Interactive Sediment Remedy Assessment Portal (ISRAP): A Tool to Facilitate Design of Long-term Remedial Monitoring Strategies

Victoria Kirtay, Bart Chadwick
Space and Naval Warfare Systems Center San Diego

and

Jason Conder, Alan MacGregor and Victor Magar
Environ Corporation

Why Monitor?

- Characterize Baseline
  - Baseline Monitoring
    - Remedy feasibility
    - Supplement data to enable before & after comparison
- Demonstrate Compliance
  - Construction Monitoring
    - Attainment of remedy design
    - Address acute risks to community, ecology, and workers
  - Performance Monitoring
    - Assessment of remedy function, now and in future
- Demonstrate Success
  - Remedy Goal Monitoring
    - Assess remedial action objectives (RAOs) and in reducing human health and/or environmental risk

Why Monitor?

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Other Terms

"short-term"
or
"interim"

Better to focus on **why** you're monitoring rather than **how long**

"long-term"

Why Monitor?

Remedy-Specific Monitoring

Primary Remedy Functions

MNR

- Chemical transformation
- Chemical sequestration
- Physical isolation (natural sedimentation and burial)
- Offsite transport

CAPPING

- Physical isolation
- Chemical sequestration
- Creation of a clean sediment surface

DREDGING

- Sediment and contaminant removal
- Reduce contaminant mass in sediment

Why Monitor?

Remedy-Specific Monitoring

Example Monitoring Needs

MNR

- Validate CSM
- Reduced contaminant availability
- Ongoing transformation processes
- Ongoing sedimentary processes
- Future performance concerns:
  - Geochemical stability
  - Sediment stability

CAPPING

- Validate construction
- Future performance concerns:
  - Demonstrate cap stability, long-term isolation
  - Cap surface recontamination potential

DREDGING

- Validate construction and mass removal
- Evaluate surface sediment concentrations
- Validate backfill
- Future performance concerns:
  - Sediment/residuals stability and natural recovery

What's the Problem?

- Public and industry uncertain of effectiveness and long-term stability of remedies.
- Need for the development of improved methods for assessing ecosystem recovery at contaminated sediment sites to better understand the impact of remedial management strategies on the ecosystem.
- Need for guidance that standardizes long-term monitoring methods and approaches and which supports the Navy policy on sediment investigations and response actions (CNO, 2002).
- Several resources identify general monitoring needs and approaches for sediment sites and specific details concerning monitoring tools.
  - No current framework that links remedy-specific and goal-specific monitoring needs with appropriate monitoring tools and approaches.

Sediment Monitoring Resources: Approaches, Needs, Tools

- USEPA. 2005. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*.
- USEPA. 2005. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Metal Mixtures; Endrin; Dieldrin; and PAH Mixtures.*
- USEPA. 2004. *Guidance for Monitoring at Hazardous Waste Sites: Six-Step Process for Developing and Implementing a Monitoring Plan.*

  USEPA. 2003. *A Compendium of Chemical, Physical and Biological Methods for Assessing and Monitoring the Remediation of Contaminated Sediment Sites*.
- USEPA. 2001. *Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual.*

Matching Monitoring Tools with Monitoring Needs

- Abundance of tools and approaches, but finite resources
- Monitoring tool considerations for selection:
  - Baseline monitoring tools
  - Capability to satisfy more than one monitoring need or serve as additional/supplementary line of evidence
  - Suitability under site conditions
  - Cost
  - Availability in marketplace
  - Spatial experimental design/results complexity
  - Temporal experimental design/results complexity
  - Logistical concerns
  - Efforts needed to interpret results and share with stakeholders
  - Ability to address monitoring need with low uncertainty

What's (part of) the Solution?

1. Develop a framework that links remedy-specific and goal-specific monitoring needs with appropriate monitoring tools and approaches.
2. Develop Web-Tool
   - Guidance - provide remedy-specific recommendations for sediment monitoring programs.
   - Online, interactive web-tool - help RPMs focus on key issues associated with site-specific monitoring needs and facilitate a comparison of effective monitoring tools.

1. Develop Framework

Linking Remedy-Specific Monitoring Phases to Monitoring Needs and Tools

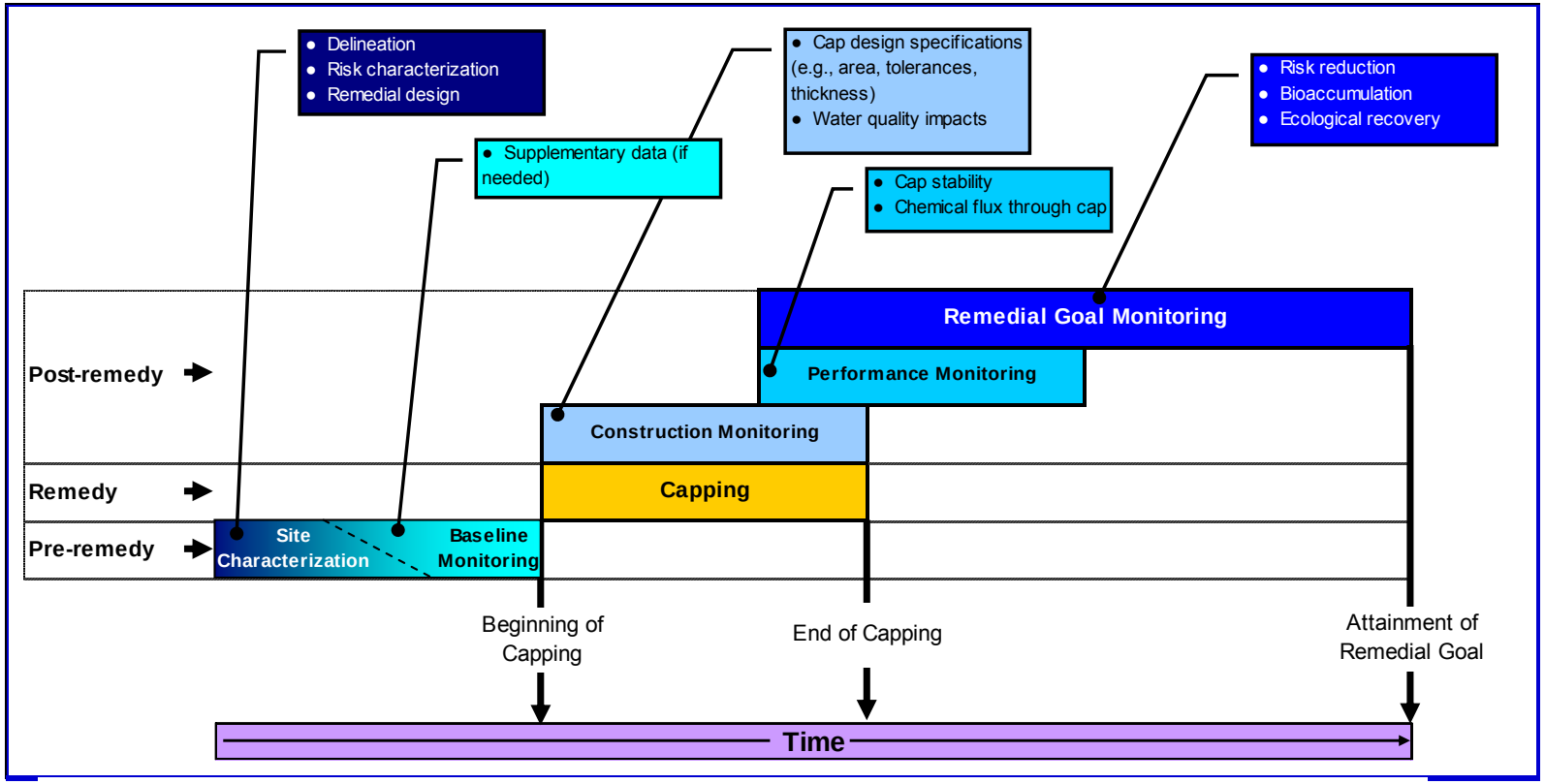

Figure 2. Illustration of the temporal relationships between monitoring associated with capping. Callout boxes provide examples of monitoring needs associated with post-remedy monitoring phases.

2. Interactive Sediment Remedy Assessment Portal (ISRAP)

- On-line web-tool
  - Guidance
  - Interactive matrix of monitoring needs and tools
  - Case Studies
  - Publicly accessible
  - Updatable

REMEDIES

3 (Capping, Dredging, MNR)

MONITORING PHASES

3 (Construction, Performance, Remedial Goal; as appropriate to each remedy)

MONITORING NEEDS*

24 unique needs

MONITORING TOOLS*

44 unique classes of tools or individual tools

* One tool can often address multiple monitoring needs and/or can supplement other tools.

ISRAP

INTERACTIVE SEDIMENT REMEDY ASSESSMENT PORTAL

Matrix
Guidance
EPA Fact Sheets

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P

Welcome

Welcome to the Interactive Sediment Remedy Assessment Portal (ISRAP), an online interactive portal to assist in understanding monitoring requirements and monitoring tools associated with sediment remediation. The main feature of this site is the **sediment monitoring tools matrix** , a database of sediment monitoring tool information to facilitate the design and optimization of sediment monitoring programs. The matrix can be browsed in a step-by-step mode by selecting "Matrix" via the toolbar at the left. For first-time users, a **Frequently Asked Questions (FAQ)** link is provided, and contains a tutorial and other resources that provide a functional overview of the matrix design and navigation, as well as a short primer to understanding sediment remediation monitoring needs and tools. The "**Guidance**" link in the toolbar at left provides the full, in-depth guidance document (pdf file) that supports the work showcased in the ISRAP.

Slide Show

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Dredging

04

Quick Links

- NAVFAC Environmental Restoration
- EPA Contaminated Sediment
- NOAA Benthic Habitat Mapping
- Hazardous Waste Clean-Up Information (CLU-IN)
- Navy Eco Risk Guidance

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Home FAQs About

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INTERIM GUIDANCE DOCUMENT
August 2007

Long-Term Monitoring Strategies for Contaminated Sediment Management

Space and Naval Warfare Systems Center San Diego
and
ENVIRON International Corporation

Draft Document
Not Approved for Release
(Funded by: 0817 Pollution Abatement Ashore Program)

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ISRAP

INTERACTIVE SEDIMENT REMEDY ASSESSMENT PORTAL

Welcome

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- Navy Eco Risk Guidance

Site Name: Naval Station Alpha Scenario: Cap Entire Site

1 Remediation Phase > 2 Monitoring Need > 3 Monitoring Tool > 4 Monitoring Design

Select Remedial Action

- Capping
- Dredging
- Monitored Natural Recovery

Select Monitoring Phase

NEXT

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Site Name: Naval Station Alpha Scenario: Cap Entire Site

1 Remediation Phase > 2 Monitoring Need > 3 Monitoring Tool > 4 Monitoring Design

Select Remedial Action

- (•) Capping
- ( ) Dredging
- ( ) Monitored Natural Recovery

Select Monitoring Phase

- ( ) Compliance (Construction)
- (•) Compliance (Performance)
- ( ) Remedial Goal

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Site Name: **Naval Station Alpha** Scenario: **Cap Entire Site**

1 Remediation Phase → 2 Monitoring Need → 3 Monitoring Tool → 4 Monitoring Design

Capping
- Compliance (Performance)

BACK NEXT

	Monitoring Need	Description	Timing	Frequency
☑	Cap stability	Assess settlement and stability of cap over time	Weeks-years after cap placement or after damaging events	Every 1-5 years
☐	Chemical flux through cap	Assessment of chemical flux through the cap	After cap placement	Every 1-5 years
☐	Impacts on hydrodynamics and sediment transport	Assessment of the physical impacts of the cap on hydrodynamics and sediment transport	After cap placement	Once

BACK NEXT

Site Name: **Naval Station Alpha** Scenario: **Cap Entire Site**

1 Remediation Phase → 2 Monitoring Need → 3 **Monitoring Tool** → 4 Monitoring Design

Capping
- Compliance (Performance)

- Cap stability

BACK NEXT

Cap stability - Assess settlement and stability of cap over time

Monitoring Tool	Description	Type	Special Considerations	Mor
Acoustic sub-bottom profiling	High-resolution survey to detect differences in sub-sediment surface strata; Useful to detect changes in cap thickness and stability over time	Physical	More accurate than bathymetric data. May not work in cases where cap materials are similar to underlying sediment with respect to grain size and composition.	
Bathymetric survey	Bathymetric survey of capped area to detect changes in cap thickness and stability over time	Physical	Other acoustic survey methods (e.g., side scan sonar) may be more accurate	
Cap sample physical analysis	Physical analysis of cap material (grain size, porosity, specific gravity, vane shear strength, etc.) to evaluate resistance of cap to erosion	Physical	Some methods have in situ capability (e.g., vane shear tests)	
Sediment coring	Sediment coring to investigate sediment profile for changes in cap thickness and stability over time	Physical	Destructive monitoring method that may damage cap	
Sediment profile photography	Sediment subsurface profile to assess to detect changes in cap thickness and stability over time	Physical	Destructive monitoring method that may damage cap	
Sediment surface photography	Benthic photography and videography of cap and sediment surface to detect damage to cap and changes in cap stability over time	Physical	Limited to sediment surface; Study design may be difficult due to site conditions (turbidity)	
Settlement plate	Settlement plate placement and monitoring to assess changes in cap thickness over time	Physical		
Side scan sonar	Side scan sonar to detect changes in cap thickness and stability over time	Physical	More accurate than bathymetric data	

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BACK NEXT

Cap stability - Assess settlement and stabili

	Monitoring Tool		Special Considerations	More
☑	Acoustic sub-bottom profiling	High Usef	etric data. May not work in cases where cap rlying sediment with respect to grain size and	
☑	Bathymetric survey	Bath stab	ods (e.g., side scan sonar) may be more accurate	
☑	Cap sample physical analysis	Phys shea	capability (e.g., vane shear tests)	
☑	Sediment coring	Sedi and	od that may damage cap	
☑	Sediment profile photography	Sedi stab	od that may damage cap	
☑	Sediment surface photography	Bent dama	Study design may be difficult due to site	
☑	Settlement plate	Sett thick		
☑	Side scan sonar	Side	etric data	

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EPA Fact Sheet
2.2.1-13
http://www.csc.noaa.gov/benthic/mapping/techniques/sensors/subbottc

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Benthic Habitat Mapping

Mapping Techniques: Acoustics

Sub-bottom Profiling

Sub-bottom profiling systems identify and measure various sediment layers that exist below the sediment/water interface. These acoustic systems use a technique that is similar to simple echosounders. A sound source emits a signal vertically downwards into the water and a receiver monitors the return signal that has been reflected off the seafloor. Some of the acoustic signal will penetrate the seabed and be reflected when it encounters a boundary between two layers that have different acoustical properties (acoustic impedance). The system uses this reflected energy to provide information on sediment layers beneath the sediment-water interface.

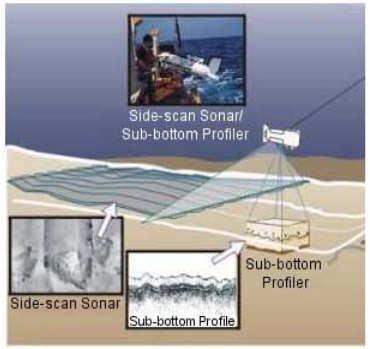

Diagram of a combined sub-bottom profiling system and side-scan sonar.
Courtesy: Science Applications International Corporation

Acoustic impedance is related to the density of the material and the rate at which sound travels through the material. When there is a change in acoustic impedance, such as the water-sediment interface, part of the transmitted sound is reflected. However, some of the sound energy penetrates through the boundary and into the sediments. This energy is reflected when it encounters boundaries between deeper sediment layers having different acoustic impedance. The system uses the energy reflected by these layers to create a profile of the sub-bottom sediments.

Several sonar parameters (output power, signal frequency, and pulse length) affect the instrument performance.

- An increase in output power gives better penetration into the sub-bottom layers. This will usually provide deeper penetration into the sub-bottom layers. Sometimes however, if the bottom is very hard or not very deep, the increase in power will cause more signal to be reflected back off the seafloor. The signal might then be reflected off the sea surface, leading to multiple reflections and "noise" in the data.
- Signal frequency also has an effect on system performance. Higher frequency systems (2 to 20 kHz) will produce high definition data of the upper seafloor sediment layers. These higher frequency signals have shorter wavelengths, and they are able to discriminate between layers that are close together. Lower frequency systems will give greater penetration but at a lower resolution.

Site Name: **Naval Station Alpha** Scenario: **Cap Entire Site**

1 Remediation Phase → 2 Monitoring Need → 3 Monitoring Tool → 4 Monitoring Design

Capping
- Compliance (Performance)

- Cap stability

BACK NEXT

Cap stability - Assess settlement and stability of cap over time

Monitoring Tool	Description	Type	Special Considerations	More
Acoustic sub-bottom profiling	High-resolution survey to detect differences in sub-sediment surface strata; Useful to detect changes in cap thickness and stability over time	Physical	More accurate than bathymetric data. May not work in cases where cap materials are similar to underlying sediment with respect to grain size and composition.	
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- Compliance (Performance)

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Capping > Compliance (Performance)

Monitoring Need	Monitoring Tool	Tool Type	Spatial Complexity	Temporal Complexity	Logistical Complexity	Difficulty Locating in Market	Relative Cost	Required Interpretation Expertise	Uncertainty Addressing Need	Design Details
Cap stability	Acoustic sub-bottom profiling	Physical	Low	Low	Medium	Low	Medium	Low	Low	
Cap stability	Bathymetric survey	Physical	Low	Medium	Low	Low	Medium	Low	High	
Cap stability	Cap sample physical analysis	Physical	Low	Medium	Low	Low	Low	Medium	Medium	
Cap stability	Sediment coring	Physical	Medium	Medium	Low	Low	Low	Low	Medium	
Cap stability	Sediment profile photography	Physical	Medium	Medium	Medium	Medium	Medium	Low	Medium	
Cap stability	Sediment surface photography	Physical	Medium	Medium	Medium	Low	Medium	Low	High	
Cap stability	Settlement plate	Physical	Medium	High	Medium	Low	Medium	Low	Medium	
Cap stability	Side scan sonar	Physical	Low	Medium	Medium	Low	Medium	Low	Medium	

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Site Name: **Naval Station Alpha** Scenario: **Cap Entire Site**

1 Remediation Phase → 2 Monitoring Need → 3 Monitoring Tool → 4 **Monitoring Design**

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- Cap stability

Capping > Compliance (Performance)

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Uncertainty Addressing Need
Accurate method for assessing cap when cap materials differ from underlying sediment

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Capping > Compliance (Performance)

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Cap stability	Sediment profile photography	Physical	Medium	Medium	Medium	Medium	Medium	Low	Medium	
Cap stability	Sediment surface photography	Physical	Medium	Medium	Medium	Low	Medium	Low	High	
Cap stability	Settlement plate	Physical	Medium	High	Medium	Low	Medium	Low	Medium	
Cap stability	Side scan sonar	Physical	Low	Medium	Medium	Low	Medium	Low	Medium	

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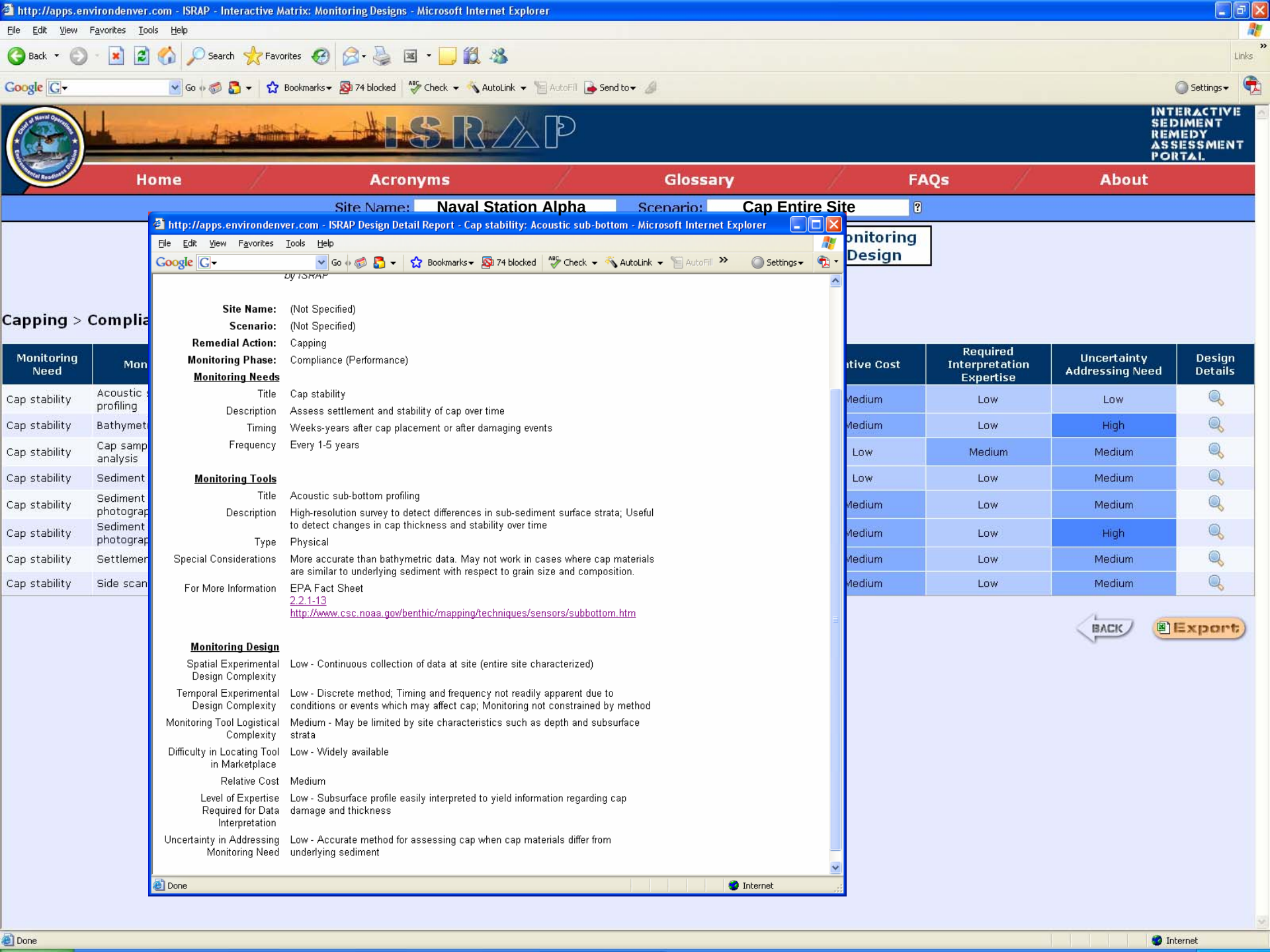
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Home Acronyms Glossary FAQs About
Site Name: Naval Station Alpha Scenario: Cap Entire Site
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by ISRAP
Site Name: (Not Specified)
Scenario: (Not Specified)
Remedial Action: Capping
Monitoring Phase: Compliance (Performance)
Monitoring Needs
Title Cap stability
Description Assess settlement and stability of cap over time
Timing Weeks-years after cap placement or after damaging events
Frequency Every 1-5 years
Monitoring Tools
Title Acoustic sub-bottom profiling
Description High-resolution survey to detect differences in sub-sediment surface strata; Useful to detect changes in cap thickness and stability over time
Type Physical
Special Considerations More accurate than bathymetric data. May not work in cases where cap materials are similar to underlying sediment with respect to grain size and composition.
For More Information EPA Fact Sheet 2.2.1-13 http://www.csc.noaa.gov/benthic/mapping/techniques/sensors/subbottom.htm
Monitoring Design
Spatial Experimental Design Complexity Low - Continuous collection of data at site (entire site characterized)
Temporal Experimental Design Complexity Low - Discrete method; Timing and frequency not readily apparent due to conditions or events which may affect cap; Monitoring not constrained by method
Monitoring Tool Logistical Complexity Medium - May be limited by site characteristics such as depth and subsurface strata
Difficulty in Locating Tool in Marketplace Low - Widely available
Relative Cost Medium
Level of Expertise Required for Data Interpretation Low - Subsurface profile easily interpreted to yield information regarding cap damage and thickness
Uncertainty in Addressing Monitoring Need Low - Accurate method for assessing cap when cap materials differ from underlying sediment
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ISRAP Transition

- Modifications & Review
  - ISRAP Modifications
  - Internal Review
  - External Peer Review
- Revisions
  - Review Comments
  - Revise ISRAP
  - Prepare for Transition
- Transition & Release
  - Transition ISRAP to NFESC ERT2
  - Public Release
  - RITS
  - Publications

Summer 08 | **Fall 08** | **Spring 09**

Challenges Ahead

- How to improve cost estimation?
  - Incorporation of cost ranges for tools/classes of tools.
- How to develop achievable exit criteria?
  - Examples from other sites
  - Guidance for specific remedies

    e.g. DoD MNR Guidance

    Provides examples on the translation of RAOs to measurement endpoints and success criteria.

Summary

- Many standard and novel monitoring tools available
  - One tool can often address multiple monitoring needs and/or can supplement other tools
  - Consider monitoring tools used during RI/FS
  - Carefully consider DQOs in monitoring tool selection and monitoring design
    - Strive to define success criteria that relate to RAOs (DQO Step 6, Establish Management Decision)
- The remedy-specific approach described in the guidance document is intended to:
  - Provide a systematic framework for designing and selecting monitoring alternatives
  - Increase consistency among (Navy) sites and decrease uncertainties