Synergies in Climate Mitigation and Adaptation Actions at Contaminated Site Cleanups

Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency

AquaConSoil
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EPA
United States
Environmental Protection
Agency

Agenda

- Cleaning up contaminated sites - remediation work that needs to be done
- Building sustainability into remediation projects, green remediation and beyond
- Ensuring resilient remedies in a changing climate
- Green remediation and climate adaptation actions working together
- Ecosystem services as a currency

2021 U.S. Executive Order 14008: Tackling the Climate Crisis at Home and Abroad

- The EO Places climate change at forefront of U.S. foreign policy and national security plans
- Requires sustainability officers in each agency to take actions
  - » Increase production of renewable energy on public lands and offshore waters
  - » Drive innovation and deployment of clean energy technologies
  - » Develop critical clean water infrastructure
  - » Strengthen clean air and water protections
  - » Sequester carbon in soils and vegetation
  - » Conserve public lands
  - » Restore coastal ecosystems such as wetlands
  - » Ensure robust protection of ecosystems and biodiversity
  - » Use nature-based solutions to climate-related challenges
  - » Create jobs in clean energy industries
  - » Deliver environmental justice across U.S. communities
  - » **Invest in remediation and reduce legacy pollution**

Supplying clean, affordable and secure energy

Preserving and restoring ecosystems and biodiversity

"… key Federal actions to reduce climate pollution; increase resilience to the impacts of climate change; protect public health; conserve our lands, waters, oceans, and biodiversity; deliver environmental justice; and spur well-paying union jobs and economic growth."

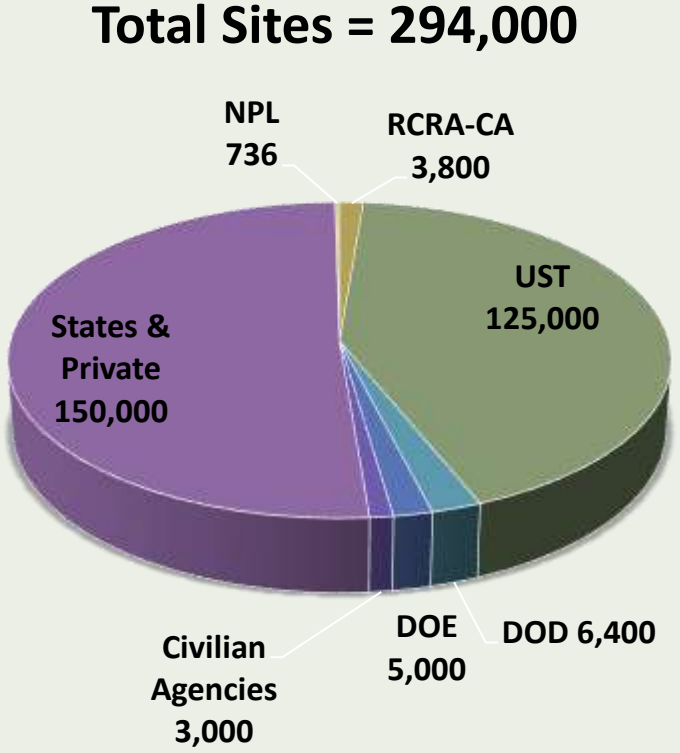
Synergy in policy implementation across U.S. federal agencies

Leave no one behind (Just Transition)

EPA Contaminated Site Programs: We Still Have a Lot of Remediation Work to Do

- We have made great progress cleaning up contaminated sites but …
- The National Academies of Sciences estimates 126,000 sites across the U.S. still have contaminated groundwater, and their closure is expected to cost at least $110-$127 billion
- We continue to invest over $8 billion a year in remediation (U.S. EPA, EBJ)
- We have opportunities to apply lessons learned, innovations and best management practices to future sites
- New remediation challenges exist, such as treating landfill leachate containing PFAS
- Re-evaluation of human health risks posed by registered products such as captan may affect remediation planning

Estimated Number of Contaminated Sites
(U.S. EPA 2004)
(United States, Cleanup horizon: 2004 – 33)

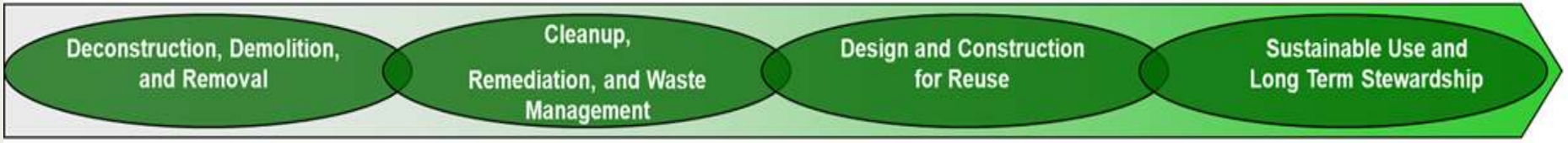


Sources: www.clu-in.org/market; http://www.nationalacademies.org/; http://www.ebiusa.com/

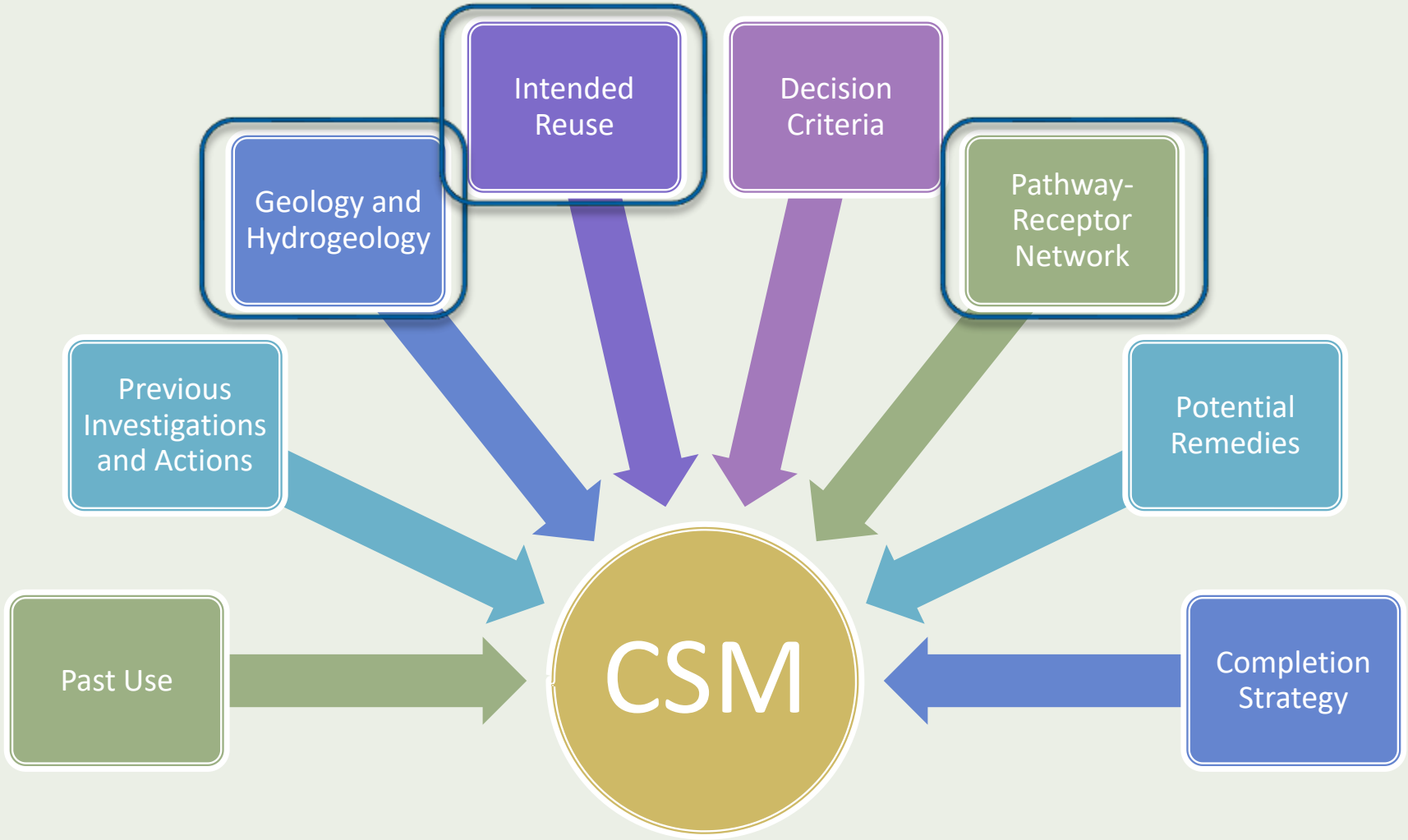
The Remediation to Redevelopment Continuum

- Hazardous substances found at contaminated sites can cause serious health effects - Acute injuries, cancer, birth defects, other chronic non-carcinogenic effects (e.g., kidney, liver, nervous and endocrine systems)
- Contamination can affect drinking water sources and be hazardous substances are harmful to plants, animals, and the functioning of ecological systems
- Hazardous waste sites remain vacant or underutilized and stifle local economies and present future risks if site uses change
- Two main options to address risk when needed
  - » Exposure pathway management (preventing contact)
  - » Remediate by removing, destroying, or immobilizing contamination or reducing contaminant toxicity
- Reuse may determine cleanup levels or be determined by them



The Conceptual Site Model (CSM) Drives Cleanup Decisions



General Environmental Cleanup Steps	CSM Life Cycle	CERCLA - Superfund	RCRA	Brownfields	UST	VCUP Varies by State
Site Assessment	**Preliminary CSM** → **Baseline CSM** (Conceptual)	Preliminary Assessment (PA) Site Inspection (SI) National Priorities List (NPL) No Further Remedial Action Planned (NFRAP)	Facility Assessment (RFA)	Phase I Environmental Site Assessment (ESA)	Initial Site Characterization Initial Response	PA SI
Site Investigation and Alternatives Evaluation	**Characterization CSM Stage**	Remedial Investigation/ Feasibility Study (RI/FS) Removal Actions - Emergency/ Time Critical/Non-Time-Critical	Facility Investigation (RFI) Corrective Measures Study (CMS)	Phase II ESA	SI Corrective Action Plan (CAP)	RI/FS
Remedy Selection	**Design CSM Stage**	Proposed Plan Record of Decision (ROD)	Statement of Basis (SB) Final Decision and Response to Comments	Remedial Action Plan (RAP)	Cleanup Selection	ROD
Remedy Implementation	**Remediation/ Mitigation CSM Stage**	Remedial Design (RD) Remedial Action (RA) – Interim and Final	Corrective Measure Implementation (CMI)	Cleanup and Development	Corrective Action - Low-impact site cleanup - Risk-based remediation - Generic remedies - Soil matrix cleanup	RD RA
Post-Construction Activities	**Post-Remedy CSM Stage**	Operational & Functional Period Operation & Maintenance (O&M) Long term monitoring (LTM) Optimization Long Term Response Action (Fund-lead groundwater/surface water restoration)	O&M On-site inspections and oversight	Property Management Long-term O&M Redevelopment Activities (Private- and Public-led)	LTM	O&M LTM
Site Completion	(Quantitative)	Construction Complete (CC) Preliminary or Final Close Out Report (PCOR/FCOR) Site Completion - FCOR Site Deletion O&M as appropriate	Certification of Completion Corrective Action Complete with Controls or without Controls	CC Property Management	No Further Action (NFA)	CC

Cleanup Pipeline

Potential for Mitigation and Resilience Exists for Most Common Remediation Technologies *

Groundwater Technologies	FY 2015-17	% of Groundwater Decision Documents
Ex Situ Treatment (P&T)	22	20%
In Situ Treatment	56	51%
Bioremediation (anaerobic, aerobic, bioaugmentation)	30	27%
Chemical Treatment (oxidation, reduction, neutralization)	26	24%
Thermal Treatment	6	5%
Permeable Reactive Barrier	5	5%
Other Types	16	1-4%
Monitored Natural Attenuation	22	20%
Institutional Controls	78	71%

Source Control Technologies	FY 2015-17	% of Source Control Decision Documents
Ex Situ Treatment	50	29%
In Situ Treatment	35	20%
Solidification/Stabilization	9	5%
Soil Vapor Extraction	9	5%
Thermal Treatment	8	5%
Bioremediation	6	3%
Chemical Treatment	5	3%
Containment/Disposal	117	67%
MNA/Enhanced MNA	6	3%
Institutional Controls	124	71%
Other (e.g. wetlands or habitat restoration, revegetation)	43	25%

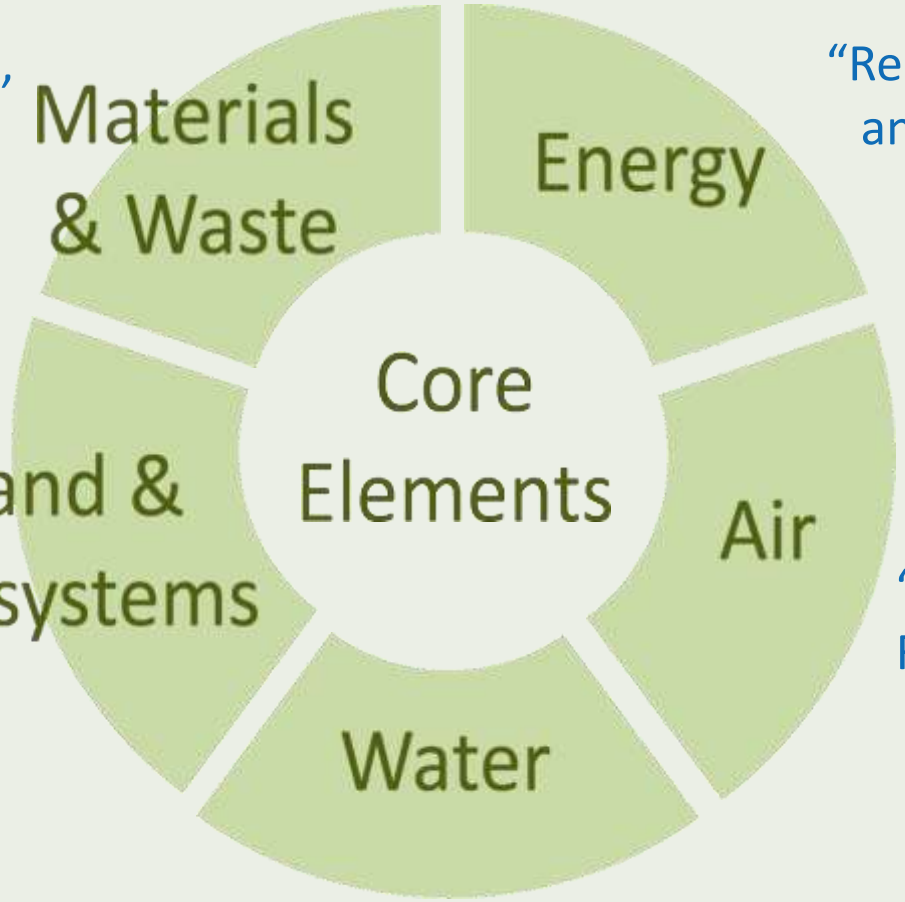
* http://cluin.org/srr

What is "Green Remediation" ?

The practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions

- Applicable to ***any*** remedy and ***any*** remediation technology
- Relevant to ***any*** phase of the cleanup pipeline

Core Elements of Green Remediation



"Minimize, Reuse, and Recycle…"

"Reduction, Efficiency, and Renewables…"

"Conserve, Protect, and Restore…"

"Protect Air Quality; Reduce Greenhouse Gases…"

"Improve Quality; Decrease Quantity of Use…"

Deployment of Green Remediation Practices

Cleaner Air

A new generation of clean diesel technology for off-road engines and equipment (Tier 4) has made its way onto remediation job sites across the country, such as the Elizabeth Mine NPL site in Vermont (Region 1).

Water Resource Protection

More permanent solutions are used to manage stormwater at urban sites. A subsurface geotextile-lined stormwater basin was installed during remedy construction at the Whitney Young Branch Library brownfield site in Chicago (Region 5) to complement future site reuse and the city's developing green infrastructure. *Winner of 2015 IL Governor's Sustainability Award*

Renewable Energy

Off-grid renewable energy systems are increasingly used at remote sites. A mobile 25-kW SolaRover hybrid system supported Superfund removal action at the Pennsylvania Mine near Keystone, CO (Region 8); the system's generator recharged portable tools and sampling devices and powered communication equipment and EPA's mobile lab.

Deployment of Green Remediation Practices (cont'd)

Ecosystem Restoration

More attention is given to accelerating restoration of damaged ecosystems and increasing ecosystem services. At the Pharmacia-Upjohn site in North Haven Connecticut (Region 1), RCRA corrective action included restoring ecosystems along portions of the Quinnipiac River and creating a new upland meadow providing habitat for pollinators, songbirds, reptiles and other wildlife.

Waste Reuse

Industrial by-products frequently substitute for virgin resources or processed materials. Through a state-voluntary partnership, coal ash from a local power plant and spent mushroom compost from a nearby agricultural producer are used to treat acid mine drainage in the De Sale Restoration Area of western Pennsylvania (Region 3).

Sustainable Materials

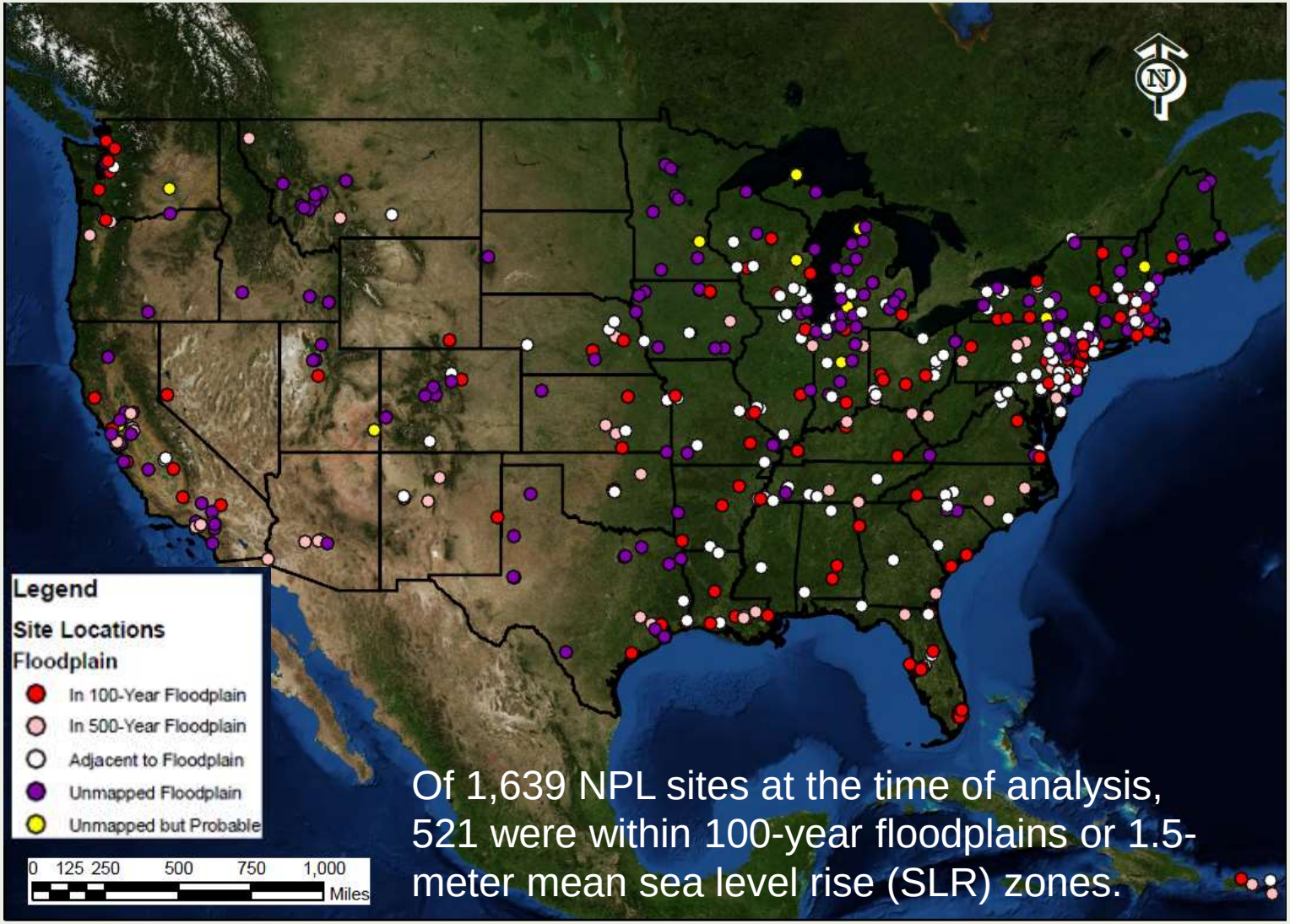
Greater efforts are made to choose greener products. Removal and remedial actions at the Lawrence Aviation Industries NPL site in Port Jefferson Station, NY, (Region 2) involved building groundwater treatment facilities made of certified green lumber, low-toxicity siding and insulation, and products containing recycled or rapidly-renewable materials.

Four Main Routes by Which Contaminated Site Management Supports Climate Change Mitigation

- **Reduction in Greenhouse Gas Releases through increased system efficiencies and the use of renewable energy sources (Green remediation)**
- **Remediating contaminated sites in urban areas reduces pressure on the development of green space at a ratio of one-to-four**
- **Building renewable energy generating capacity on impaired lands***
- **Carbon capture through the use of soil amendments to regenerate O and A soil horizons at abandoned mine sites**

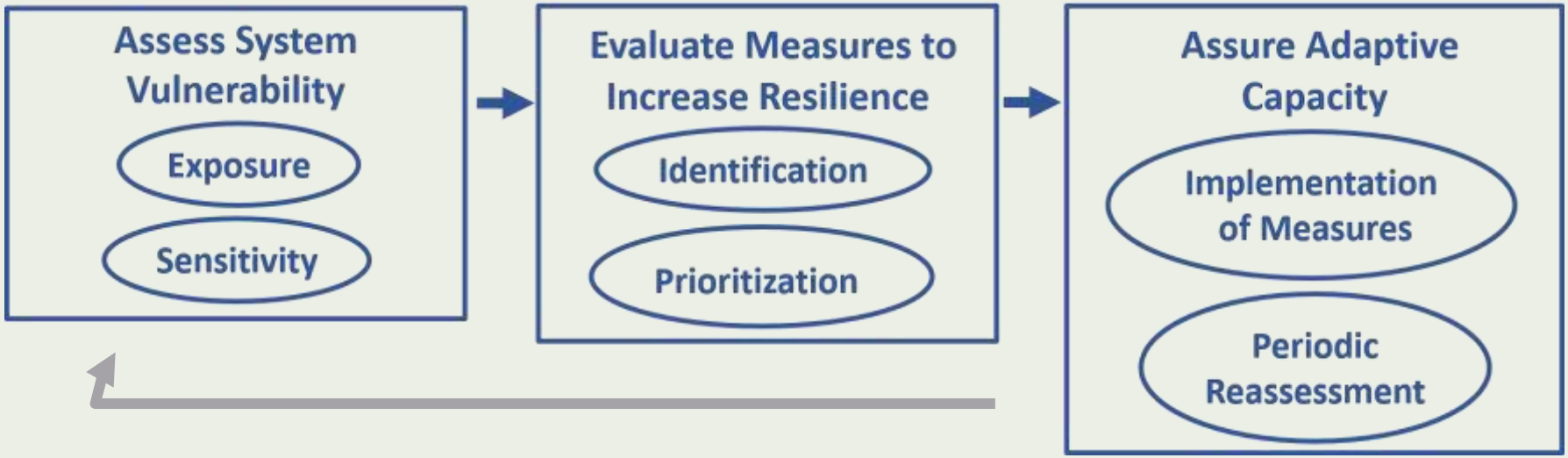
Key Climate Resilience Question in Contaminated Site Remediation:

"How is extreme weather likely to affect the protectiveness of your remedy, and how can it be made more resilient?"

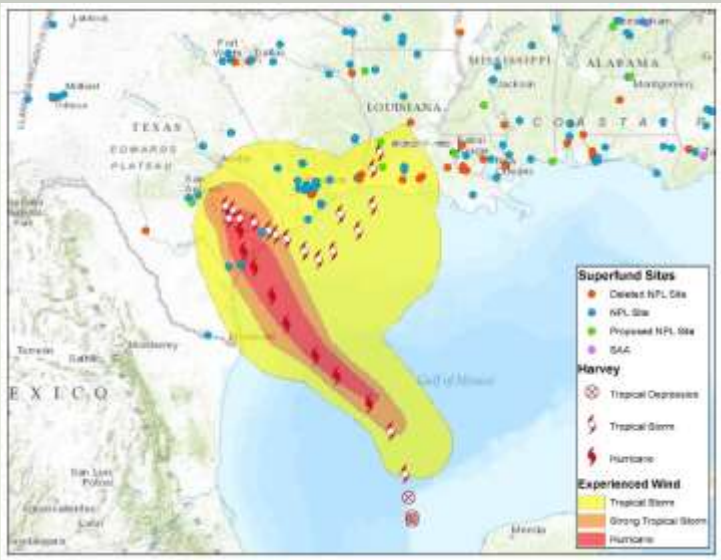


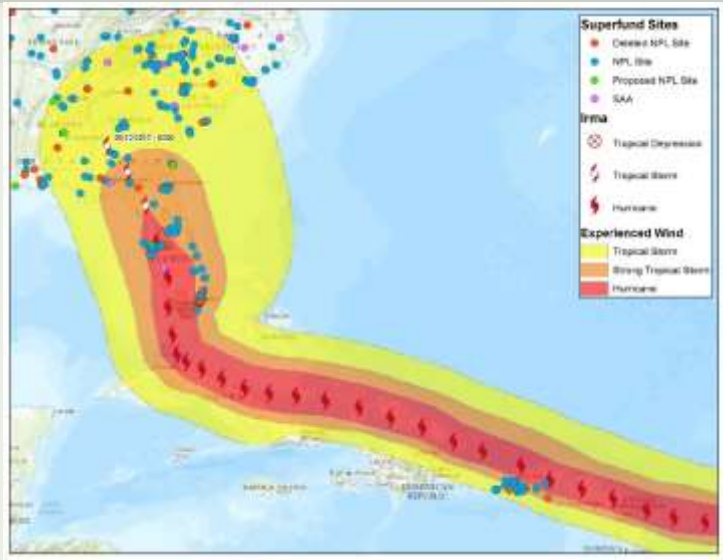
Superfund Climate Resilience Strategy

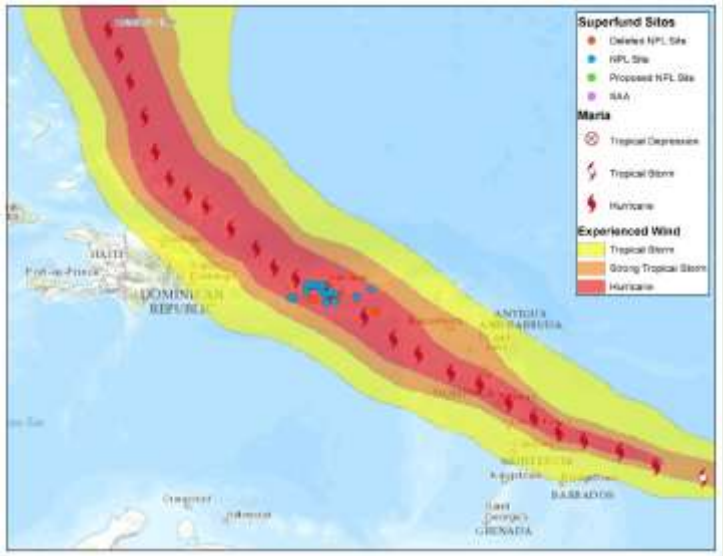
- Apply climate change and weather science as a standard operating practice in cleanup projects
- Raise awareness of vulnerabilities
  - » Understand how a changing climate affects weather at a local level and affects the intensity, frequency and duration of extreme weather events
  - » Quantify effects on remedy resilience and site operations, and consider adaptation options that add resilience where needed
  - » Use the Superfund five-year review process to evaluate changing site conditions



2017 Hurricane Season
Superfund Remedy Resiliency Report







National Hurricane Center Experience Wind Data

- Hurricane Harvey (above)
- Hurricane Irma (top right)
- Hurricane Maria (bottom right)

Remedy Resiliency Report: Overview of Findings

- **Key Finding: The state of the remedies is "Resilient"**
- Analysis of remedies affected by Hurricanes Harvey, Irma and Maria
  - 445 sites located in EPA Regions 2, 4 and 6 were affected
  - 251 sites were exposed to tropical force winds or higher
  - 63 sites experienced flooding (of which 62 saw TF or + winds)
  - 17 sites reported minor damage; none at this point indicate impairment to remedy protectiveness
  - Of 42 impacted sites, 31 reported resiliency design measures or preparedness actions
  - Loss of grid power was a widespread issue

The U.S. EPA finalized the report in 2018 and subsequently released the report in response to a 2019 FOIA request.

Sample of 2017 Hurricane Impacts and Resilience: Tutu Wellfield

- East-central St. Thomas, Virgin Islands
- Remedies
  - » Groundwater pump and treat
  - » Soil vapor extraction
- Hurricanes Irma and Maria
  - » Hurricane-force winds experienced
  - » 5-month power outage caused component oxidation

- Resiliency measures
  - » Remediation systems housed in hurricane-proof structures with concrete walls and roofs and steel doors, which remained intact
  - » Extraction wells constructed in flood-resistant vaults

Sample of 2017 Hurricane Impacts and Resilience: Anniston Army Depot (Southeast Industrial Area)

- Active U.S. Army installation in Alabama
- Remedies
  - » Contaminated soil cover
  - » Groundwater pump and treat
- Hurricane Irma
  - » Tropical storm-force winds experienced
  - » No reported damage
- Resiliency measures
  - » Riprap along ditches
  - » Alarms to notify operators of faults, and auto shutoff groundwater pumps to prevent tank overfilling

Resilience Integration Along the Superfund Pipeline: Early – Remedy Decision

San Jacinto River Waste Pits
Houston, Texas

- FY 2018 ROD "Summary of the Rationale for the Selected Remedy"

"The area has a high threat of repeated storm surges and flooding from hurricanes and tropical storms, which if the material was left in place, could result in a release of hazardous substances. Modeling by the U.S. Army Corps of Engineers projects a significant erosion of cap armor, even with the two most robust capping alternatives, as result of combined hurricane and flood conditions."

"EPA considered several options for addressing contaminated materials at the site. EPA selected a remedy that includes removal of contaminated materials above cleanup levels for the waste impoundments and MNR for the lower contamination level in the Sand Separation Area."

Resilience Integration Along the Superfund Pipeline: Design & Construction Example

Malone Services Co. Superfund Site
(Texas City, Texas)

- Primary Hazard: Onsite flooding due to hurricane storm surge or sea level rise along Galveston Bay
- Used NOAA models to analyze storm surge and wave run-up under various hurricane scenarios and predicted SLR
- Constructed an 18-foot-high levee to enclose two waste containment cells
- Installed armor along vulnerable sides of the cells and the levee
- Replaced topsoil and hydromulch in cell areas experiencing erosion or washout due to Hurricane Harvey

Resilience Integration Along the Superfund Pipeline: Operating Phase

American Cyanamid Superfund Site
Bridgewater, New Jersey

- Primary Hazard: Onsite inundation due to river flooding
- 2015 FYR evaluated 2011 Hurricane Irene-related flooding/response and recommended improvements
  - » Elevated critical electrical instrumentation 5 feet higher than Hurricane Irene flood waters
  - » Installed submersible pumps in bedrock wells to maintain hydraulic control during future floods
  - » Reinforced earthen berms surrounding two highly contaminated waste impoundments
  - » Required future capping systems to be designed to withstand a 500-year flood event

Synergies in Climate Mitigation and Adaptation Actions

Examples of green remediation practices that reduce GHG emissions and provide climate resilience

- Renewable energy: Continued power supply and reduction n GHG emissions
- Carbon sequestration through revegetation: Carbon removed form the atmosphere while immobilizing contaminated media
- Stormwater control through Green infrastructure: Protecting remedy performance while naturally (low/no energy) treatment of surface water quality and quantity

Site Example of Synergy: Renewable Energy

Former St. Croix Alumina Plant, St. Croix

Remedy implementation

- Extracting and transferring commingled oil and groundwater incrementally via:
  - 24 solar panels powering submersible pumps
  - Four wind-driven electric generators powering submersible pumps, and four wind-driven compressors
  - In-well solar "sippers" with integrated compressors deployable where needed
- 100% off-grid operation
  - Using on-demand, direct-drive power instead of continuous pumping system to recover fluids
  - Avoided $100K cost to connect to existing grid

According to the U.S. EPA Re-Powering America's Land initiative, more than 400 renewable energy projects have been completed on formerly contaminated lands, landfills and mine sites.

Mitigation of GHG emission

Site Example of Synergy: Revegetation

Ballard Mine site, Idaho

Record of decision (ROD) components

Carbon sequestration across 500 acres

- Design and construction of evapotranspiration (ET) cover
  - » Prevents contaminant migration or entrance to shallow aquifer due to contact between waste rock and rainwater/snowmelt
  - » Promotes clean runoff while preventing erosion
  - » Stores water during wet periods and releases water to atmosphere during dry periods
- Upper cover layer of native seed mixes and vegetation
  - » Provides roots penetrating most of vertical cover profile without penetrating waste rock
  - » Slows flow of stormwater and snowmelt runoff
  - » Limits soil erosion
  - » Requires minimal maintenance
  - » Provides wildlife habitat
  - » Avoided $100K cost to connect to existing grid

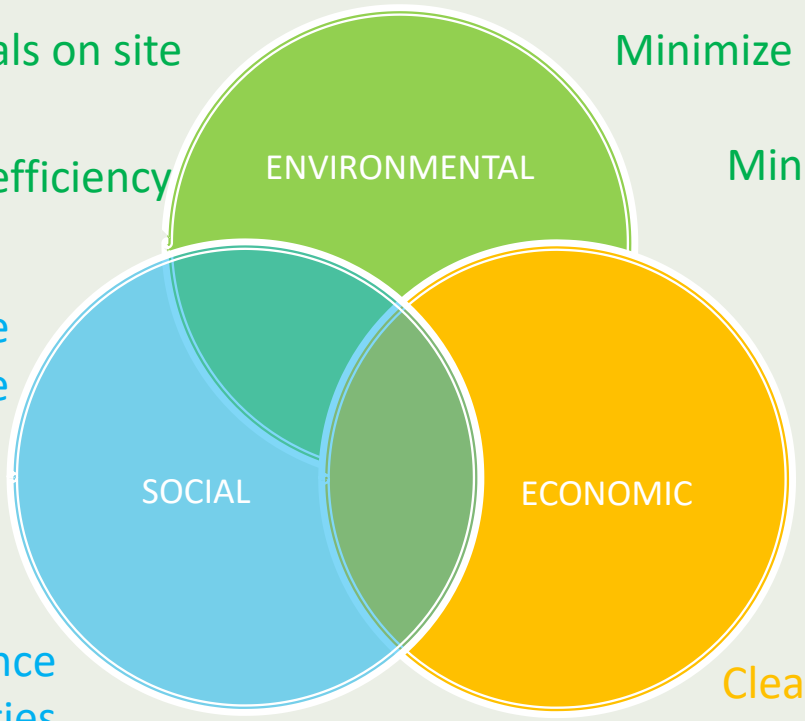
Site Examples of Synergy: Stormwater Management

Integrated site remediation and reuse planning

- **Continental Steel Corp. – Kokomo** (Indiana)
  - » Reuse of an excavated 4-acre former quarry pond as a new stormwater retention basin for the municipality's combined sewer system
- **Pharmacia & Upjohn Company LLC Site** (Connecticut)
  - » Six-acre constructed wetland for long-term stormwater management across 78 acres formerly used for manufacturing, through planning with non-profit environmental groups
- **Murdock Groundwater Plume Site** (Nebraska)
  - » Vegetated berm along a meandering basin designed to detain routine stormwater and withstand a 100-year flood, as part of removal actions to address contamination from a nearby grain storage facility

Erosion prevention and water storage

Sustainability Principles in Cleanup Programs Now and in the Future…



Protect public health and the environment now and for future communities

Ecosystem Services: A Currency for Green Remediation, Resilience and Sustainability

- Examples of ecosystem services:
  - Sequester carbon
  - Provide wildlife habitat
  - Reduce wind and water erosion
  - Protect water resources
  - Create green space and corridors
  - Improve property values and aesthetics

Lower Basin of Coeur d'Alene River Superfund site in northern Idaho

- Examples of U.S. guidelines:
  - U.S. EPA 2020 *National Ecosystem Services Classification System (NESCS) Plus* framework
  - U.S. EPA *Engineering Forum Issue Paper: Ecosystem Services at Contaminated Site Cleanups*
  - U.S. Department of Defense (DOD) *Value and Resiliency of Ecosystem Services on Department of Defense Lands*, a methodology for estimating ecosystem service benefits to the public and improving resilience of DOD installation operations

Identify
Measure
Quantify
Value
Account

Links to More Information

Green Remediation:

https://www.epa.gov/greenercleanups

https://www.epa.gov/superfund/superfund-green-remediation

https://clu-in.org/greenremediation/

Climate Resilience:

https://www.epa.gov/superfund/superfund-climate-resilience

Ecosystem Services:

https://www.epa.gov/eco-research/national-ecosystem-services-classification-system-nescs-plus

https://www.epa.gov/sites/production/files/2017-09/documents/ecosystem_services_at_contaminated_site_cleanups_ef_issue_paper.pdf

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Infrastructure-Resiliency/Vulnerability-and-Impact-Assessment/RC18-1605/RC18-1605

Green Infrastructure:

https://www.epa.gov/green-infrastructure

Renewable Energy:

https://www.epa.gov/re-powering

Superfund Remedy Report:

https://www.epa.gov/remedytech/superfund-remedy-report

Brownfields:

https://www.epa.gov/brownfields/brownfields-program-environmental-and-economic-benefits

https://www.epa.gov/land-revitalization/climate-smart-brownfields-manual

Thank you

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