LA-UR- 09-00416

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Title: Adaptive Management: A Paradigm for Remediation of Public Facilities

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Intended for: Waste Management 2009
March 1-5, 2009
Phoenix, Arizona USA

Los Alamos NATIONAL LABORATORY EST. 1943

Adaptive Management: A Paradigm for Remediation of Public Facilities – 9428

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ABSTRACT

Public facility restoration planning traditionally focused on response to natural disasters and hazardous materials accidental releases. These plans now need to integrate response to terrorist actions. Therefore, plans must address a wide range of potential vulnerabilities. Similar types of broad remediation planning are needed for restoration of waste and hazardous material handling areas and facilities. There are strong similarities in damage results and remediation activities between unintentional and terrorist actions; however, the uncertainties associated with terrorist actions result in a re-evaluation of approaches to planning. Restoration of public facilities following a release of a hazardous material is inherently far more complex than in confined industrial settings and has many unique technical, economic, social, and political challenges. Therefore, they arguably involve a superset of drivers, concerns and public agencies compared to other restoration efforts. This superset of conditions increases complexity of interactions, reduces our knowledge of the initial conditions, and even condenses the timeline for restoration response. Therefore, evaluations of alternative restoration management approaches developed for responding to terrorist actions provide useful knowledge for large, complex waste management projects.

Whereas present planning documents have substantial linearity in their organization, the "adaptive management" paradigm provides a constructive parallel operations paradigm for restoration of facilities that anticipates and plans for uncertainty, multiple/simultaneous public agency actions, and stakeholder participation. Adaptive management grew out of the need to manage and restore natural resources in highly complex and changing environments with limited knowledge about causal relationships and responses to restoration actions. Similarities between natural resource management and restoration of a facility and surrounding area(s) after a disruptive event suggest numerous advantages over preset linearly-structured plans by incorporating the flexibility and overlap of processes inherent in effective facility restoration.

We discuss three restoration case studies (e.g., the Hart Senate Office Building anthrax restoration, Rocky Flats actinide remediation, and hurricane destruction restoration), that implement aspects of adaptive management but not a formal approach. We propose that more formal adoption of adaptive management principles could be a basis for more flexible standards to improve site-specific remediation plans under conditions of high uncertainty.

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INTRODUCTION

Large public facilities require planning for restoration due to a range of potential vulnerabilities. Sites with hazardous wastes and material could be particularly vulnerable because of inherent risks associated with the materials; thus, planning for restoration of waste and hazardous material handling areas, process facilities, and the neighboring environments are particularly important. Unfortunately, we now have to plan beyond the scope of natural disasters and hazardous materials accidental releases, we now have to integrate terrorist actions.

In a recent paper in [1], we presented the paradigm of Adaptive Management [2, 3, 4] and applicability to planning and implementing remediation of public facilities following a terrorist attack. Key aspects of that analysis included, the opportunity to shift from linear plans for restorations to plans that integrate inherent parallelism in restoration operations. Parallelism in operations, for example between characterization and decontamination phases, is particularly important when uncertainties are large and there are imperatives for rapid response.

Rapid and effective response specifically requires indentifying, communicating, and even resolving uncertainties early in the restoration process. Early resolution of uncertainties that might occur at any stage of the restoration process (e.g., from data collection through stakeholder acceptance) is critical to the success and speed of the restoration and is a central feature of the adaptive management paradigm. The general point is that there needs to be consideration of critical knowledge gaps, and the cross teaming necessary to address gaps, from the beginning of the restoration, and plans made to quickly answer some key questions, even if only qualitatively. Some of these actions will inevitably occur, even with linearly structure plans; however, the adaptive management paradigm explicitly raises and integrates them. The information gathered and documented in these studies will be used to guide and adjust restoration activities and can be used to justify the decisions made during the response, which could later prove to be operationally and legally important [5].

The adaptive management paradigm has most often been associated with management of natural resources, been it has also been effectively applied in a limited set of restoration activities at contaminated sites (as illustrated in case studies later in this paper). Despite difficulties in some instances, there have been several positive outcomes of adaptive management trials [6, 7, 8]. First, iterative studies have shed important insights into ecological process that were important to consider for resource management. Second, the process of involving varied stakeholders improved understanding across groups through discussion, even though consensus was not always reached. Finally, through gained experiences with adaptive management, the limitations of this approach have been tested and refined, leading some to suggest that adaptive management would work well for complex problems whose impacts span across medical, social, economic and political boundaries, and where a holistic approach is needed. These are the likely conditions following a terrorist attack, again suggesting advantages in incorporating adaptive management principles into restoration plans.

RESTORATION

Restoration following any large-scale release of hazardous materials, but especially following a terrorist attack, will likely involve a superset of drivers, concerns and involved public agencies compared to other more typical restoration efforts. These include increased public fear, forensics, media attention, high stakeholder interest, greater security, and unknowns in agent mobility. This superset of conditions increases complexity of interactions, reduces our knowledge of the initial conditions, and even condenses the timeline for restoration response.

Immediate and effective response to a large-scale release is critical to limit human and environmental harm, effectively restore facility function, and maintain public confidence. This will be especially true in cases of terrorist actions where public reassurance rests on competent response and restoration. This will not be easy. Restoration of waste and public facilities for large scale release of a hazardous material will be inherently far more complex than smaller releases in confined industrial settings and will have many unique technical, economic, social, and political challenges. Importantly, critical information needed for quantitative risk assessment and effective restoration must be anticipated to be incomplete and uncertain. These unique challenges require robust remediation strategies, and though there have been recent terrorist attacks in public facilities that we have learned from (e.g., attacks on the World Trade Center Towers and anthrax releases), overall our experiences in restoration of affected public facilities and/or lands following a terrorist attack are limited. Consideration of these complexities and uncertainties is clearly required to effectively managing restoration following large and complex incidents.

Whereas present planning documents have substantial linearity in their organization, the "adaptive management" paradigm provides a constructive parallel operations paradigm for restoration of facilities that anticipates and plans for uncertainty, inefficiencies, multiple/simultaneous public agency actions, and stakeholder participation. Adaptive management grew out of the need to manage and restore natural resources in highly complex and changing environments with limited knowledge about causal relationships and responses to restoration actions. Similarities between natural resource restoration and restoration of a facility and surrounding area(s) after a disruptive event suggest numerous advantages over preset linearly-structured plans by incorporating the flexibility and overlap of processes inherent in adaptive management principles for effective facility restoration.

PLANNING AND ADAPTIVE MANAGEMENT

Adaptive management can be defined as a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood [2, 4]. Adaptive management is a purposeful integration of experimentation into management design and implementation. The concept has been considered and used in various forms for decades but was explicitly proposed for natural resource management in the 1970's [9]. Currently, adaptive management is being widely applied in other countries (e.g., Australia and Canada). It is also being widely employed by the U.S. Department of Interior [4, 10] and has been incorporated into U.S. Forest Service National Environmental Policy Act regulations and into the Bureau of Land Management Resource Management Planning and NEPA processes.

Adaptive management was proposed as a process to allow management actions to be taken under conditions of large uncertainty (e.g., incomplete knowledge), multiple stakeholders, and a pressing need to make decisions. Some of the biggest challenges in natural resource management are the complexity of ecosystems, the diversity of responses of ecosystems to natural and anthropogenic changes and inputs, and our fundamental lack of complete data and knowledge about the systems and their response to various events. In addition, there are multiple stakeholders, frequently with competing and conflicting objectives, priorities, and end-point goals. A simplistic illustration of descriptive management approaches likely used successfully under varying conditions of uncertainty and management control has been developed (Figure 1, adapted from [4]). Overlain on this range of approaches is a conceptual view of the shift in conditions from "normal" operations to terrorist/disaster/accident response. These same challenges in natural resource management are not unusual (and may be typical) in restoration projects. In addition, restoration of large sites directly over-laps with natural resource management related to resources impacts and end-use goals.

Site remediation, like forest management, is an example of high uncertainty and controllability. Remediation requires knowledge of the intimate relationship between the biotic and abiotic environment and the interactions among species (structural and functional), as well as recognition of important, but uncontrollable, environmental conditions. These relationships are multi-dimensional, dynamic, often hard to predict, and impossible to completely control. In addition, there are diverse societal perspectives on what constitutes proper remediation (e.g., residential use, brownfield use) and acceptable goals (e.g., no residual contamination detectable, limited detectable levels). Multiple State and Federal regulators, end-users, adjacent property owners, general public, elected officials, and so on all have their own unique and valuable perspective on the site management, risk perceptions, and remediation objectives that requires some level of balance in the short- and long-term. These challenges required a management process that recognized (1) there will be incomplete information at the start, (2) the forest system and human society/expectations will respond uniquely to the managed actions, (3) the complexity of the system and potential for making mistakes, (4) limited resources and time to complete the actions, (5) potential for disagreements on management objectives and efficacy, and (6) a need to build continuous consensus. The similarities between natural resource management and site remediation are further supported by the National Academy of Science (NAS) committee recommendation of using adaptive management to restore naval lands. [3]

Three variations of adaptive management have been identified [10]. The first two are at best partial implementation of the adaptive management process. Incremental adaptive management (i.e., learning-as-you-go or trial-and-error model) is considered to be a reactive management, has no specified objectives, and learning is nearly a secondary outcome. Passive adaptive management (i.e., sequential learning) uses historical data to identify a single best linear approach that is assumed to be correct (i.e., assumptions and earlier system conditions are applicable). This model applies a formal, rigorous, analysis to historic, secondary data and experiences as a means of framing new choices, understanding, or decisions. However, this process can not differentiate between natural changes and management impacts, and may limit identification of alternative system models that may be more fully reflect the system (i.e., results are effective but the reason fro the effect is based on an erroneous model). Active adaptive management (i.e., parallel learning) has more balance between learning and achieving management objectives. It provides data and feedback on the relative efficacy of alternative models and actions, instead of relying on a single model or action.

Murray and Marmorek [11] describe adaptive management as more than just "learning as you go". Rather, it is a deliberate and systematic approach for gathering information by applying management actions as "experiments" (similar to interim actions in CERCLA environmental operations) but the focus is on experiments whose results are needed to make critical evaluations and increasingly robust consensus decisions to complete the restoration. How adaptive management integrates objectives to gather information is critical for effective action. The general management paradigm is focused on management objectives and processes (similar to that outlined in Figure 1), with minimum allowance for uncertainty or unexpected results. A focus on learning objectives is integrated into the Adaptive Management paradigm, where basic research is conducted without the necessity of immediate progress toward the. Adaptive management thus is a hybrid integration of these two management approaches.

Adaptive management is an inherently circular process, which recognizes the uniqueness of each situation and does not promote a "standard procedure" or recipe to be used for all situations [12]. There are two critical considerations, however. First, both management objective(s) and learning objective(s) actions can occur out of sequence or simultaneously. Second, the process does not cycle endlessly, but it is under continuous pressure to converge on set management objectives (spiral development and execution). The criticism of over-studying a problem without taking substantive steps toward project goals is commonly made, but the intent of experiments in the adaptive management paradigm is to study the problem only to a level where the experimental results can be used in a meaningful way and at the earliest possible time.

ADAPTIVE MANAGEMENT PRINCIPLES

Adaptive management is only one approach to remediation management. Like using proven management actions and scenario planning approaches, it is one approach that may be more suitable given a set of conditions (Figure 1).

Two key conditions have been identified in evaluating the applicability of an Adaptive Management approach [4], "there must be a mandate to take action in the face of uncertainty" and "there must be the institutional capacity and commitment to undertake and sustain and adaptive program." In addition, there are four main principles that repeatedly emerge in the adaptive management literature. First, adaptive management is predicated that there are large areas of uncertainty, which need to be addressed in the management approach. The uncertainty can be associated with our knowledge of the issues, applicability of existing response tools and processes, level of success needed, etc. Therefore, our knowledge base needs to be expanded to accomplish the objective and to be able to repeat the success in the future. The second principle is that adaptive management is outcome-centric with explicit objectives and goals. It is focused on achieving a positive management outcome. Therefore it requires performance metrics and monitoring of progress and the ability to adjust actions depending on the observed trends versus the desired outcome. The third principle is that stakeholder participation is mandatory. Without stakeholder participation and general consensus, objectives can not be correctly identified, which will result in an incomplete set of performance metrics. Fourth, the adaptive management approach must be consistent with applicable laws and regulations. Therefore, operational and regulatory agencies must be able to develop, adopt, or accept flexible standards and site-specific remediation plans. These principles clearly interact and influence the design and specific methods used in adaptive management. There is no set recipe for successful implementation of adaptive management, only signposts.

RESTORATION CASE STUDIES

Flexible management can be and has been achieved in many actual restoration cases. Examples include the Hart Senate Office Building anthrax restoration, US DOE Rocky Flats actinide remediation, and natural disaster restoration, particularly for recent hurricane events. Here, we provide a brief description of these three cases for examination of potential enhanced planning through implementation of Adaptive Management concepts.

Restoration of the Hart Senate Office Building following Anthrax Attack

Anthrax attacks on several media facilities and the Hart Senate Office building during the fall of 2001 provide a good case study showing advantages of adaptive management aspects for restoration. The restoration of the Hart building was particularly well documented and numerous lessons were learned [13]. One of the key lessons relevant to potential for application of adaptive management was summarized in the executive summary in the NAS (2005) report [13] that there was a "...recognition that there is a lack of information that could influence both the effectiveness and cost of decontamination, a state of affairs that should be remedied." Several of the key unknown elements of restoration of the Hart Building included 1) being surprised by spatial extent of the contamination because of unexpected pathways spreading the virus beyond expected boundaries, 2) a lack of knowledge regarding the sampling efficiency of the different surface sampling techniques impacting results and interpretation of the data in unknown ways, and 3) an evolving definition and consensus on acceptable residual contamination levels. While adaptive management techniques were apparent in later phases of the anthrax restoration, they grew organically as the occasion required, but they were not planned for from the beginning. Adopting adaptive management principles from the beginning could have made the restoration more effective, both in terms of timeliness and cost [1]. For example, adaptive management paradigm might have prompted early identification of unknowns (e.g., alternate pathways and sampling efficiencies) and prompted quick and focused measurements to effectively fill important information shortfalls. Also, adaptive management principles would have facilitated discussions on decisions on acceptable levels of residual contamination at very early stages of the restoration.

Restoration of US DOE Rocky Flats actinide contamination

The Rocky Flats Environmental Technology Site (RFETS) was a U.S. Department of Energy (DOE) environmental cleanup site located about 15 miles northwest of downtown Denver. More than 2.5 million people live within a 50-mile radius of the site, and 300,000 of those live in the Rocky Flats watershed. From 1952 - 1989, the Rocky Flats Plant made components for the nation's nuclear weapons arsenal using various radioactive and hazardous materials, including plutonium and uranium; toxic metals such as beryllium; and hazardous chemicals, such as cleaning solvents and degreasers. In 1989, the FBI and EPA abruptly halted nuclear production work to address environmental and safety concerns, and in 1993, the Secretary of Energy announced the end of the Rocky Flats nuclear production mission. Nearly 40 years of nuclear weapons production and the sudden shutdown left behind a legacy of large quantities of plutonium and other hazardous substances in various stages of processing and storage, contaminated facilities, soils, surface and ground water. Accordingly, RFETS was designated as an EPA Superfund cleanup site.

Since plutonium is dangerous to human health, even in minute quantities, the cleanup of plutonium-contaminated materials is complex, tedious, labor-intensive and slow. In March of 1995, DOE estimated the cleanup for Rocky Flats would cost in excess of $37 billion and take 70 years to complete [14]. That was also the year that DOE and Kaiser-Hill initiated a massive accelerated closure planning effort that called for accelerated closure of Rocky Flats by December 31, 2006 at a contracted cost of $7 billion. After a troubled start, Kaiser-Hill completed the task nearly a year ahead of schedule. Many around the US Nuclear Weapons Complex are analyzing the factors that led to the turnaround. Without question, the incentive-laden contract, strong support and stable funding from Congress, high-level DOE support that mobilized the entire complex to assist the cleanup, technological and operational innovation, and scientific understanding were all contributing factors. Much has been made of the huge bonuses and the contractor's fee of more than $500 million, but less has been said about the role that scientific understanding played in guiding key cleanup decisions.

The drive to understand the science behind plutonium contamination gained momentum in 1995, wet spring conditions and intense rainfall events at the site caused Site personnel and stakeholder groups to raise concerns about the potential for increased plutonium mobility in the RFETS environment, and the potential for increased offsite transport. These events led many to focus on the potential for soluble forms of plutonium in surface and ground waters in order to account for the appearance of small amounts of plutonium that exceeded the discharge standards at Site boundary monitoring stations. This situation led to public mistrust and lack of confidence. When coupled with other questions regarding the mobility of different actinide elements (U, Pu, Am) at different Site locations, this situation prompted DOE and the site contractor to establish the Actinide Migration Evaluation (AME) advisory group in 1996 to provide guidance on issues of actinide behavior and mobility in the air, surface water, groundwater, and soil [15, 16, 17], and development of the Radionuclide Soil Action Level Oversight Panel [18]..

Through a combination of on-site measurements and experiments, expert judgment backed up by state-of-the-art scientific measurements [15, 16, 17], it was shown that under environmental conditions at Rocky Flats, plutonium and americium form insoluble oxides. These insoluble materials can migrate in the Rocky Flats environment by wind and surface water sedimentation/resuspension processes. This scientific understanding showed that soluble transport models were not appropriate, and led to the development and application of erosion/sediment transport models. The scientific understanding developed through these integrated studies contributed directly to the basis for plutonium and americium cleanup levels in soils and concretes [16, 17]. Extensive communications between site contractors, outside experts, regulators, government entities and the public helped all parties focus remediation efforts on surficial contamination and transport pathways that posed the greatest risk to human health and the environment, guide selection of surface-specific removal technologies, and future land configuration strategies. While not designed and operated as an Adaptive Management system, many key attributes of such a paradigm can be identified, which resulted in scientific understanding through advanced measurement techniques that developed into science-based communication and decision-making for the contractor , DOE, and stakeholders that helped focus Site-directed efforts. This substantially aided the DOE in its effort to close the RFETS in December 2005, one year ahead of schedule.

Restoration of Hurricane Katrina destruction

Hurricane Katrina swept ashore from the Gulf of Mexico on August 29, 2005, resulting in flooding of eventually more than 80% of New Orleans that took the lives of more than 1,800 people, injured thousands more, and drove more than 770,000 people from their homes, hundreds of thousands of which were destroyed or rendered uninhabitable – but the disaster reached far beyond New Orleans. The disaster response involved government (local, state, and federal), business and non-governmental organizations, through which a massive amount of physical, material and financial aid was provided.

There was, before the storm, significant understanding of what might happen and what should be done in preparation that was, surprisingly, not acted upon [19], and remains in many ways still neglected. There is little agreement or even understanding of the complexity of the planning and distribution issues. In particular, discussions have focused on the lack of the Department of Homeland Security activation of a section of the National Response Plan [20] (now replaced by the National Response Framework [21]) that deals specifically with responding to catastrophes. This section was interpreted by decision makers as intended to only be used during no-notice catastrophic incidents when there is no awareness of an impending disaster and no pre-staging of people, resources, and response forces. This resulted in leaving the local and state governments in charge to be overwhelmed by the scale and complexity of the disaster. Therefore, the Hurricane Katrina disaster response raised numerous questions, such as what happens when local infrastructure is wiped out, while the NRP was based on a local community being able to respond and ask the federal government for help. The scale of the disaster, involving hundreds of thousands of citizens and multiple impacted jurisdictions at local through state levels, was likely not an exercised scenario, except possibly by the far-our gamers [22]. Simultaneously, Garnett and Kouzmin [23] have described a communication disaster as much as a natural and bureaucratic disaster. Their analysis identified communication gaps, missed signals, information technology failures, administrative buffering, turf battles, and deliberate and unintentional misinterpretations; all delayed and handicapped both the recognition of the crisis that Katrina had created and the response to its devastation. The communications disaster was not, however, a complete impediment to successful response, particularly at more local scales. Jones [24] identifies clear objectives conveyed organizationally before disaster strikes and adaptability in "the plan" as components that allowed the people responding to make disaster plans work and not just be policies.

DISCUSSION

The three restoration cases presented above span a range of initial problems that required restoration. However, following the terrorist action (Hart Senate Office Building), decision to close and remediate the large government nuclear industrial site (Rocky Flats), and the natural disaster (Hurricane Katrina), the key conditions were present of a mandate to take action in the face of uncertainty and institutional capacity and commitment to restoration that are identified with applicability of an Adaptive Management approach.

In the case of the restoration of the Hart Senate Office Building from the anthrax attack, uncertainties regarding extent of contamination, specifics of applicable technology and restoration objectives and outcomes, were combined with intensive stakeholder interactions and visibility [13]. Actions consistent with Adaptive Management grew during the restoration process, including evaluation of uncertainties through implementation of technical and management actions as experiments.

For the case of restoration of the Rocky Flats Site, the combination of natural conditions in the form of intense rainfall during a wet spring near the beginning of the new contract for restoration resulted in extensive stakeholder attention. This highlighted the uncertainties in plutonium contamination amounts, form, extent and mobility, as well as remediation outcome objectives and requirements, which became clear points of discussion, study and actions [15, 16, 17, 18]. As a result, the four main principles of the Adaptive Management paradigm became integrated into the program at an early stage.

Hurricane Katrina provides an example case in which the scale and complexity of the disaster overwhelmed integrated response through the region [23]. Clear objectives defined before the disaster and adaptability [24], such as that displayed by Coast Guard units in the face of tremendous uncertainty, did however occur. This suggests that the Adaptive Management paradigm could have value, even for events at such a regional scale. These ideas are supported by evaluation of Florida response to the four hurricanes of 2004 [25] in which the effectiveness in coordinating community disaster response was significantly impacted by pre-season planning, open communication, and the use of technology.

Von Lubitz, Beakley and Patricelli [26] have evaluated the development of the field of disaster response, focusing specifically on the role of information and knowledge management. They note that, even in mega-disasters, response is essentially local. Simultaneously, they conclude that, as repeatedly shown by many recent incidents, response to mega-disasters is inefficient and exceedingly costly. However, response efficiency was found to depend on local, national and even international preparedness, and demanded utilization of inter- and cross-disciplinary knowledge from outside that typically drawn on in disaster management. In addition, they recommend utilization of an observe, orient, decide, and act loop (local problem-solving) to enhance decision-making in unpredictable and dynamic environments to help address constraints in approach imposed by existing historic knowledge and processes.

Recognizing during planning stages that crises with great uncertainty in content and uncertainty in likelihood are particularly hard to manage and explicitly plan, allows enhancement of response to crises [27]. This is especially the case for crises with profound impacts on a group of citizens such as terrorism, natural disaster, disease epidemic, waste and hazardous materials release, food contamination, and product defectiveness. Two essential components of crisis management, and therefore planning, can be generalized as (1) allowing adequate communication and processing of information, and (2) permitting the properly leveled exerc ise of decision-making. Framework assumptions for response actions, including those of the three case studies presented here generally start from a command-and-control model in which alignment is focused around common and agreed-upon (expected) goals. However, during disasters, organizations and plans require the explicit flexibility to become locally and even broadly aligned more by problem-solving model(s). Coordination of such problem-solving, for system aspects involving substantial uncertainty, with high-level command-and-control, necessary to achieve actions that significantly influence system conditions, is an essential feature of the principles of Adaptive Management (Figure 1).

CONCLUSIONS

This evaluation is intended to raise Adaptive Management principles as a paradigm into the discussion of disaster response to help various operational and regulatory agencies develop flexible standards and site-specific plans for remediation prior to need for use. While the techniques of flexible management can be and have been achieved in many actual restoration cases (e.g., the Hart Senate Office Building anthrax restoration, Rocky Flats actinide remediation, and hurricane destruction restoration), a more formal pre-planning, implementation, exercise, and assessment of the value of the Adaptive Management paradigm and principles integrated into formal emergency plans and training exercises creates a process:

- that recognizes, communicates, and utilizes in positive actions the 'certainty of uncertainties',
- that more efficiently plans processes to be managed and communicated in the parallel mode that will actually occur,
- that benefits from missteps and/or uncertainties, and
- that integrates evaluation of multiple options and outside expertise to make optimal decisions.

Properly developed and implemented, consideration of the Adaptive Management paradigm has great potential to improve cleanup efficiency, communication, and cost, and to broaden/quicken consensus for the whole range of restorations, including public facility restoration in response to terrorist attack(s), as well as natural disaster, environmental remediation, waste/hazardous material release, and,accident situations.

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Figure

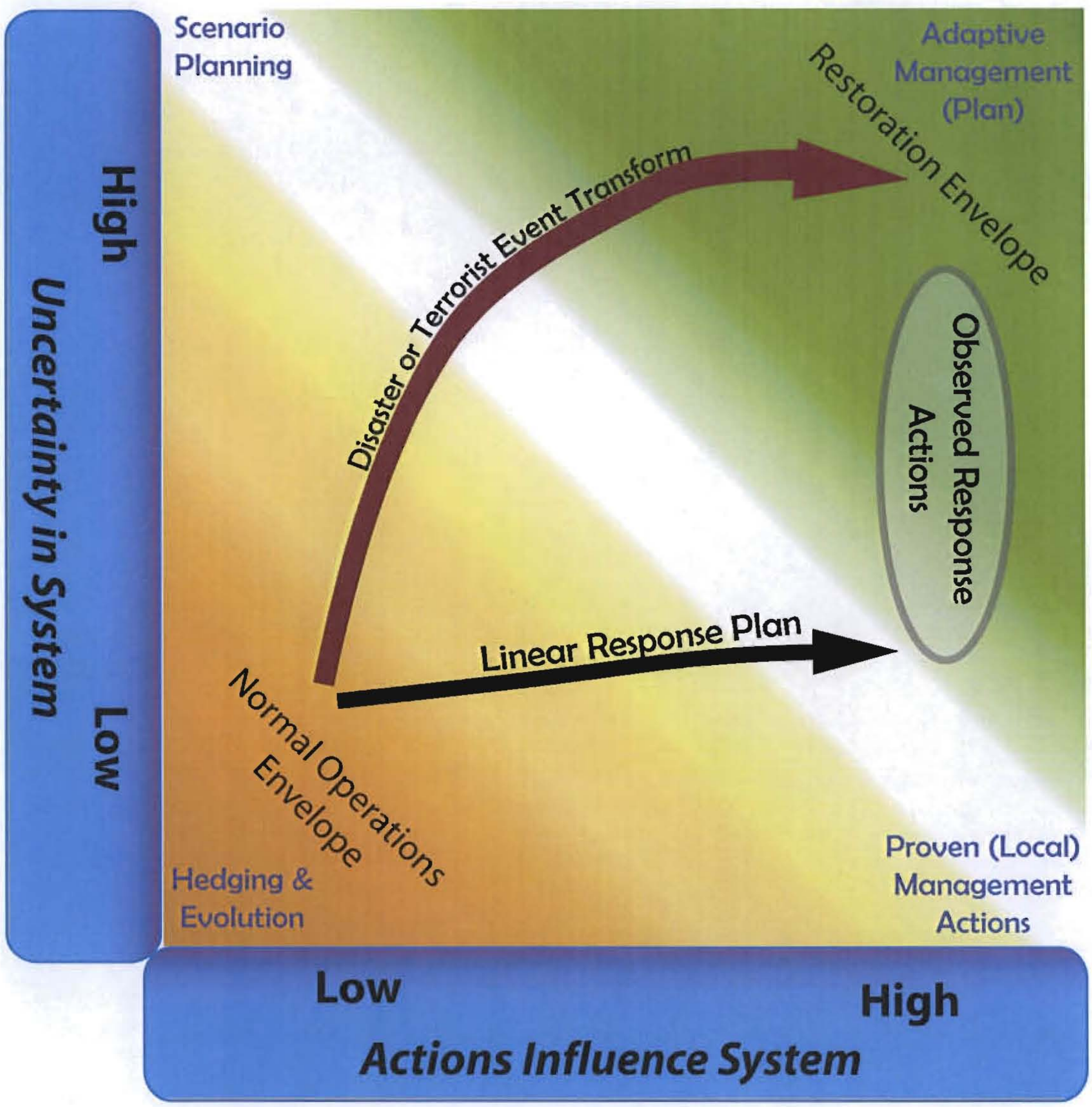

Figure 1. Event response represented in the context of approaches to decision making (corner labels) that depend on the influence decisions can have on system behavior and the amount of uncertainty about management impacts [adapted from 4]. Linear response plans represented by the black arrow focus on well defined sequential processes of assessment, characterization, decontamination, verification and reoccupation with long-term monitoring [1]. Disaster and terrorist events typically involve rapid transfer to high uncertainty and then shift across to situations in which restoration actions are effective, represented by the dark red arrow. The case studies discussed here (represented by the gray oval field) involve responses in which aspects of Adaptive Management [2, 3, 4] are evident, even without explicit inclusion in the plans utilized.