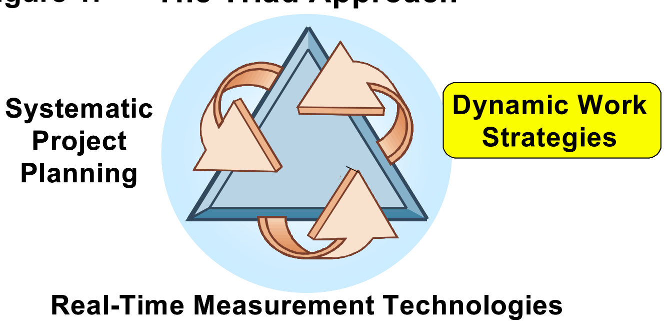
Use of Dynamic Work Strategies Under a Triad Approach for Site Assessment and Cleanup – Technology Bulletin
September 2005

Since its inception in 1995, the U.S. Environmental Protection Agency's (EPA) Brownfields Initiative and other revitalization efforts have grown into major national programs that have changed the way contaminated property is perceived, addressed, and managed in the United States. In addition, over time, there has been a shift within EPA and other environmental organizations in the way that hazardous waste sites are cleaned up. Project managers, regulators, technology providers, and other stakeholders are increasingly recognizing the value of implementing a more dynamic approach to site cleanup that is flexible and focuses on real-time decision-making in the field to reduce costs, improve decision certainty, and expedite site closeout. As shown in Figure 1, the Triad approach uses (1) systematic project planning, (2) dynamic work strategies (DWS), and (3) real-time measurement technologies to reduce decision uncertainty and increase project efficiency.

Figure 1: The Triad Approach



The EPA Brownfields and Land Revitalization Technology Support Center (BTSC) is preparing a series of technical bulletins to provide additional information about how to implement specific aspects of the Triad approach. This bulletin focuses on planning and implementation of DWSs, presenting:

1. Answers to frequently asked questions on implementing a DWS
2. Summaries of the application of DWS at two redevelopment sites, including:
   - Former Cos Cob Power Plant, Greenwich, CT
   - Assunpink Creek Greenway, Trenton, NJ
3. Sources of additional information for communities and project teams desiring to implement a DWS and the Triad approach

Additional information on the BTSC is presented in the box to the right.

IMPLEMENTING A DYNAMIC WORK STRATEGY

What is a dynamic work strategy?

A DWS allows data collection and cleanup activities to be performed in real time as parts of an integrated field effort. The actual number of field mobilizations depends on the complexity and constraints of a project but is always fewer than would be required under a static work plan design. Under the Triad approach, a DWS is specifically structured to resolve uncertainties about the presence and extent of contamination, exposure pathways, and selection of the right cleanup strategy. Real-time project execution allows projects to reach a successful conclusion faster, with less expense, and with greater certainty. Depending on the nature of a project and the judgment of the project team, a DWS can be planned and written to deal only with the data collection phase or to encompass both data collection and remedy implementation. DWSs that incorporate both sets of activities require more comprehensive planning and are more technically demanding, but they greatly improve the efficiency of field work because collection of additional data, refinement of the data collection design, selection of the remedy (from a pre-planned short list of options), and remedy implementation all can be performed while the project team is still on site.

About the Brownfields and Land Revitalization Technology Support Center (BTSC)

EPA established the BTSC (see www.brownfieldstsc.org) to ensure that brownfields and other land revitalization decision-makers are aware of the full range of technologies available for conducting site assessments and cleanups, and can make informed decisions about their sites. The center can assist federal, state, local, and tribal officials plan for use of the Triad approach at a specific brownfields or land revitalization site. This type of support includes evaluating available planning documents to determine how to incorporate elements of the Triad, such as better use of field analytical techniques or use of decision support tools. Localities can submit requests for assistance through their EPA Regional Brownfields Coordinators, online, or by calling 1-877-838-7220 toll free. For more information about the BTSC, contact Dan Powell at (703) 603-7196 or powell.dan@epa.gov.

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Even if a DWS involves data collection only, the project's bottom line will benefit from rapid generation of higher data densities in areas of the site where the information is needed most.

Important features of a DWS include:

- A ***flexible and adaptable approach to sampling and data collection***, that can continually be ***adjusted and refined in the field*** as new data are generated and data gaps are identified.
- An ***analytical quality control (QC) program*** that is also ***adaptive*** in nature, collecting QC samples that focus on the ***principal sources of uncertainty*** and incorporating ***real-time data QC review***.
- A ***clear decision logic*** applied in the field to guide the DWS, established and approved prior to the field program by the project stakeholders. The decision logic, along with the lines of ***responsibility, authority, and communication for decision-making***, is based on the site-specific exposure pathways of concern, reuse objectives, and data collection technologies. It is documented in project planning documents (see the discussion below).

Figure 2 shows a proposed example decision flow diagram, prepared with the assistance of the BTSC, for a targeted brownfields assessment (TBA) planned for a chemical site with concerns about volatile compounds. This flow diagram presents a synopsis of the entire technical approach for the investigation of the site, encompassing multiple environmental media and a range of potential chemical classes of concern. The diagram allows the stakeholders to reach major remedial and reuse decisions concerning the site in a single mobilization that employs a DWS.

The results of data collection using a DWS are used to continually refine the conceptual site model (CSM, the decision-makers' "picture" of site contamination) and the sampling and analytical approach in real time; in cases where there are significant unexpected results, revisions to the decision logic itself or to the overall project objectives may be needed. The field work continues until all decision objectives established for the project are attained with an acceptable level of certainty. The level of certainty is predetermined by the project decision-makers during systematic planning efforts. The soundness of project decisions and attainment of the project objectives should be verified before demobilization by performing quality assurance (QA) activities such as a data quality assessment (DQA) (EPA 2000b).

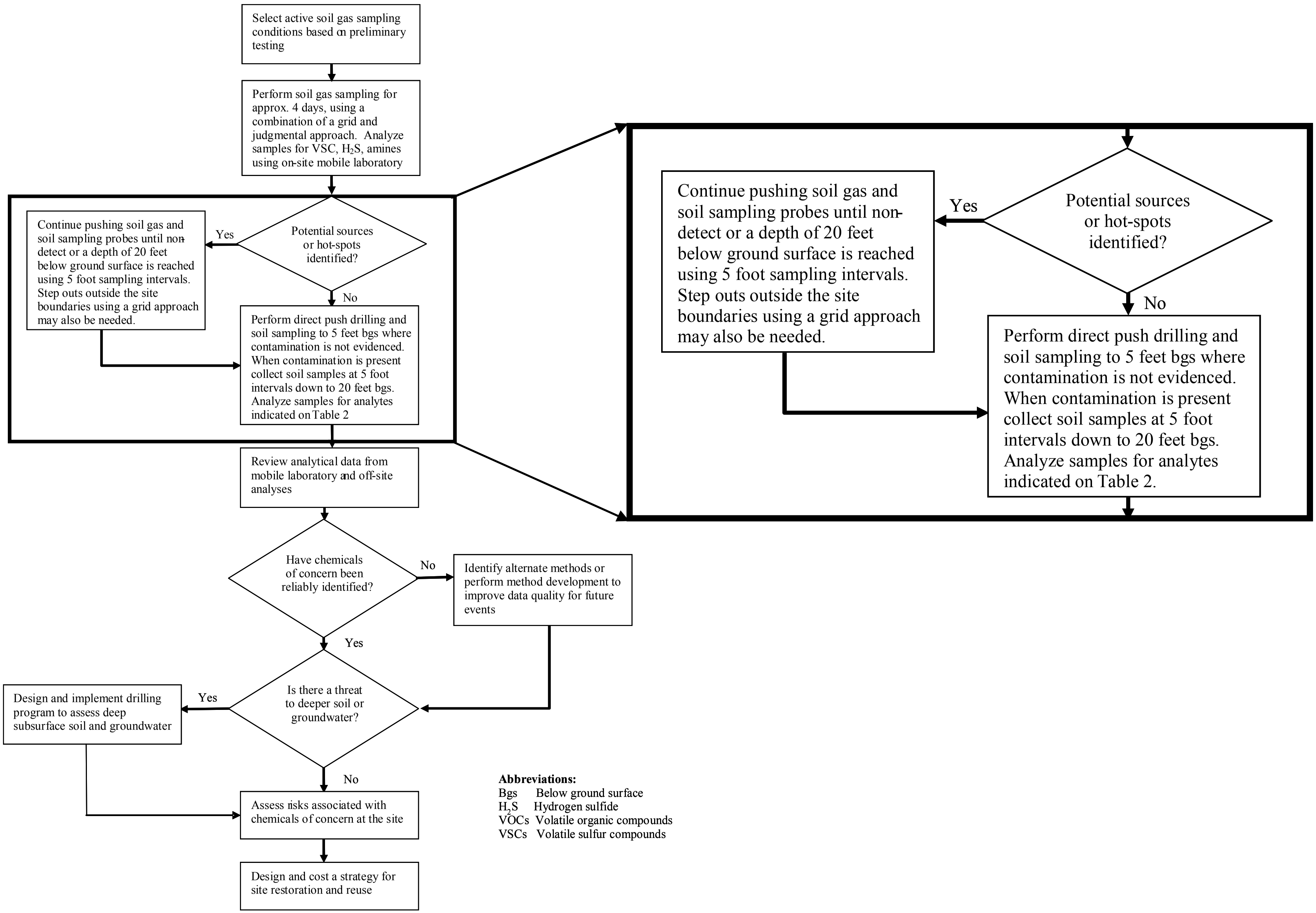
Fundamental to the success of a DWS is the ability to ***manage, review, and report data from the field to support fast decision-making***. An increasing number of tools are available to assist project teams with efficient management of field data. For example, the ***Scribe*** and ***Scriblets*** database programs available from the EPA Environmental Response Team (see *www.ert.org*) are designed for data entry and upload in the field from laptops and personal digital assistants (PDAs). The uploaded database can be ported to statistical packages and decision support tools (DST, such as the ***FIELDS*** and ***SADA*** software packages); see http://www.frtr.gov/decision support for further information about various software tools used for decision-making and data presentation. DSTs are discussed in a separate BTSC bulletin.

How is a dynamic work strategy incorporated into project planning documents?

A DWS does not require a separate project document. Rather, a DWS is incorporated into the plans typically prepared for a project, including work management plans (WMP), sampling and analysis plans (SAP), and QAPPs, and is thus captured along with the other components of the Triad approach, including systematic project planning and real-time measurement technologies. The difference is that, unlike work plans developed under traditional approaches, a DWS does not attempt to identify all sample types, locations, and quantities at the outset of an investigation. Within the planning documents, the DWS may identify general sampling approaches (for example, statistical or judgmental) or initial sampling locations, but it leaves the details of the data collection approach to be developed and adapted in the field. This adaptive strategy applies not only to the sampling approach but also to the analytical methods, the QA/QC program, the communication strategy, and other project elements, which are continually revised and adjusted as data are generated. Key items to be captured in the project planning documents are listed below.

- The systematic planning process – the project stakeholders, the project team, site reuse objectives, types of decisions to be made, the preliminary CSM, and the amounts and types of decision uncertainty that can be tolerated
- Decision logic and decision trees – decision rules written as specifically as possible to guide the field program

Figure 2: Proposed Example Decision Tree Incorporating Dynamic Work Strategy



- Standard operating procedures (SOP) – clear methods for sampling and analysis that are not "off the shelf" but have been evaluated and refined as necessary to meet the specific project data and decision needs (for example, through a demonstration of method applicability)

- Data assessment and QA/QC – the tools to be used for data assessment (for example, statistical routines and models) as well as the means by which data quality will be assessed and uncertainty will be managed in real time through QC checks and QA oversight activities

- Data management and documentation – the pathways, tools, and formats by which data will quickly and securely flow from the analytical instruments to the decision-makers as well as the documentation trail that will support real-time decisions while the investigation team is in the field

- Communication strategy – roles and responsibilities, authority, lines of communication and information flow, communication tools, and the frequency for decision-making and decision approval

- Scheduling and logistical considerations – optimal investigation time frames as well as how different field activities, staff, and equipment will be coordinated for maximum efficiency

- Contingencies – major uncertainties associated with the scope or direction of a DWS that may require identification of additional or alternate methods in planning documents (so that the methods are ready for rapid implementation or expansion as the field program progresses)

What types of strategies are used to manage uncertainty in a dynamic work strategy?

Sound defense of project decisions requires effective management of uncertainty. Under a Triad approach, it is important that decision uncertainty be managed during the investigation. Under traditional data collection strategies, data uncertainty is a major source of decision uncertainty. Data uncertainty is caused by many different factors. A very common and important cause of data uncertainty is that the number of samples collected is found to be insufficient for decision-makers to be sure that all contamination has been located. Uncertainty caused by insufficient sampling density also greatly impacts estimates of remedial costs because not enough information is available to know what the most effective cleanup option might be. Data uncertainty can also be caused by improper selection or use of analytical methods; in this case, the decision-makers do not have the right kinds of data to support risk and remedy decisions. Triad's systematic planning process addresses all these kinds of issues and builds their resolution into the project planning documents before field work begins. Geoscientists and chemists who are familiar with field sampling and analytical technologies should be involved in project planning and in writing the planning documents. While field work is being done, these personnel should monitor data generation and the QC results to make sure that the data will be usable to support project decision-making within the agreed-upon tolerances for uncertainty. These tolerances may be expressed qualitatively using professional judgment or quantitatively using statistics. Presented below is a partial list of uncertainty management techniques that have been used successfully to improve data quality in recent DWS projects:

- "Front-loaded" QC sampling – collecting a higher proportion of QC samples (for replicate measurements and spikes) at the beginning of a field program to allow a confident assessment of method performance. Once the baseline performance is established, the QC sampling frequency can be reduced.

- Focused QC checks – altering the nature or frequency of QC checks to focus on managing relevant uncertainty because of changes in field conditions or instrument performance. Examples include increasing the QC sampling frequency for a complex or variable matrix that is encountered during the investigation, adding a new target compound to calibrations, adjusting the range of the calibration curve, and increasing or decreasing QC spike mixtures used as analytical controls.

- Use of collaborative methods – using results of different methods to corroborate or confirm the results of a specific field-based method. Many programs have historically used off-site laboratories (for example, laboratories employing SW-846 methods) to corroborate results of field methods such as immunoassay test kits. This approach can foster a powerful collaborative data set that can be used to manage multiple sources of uncertainty; the high data density afforded by the test kits can be used to manage sampling uncertainty (heterogeneity), while the laboratory methods can be used to manage analytical uncertainty. Collaborative data sets are particularly important when samples have chemical concentrations near an action level and the analytical precision of the field method is insufficient to establish compliance with or exceedance of the threshold. Well-homogenized split samples can be submitted for more rigorous analysis to obtain data that are precise enough to allow management of this type of decision uncertainty.

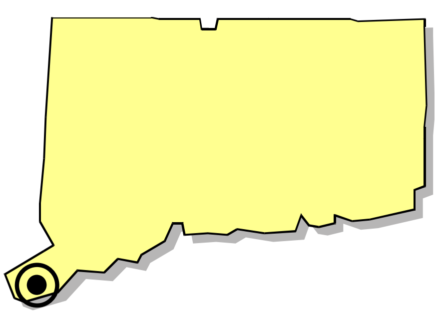
- Anticipation of contingencies for measurement methods – being capable of performing minor method modifications in the field as necessary. Examples include adjusting sample volumes, extraction parameters, or calibration procedures and adding new method steps (such as sample cleanup steps).

Using a DWS for data collection requires good coordination among multiple members of a project team (field crews, project decision-makers, and other stakeholders) and may challenge the team members in terms of their roles and level of effort needed. As such, effective implementation of a DWS requires a cooperative relationship among all the members of the project team and a firm commitment to real-time decision-making.

Case studies and brief project profiles describing DWSs in the context of Triad projects for a broad range of sites are available at ***www.triadcentral.org***. Two examples are summarized below.

EXAMPLES OF HOW A DYNAMIC WORK STRATEGY IS IMPLEMENTED FOR REDEVELOPMENT INVESTIGATIONS

Example#1: Cos Cob Power Plant, Greenwich, Connecticut



The Cos Cob Power Plant site is located in the southeastern corner of Connecticut on Long Island Sound. The Town of Greenwich plans to reuse the site and received a TBA grant to assess potential reuse options. EPA Region 1 requested assistance from the BTSC in maximizing the efficiency of the TBA by applying the Triad approach.

Site Facts

- ✓ Former coal-fired power plant that operated from 1907 to the 1960s
- ✓ Planned for recreational reuse (walking trails and playing fields)
- ✓ Principal threat is direct contact with contaminated surface soil
- ✓ Contaminants of concern (COC) included petroleum-related substances, polychlorinated biphenyls (PCB), and arsenic associated with fly ash (used as fill) and transformers

Work Plan Development

With the BTSC's assistance, EPA Region 1 revised the limited, traditional sampling approach originally proposed for the site and developed a DWS. The DWS called for random grid sampling and field-based measurement technologies to expand the extent and density of investigation across the site for total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), and PCBs. The goal was to delineate the COCs in soils at the site in a single mobilization rather than use the phased approach originally envisioned for the TBA.

During the development of the TBA work plan that documented the DWS, ultraviolet fluorescence (UVF) test kits were verified as useful field-based methods for TPH and PAH measurement through a method applicability study. This study also allowed the development of correlation curves between the field test kits and laboratory analytical methods, allowing estimation of field-based action levels to be used with the test kits to classify sampling locations in three ways: "clean," "dirty," or "uncertain" (requiring collaborative off-site laboratory data). The field-based criteria were further developed into decision trees and incorporated into the work plan to support decision-making in the field. In addition to the UVF test kits, the TBA work plan specified field-based gas chromatography (GC) analysis for PCBs by EPA Region 1's mobile laboratory.

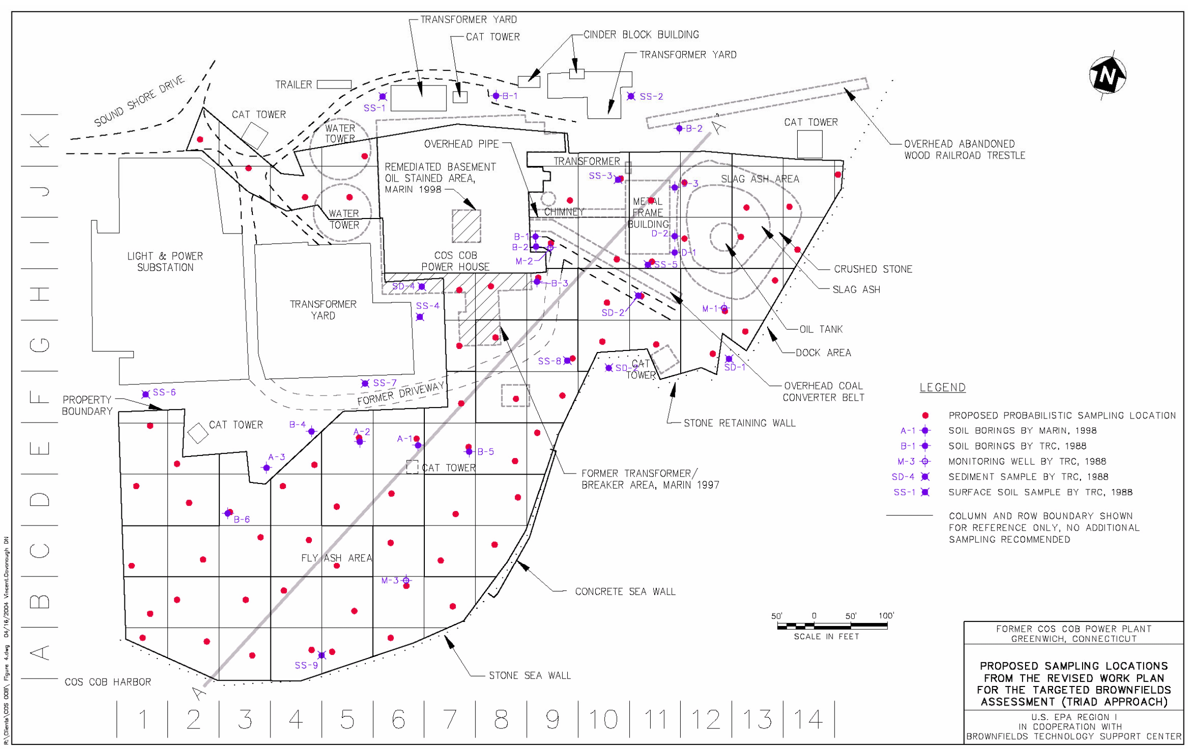
Implementation of Dynamic Work Strategy

The field effort at the Cos Cob Power Plant site was completed in 1 week in February 2003. Direct-push methods were used to collect soil samples down to 4 feet below ground surface (bgs) within a 70- by 70-foot sampling grid extending across the site (see Figure 3). The sampling location within each grid element was selected randomly unless a specific area of potential contamination was identified, in which case a judgmental (biased) sample was collected. Initially, only samples collected from the top two 1-foot intervals at each location were analyzed in the field, and a percentage of the samples collected were sent off site for collaborative analyses. Field analyses were performed for TPH and PAH at all locations using the UVF test kits, whereas PCB analyses were performed only in grid elements where PCB releases were believed to be possible based on historical information. Selection of samples for off-site TPH and PAH analysis was biased toward samples with test kit concentrations in the "uncertain" range (that is, the concentration range where samples could not be called "clean" or "dirty" with an acceptable level of certainty based on the method applicability study). Selection of samples in this manner allowed for refinement of field-to-laboratory correlations and of the field-based decision criteria as the investigation progressed.

Project Results

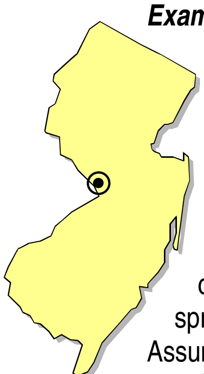
The dynamic field program at the Cos Cob Power Plant site rapidly clarified the principal reuse questions and remedial options for the project team and the Town of Greenwich. Field-based technologies were used to increase site coverage (that is, data density) and to limit decision uncertainty. Key ranges of concentrations and safety factors were identified and refined to guide data interpretation and decision-making in the field using real-time methods, and these ranges also became the focus of collaborative data collection using off-site methods to increase decision confidence. Although concentrations of some COCs (TPH, PAHs, and arsenic) exceeded Connecticut residential criteria at a number of site locations, these concentrations were nevertheless relatively low given the reuse plan for the site. These findings suggested that limited remedial action combined with modification of the reuse alternatives or the cleanup criteria could facilitate site reuse. The Town intends to use the TBA data to prepare a remedial action plan, which may involve limited excavation of some areas along with capping and land use restrictions (to prevent excavation) in other areas. The Town is planning a recreational reuse for the site as a waterfront park. Remedial actions (e.g., caps) will be incorporated into the park design.

Figure 3: Sampling Locations for Dynamic Work Strategy – Cos Cob Power Plant Targeted Brownfields Assessment



Source: EPA. 2004. Case Study of the Triad Approach: Expedited Characterization of Petroleum Constituents and PCBs Using Test Kits and a Mobile Chromatography Laboratory at the Former Cos Cob Power Plant Site. July.

The DWS applied at the Cos Cob Power Plant site established the principal contamination issues and reuse options for the site without the need for additional mobilizations. The cost savings realized by the DWS as compared with use of a more traditional, phased investigative approach were estimated at between 20 and 40 percent. Time was also saved in that the project was completed in a single mobilization and TBA funding cycle.



Example#2: Assunpink Creek, Trenton, New Jersey

The City of Trenton has been aggressively implementing the Triad approach since 2001 as part of its program to redevelop a large number of abandoned industrial sites. DWSs in particular were used to characterize contamination at approximately 40 acres spread out over 5 parcels of land along the Assunpink Creek which are targeted for recreational reuse.

Site Facts

- ✓ Sites of interest included a former wire manufacturer, a railroad freight yard, and repair shops
- ✓ COCs included heavy metals, petroleum hydrocarbons, PAHs, and PCBs
- ✓ The area had been industrialized since the late 1800s; previous investigations had revealed a need to differentiate between the impacts on specific sites from general fill materials, because these are treated differently under NJ State law

Work Plan Development

Through a systematic planning process involving multiple stakeholder meetings, a preliminary CSM was developed, and an investigative approach was formulated that involved two phases. Phase I was designed to address the nature and distribution of the historical fill materials and identify specific COCs and areas of concern (AOC) for further investigation. Phase I also included a method applicability study to demonstrate that the field-based methods proposed for use in the study area could produce effective data for decision-making.

Based on the Phase I findings, a dynamic work plan was developed for Phase II investigation of AOCs at the former wire manufacturer (Crescent Wire) site and the railroad freight yard. The work plan included multiple features designed to promote real-time decision-making in the field, such as:

- Technical approach sections that presented the preliminary CSM for each AOC along with decision rules, cleanup levels, and "possible scenarios" encountered in the field that could drive further data collection and completion of the CSM
- Project-specific field sampling and analytical procedures established during the method applicability study in Phase I, including geoprobe soil and groundwater sampling with continuous soil conductivity measurement and use of field gas chromatography/mass spectrometry (GC/MS) for PAHs, immunoassay (IA) test kits for PCBs and TPH, and x-ray fluorescence (XRF) for metals
- A data management and communication section describing field documentation requirements and protocols for communication between the field team, the project management team, and off-site stakeholders (the City of Trenton and the New Jersey Department of Environmental Protection [NJDEP])
- A schedule and logistics section describing the preferred time frame for mobilization and the anticipated duration of the field program

An example of the decision logic presented in the work plan for the Crescent Wire site is shown in Figure 4.

Implementation of Dynamic Work Strategy

The DWS was incorporated into a request for proposals (RFP) to hire a technical support contractor for the field investigation. The project team found that the DWS and the Phase I results presented in the RFP greatly improved the quality and creativity of the bid packages and produced focused yet flexible pricing schemes. The contractor selected also assisted in finalizing the DWS in the work plan. When the field investigation began, the DWS relied on a three-tiered analytical program of collaborative methods to achieve high sample densities while still attaining low detection limits for specific COCs at decision points. The three tiers of methods included field-based, semiquantitative methods with high sample throughput for classes of COCs (IA methods); field-based, noncertified methods with higher specificity (mobile laboratory GC/MS and XRF); and off-site, certified methods for specific COCs (SW-846 methods). Sample results produced using these methods were integrated on a continual basis to support daily field decisions.

Figure 4: Excerpt from Dynamic Work Plan for PCB/Oil-Impacted Area of Crescent Wire Site
Assunpink Creek Greenways Project, Trenton, New Jersey

Path	Objective(s)	Sampling Requirements	COC	Field Analytical Method	Delineation Criteria	Decision Rule
1	Delineate the lateral and vertical extent of PCB/Oil impacts in on-site saturated soils, identify a possible onsite source area(s).	Saturated soils around the known impacted area.	PCBs	Immunoassay test kits	NJDEP Soil Cleanup Criteria (SCC)	From location where impacts were previously observed, step out at 25-foot intervals and down at 5-foot intervals until concentrations are below the delineation criteria. Once concentrations are below delineation criteria, step in once 10 feet. If a potential on-site source is identified, follow Path 3.
			TPH	Immunoassay test kits	1,000 mg/kg	
			Metals	XRF	No Criteria	
2	Delineate the lateral and vertical extent of PCB/Oil impacts in on-site groundwater.	Groundwater around the known impacted area.	PCBs	Immunoassay test kits	Class IIA Groundwater Quality Standards	From center of worst case soil impacts determined from Path 1, step out at 25-foot intervals and down at 5- to 10-foot intervals until concentrations are below delineation criteria.
3	Delineate PCB/Oil impacts in unsaturated soils, a potential on-site source area(s).	Unsaturated soils overlying most impacted saturated soils and/or groundwater.	PCBs	Immunoassay test kits	SCC	From the potential on-site source area, step out at 25-foot intervals and down at 5-foot intervals until concentrations are below delineation criteria. Once concentrations are below delineation criteria, step in once 10 feet.
			TPH	Immunoassay test kits	10,000 mg/kg	
			Metals	XRF	No Criteria	

Source: Langan Engineering and S2C2, Inc. 2002. Dynamic Work Plan for Site Investigation and Remedial Investigation Activities - Assunpink Creek Greenways Project. December.

The DWS framework allowed for shifts in decision logic to address new study questions and data gaps as they arose during the field investigation. As an example, Figure 5 shows the sampling approach that evolved dynamically for the Crescent Wire site. Initial sampling locations were selected to delineate a potential hot spot of PCBs and TPH found during Phase I. However, when the real-time results for the samples indicated a contaminant plume rather than a hot spot, the decision logic shifted from hot spot delineation to assessing the width and source of the plume. Sampling along the boundary of the upgradient property revealed similar COCs, and sample collection continued along the boundary until the edges of the plume were identified. Now that the CSM had been substantially improved by the determination that the plume originated from an upgradient source and was confined to a thin layer of floating, weathered product, the decision logic called for a determination of whether the contaminants in the plume had impacted creek sediments downgradient of the Crescent Wire site. Under this final phase of the DWS, a pattern of borings was established along the eastern, downgradient edge of the site immediately upgradient of Assunpink Creek. The borings were used to rapidly map the extent of the PCB and TPH smear zone and to establish that there were no downgradient impacts on the creek from the site or the upgradient source. Overall, therefore, the DWS quickly resolved the primary decision questions regarding the extent of contamination at the Crescent Wire site in a single mobilization.

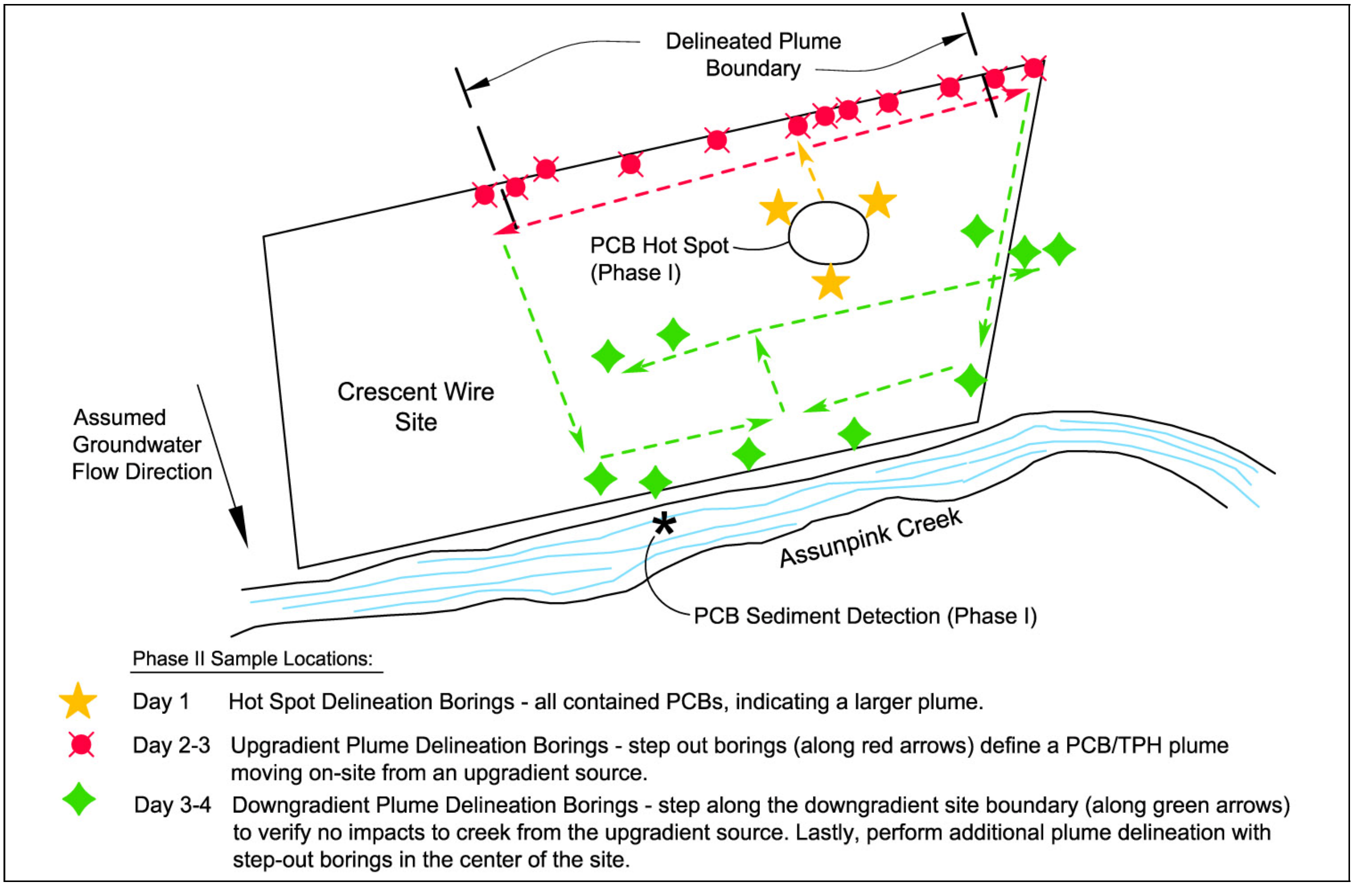
<u>Project Results</u>

The data set collected during the 4-day field program at the 3-acre Crescent Wire site was of sufficient quality to support an agreement among the stakeholders regarding a remedial and reuse strategy for the property. The project team was convinced that application of the Triad approach during Phase II allowed successful completion of the site investigation in a shorter time frame than would have been required by traditional approaches while producing a more detailed data set and greater decision certainty. As a whole, the Phase II investigation activities for AOCs along Assunpink Creek lasted less than 1 month, and the final report was approved within 3 months of completion of the final dynamic work plan.

SOURCES OF ADDITIONAL INFORMATION

The Triad approach is encountering ever greater acceptance by EPA and other federal and state agencies, as well as by professional and industry organizations. Communities and project teams interested in implementing the Triad are encouraged to contact the BTSC for more information on these organizations, and for successful examples of Triad applications. More detailed information on DWSs 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 http://www.brownfieldstsc.org; see the text box on the first page of this bulletin. Project profiles, case studies, and other information on applying the Triad approach can be found at http://www.triadcentral.org. As additional bulletins about other aspects of the Triad approach are developed, the BTSC will make them made available through these web sites.

Figure 5: Summary of Dynamic Work Strategy Implemented for Sampling of the Crescent Wire Site Assunpink Creek Greenways Project, Trenton, New Jersey



Source: James Mack et al. 2003. "Characterizing a Brownfields Recreational Reuse Scenario Using the Triad Approach – Assunpink Creek Greenways Project." *Remediation*. Autumn.

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This bulletin was prepared by EPA's Office of Solid Waste and Emergency Response under EPA Contract No. 68-W-02-034. The information in this bulletin is not intended to revise or update EPA policy or guidance on how to investigate or cleanup Brownfields or other revitalization sites. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

This bulletin can be downloaded from EPA's Brownfields and Land Revitalization Technology Support Center at www.brownfieldstsc.org. For further information about this bulletin or about the Triad approach, please contact Dan Powell of EPA at (703) 603-7196, or powell.dan@epa.gov.