Ecosystem Services – Benefits and Considerations for the Cleanup of Contaminated Mine Sites

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Outline

Part 1 Matt Harwell

- What are ES?
  - Beneficiaries & Stakeholders
- Key Process Questions
  - Authorities/Guidelines
  - Engineering Forum Issue Paper
  - Operationalizing
- Key Take Homes

Part 2 Michele Mahoney

- ES from a Mining Context
  - Setting the Stage
- Examples
  - Fishing
  - Erosion Control
  - Pollinators
  - Timber
  - Water

Open Discussion

Ecosystem Goods & Services (ES) - 101

Ecosystem Services are “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. They maintain biodiversity and the production of ecosystem goods. . .“ (Daily 1997)

From the Millennium Ecosystem Assessment (2005)

Type	Example
Provisioning	food and water
Regulating	flood and disease control
Cultural	spiritual, recreational, and cultural benefits
Supporting	nutrient cycling

References: Daily (**1997**); MEA (**2005**)

Final Ecosystem Goods & Services

To operationalize Ecosystem Services, specifics are needed about:
"What?", "Where?" and "For whom?" or "For what?"

Connecting these three elements are referred to as
Final Ecosystem Goods and Services – those that directly benefit people

Final Ecosystem Goods and Services (FEGS)

"[biophysical] components of nature, directly enjoyed, consumed, or used to yield human well-being" *(Boyd & Banzhaf 2007)*

Reference: Boyd & Banzhaf. (**2007**)

Connecting ES to People

ES		*Final* EGS
Habitat for fauna	What?	**Water salinity** in **groundwater** that local **farmers** depend on for irrigating crops.
Water quality	Where?	**Water nutrient levels** in **local streams** to support safe **recreational fishing**.
Water quantity	For whom? or For what?	**Water turbidity** in **rivers** that are visited by **recreational boaters**.

Reference: DeWitt et al. (**2020**)

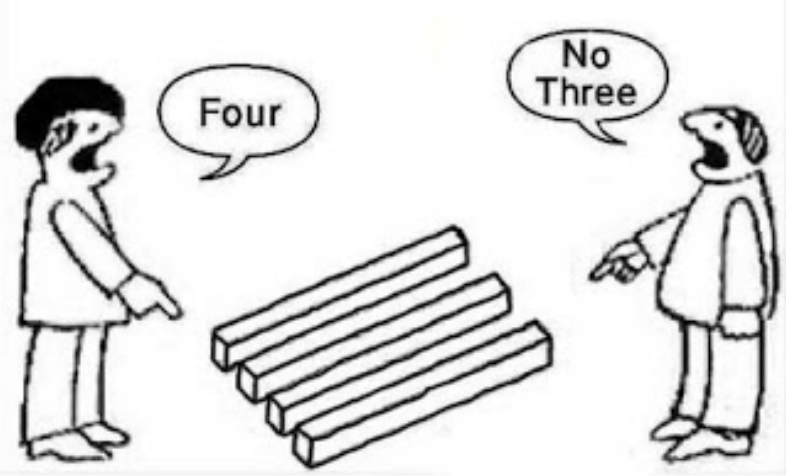
Stakeholders & Beneficiaries

Stakeholders

- Different parts of cleanup processes
- Range of activities/opportunities
  - Right to be informed
  - Right to engage in public comments
  - Ability to play active role

Beneficiaries

- Have different priorities
- Have different perspectives
- Are not people!
  - More like roles or slices of people



Why a Beneficiary Perspective?

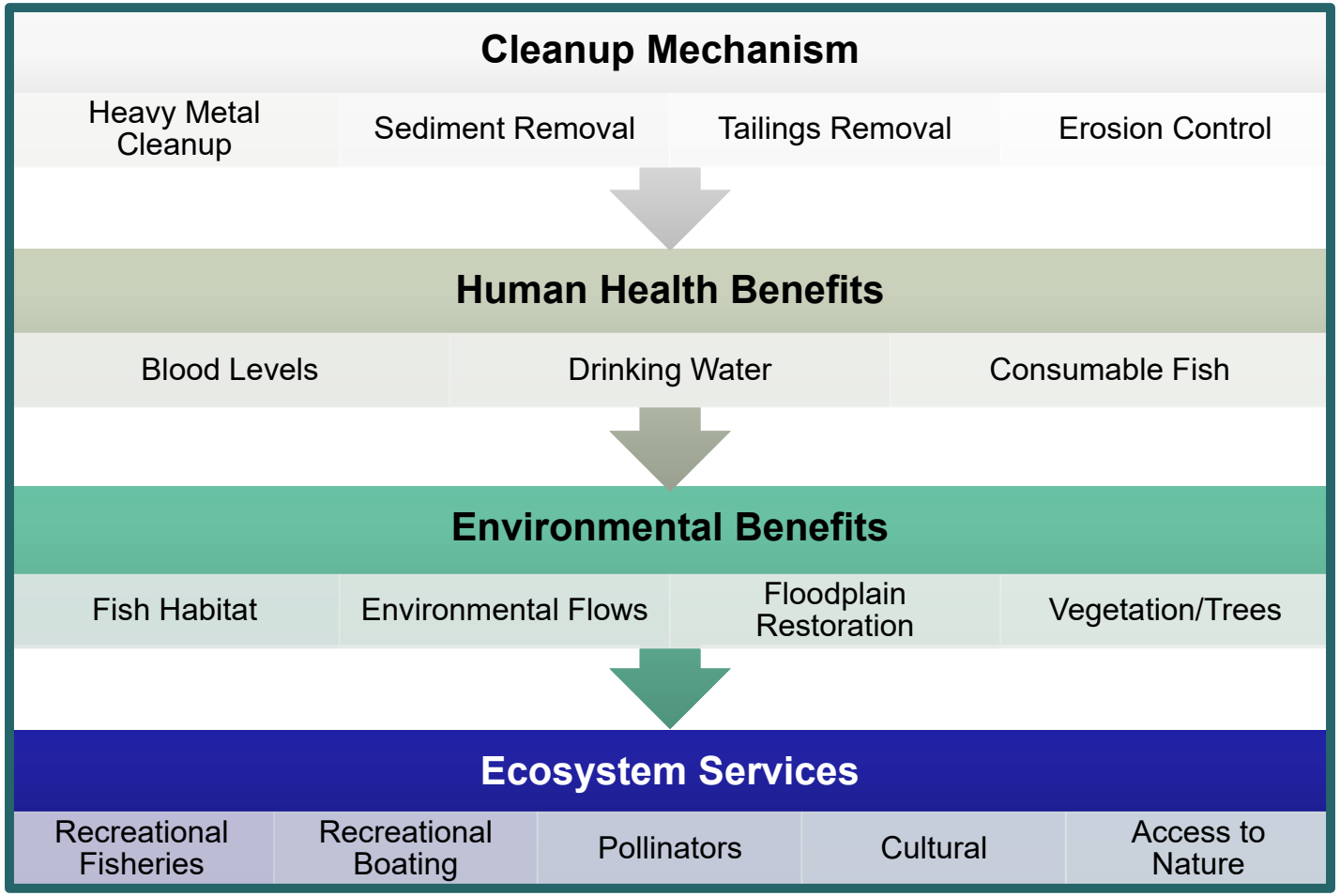
More Intuitive Entry Points for Stakeholder Discussions

- Challenging: X parts per million of contaminant Y in sediments means _____
- Easier: Concepts of “Safe enough to boat in”; “Safe enough to swim in”; and “Safe enough to drink”

Use “Loss of” or “Increase of” a Beneficial Use to Reduce Social Stigmas

- Focus language on ultimate goals and not negative condition
- Stakeholders more receptive to involvement in process
- Greater Stigma: Need to reduce contaminants in neighborhood
- Less Stigma: Need for increased recreational opportunities in neighborhood

A Beneficiary Perspective Helps Identify ES



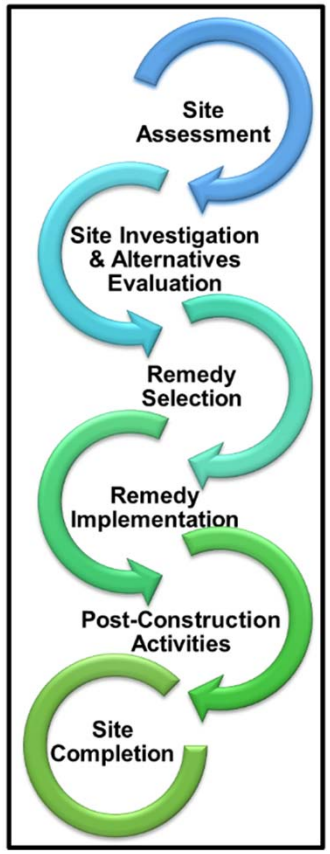
Key Process Questions

Authorities & Guidelines

- What are relevant authorities & guidelines for focusing on ES at a cleanup site? *

Operationalizing

- When in the assessment & cleanup are ES evaluated and planned?
- What tools are available to evaluate ES?
- Who reaps the benefits, & can they add value?



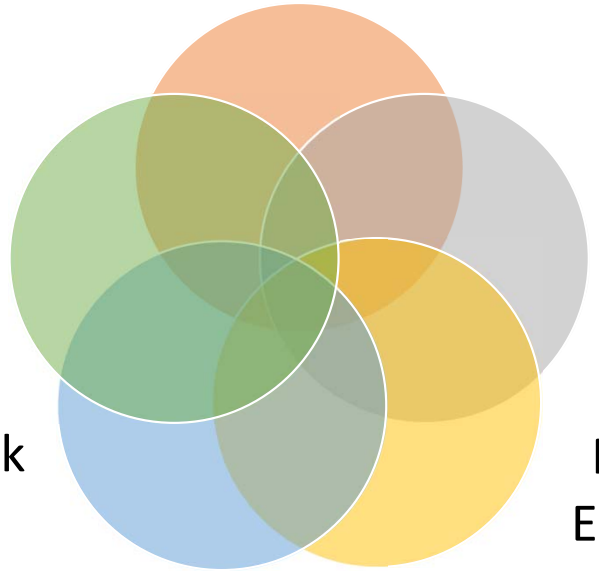
* Reference: Harwell. (**2020**)

Basis for Considering ES at Superfund Cleanups

Green & Sustainable Remediation (2008+)

Engineering Forum Issue Paper (2017)

Ecological Revitalization (2009)



Ecological Risk Assessment ES-GEAEs (2016)

Reduction of Environmental Footprint of Cleanup (2012)

BMPs

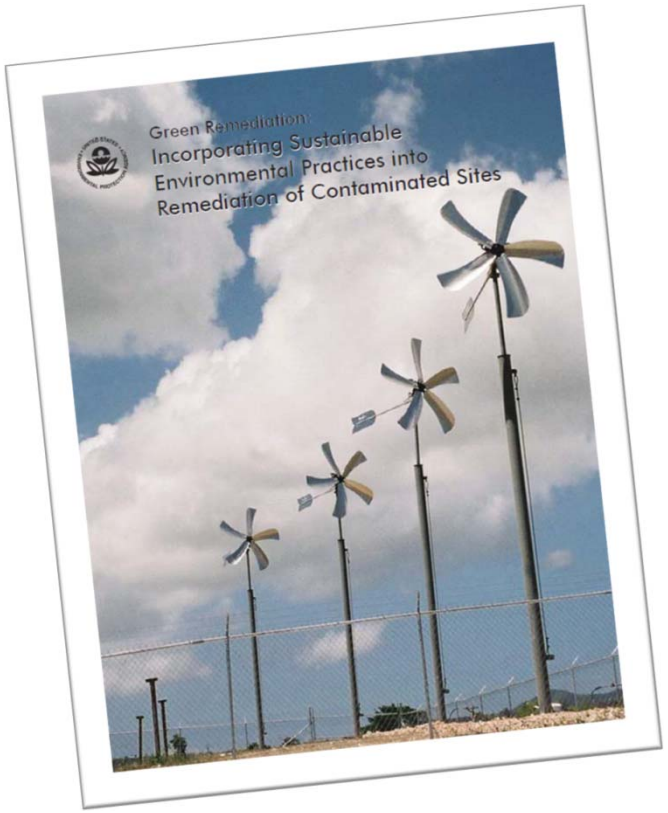
RAFLU

Footprint Methodology

ERA Metrics

Steps in ES Consideration ***(2021 paper)***

Green Remediation Strategies: 2008+



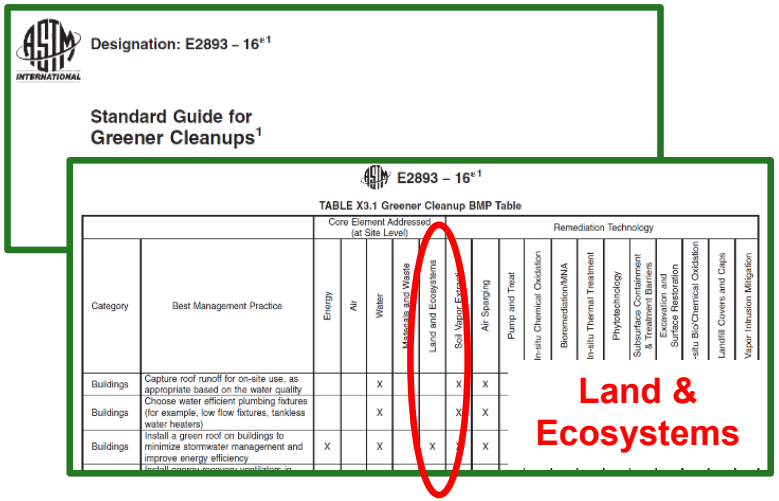
- Builds on statute/regulatory programs goals to achieve greater net environmental benefit of a cleanup
- Although criteria/standards vary with statutory or regulatory authority, goals remain common among different cleanup programs
- Practices provide a whole-site approach, accelerating reuse of degraded land while preserving wildlife habitat and enhancing biodiversity
- Site management plans can describe approach to ecological preservation that considers anticipated reuse as well as natural conditions prevailing before contamination occurred

U.S. EPA. (**2008**). Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites. EPA542-R-08-002. https://clu-in.org/greenremediation/docs/Green-Remediation-Primer.pdf

Green Remediation Focus

Minimizing the environmental footprint of site cleanup

Site Name	State	Core Elements					
(Click on any of these site names to learn the details)		Energy: Efficiency	Energy: Renewable	Air Emission	Water	Land & Ecosystem	Materials & Waste
Aerojet-General Corporation *Update*	CA		☀	☁	💧	🌲	
Altus Air Force Base *Update*	OK		☀	☁	💧		♻
Apache Nitrogen Products, Inc.	AZ		☀	☁	💧		
Barksdale AF Base	LA				💧	🌲	♻
BP Casper	WY					🌲	♻
BP Paulsboro *Update*	NJ		☀	☁			
Busy Bee's Laundry	MO	⚙	☀	☁		🌲	♻
California Gulch	CO			☁			♻
Camp Lejeune Military Reservation *New*	NC	⚙	☀	☁	💧	🌲	♻
Continental Steel Corp. *New*	IN	⚙	☀	☁	💧	🌲	♻
Crozet Orchard	VA		☀	☁	💧		



Designation: E2893 – 16ε1

Standard Guide for Greener Cleanups[1]

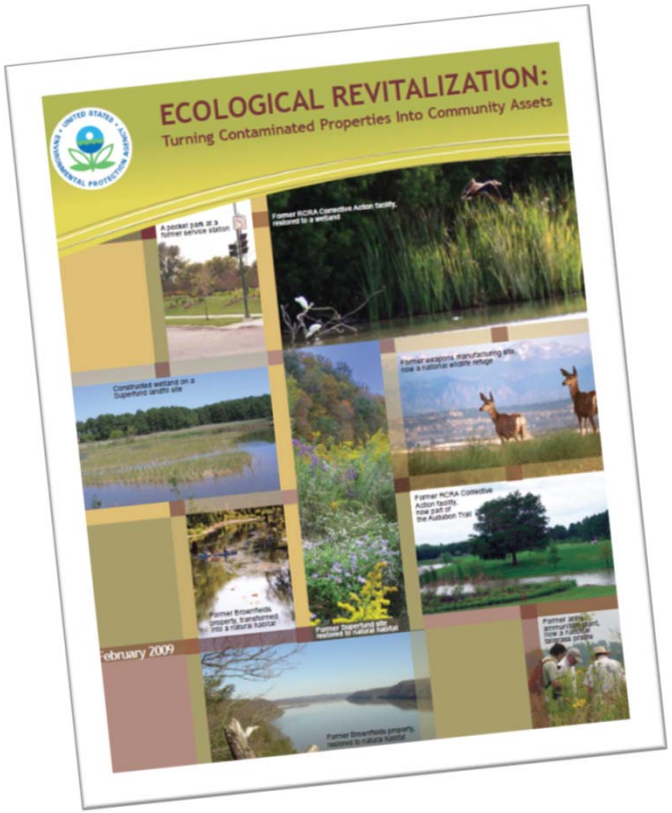
E2893 – 16ε1

TABLE X3.1 Greener Cleanup BMP Table

Category	Best Management Practice	Core Element Addressed (at Site Level)					Remediation Technology													
		Energy	Air	Water	Materials and Waste	Land and Ecosystems	Soil Vapor Extraction	Pump and Treat	Air Sparging	In-situ Chemical Oxidation	Bioremediation/MNA	In-situ Thermal Treatment	Phytotechnology	Subsurface Containment & Treatment Barriers	Excavation and Surface Restoration	In-situ Bio/Chemical Oxidation	Landfill Covers and Caps	Vapor Intrusion Mitigation		
Buildings	Capture roof runoff for on-site use, as appropriate based on the water quality			X			X	X												
Buildings	Choose water efficient plumbing fixtures (for example, low flow fixtures, tankless water heaters)			X			X	X												
Buildings	Install a green roof on buildings to minimize stormwater management and improve energy efficiency	X		X		X	X	X												

Land & Ecosystems

Ecological Revitalization



- Returning land from a contaminated state to one that supports a functioning & sustainable habitat
- Ecological revitalization not typically considered an "enhancement," so can generally be funded by EPA (e.g., under Superfund) & may be required by CWA § 404
  - E.g., Developing a wetlands design that will achieve the stated ecological functions
  - E.g., Designing & implementing cleanups that facilitate ecological revitalization of streams & stream corridors
  - E.g., Property-specific plant selection with preference for native plants in terrestrial environments
- Long-term stewardship necessary to ensure protectiveness of remedy & functioning of associated ecosystems

U.S. EPA. (**2009**). Ecological Revitalization: Turning Contaminated Properties into Community Assets. EPA 542-R08-003.
https://www.epa.gov/remedytech/ecological-revitalization-turning-contaminated-properties-community-assets

Environmental Footprint

"a qualitative or quantitative estimate of various environmental contributions of a cleanup phase or activity to the core elements of a greener cleanup."

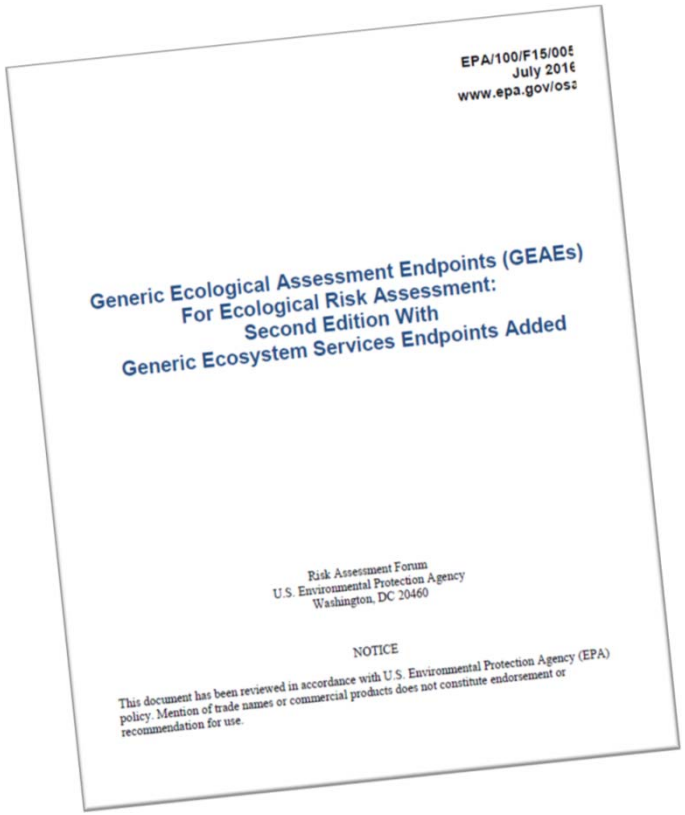
The 2012 methodology suggests use of descriptions of remedy effects on land & ecosystem services (e.g., nutrient uptake & erosion control)

Figure 3.1. Overview of Footprint Methodology

Step 1:	Set Goals and Scope of Analysis
Step 2:	Gather Remedy Information
Step 3:	Quantify Onsite Materials and Waste Metrics
Step 4:	Quantify Onsite Water Metrics
Step 5:	Quantify Energy and Air Metrics
Step 6:	Qualitatively Describe Affected Ecosystem Services
Step 7:	Present Results

U.S. EPA. (**2012**). Methodology for Understanding and Reducing a Project's Environmental Footprint. EPA 542-R-12-002. https://www.epa.gov/sites/default/files/2015-04/documents/methodology_enivro_footprint.pdf

ES as ERA Endpoints: 2015+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www.epa.gov/os

Generic Ecological Assessment Endpoints (GEAEs)
For Ecological Risk Assessment:
Second Edition With
Generic Ecosystem Services Endpoints Added

Risk Assessment Forum
U.S. Environmental Protection Agency
Washington, DC 20460

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency (EPA) policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

- ES as endpoints to enhance ecological risk assessments
- Going beyond conventional assessment endpoints to describe the valued attributes of endpoints may be useful or essential to success in informing risk decisions
- Not required, but can be useful when benefits of protection must be estimated or when benefits to humans are not obvious & must be described to decision makers, stakeholders, or public to help justify or inform a decision

U.S. EPA. (**2016**). Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment: Second Edition w/ Generic Ecosystem Services Endpoints Added. EPA/100/F15/005. https://www.epa.gov/sites/production/files/2016-08/documents/geae_2nd_edition.pdf

Attributes & Entry Points in ERA

- Stressor Characteristics
- Ecosystem & Receptor Characteristics
- Management Goals
- Input by Interested Parties
- Policies or Precedents

ERA Phases	Potential Ecosystem Services Entry Points
Planning and Scoping	Identify ecosystem services in site landscape
Problem Formulation	Describe ecosystem services benefits Estimate magnitudes of benefits Incorporate ecosystem services into conceptual site model (CSM)
Analysis	Evaluate potential ecosystem services /site contaminants connectivity Evaluate potential effects of site contaminants on ecosystem services Evaluate ecosystem services condition (functionality, impairment level) Evaluate resilience/vulnerability to site contaminants Calculate ecosystem services cost savings and other benefits Assess ecosystem services capacity (type, temporal, seasonal) Assess ecosystem services importance to stakeholders Assess ecosystem services maintenance effort and cost Identify key features or parameters to protect ecosystem services benefits
Risk Characterization	Compare costs and benefits of ecosystem services Characterize site contaminant threats to ecosystem services Characterize ecosystem services impairment level by site contaminants
Risk Communication	Articulate ecosystem services benefits and costs

References: U.S. EPA. (**2016**); Maurice et al. (**2019**)

Engineering Forum Issue Paper


EPA 542-R-17-004
August 2017

EPA United States Environmental Protection Agency

Engineering Forum Issue Paper

Agriculture-to-wetland project at the Lower Basin of Coeur d'Alene River Superfund site in northern Idaho. Photo Credit: Jawal Lipps

Ecosystem Services at Contaminated Site Cleanups

Contents

1. Purpose
2. Ecosystem Services
3. Considerations During Cleanup
4. Community Involvement
5. Ecosystem Services Evaluation Tools
6. Best Management Practices for Ecosystem Services
7. Summary
8. Acknowledgements
9. Notice and Disclaimer
10. Selected Resources
11. Cited References

Appendix A. Ecosystem Services Evaluation Tools

The Technical Support Project (TSP) Engineering Forum issue papers provide information on remediation technologies or technical issues of interest. The information is not guidance or policy.

"Ecosystem goods and services are the many life-sustaining benefits we receive from nature—clean air and water, fertile soil for crop production, pollination, and flood control."

- U.S. Environmental Protection Agency, 2017
www.epa.gov/eco-research/ecosystems-services

1. Purpose

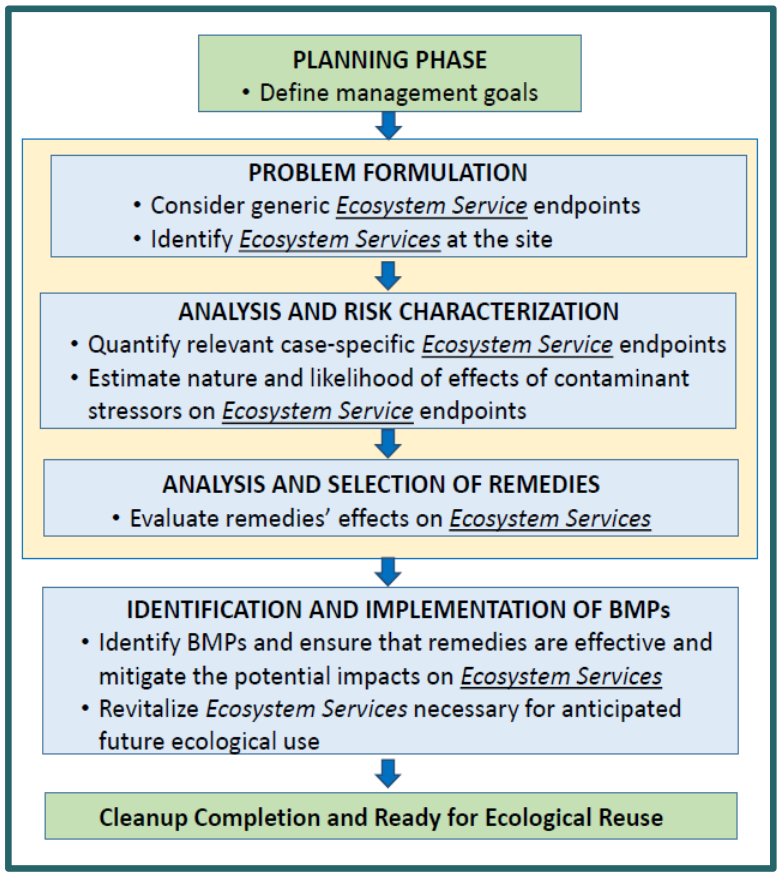
The U.S. Environmental Protection Agency (EPA) developed this issue paper to provide cleanup site teams with information about ecosystem services. These concepts and tools are useful in communicating the positive results of cleanup in addition to achieving the goals of cleanup. Information about ecosystem services may be considered in characterization of future land use options or design of a cleanup that is consistent with anticipated ecological reuse, depending on the regulatory authority of the cleanup program. This document does not provide guidance on how ecosystem services may or may not be factored into specific cleanup programs.

Ecosystem Services at Contaminated Site Cleanups

- Engagement with the public & stakeholders about anticipated future ecological use
- Replicable, defensible selection of greener cleanup BMPs
- Can inform environmental decision making at different parts of clean-up process
- Transparent documentation of the ecosystem conditions on the site "before and after" cleanup
- Communication of the benefits & societal relevance of ecological risk-based cleanups

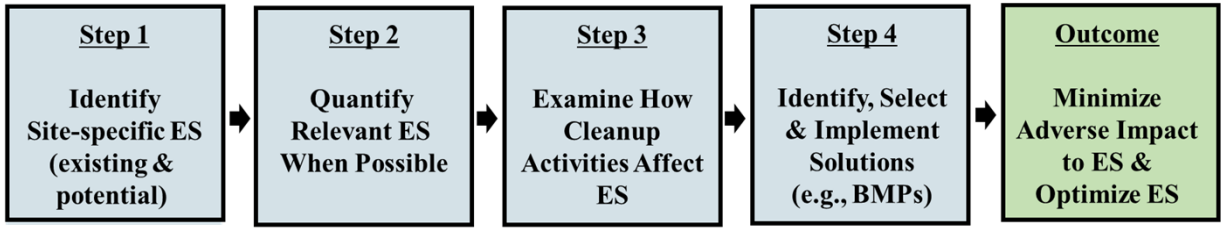
U.S. EPA. (**2017**). Ecosystem Services at Contaminated Site Cleanups. Engineering Forum Issue Paper. EPA/542/R-17/004. https://semspub.epa.gov/work/HQ/100000459.pdf

Operationalizing ES Concepts



Coeur d'Alene River, ID

- Watershed-scale site
- Undeveloped; mining
- Rocky Mountain west



Lower Darby Creek Area Philadelphia, PA

- Smaller site
- East Coast urban setting

Step 1: Identify Site-specific ES

Activities for Site Team

- Develop a draft list of ES relevant to the site (inc. information about beneficiaries)
- Discuss draft list w/ stakeholders to determine missing items & understand stakeholder priorities, including local, scientific, & traditional knowledge
- Incorporate stakeholder interest in: the protection of existing ES; ecological reuse at the site; & creation/revitalization of a functional ecosystem
- Include ES endpoints in an ERA, if appropriate
- Finalize list of ES
- Document information about ecological condition of the site relevant to ES in the list &, if practicable, add ES components to data collection procedures

Step 1

Identify Site-specific ES (existing & potential)

Reference: Harwell et al. (**2021**)

Step 2: Quantify Relevant ES When Possible

Activities for Site Team

- Include consideration of ES in the "Statement of Work" for site contractors
- Examine options to conduct quantitative analyses in support of ES performance objectives
- Select and use analysis tools based on considerations suited for the site

Step 2

Quantify Relevant ES When Possible

Journal of Environmental Management 285 (2021) 112102

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: http://www.elsevier.com/locate/jenvman

Research article

Ecosystem services consideration in the remediation process for contaminated sites

Matthew C. Harwell [a,*], Chloe Jackson [b], Michael Kravitz [c], Kira Lynch [d], Jewel Tomasula [e], Anne Neale [f], Michele Mahoney [g], Carlos Pachon [g], Karen Scheuermann [h], Gregory Grissom [i], Kristen Parry [j]

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[j] Tetra Tech, Inc., Owings Mills, MD, 21117, United States

Harwell, M.C., Jackson, C., Kravitz, M., Lynch, K., Tomasula, J., Neale, A., Mahoney, M., Pachon, C., Scheuermann, K., Grissom, G., Parry, K. (2021). Ecosystem services consideration in the remediation process for contaminated sites. *Journal of Environmental Management*. 285: 112102. https://www.sciencedirect.com/science/article/pii/S030147972100164X?via%3Dihub

Reference: Harwell et al. (**2021**)

Step 3: Examine How Cleanup Activities Affect ES

Activities for Site Team

- Consider components of remedy implementation, such as:
  - Will placement of equipment disturb existing habitat?
  - Will implementation require cutting down mature trees?
  - Can revegetation actions include native plants for pollinators & wildlife?
  - Can revegetation improve habitat corridors or connectivity?
- Specify biophysical, economic, or cultural values of site ES & consider:
  - How are ES affected by the remedy, positive or negative?
  - How will changes in ES be weighted (by type of users, number of users, value to users, how much influence users have, how to address specific uncertainty in ES values, etc.)?
- Consult technical experts (i.e., ecologists, biologists, ES experts, sustainability scientists, risk assessors, environmental economists)

Step 3

Examine How Cleanup Activities Affect ES

Reference: Harwell et al. (**2021**)

Step 4: Identify, Select, & Implement Solutions

Activities for Site Team

- Discuss ES evaluation results and implications for site management with stakeholders
- Review BMP options lists, focusing on categories such as “land and ecosystems,” “site preparation,” “restoration,” or “ecological revitalization”
- Select site-specific, relevant BMPs using professional judgement, technical expertise (including ecologists and sustainability scientists), & ES evaluation results
- Implement BMPs during remedy construction and operation
- Document BMP selection and implementation process
- Monitor performance of BMPs & impact on ES

Step 4

Identify, Select & Implement Solutions (e.g., BMPs)

Reference: Harwell et al. (**2021**)

Using ES Tools

Step 1

Identify Site-specific ES (existing & potential)

Step 2

Quantify Relevant ES When Possible

Step 3

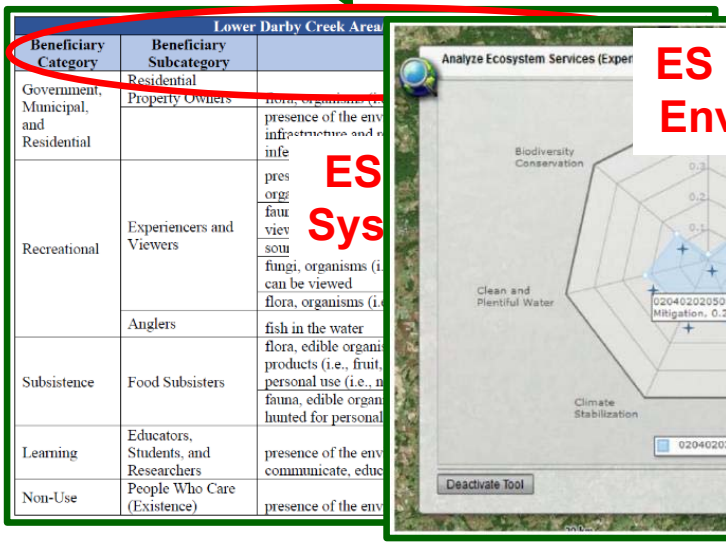
Examine How Cleanup Activities Affect ES

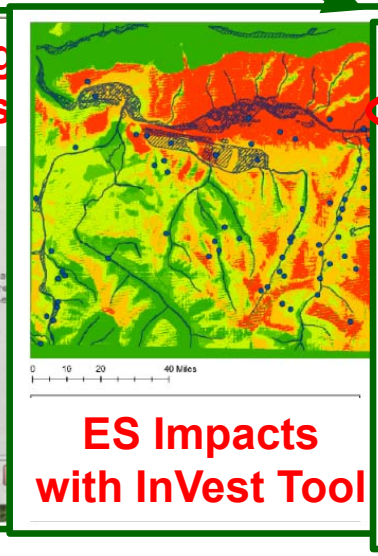
Step 4

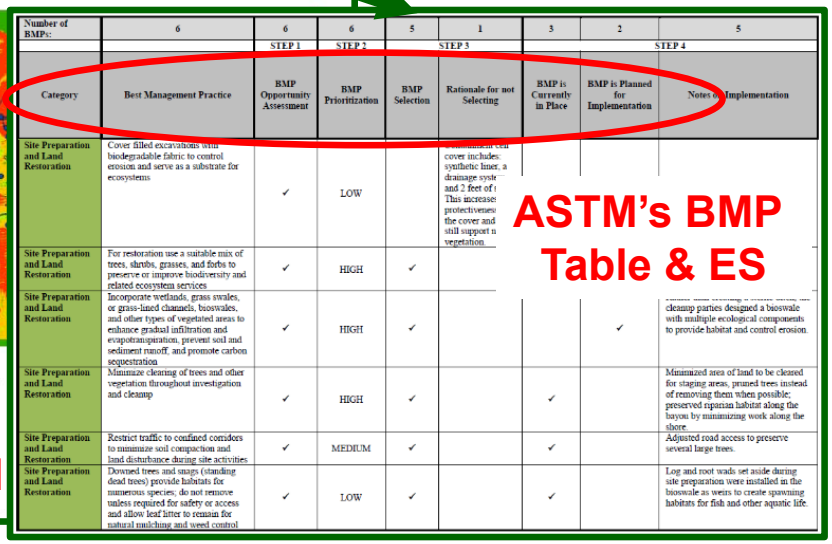
Identify, Select & Implement Solutions (e.g., BMPs)

Outcome

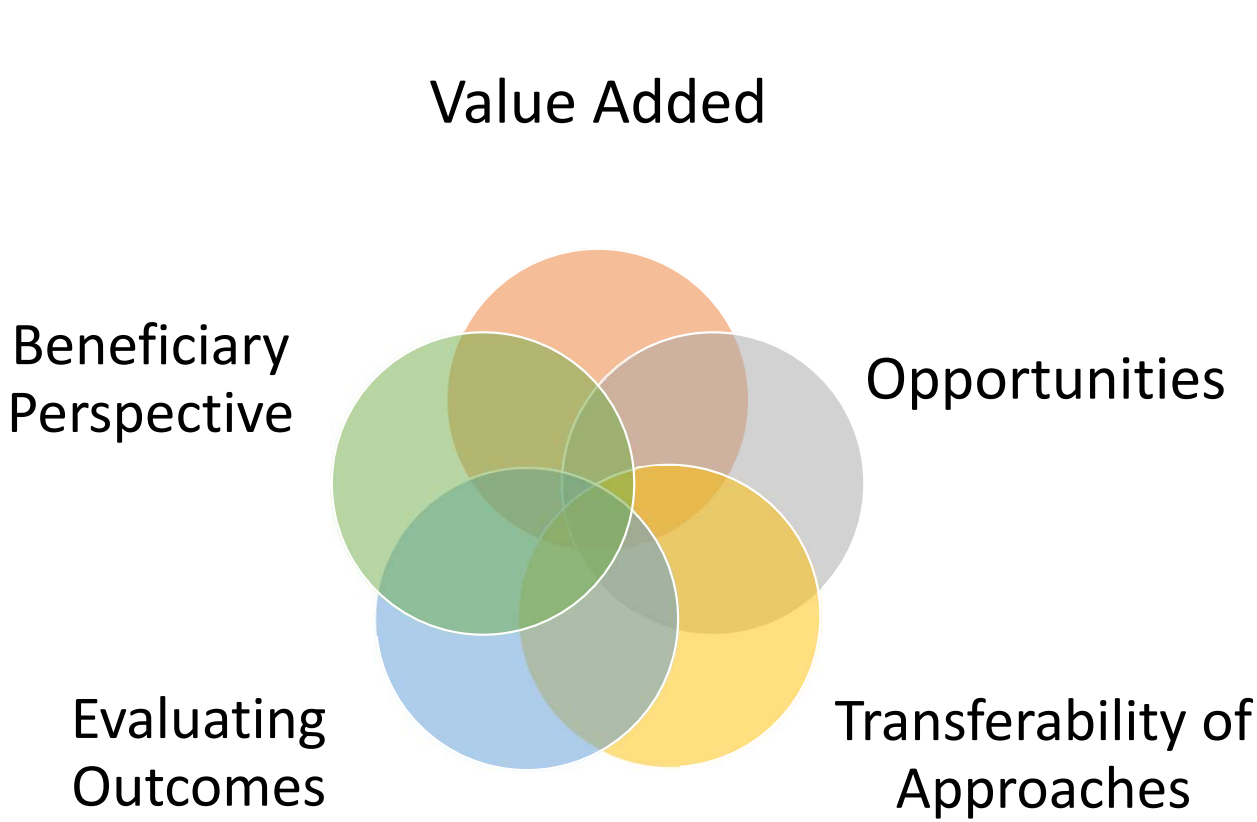
Minimize Adverse Impact to ES & Optimize ES







Key Take Homes Connecting ES to Remediation



- Increase Benefits
- Increase On-The-Ground Applications
- Concepts & Approaches Elsewhere
- Apply ES Metrics & Tools
- A Enhance Stakeholder Engagement

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