site conditions and focusing future efforts on key uncertainties or data gaps.

The CSM is an iterative, 'living representation' of a site that is used to guide the entire cleanup process; from project planning to site closure. Accordingly, the life cycle of a CSM is comprised of two milestone deliverables: Preliminary CSM and Baseline CSM; and four evolutionary stages: Characterization CSM Stage, Design CSM Stage, Remediation/Mitigation CSM Stage, and Post Remedy(s) CSM Stage.

To effectively support project and site decision making, the CSM must be updated, or 'evolved', with new information to reflect revised understandings of site conditions. This is best achieved when the CSM is evolved in alignment with the major phases of an environmental cleanup project's programmatic regulatory requirements. Figure 1 shows how each stage of the CSM life cycle aligns with the general site investigation, and cleanup process and seven of the primary environmental regulatory programs, as well as how SPP and the other Triad BMPs apply to all project phases.

A CSM prepared under Triad is information-intensive, building on the CSM formats typically associated with site investigation and cleanup efforts. For example, network-receptor diagrams are commonly used as CSMs for Superfund or other sites to illustrate the connective relationships between sources, pathways, receptors, and exposure routes. Triad integrates these diagrams with other site information and data to generate a more comprehensive CSM. The CSM is then directly used to identify specific data gaps that drive the development of the DWS during SPP efforts. A CSM can involve a combination of narrative, visual, tabular, modeling, and conceptual tools to document site conditions, contaminants and potential sources, pathways and receptors of concern, geologic conditions, hydrogeologic conditions and a host of other valuable site information. Complex geologic, hyrdogeologic, and chemical processes are often summarized and represented by a simplified block diagram or 3-D visualization.

Figure 2 shows an example of a Preliminary CSM developed prior to an SPP effort for a site in Colorado that included a former manufactured gas plant (MGP), an above-ground storage tank (AST), a landfill, a contaminant plume, and an adjacent river. This 2-D format provides a simplified visualization of the 'state of knowledge' for a site for stakeholders to prepare for an SPP meeting.

Using the Preliminary CSM as a starting point, a Baseline CSM is developed during an SPP effort to provide a visual representation of data completeness, uncertainties, and potential data gaps. The Baseline CSM is then used to develop site-specific sampling designs and DWS decision logic for the field investigation effort. If competing views on the Baseline CSM are articulated by team members or stakeholders, these disparities should collectively serve as the basis for subsequent sampling and information collection efforts.

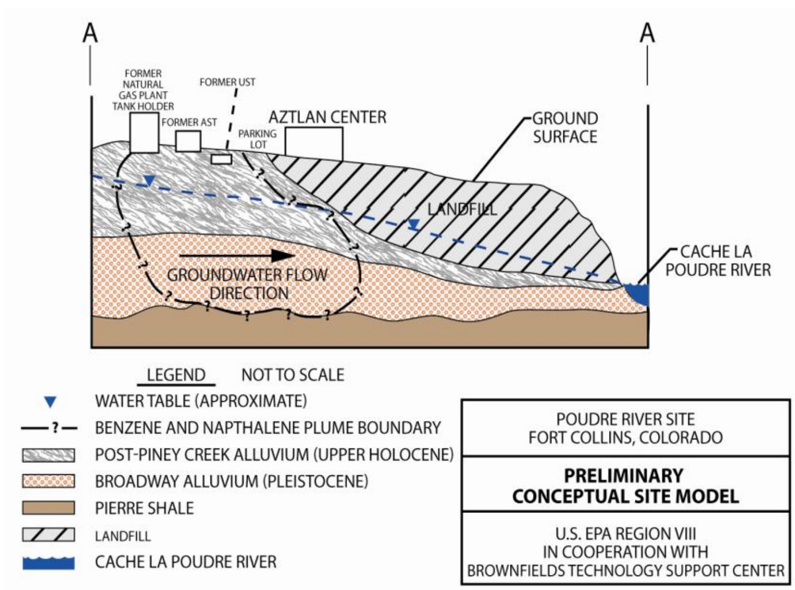

Figure 2: Preliminary CSM Representation. This Preliminary CSM summarizes general site information, including primary site attributes, geologic stratigraphy, groundwater potentiometric surface and flow direction, groundwater-surface water relationship, and presumed extent of soil and groundwater contamination. This form of CSM can be an effective method of communicating site conditions to a diverse audience in an easy-to-understand format.

General Environmental Cleanup Steps	CSM Life Cycle	Best Management Practices SPP DWS/RTMT	CERCLA - Superfund	RCRA	Brownfields	UST	VCUP Varies by State	IRP/ERP	MMRP
Site Assessment	**Preliminary CSM** **Baseline CSM**		Preliminary Assessment (PA) Site Inspection (SI) National Priorities List (NPL) No Further Remedial Action Planned (NFRAP)	Facility Assessment (RFA)	Phase I Environmental Site Assessment (ESA)	Initial Site Characterization Initial Response	PA SI	PA SI	PA SI MR Site Prioritization Protocol (MRSPP)
Site Investigation and Alternatives Evaluation	**Characterization CSM Stage**		Remedial Investigation/ Feasibility Study (RI/FS) Removal Actions - Emergency/ Time Critical/Non-Time-Critical	Facility Investigation (RFI) Corrective Measures Study (CMS)	Phase II ESA	SI Corrective Action Plan (CAP)	RI/FS	RI/FS NFRAP	RI/FS
Remedy Selection	**Design CSM Stage**		Proposed Plan Record of Decision (ROD)	Statement of Basis (SB) Final Decision and Response to Comments	Remedial Action Plan (RAP)	Cleanup Selection	ROD	Proposed Plan ROD	Remedy Selection
Remedy Implementation	**Remediation/ Mitigation CSM Stage**		Remedial Design (RD) Remedial Action (RA) – Interim and Final	Corrective Measure Implementation (CMI)	Cleanup and Development	Corrective Action - Low-impact site cleanup - Risk-based remediation - Generic remedies - Soil matrix cleanup	RD RA	RD RA – Interim and Final Remedy in Place (RIP)	RD Time Critical Removal Action (TCRA) RA RIP
Post-Construction Activities	**Post-Remedy CSM Stage**		Operational & Functional Period Operation & Maintenance (O&M) Long term monitoring (LTM) Optimization Long Term Response Action (Fund-lead groundwater/surface water restoration)	O&M On-site inspections and oversight	Property Management Long-term O&M Redevelopment Activities (Private- and Public-led)	LTM	O&M LTM	Shakedown period Operating Properly and Successfully O&M LTM	Shakedown period Long Term Management
Site Completion			Construction Complete (CC) Preliminary or Final Close Out Report (PCOR/FCOR) Site Completion - FCOR Site Deletion O&M as appropriate	Certification of Completion Corrective Action Complete with Controls or without Controls	CC Property Management	No Further Action (NFA)	CC	Response Complete (RC) NFA	RC NFA

Abbreviations:

SPP = Systematic Project Planning
DWS = Dynamic Work Strategies
RTMT = Real Time Measurement Technologies

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act
RCRA = Resource Conservation and Recovery Act

UST = Underground Storage Tanks
TSCA = Toxic Substances Control Act
VCUP = Voluntarily Clean Up Programs

IRP/ERP = Installation Restoration Program/ Environmental Restoration Program
MMRP = Military Munitions Response Program

Figure 1. Crosswalk of Regulatory Programs, CSM Life Cycle, and Triad BMPs. Triad provides a flexible and comprehensive framework to facilitate site decisions during the entire site-cleanup process, irrespective of the environmental program driving site cleanup. Using SPP, evolving the CSM, and leveraging DWS and RTMT at each key project stage can improve project efficiency and effectiveness.
Note: The width and gradation of the blue arrows demonstrating BMPs indicate the relative level of effort applied and the resulting impact and value of performing the BMPs at the indicated project stages.

A Characterization CSM utilizing 3-D visualization (Figure 3) provides a more detailed understanding of actual site features and the complexity of subsurface conditions.

During field activities, the Characterization CSM is used to focus and guide the data collection program and is updated in real time with newly collected data. This allows the project team to maintain consensus on the CSM in support of project decision making. Site complexity may drive the need to use SPP practices to incorporate timely input of specialized expertise for Characterization CSM revision, such as from a geophysicist or statistician. This is one example of how SPP can add value at any stage of a Triad project life cycle.

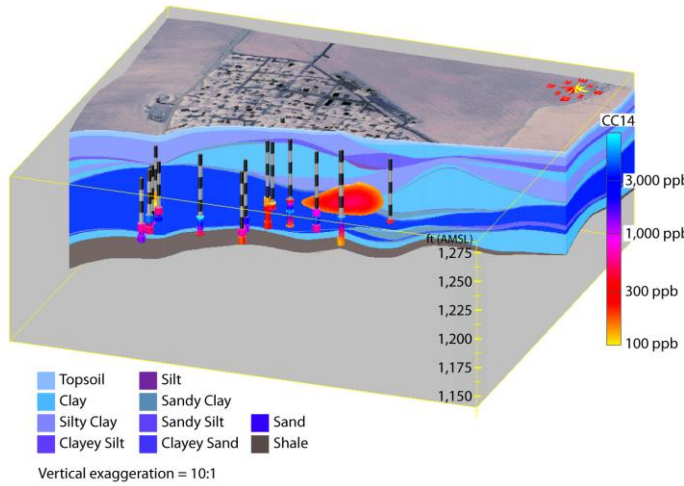

Figure 3: Characterization CSM Visualization. This 3-D visualization captures information regarding a chlorinated solvents plume at a site in Nebraska, including geologic stratigraphy; well locations and screened intervals; and contaminant concentration, location and depth all in relation to the local community. Visualization software and other tools can be used to calculate contaminant volume and mass, as well as model fate and transport. Diagram provided courtesy of Sundance Environmental & Energy Specialists, Ltd.

When the Characterization CSM is used effectively in the context of SPP-derived project objectives, site uncertainty eventually is reduced to a level wherein stakeholders can confidently agree that the site is adequately characterized to proceed with subsequent project phases. At this point, the role of the Characterization CSM shifts to supporting optimization of decisions for a more diverse set of project needs. For example, the nature and scale of decisions changes when the project focus changes from collecting data in support of risk assessment to evaluating data for the purposes of technology selection and remedial design.

In post-characterization phases, the project team revises the CSM to accommodate the evolution of site information in direct support of remedy selection and design (Design CSM stage), remediation or mitigation (Remediation/Mitigation CSM stage), and site closure (Post-Remedy[s] CSM stage). For example, for a site that is being positioned to achieve closure, SPP and the Design CSM can be used to facilitate key stakeholder agreement on the specific steps and performance metrics required to reach closure. The Remediation/Mitigation CSM would then be used to guide remediation/mitigation efforts such as directing and documenting excavation activities, managing phased remediation programs, managing secular (operable unit [OU]-based) remediation efforts, and responding to changed conditions encountered in the field. Continuous updating of the CSM can be used to maintain stakeholder consensus as remediation/mitigation progresses. The Post Remedy CSM would then be used to document the attainment of remediation goals with specific applications such as supporting No Further Action (NFA) determinations, providing a basis for using statistical methods for remedy evaluation, benchmarking performance metrics for triggering options in the ROD, and reducing a system design after an agreed period of operations and maintenance (O&M).

Evaluating and planning for managing risk-related uncertainties
SPP involves careful selection of data gathering tools, quality assurance and quality control (QA/QC) protocols, and communication strategies to meet project data needs and effectively manage sources of uncertainty. Evaluating known and probable uncertainties and allocating resources to the development of strategies to control those uncertainties with the greatest potential impact is essential for the success of a Triad project. Uncertainty is present in all data used to make decisions, model results, collect samples, analyze or interpret information, and in the relationship between estimations used to support decision making and the true or actual conditions present at a site.

Comprehensive SPP can help manage decision uncertainty to acceptable levels through CSM development and refinement and the use of real-time measurement technologies within a DWS framework. A well-designed CSM captures what is known about a site, but can also be used to illustrate one or more hypotheses of what might be occurring at a site. Thus, the CSM can be used to support decision-making with variable degrees of uncertainty, as well as to provide the foundation for developing data-gathering programs to reduce site uncertainties, decreasing decision-making uncertainty to more acceptable levels.

Development of a DWS requires the participation of diverse stakeholders and support personnel for technical and other inputs. It also requires the creation of a concise, yet often complex plan of action to reduce site uncertainty, and to do so within the constraints of cost- and time-critical performance requirements. Given this environment, an efficient and collaborative DWS development effort is best managed using SPP.

Real-time measurement technologies can help manage uncertainty by producing sufficient quantities of data quickly enough to direct the progress of characterization or remediation activities while they are underway. Often, SPP efforts on a Triad project include planning and completing a DMA effort to ensure data of appropriate quality, as agreed to by the stakeholders, will be collected using the selected or proposed real-time measurement technologies, innovative sampling strategies, or both. A DMA refers to an initial testing of field equipment and procedures, fixed-base laboratory methods, communication and information sharing strategies, and data recording and management to ensure that deployment of the technologies will be successful during full field mobilization.

Detailed information on performing DMAs in support of Triad projects is available at www.clu-in.org/download/char/demonstrations_of_methods_applicability.pdf.

Once the data collection tools are selected, it is important to establish decision criteria and collaborative data relationships that will be used during dynamic work activities. Designing appropriate data management and communication strategies during SPP is also critical to ensure timely stakeholder review, input and decision making, and documentation at the point of data generation. Doing so will maximize the benefits of real-time information and ensure effective management of high density data sets.

Leveraging the efficiency of DWS

DWS are designed to focus sampling efforts to improve project efficiency and reduce uncertainty. A well-designed and executed DWS can result in project life cycle cost and time savings (see Figure 4). Impediments to using DWS as a means to manage and constrain decision uncertainty can include inadequate site access, unique contaminants, restrictive media, and regulatory limitations to using a dynamic sampling approach. Procurement practices and contract language may need to be slightly modified to include optional activities and grouping of related activities so resources can be shifted on an as-needed basis and overall costs can be managed downward.

Non-dynamic work plans specify the exact type, quantity, quality, and location of data collection prior to any field activities. Uncertainty management under non-dynamic approaches primarily focuses on analytical uncertainty, which is often one of the smallest contributors to overall site decision uncertainty. Conversely, DWS approaches focus on heterogeneity, spatial and temporal factors, which tend to be the largest contributors to overall decision uncertainty. DWS approaches also consider real-time management of project resources, enhancing efforts to collect the appropriate data necessary to comply with the requirements of the sampling and analysis plan. The increased flexibility and real-time feedback embodied in the DWS approach results in significant decreases in data gaps, which is the primary driver of site remobilization and extended characterization efforts.

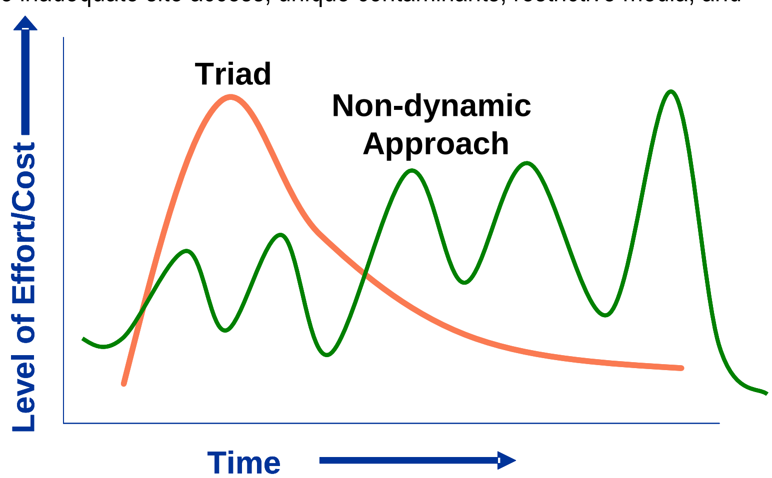

Figure 4: Dynamic approaches vs. non-dynamic approaches. This graph illustrates the level of effort, cost and time required for the Triad Approach (orange curve) is less than a comparable project performed using a non-dynamic cleanup approach (green curve).

At many sites, Baseline CSM assumptions that form the basis for designating sampling frequency and locations need to be updated early during field activities. Without real-time information and a flexible DWS approach to target areas of concern, project teams can encounter difficulties in reacting to these CSM discrepancies during a single mobilization. Each mobilization can identify additional data needs that require changes to the CSM, subsequent data collection, and corresponding work plan development, which significantly affect the project schedule and lead to cost inefficiencies. In recent years, more project teams have identified the need to develop geologic and hydrogeologic context for data derived from chemical analyses in order to appropriately interpret those results. High-density information, collected using a DWS and integrated into an evolving CSM, leads to placement of sampling locations, monitoring wells, and well screen intervals to best represent site conditions and manage perceived or actual uncertainties. EPA recently published companion Technology Bulletins about performing DMAs, managing and interpreting data, and using DWS under a Triad approach, which are available at www.brownfieldstsc.org.

Summary

The interplay between building social capital, defining clear project objectives, developing a comprehensive CSM to identify data and resource needs, and evaluating and managing risk and uncertainties are unique characteristics of Triad-based projects. Using the SPP process under Triad to drive project design can improve overall project efficiency and decision certainty on environmental cleanup project for sites under various regulatory frameworks. Projects at all stages of the cleanup process can benefit from the use of a robust SPP effort throughout the life cycle of the project, beginning with site assessment and investigation and continuing through cleanup design and implementation, and even long-term remediation system optimization.

While Triad's emphasis on more comprehensive upfront SPP may increase initial project resource requirements, projects with SPP efforts performed at collaboration-intensive stages of the project can save significant time and costs, provide more defensible decisions as the project progresses, and ultimately result in more effective and efficient cleanup. The success of SPP under Triad results from establishing consensus on the Baseline CSM and a clear exit strategy, and focusing and adjusting resources based on project needs driven by the life cycle evolution of the CSM. Additionally, the use of DWS and real-time measurement technologies help improve project efficiency during implementation while at the same time improving decision certainty. Achieving stakeholder consensus on reuse goals and the strategy and plan for site cleanup improves a project team's ability to perform risk management, address redevelopment concerns, ensure the scientific and legal defensibility of results, and achieve site closeout as efficiently as possible.

FREQUENTLY ASKED QUESTIONS

How does SPP under Triad differ from conventional approaches to project planning?

Relative to traditional project execution, SPP under Triad stresses up-front involvement and buy-in of all stakeholders (that is, social capital) that could potentially affect site decisions during the entire project life cycle. Stakeholder focus is on developing an exit strategy intent on reaching project objectives or goals quickly and in a cost-effective manner while maximizing resources and protectiveness. The value of building team trust and demonstrating technical competence among interested parties cannot be overstated. Stakeholder involvement in SPP under Triad allows the identification and management of non-technical factors that can have significant project impacts at the beginning of the project, as well as at critical planning-intensive project phases. The process seeks to educate all team members on the technical and economic implications of meeting individual stakeholder needs so that the team can develop an exit strategy that is amenable to all members. SPP under Triad also places greater emphasis on the use of a CSM that evolves to support specific project phases, the use of DWS, real-time measurement technologies, collaborative data sets, and unique procurement characteristics. SPP under Triad seeks to identify project goals and subsequent data needs clearly and specifically to utilize coordinated data collection efforts to indicate what needs to be done at a site. Triad SPP minimizes surprises, conflicting data, changes in stakeholders' roles, and the effects of personnel changes.

How do project managers address SPP during procurement for a Triad project?

Triad practitioners are developing a growing collection of information about the implementation of Triad best management and technical practices, such as SPP. Project managers should plan for and allocate resources necessary to complete SPP and associated work products, including CSM visualizations, DWS decision logic diagrams and DMAs. Specifically, the dynamic nature of Triad-based projects require that relevant procurement issues be addressed—namely, to provide the flexibility and adaptability during project implementation that is crucial to the success of a Triad project. EPA has summarized some of the available options in a document entitled *Understanding Procurement for Sampling and Analytical Services Under a Triad Approach*, available at www.brownfieldstsc.org/procurement.cfm that highlights methods and strategies that have been successfully used to procure technical services under a Triad framework. This document includes examples and lessons learned from actual Triad projects implemented in the federal, state, local and private sector arenas.

What are some the keys to success in Triad procurement efforts?

- Involving the contracting staff in the planning process before the final procurement strategy is identified. Experienced contracting staff can identify the best contract mechanism and approach to provide for the flexibility and adaptability required under the Triad approach while maintaining appropriate controls over the contract and the project.

- Using unit costs to allow better estimation and tracking of project costs. A unit cost under Triad is defined as a combination of discrete activities managed together that can be used as a basis for estimating and tracking costs. Unit costs are typically vendor-specific but can be customized to meet the specific needs of a project. Developing options and unit rates based on the anticipated data needs of a project will increase the flexibility of procurement and project efficiency. A planning process that allows decision-makers to understand the specific services and equipment to be provided and the associated 'units' is essential for a successful procurement. For example, using unit costs in a Triad project allows the project manager flexibility in ordering field services while at the same time being able to calculate costs. The contractor will provide unit costs for each type of activity, e.g., $2,000 per day for direct push soil sampling. The project manager then orders the amount via technical direction, such as conducting up to 10 days of services during one or more 10-day field effort cycles.

- Clearly identifying how flexibility will be incorporated into the project while maintaining control over overall project and contract objectives. This requires up-front planning to establish (1) clear decision criteria for data collection; (2) clear methods and lines of communication to facilitate rapid decision-making, including real-time meetings and effective coordination among decision-makers; (3) a clear understanding of the cost implications of scope changes and how optional tasks will be triggered and managed; (4) a rationale for 'ranges' of samples to be collected and analyzed; and (5) clear decision rules for how sampling locations may be determined and revised in the field. Using unit costs within a fixed budget, Triad teams can identify initial sampling locations, technologies and analyses, use a DWS to place additional locations or collect collaborative data, and end with a maximum or threshold value for the number of locations and analyses a procurement and/or field effort can accommodate.

- Considering use of a two-part approach to procurement in which the up-front development of the Preliminary CSM and the SPP (including the Baseline CSM and DWS) are procured as a separate activity from the field implementation services can assure the project scope is well-defined before funds are allocated. A two-part approach can provide the buyer with several advantages. For example, if the buyer does not possess the necessary technical expertise, this approach gives the buyer the ability to procure the expertise needed to develop a DWS with sufficient technical detail for the statement of work to procure the field services. In addition, this approach gives the buyer the ability to increase competition for the work by allowing a broader universe of contractors to bid on the field work component. A two-part approach is also useful in cases where different contractors have different skills and areas of expertise.

What tools are available to help with SPP?

There are a variety of tools and strategies to assist project teams with SPP at EPA's *Triad Best Management Inventory* available at www.triadcentral.org/ref/ref/index.cfm.These tools are comprehensive and are not intended to list required activities for SPP under Triad but rather to identify many of the issues that should be considered or addressed. Users are encouraged to evaluate the potential effect on their projects from items in these checklists and inventories to determine which have the greatest potential effect on project success and then apply resources appropriately to address these.

At contentious sites or those with team functionality problems, the use of a third-party facilitator with Triad expertise can provide tremendous advantages to move projects from historical impasses toward a common goal. The facilitator can assist each side with technical or non-technical issues, encourage all sides to articulate project needs, and then work with stakeholders to develop actionable goals. Triad technical support and SPP facilitation is available through the BTSC technical support team at www.brownfieldstsc.org/request_support.cfm and interested stakeholders are encouraged to seek assistance from experienced Triad practitioners such as members of the Triad Community of Practice (CoP) at www.triadcentral.org/user/cop/.

Distance collaboration tools such as virtual meetings, Web conferences, ftp sites, and secure project team Web pages are increasingly being utilized to facilitate SPP for Triad projects. Traditional meetings can be augmented using these tools, thus limiting the need for extensive travel or multiple live stakeholder meetings that can be logistically difficult to coordinate. Although face-to-face SPP meetings are extremely valuable for social capital aspects of many Triad projects, these additional resources provide economic and scheduling benefits by expediting document preparation and review, assisting with schedule and budget development, technical scope development, and a host of other project components.

Triad project teams can also use simple tables to track, resolve and prioritize sampling and non-sampling uncertainties identified during SPP (Figure 5). These tables allow stakeholder and core technical team members to discuss potential resolutions and assign responsibility to specific core technical or field team members to address sampling and non-sampling uncertainties recognized during DWS planning. Prioritization of sampling and information needs based on these tables allows development of activity sequencing to focus existing resources and plan for future efforts.

Site XYZ

Uncertainties for which sampling is required (i.e., to be incorporated into the Work Plan)

No.	Uncertainty	Recommended Resolution	Type of information required	Quality	Quantity	Responsibility	Priority
1	XRF and ICP correlations. Field based action levels?	TAL (metal) XRF (Manufacturer, model, software, source or x-ray tube?) Encourage contractor to evaluate newer hand held units to allow real time measurement in the field.	Demonstration of method applicability. Evaluate DLs, count times, sample prep, matrix variability.	SW-846 or CLP collaborative methods. Develop XRF SOP?	10-20% of total XRF samples. Front loaded QC during DMA.	EPA HQ	High

Uncertainties for which sampling is not required

No.	Uncertainty	Recommended Resolution	Type of information required	Quality	Quantity	Responsibility	Priority
1	Reuse scenarios for processing area? Reuse scenarios for wetlands area?	Agree on industrial reuse scenarios. Develop recreational exposure scenarios and assess ecological risk.	Signed agreement from EPA region, township, state. What records do we need? Are hunters or fisherman using resources as a food source?	Signed agreement from EPA region, township, state. State agreement to restrict thee use of annex area as state managed resource?	EPA HQ 8/2008 EPA risk assessor USFWS 8/2008	High	

Figure 5: Project teams can use a relatively simple tool like this to track major sources of site uncertainty. The recommended resolutions, information requirements, and priority of uncertainties can be an effective tool for project and site decision-making.

Project managers are encouraged to identify resources for data management and decision assistance. Although many Decision Support Tools (DSTs) are beneficial for DWS, they are often identified during SPP and can support some planning activities like sampling design and estimation of CSM certainty. Project managers, site owners, environmental consultants and others use DSTs in a variety of ways to support activities such as site assessment and remediation, data management and visualization, and optimization.

Developing contingencies for drilling platforms, sample collection, sampling design, and field or laboratory analysis strategies are also considered during SPP. Since many project activities result in a few surprises and no project team can anticipate all potential technical and non-technical issues that may arise, a simple process of prioritizing contingencies based on potential impact to project success allows project teams to manage tasks and determine appropriate resources (Figure 6).

During Triad projects, DSTs have been used to assist project teams in managing data, identifying sampling locations, groundwater modeling, data contouring, managing uncertainty, and other critical project aspects. DSTs used in environmental applications also include numerous statistical data and modeling packages, from both commercial and public sources. EPA recently published a matrix of publicly-available DSTs including several that are beneficial to SPP and available at www.frtr.gov/decisionsupport.

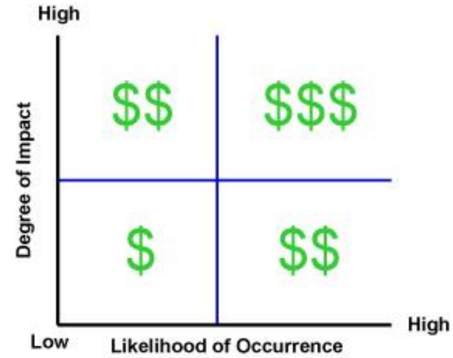

Figure 6: Example decision matrix for prioritizing project contingencies. Project teams can use simple decision tools like this to determine the appropriate resources to apply to a project. Prioritizing and assessing the contingencies based on the degree of impact to the project and likelihood of occurrence is an effective way to manage uncertainty-based risks.

Simple decision assistance spreadsheets (Figure 7) allow stakeholders to track and address CSM uncertainties, identify areas of data needs, evaluate stakeholder consensus or outlier opinions, determine when sufficient data have been collected, document decision rationale, and screen potential remedial options for effectiveness. These spreadsheets are developed on a project-specific basis based on technical and programmatic site settings, project data objectives, and desired outcomes. How questions are phrased, scoring ranges, and potential answers must be agreed upon by stakeholders. In addition, all members must be committed to consensus, engaged, and invested in the process in order to use these types of tools effectively. At a minimum, when geared toward answering principle CSM or study questions, these tools can be effective in highlighting areas of contention when some stakeholders do not articulate concerns during SPP meetings. They can also identify, document, and rationalize stakeholder positions.

How do you evaluate the effectiveness of SPP?

It is sometimes difficult to estimate when SPP efforts are sufficient to meet project goals and objectives. Ideally, SPP has been most effective if it facilitates the project reaching a clearly-defined conclusion or other important stage acceptable to the stakeholders. While there is always room for improvement, SPP is effective when sufficient information has been gathered, reviewed, and used to structure a DWS so the potential for success is high. For cost and timing reasons, it is desirable to achieve as much as possible or logical initially without the need for continual major adjustments and remobilizations. Nevertheless, for even small efforts, some refinements will be needed as more is learned. The key to successfully reducing mobilizations, for example, lies in building in sufficient flexibility to the proposed approach and existing plans so some degree of change can be managed in real-time.

Project teams can also waste time when documentation is insufficient and they have to redo work because the determined result(s) cannot be adequately verified. Every job is unique; there is no one method for assuring that SPP is complete. However, some of the items that many projects have in common and products that can be expected from a thorough SPP effort at the start of a project include:

- Preliminary CSM to identify data gaps
- Defined roles and responsibilities
- Clear project goals and objectives
- Resource utilization plan
- Project schedule and milestones
- Plan to evaluate practical constraints (DMA design)
- Decision-making criteria and alternatives
- Focused QA/QC program design
- Consensus on identified data gaps and priorities
- Methods for data collection and communication
- Contingency plan for problem resolution
- Real-time data management and communication strategy
- Required level of documentation
- List of potential remedies and exit strategies
- Determination of and plan to assess performance metrics

Technical Factors				
T-1	**Are all above-grade and/or sub-grade contaminant release mechanism(s) identified at the site?**	1.0	3-60-90%	3.00
	If the source of the original contaminant release is no longer in use, has it been properly decommissioned, abandoned, demolished, or removed			
	If the facility is active, are routine leak test performed with adequate detection limits to prove that leakage is absent?			
	If the facility is active, are routine accidental spills adequately contained to prevent a pathway to the subsurface?			
T-2	**Is the presence of mobile - and/or residual-phase LNAPL in the vadose and saturated zones well understood?**	1.0	4 - >90% Complete	4.00
	Have measurements of in-well LNAPL thicknesses been made in monitoring well(s)?			
	Have soil and groundwater samples been collected and physically observed for LNAPL?			
	Have LNAPL indication tools (laser-induced fluorescence, ribbon sampler, Sudan IV dye, etc.) been used?			
	Have contaminant partitioning equations been used to back-calculate the potential presence of free-phase LNAPL using soil and/or groundwater sample results?			
T-3	**Is the source material (e.g., mobile-, residual-, or sorbed-phase contamination that emits mass to the soil gas or groundwater) geometry well characterized?**	1.0	1 - <30% Complete	1.00
	Has the lateral extent of source material been defined to within an appropriate tolerance?			
	Has the vertical extent of source material been defined to within an appropriate tolerance?			
	Are inconnections of multiple sources, if present well characterized?			
	Has contaminant distribution and lithology been correlated (e.g., is the LNAPL trapped within low permeability lithology)?			
	Has the mass fraction of contaminants in the LNAPL-phase been estimated?			
Total Technical Factors				**19.20%**
Maximum Possible Technical Factor Score				26.40%
Total Technical Factor Conceptual Site Model Certainty				72.7%
Criteria that are answered "1 - <30% Complete" are highlighted in RED and, if given a high importance, should be further characterized.				
Criteria that are answered "2 - 30-60% Complete" are highlighted in Orange and, if given a high importance, should be further characterized.				
TOTAL SCORE INTERPRETATION				
>90%	*The site is well characterized and suitable as a basis for remedial decision making.*			
60-90%	*The site is adequately characterized and may be suitable for remedial decision making. Increased certainty in some factors may be desired prior to remedy design.*			
30-60%	*Site characterization is inadequate for use as a basis for most remedial action decisions. Additional work is prudent to improve certainty.*			
<30%	*The site is poorly understood and should not be used as a basis for remedial decision making. Additional work is required to improve certainty.*			

Figure 7: Example of a CSM-based site decision tool. This relatively simple yet sophisticated spreadsheet identifies and prioritizes further characterization and data needs at the site based on CSM certainty. The questions and scoring range used in the spreadsheet were developed based on site-specific project objectives and conditions. Table provided courtesy of CH2M Hill.

How important is the CSM in the SPP Process?

Developing and evolving a CSM that addresses the unique needs of each major stage in a project's life cycle is essential to any project's success. The core technical team should select a platform for the CSM that can be easily revised as more site information is learned, such as geology, hydrogeology, well completions, sampling locations, and contaminant distributions. Building a project information repository using a relational database tool is essential. Using a visualization platform, where site information can be viewed in three dimensions, preferably in a temporal context, is a highly-effective method of communicating, reaching consensus and building social capital with stakeholders. EPA information on data management and interpretation tools is available at www.brownfieldstsc.org/pdfs/Management_and_Interpretation_of_Data.pdf.

How does SPP ensure a cohesive team once work begins?

Developing a sense of teamwork and trust comes from well-defined roles and responsibilities. Clear project goals and objectives keep everyone on a project team, including stakeholders, engaged and confident that the project is moving in the right direction. Project resources should target areas where the highest uncertainties exist and the greatest social capital will be realized. Practical constraints must be tested to make sure a DWS is logistically viable and can flow smoothly.

Empowering field teams with pre-defined decision criteria and logic ensures that a project moves along with limited delays or interruptions. A focused QA/QC program targeting the site conditions and uncertainties with the greatest potential to affect the project results in efficient use of resources and builds continued trust among the parties involved. Real-time data sharing via the internet continues to nurture trust among all interested parties and allows for the development of strategies to resolve problems quickly as they arise. A well-established executive record of documentation makes it possible for the decisions to be independently verified once a project is complete. The resulting documentation ensures that decisions are defensible and the work will not need to be redone later. Potential remedies and exit strategies are the end goal of most projects, so keeping these items in the forefront of project planning provides maximum efficiencies. As more is learned about a site and the CSM is updated, the project team can focus on what is needed to achieve exit strategy success and shed excess efforts that become less aligned with a project's needs.

How is SPP documented?

SPP is documented through a variety of formal and informal means. The initial and perhaps most important SPP documentation are the Baseline CSM and accompanying uncertainty tables or other similar documentation. Additional documentation includes Sampling and Analysis Plans (SAPs) and Quality Assurance Project Plans (QAPPs) that are developed after the SPP effort. When written for a Triad-based investigation, these documents outline the SPP as an important component of development of data collection schemes and uncertainty management strategies. Communication methods, such as memorandums, meeting notes and project team covenants formally document the SPP process. These methods are particularly useful to document stakeholder participation and buy-in for Triad-based investigations. Informal communication methods such as project websites and electronic bulletin boards help facilitate information exchange in support of the SPP process. Informal methods also help accelerate problem resolution compared to formal document comment, revision, and submission schedules.

SUMMARIES OF SUCCESSFUL SPP

Example 1: Cache La Poudre River Site, Fort Collins, Colorado

> An effective SPP effort combined with the development and life cycle revision of a CSM allowed separate project teams to achieve and maintain site consensus, enabling them to make critical decisions in support of successful characterization and remediation of a highly-complex DNAPL site.

In May 2003, EPA Region 8 initiated a Targeted Brownfield Assessment (TBA) to further evaluate environmental issues related to the Cache La Poudre River Site (Site), a former manufactured gas plant (MGP) located in Fort Collins, Colorado. The existence of dense non-aqueous phase liquids (DNAPL) beneath the City of Fort Collins (City) property had not yet been well-documented, nor was the transport mechanism understood as to how this material was reaching the river. A Triad Approach project was recommended to expand sampling and analytical coverage at the Site including use of SPP, a DWS and real-time measurement technologies to complete the delineation and evaluation of transport pathways for contaminants.

The project leveraged all key SPP elements, including developing social capital through a stakeholder group and a series of site planning meetings, identifying project objectives, and designing sampling and data management activities to achieve project objectives. Prior to SPP, the core technical team developed a Preliminary CSM based on a review of existing data from previous investigations. The Preliminary CSM indicated that potential threats to human health and the environment included discharge of contaminated groundwater to the river and direct contact with contaminated surface water and sediments.

During Preliminary CSM development, the core technical team noted that previous bedrock surface maps for the Site were problematic and led to a number of conflicting theories of contaminant migration from the upgradient former MGP, leading to the identification of significant uncertainties regarding the CSM. Stakeholders continued to disagree over potential sources of DNAPL material detected in the river during the TBA field efforts, resulting in competing Baseline CSMs and each of the parties pursuing slightly different investigative strategies for their portions of the project. However, because of positive social capital developed through the SPP effort, the stakeholders were able to use the interest in achieving a single CSM consensus as a common basis for discussing and addressing these disagreements. This collaboration enabled the core technical team to define sampling and information collection strategies that targeted uncertainties and refined Site understanding. By acknowledging multiple CSMs, addressed individual concerns and interests of the stakeholders were addressed, which helped to further build social capital and direct planned dynamic field activities to address data gaps associated with these competing CSMs.

The core technical team solicited the involvement of all Site stakeholders in the development of a decision making strategy that outlined data collection activities and critical decisions to reach site remediation and closure. The City, in conjunction with EPA, the former MGP property owners, and consultants representing each potentially impacted property within the study area, identified the primary objective of establishing a connection between potential source areas at the Site and coal tar contamination found in the adjacent river. A second objective was to assess a former municipal landfill at the Site for closure in accordance with State of Colorado requirements. The core technical team designed data collection efforts to support these objectives in anticipation of future redevelopment planned at the Site. The sampling and data management activities identified during the SPP included a combination of both traditional field approaches and DWS using innovative means for high resolution data collection to assure the reliability of site decisions.

Working collaboratively on various portions of the project, all stakeholders reached consensus about the source of the material found in the river, which resulted in refining the Characterization CSM. Following the TBA activities, the potentially responsible party (PRP) conducted a Superfund removal action to excavate contaminated materials found in river sediments. At the same time, EPA conducted a site assessment (SA) to further identify potential pathways and source areas for DNAPL, obtain data to refine the Design CSM, determine the nature and extent of dissolved contaminants, and generate data to support implementation of the proposed remedy. Removal action and SA activities indicated MGP-related contaminants were flowing above and within fractured bedrock and discharging to the river, and that more recent diesel and gasoline spills from nearby gas stations and a fuel depot were acting as solvents or mobilizing agents to the viscous coal tar materials. Stakeholders agreed to a remedial design in 2004 and construction of a sheet pile barrier with hydraulic controls and groundwater treatment system was performed in early 2005.

The use of SPP benefitted the project in several critical ways. SPP helped stakeholders work through areas of disagreement towards a common goal. The original judgmental sampling plan was cooperatively revised by the stakeholders during SPP, to include use of a DWS and innovative field-based technologies, which significantly improved Site decision making compared to traditional strategies and investigation methods. The life cycle revision of the CSM allowed the core technical team to clearly communicate gaps in available data and illustrate the benefits of potential sampling and data management activities. The combination of these BMPs directly facilitated the successful characterization and remedy construction of this highly-complex site to the satisfaction of all stakeholders in 2 years. More information on this site case study is available at www.brownfieldstsc.org/pdfs/PoudreRiverCaseStudy.pdf.

Example 2: Milltown Redevelopment Site, Milltown, New Jersey

> The SPP process allowed for integrated stakeholder involvement, resulting in expedited completion of the project, and enabling the site developer to confidently confirm a decision to continue development.

Milltown Redevelopment (Site) is a Brownfields site located in Milltown, New Jersey. The City of Milltown (City) and Middlesex County (County) were interested in restoring the Site to active reuse as soon as possible. A Stage 2 Site Investigation/Remedial Investigation (SI/RI), as defined under New Jersey state guidance, was conducted using the Triad Approach in 2004. Triad was applied to evolve the Characterization CSM in a single investigation to determine any outstanding issues and reduce uncertainty enough to determine whether redevelopment was economically feasible to the satisfaction of Site stakeholders.

A diverse stakeholder group, consisting of representatives from Federal, state, and local agencies, as well as a potential site developer, was formed to plan, conduct, and oversee the project. The stakeholders identified several concerns through a series of SPP meetings, including the potential presence of buried drums and materials and the management of the large volume of data that would be generated by field analytical methods over a relatively short, 2-month time frame. This allowed the core technical team to target specific areas for higher density information and highlighted the need for a robust Baseline CSM to target sampling at appropriate depths and locations.

The primary project objectives identified by the core technical team during SPP included: (1) define Site reuse restrictions; (2) identify potential Site impacts to a nearby water body used for recreational purposes; and (3) estimate the cost of cleanup. The core technical team also developed a Baseline CSM for use in understanding site geology, hydrology, contaminant distributions, and the potential completeness of pathway receptor networks. As little was known about the Site's complex history, the core technical team planned to use field-based measurement technologies in a DWS framework to focus resources and increase the density of information in support of delineating potential source areas and groundwater plumes. Analyses were to be performed using a field-based command center, laboratory and data processing trailers.

The core technical team and stakeholders derived detailed procedures for decision making that would abide by the requirements of the New Jersey Technical Regulations (Tech Regs) and still allow for the majority of work to be performed in the field. The learning curve was steep for the stakeholder group as a whole, because of the diverse backgrounds of the stakeholder members. The Tech Regs also posed a unique challenge because they were developed to support primarily fixed-base laboratory, multiple phase projects. A robust SPP effort enabled the core technical team to address each of these challenges and an approach was developed that combined several levels of data quality into a decision hierarchy, allowing significant flexibility for the field team during execution of the DWS. The decision hierarchy consisted of three different tiers. Tier 1 included laboratory methods and reporting packages as described in the Tech Regs, Tier 2 included similar methods performed in the field with less rigorous reporting packages, and Tier 3 included test kits and direct sensing tools.

The DWS was used to rapidly delineate areas of concern (AOCs). Decision logic diagrams provided in the DWS work plans were used in conjunction with the Characterization CSM to guide investigative activities and data quality requirements, as well as to guide 'step out' sampling activities to ensure that characterization was substantively complete before leaving the field. In less than one week the field team identified a leaking underground storage tank as the source of the chlorobenzene plume, had source material pumped out of the tank, and delineated the extent of the plume.

Immediately preceding the field effort, the field team discovered a vat under a formerly used loading dock that had been obscured by heavy brush. Although the vat may have been discovered during a conventional study, the DWS provided a flexible means to adapt the sampling strategy immediately after the discovery was made in the field without modifying the written plans. The DWS provided clear direction to the field team and the means for quick concurrence on the sampling strategy from project stakeholders. The chlorobenzene plume was then delineated in approximately 4 days after 63 groundwater and 28 soil samples were collected from 46 sampling locations.

As further data were collected regarding the distribution of the contaminants, a secure, project-specific website on the EPA Environmental Response Team (ERT) Web server was used to update stakeholder understanding of the Site. Maps were posted, along with progress reports and information about meeting times and places. The website allowed stakeholders, including those remote from the Site, to review tables and maps summarizing the core technical team's updated understanding of the plume at the end of each day and then provide input for the next day's sampling. In addition, daily and weekly project briefing meetings were held with the stakeholders throughout the effort, strengthening project social capital and facilitating shorter review times.

Through the SPP process and the integrated stakeholder involvement, sufficient information was gathered in a single mobilization to support a decision to continue with Site redevelopment. The field team was able to sample more than 400 locations in approximately 5 weeks. At present, several of the areas addressed during the cleanup are ready for re-development and only the chlorobenzene plume remains as a significant issue. The success of the effort was directly related to the effectiveness of the SPP effort that included developing a Baseline CSM and related DWS, developing clear project objectives, and establishing clear roles and responsibilities, decision criteria and QA/QC requirements.

More information on this site case study is available on the Triad Resource Center website at www.triadcentral.org/user/includes/dsp_profile.cfm?Project_ID=30.

Example #3: Hartford Hydrocarbon Plume Site, Hartford, Illinois

The development of a Baseline CSM and DWS during SPP efforts, and the continual refinement of the CSM through the design phase of the project supported continual involvement of stakeholders in the decision making process, helping to optimize the site investigation, increase project efficiency and provide the basis for effective design.

In May 2004, the EPA signed a legal agreement with the Hartford Working Group (HWG) to investigate and clean up the refined petroleum products associated with Hartford Plume Site (Site), located in Hartford, Illinois. In late 2004, the U.S. EPA Superfund Technology Support Center (STSC) was asked to evaluate the planned approach for field activities at the Site. In particular, the STSC was asked to review the site characterization results obtained using cone penetrometer testing (CPT) technology equipped with a laser induced fluorescence tool (LIF). Utilizing the principles of the Triad Approach, EPA Region 5 on-scene coordinators (OSCs), State of Illinois Environmental Protection Agency (IEPA) representatives and members of the HWG participated in an SPP effort.

The project required developing social capital through outreach and engagement of the stakeholder group, defining clear project objectives, defining regulatory threshold limit criteria that would drive the project, defining timelines and roles and responsibilities, developing DWS for each portion of the investigation, and developing methods for communicating project results and real-time data management activities. Representatives of HWG were included in SPP activities because of their knowledge of Site conditions that might affect the design of remedial activities. The working group met monthly throughout the majority of the project to solicit feedback and keep the stakeholders informed of results and the design of follow on activities.

Objectives were agreed upon in a series of SPP meetings with all five of the responsible parties and their consultants, representatives from the state, EPA, and local village representatives. The EPA requested that STSC provide input to work plans as they were developed to identify key goals to be accomplished through the employment Triad. Because of the large size of the Site and the complexity of the environmental issues, multiple work efforts were required and planned to be implemented in a sequential fashion.

SPP began by developing a Baseline CSM based largely on a review of previous investigations conducted by consultants representing both the EPA and the HWG. The Baseline CSM was used to guide subsequent investigations to fill data gaps specific to agreed project objectives, as well as to identify geologic and hydrogeologic controls on the movement of vapors and free product. Taking into consideration the product thickness across the Site, the hydrogeologic gradients, as well as the project objectives, the proposed sampling plan was modified to target the boundary of the free product plume instead of maintaining static grid sample locations. Results from testing the Characterization CSM indicated that potential threats from vapors would likely be controlled by the proximity of hydrocarbons to the surface and the permeability of the underlying geologic formations. The sampling plan was amended to address data gaps made evident by the Characterization CSM, which further helped identify resource needs at the Site.

The Preliminary CSM presentation was designed to facilitate agreement between parties involved with implementation of characterization and remedial strategies for the Site. Through refinement of the Baseline CSM, stakeholders reached consensus on what was required to meet project objectives before new field activities were undertaken. Stakeholders then agreed to outline a path forward using a DWS, where applicable, to make additional decisions to address data gaps through refinement of the Characterization CSM.

Investigations were sequenced using a master schedule so data could be used to develop the Design CSM to support remedial design. Field-based technologies and real-time data management tools were utilized to fill data gaps and update the Characterization CSM. The DWS focused on areas of the Characterization CSM with the highest uncertainty, primarily near the edges of the plume in a downgradient direction and near the discontinuous edge of the conductive sand bodies located beneath the Site. A primary project objective was met by addressing uncertainties about the removal of free product beneath the Site by identifying where product thicknesses and hydrocarbon saturations were potentially the greatest.

Implementing an efficient remedy was supported by all elements of Triad. The aggressive use of SPP focused on refining the CSM through its life cycle stages and efficiently communicating results was extremely important to the ultimate success of the project. A well-documented DWS, which clearly defined how data would be used to support decision-making, limited project delays. The collaborative use of differing sources of information, designed during SPP, improved project efficiency. A continuously updated Design CSM was used during a series of SPP meetings as the basis to scope additional work and establish contingencies and options that might need to be built into the remedial designs planned at the Site. Social capital was built through the regular meetings and the rapid nature with which the project was conducted. Residential concerns were addressed quickly by EPA and the other stakeholders and issues mitigated as quickly as possible. A full case study for this site will be published in 2009 and be available at www.brownfieldstsc.org/publications.cfm.

SOURCES OF ADDITIONAL INFORMATION

Communities and project teams interested in implementing the Triad Approach are encouraged to contact the BTSC for more information and for successful examples of Triad applications. More detailed information on SPP and on the Triad Approach can be found in the Brownfields Technology Primer Series document *Using the Triad Approach to Streamline Brownfields Site Assessment and Cleanup*, which is available at www.brownfieldstsc.org. Project profiles, case studies, and other information on applying Triad within a variety of regulatory frameworks can be found at www.triadcentral.org. The BTSC provides other technical bulletins related to best management and technical practices embodied in the Triad approach such as *Use of Dynamic Work Strategies Under a Triad Approach for Site Assessment and Cleanup—Technology Bulletin* and *Demonstrations of Method Applicability Under a Triad Approach for Site Assessment and Cleanup—Technology Bulletin.* Additional documents providing critical information on related issues such as Green Remediation and Vapor Intrusion are also available through the BTSC.

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