Improving Sampling, Analysis, and Data Management for Site Investigation and Cleanup

The United States Environmental Protection Agency (EPA) supports the adoption of streamlined approaches to sampling, analysis, and data management activities conducted during site assessment, characterization, and cleanup. This position reflects the growing trend toward using smarter, faster, and better technologies and work strategies. EPA is coordinating with other Federal and State agencies to educate regulators, practitioners, site owners, and others involved in site cleanup decisions about the benefits of a streamlined approach. Ultimately, EPA expects to institutionalize these newer approaches and anticipates that the principles will guide the way data are collected and analyzed for future site cleanup decisions.

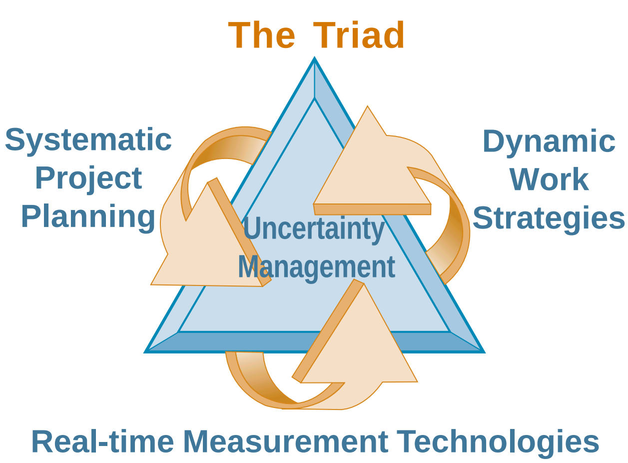
The Triad Approach

The trend toward modernization and streamlining relies on a three-pronged aproach called the ***Triad approach***. The cornerstone of the Triad is the explicit identification and management of decision uncertainties. A primary Triad product is an accurate conceptual site model (CSM) that delineates distinct contaminant populations for which risk estimation and cost-effective remedial decisions will differ. The main elements of the Triad are

▲ ***Systematic project planning*** for all site activities, ensuring that end goals for a project are clearly identified. Once goals are defined, systematic planning involves charting the most resource-effective course to reach those desired outcomes. A team of *multi-disciplinary, experienced technical staff* works to translate the project's goals into realistic technical objectives. The CSM is the planning tool that organizes what is already known about the site and helps the team identify what more must be known to make project decisions. The systematic planning process ties project goals to the necessary data collection and remediation activities by identifying information gaps in the CSM. The team then uses the CSM to direct field work, updating the CSM as site work progresses and data gaps are filled. The CSM is the key integration tool for:

★ Understanding contaminant release, fate, and migration mechanisms to predict contaminant distributions and spatial patterns;
★ Predicting exposure and designing cost-effective risk management strategies;
★ Planning site activities;
★ Modeling and data interpretation; and
★ Communicating among the team, decision makers, stakeholders, and field personnel.

▲ A ***dynamic work strategy***, often in the form of a regulator-approved decision tree, guides project teams in making decisions *in the field* about how subsequent site activities will progress. Real-time decision making requires sufficiently rapid ("real-time") turnaround of data. Success of the "dynamic" approach hinges on the presence of *experienced staff* empowered to "call the shots" while work crews are still in the field based on the decision logic developed during the planning stage. Field staff maintain close communication with project oversight during implementation of the dynamic work plan and to address any unanticipated issues.



▲ ***Real-time measurements*** might be generated in the field or in a fixed laboratory. In addition to analytical techniques, the term includes rapid sampling platforms (e.g., direct push technologies), geophysical tools, and on-site data management and display software that makes real-time decision making possible. The capabilities of advanced information technology (IT) tools permits rapid sharing of data among interested parties no matter where they may be physically or geographically located. During up-front planning, the team identifies the types, rigor, and quantities of data needed to answer the questions raised by the CSM. Those decisions then guide the design of sampling plans that address data representativeness issues stemming from environmental heterogeneity. Analytical methods are carefully mixed-and-matched to focus data collection on maturing the CSM and providing data that are representative of the decisions to be made.

Figure 1 illustrates the iterative and interlinked nature of projects managed using the Triad. The decision rules developed during systematic planning are built into the work and sampling plans. Occasionally, decision makers will discover that the original project objectives cannot be met due to technical or budgetary constraints, and pragmatic refinement of the decision rules may be needed.

Supporting Developments

Faster, cheaper, yet still protective, resolution of contaminated sites is achievable by adopting new technologies and the new strategies those technologies support. If used correctly, innovative rapid-turnaround field analytical and software tools coupled with on-site decision making can significantly condense a project's overall budget and lifetime, while significantly increasing the likelihood that the gathered data will guide better, more transparent decisions. Site professionals, policy makers, and the public should support the flexibility needed to adopt cost-effective new tools and strategies into improved site cleanup practices in conjunction with clearly defined performance goals. Economics, site redevelopment, and regulatory evolution are driving trends toward modernization and streamlining. Technology advancement and 25+ years of site cleanup experience are pointing toward a next-generation environmental data quality model that includes explicit management of sampling uncertainties by grounding them in the decision context. Specific developments that support modernization include:

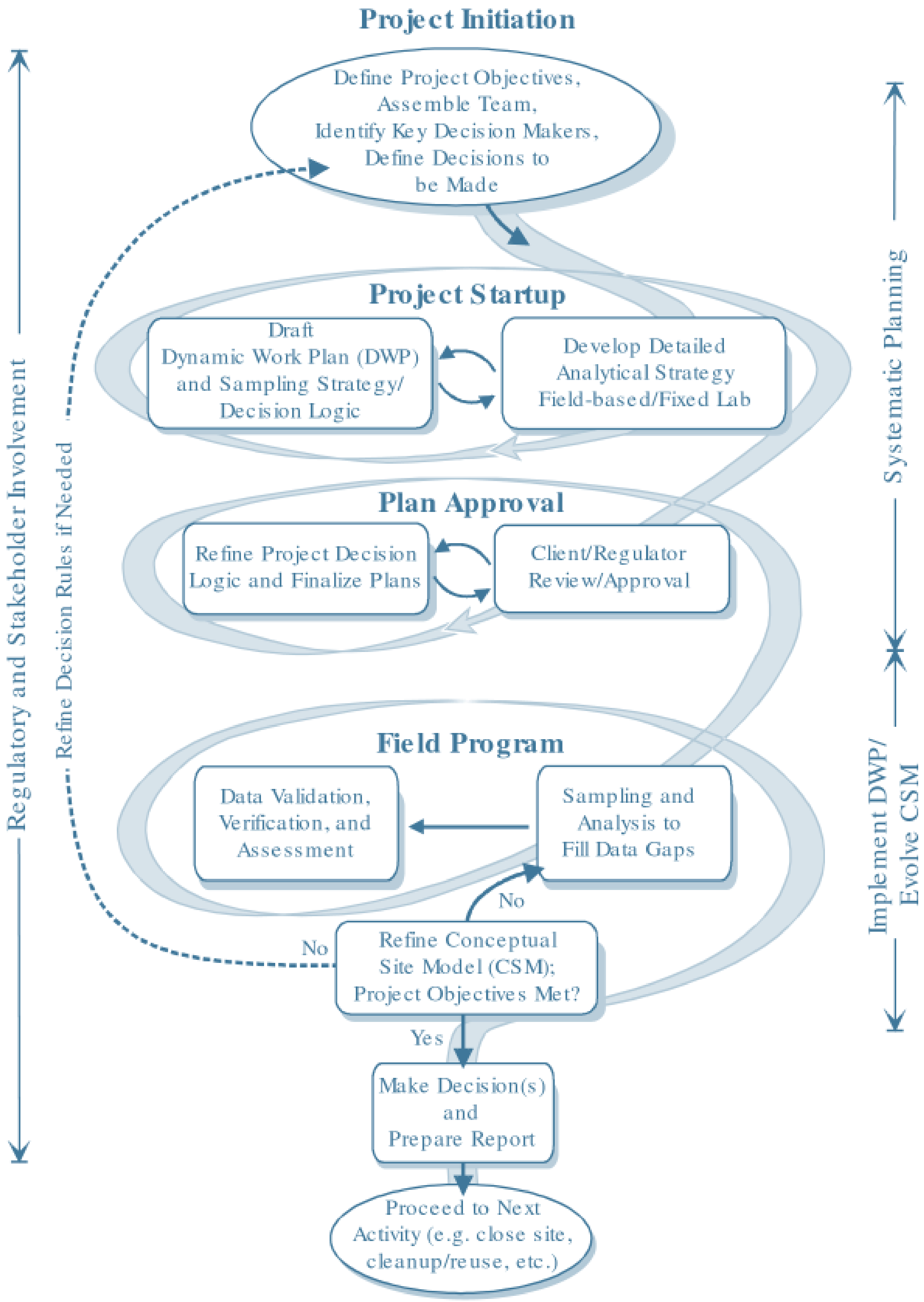
★ ***Field analytical chemistry*** has made significant advances in scientific rigor and credibility. Computerization, photonics, miniaturization, immunochemistry, and a host of other advances in the chemical, biological, and physical science disciplines are contributing to technology improvements and innovations. When field methods are used, proactively managing any excessive analytical uncertainty requires educated staff and quality control that is solidly grounded in the project decisions.

★ Successes with ***various streamlining initiatves*** such as Expedited Site Characterization (ESC), Accelerated Site Characterization (ASC), Rapid or Adaptive Site Characterization (RSC), and Adaptive Sampling and Analysis Programs (ASAPs) demonstrate the validity and cost-effectiveness of principles that are captured within the Triad framework.

★ ***Regulatory policies*** are focusing more on achieving tangible end-results. For example, EPA and other agencies support performance-based measurement systems (PBMS) as a preferred alternative to rigidly prescribing which analytical tools are used and how. PBMS principles support the use of field analytical technologies to meet the specified project needs and decision goals.

★ ***Evolving emphases in environmental programs*** [such as Brownfields, State Voluntary Clean-Up Programs (VCPs), and Base Realignment and Closure (BRAC) at military facilities] focus site activities on how the site will be redeveloped or reused. Flexible cleanup goals [such as risk-based corrective action (RBCA) levels] can be tailored to meet specific reuse objectives. When cleanup and end-use goals are articulated at the start, systematic planning can ensure a cost-effective work plan that achieves the desired outcome. Added focus on redevelopment and the involvement of insurance, banking, real

Figure 1
Modernizing Site Characterization and Monitoring



estate and land use planners create market incentives for identifying and managing all uncertainties that could delay or derail a project.

★ ***Better decision-making tools (i.e., computer software and hardware)*** facilitate rapid data management, statistical processing, and interpretation as data are being generated. These capabilities allow display and modeling of contaminant distributions and maturation of the CSM in real-time. The project team can rapidly incorporate data, modify site characterization activities, and refine cleanup decisions to target contamination and minimize repeated field mobilizations.

★ ***Modern communication technologies*** mean that the field team is no longer isolated from regulators, technical experts, site owners, and trustees. Newly developed information can be shared instantly among distant parties, while regulator buy-in and technical support can be obtained from remote locations, allowing high level staff to spend less time being physically in the field.

★ ***Increasing workloads and decreasing budgets*** have forced regulators and industry to consider innovative strategies that can increase public confidence and satisfaction by reducing uncertainties (about any threats the site may pose) while reducing the time and costs involved in cleaning up these sites.

Tools for Change

To accomplish change, the remediation industry and regulators should move toward a more innovation-friendly system that can produce defensible site decisions at an affordable cost. Such a system would:

✓ ***Focus on decision-specific performance*** requirements, rather than inflexible adherence to traditional policies or "boiler-plate" procedural checklists that do not add value or provide beneficial results. In particular, oversight must evaluate data quality as a function of ***both*** sampling and analytical uncertainties as they contribute to development of an accurate CSM, not simply as a function of the analytical method used or the location (on-site vs. off-site) where the data is generated.

✓ Employ ***transparent and logical reasoning*** to define project goals, manage uncertainties, state assumptions, plan activities, and derive conclusions so that decisions are defensible.

✓ Value technical proficiency in environmental practice through teams of ***"allied environmental professionals"*** that collectively possess the scientific, mathematical, and engineering disciplines required to competently manage the complex issues of hazardous waste sites.

✓ Facilitate application of ***innovative technologies and strategies*** by logically evaluating project-specific needs, site conditions, and prior technology performance, with residual areas of uncertainty being identified and addressed before use.

A handful of practitioners have been successfully using the Triad approach, although many ***institutional and regulatory hurdles*** still exist. EPA is encouraging project managers and regulators at-large to evaluate how Triad principles can be adopted into routine practice.

EPA is collaborating with Federal and state partners to accelerate policy development and information dissemination in support of a shift to newer, streamlined approaches. An array of educational, training, and guidance resources already exist and additional ones are in development. Access to these resources is provided through the http://cluin.org/triad website and are detailed in the companion fact sheet, ***Resources for Strategic Site Investigation and Monitoring*****, EPA-542-F-04-001b.**

Updating hazardous waste site practices to accommodate new tools and strategies has broad ramifications for both practice and policy. Revising institutional and regulatory barriers will take time and effort. Nevertheless, the protective and cost-saving benefits offered by next-generation strategies make the effort worthwhile.