Optimization Part 4: Green & Sustainable Remediation (GSR) Guidance

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Presentation Overview

- ► GSR as Part of Optimization
- GSR Tracking in NORM
- GSR Guidance Document
  - GSR Metrics (Section 2.0)
  - Metric Calculation Methods and Tools (Section 3.0)
  - GSR During Site Characterization (Section 4.0)
  - GSR During Remedy Selection (Section 5.0)
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GSR as Part of Optimization

Navy GSR Guidance describes how to incorporate GSR into cleanup within the NCP framework

- Remain focused on cleanup goals, budget, and RIP/RC dates
- NAVFAC optimization policy requires optimization and sustainability analysis throughout the ER process
- Use metrics, tools and general footprint reduction methods for each phase of the process

GSR as Part of Optimization (cont.)

- **Select remedies/technologies that will work and are appropriate**
- **Optimize the remedy**
- **Understand the footprint of the remedy**

Take-Home Point:
An Optimized Remedy is a Green and Sustainable Remedy

Select remedies/technologies that will work and are appropriate

Technologies that fail to meet the established performance objectives and remedies that are not proving to be sufficiently protective of human health and the environment are not sustainable

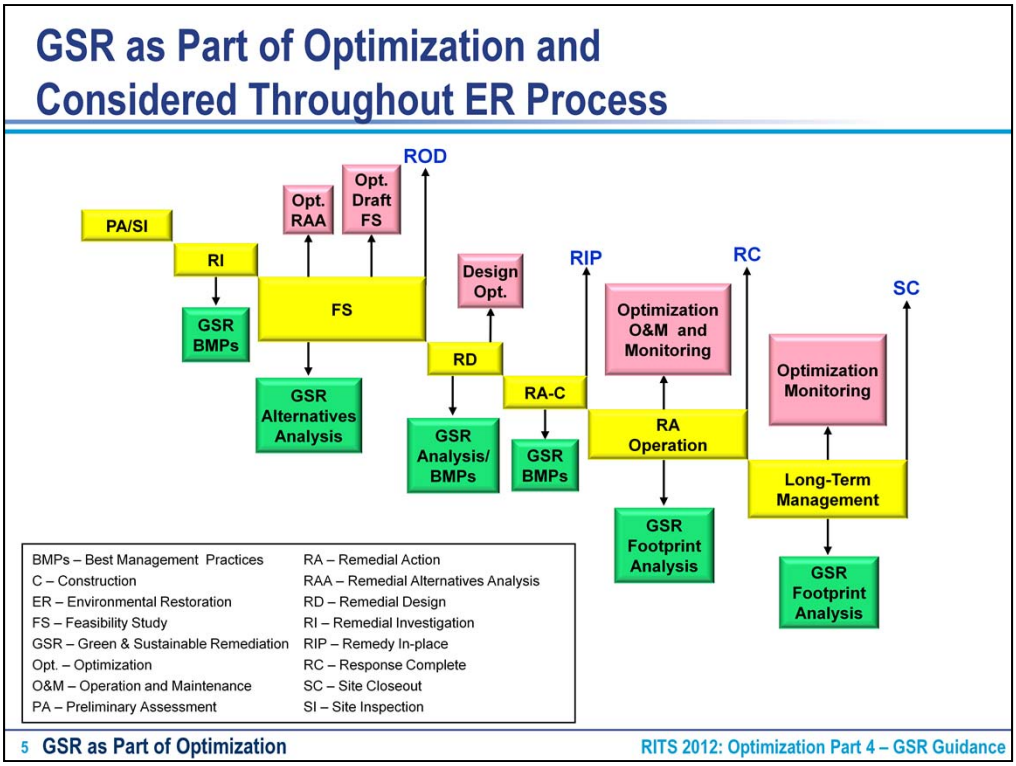
Optimize the remedy

An optimized remedy is a green and sustainable remedy

Understand the footprint of the remedy

The footprint of a remedy must be understood before it can be efficiently reduced

Small steps are ok when bigger steps are not acceptable or appropriate. If stakeholders are not able to accept a whole re-do at a site, make recommendations and implement acceptable recommendations rather than doing nothing.



The yellow boxes are the steps of the CERCLA process.

The pink boxes signify where optimization is done during the CERCLA process.

The green boxes signify where GSR is done during the CERCLA process.

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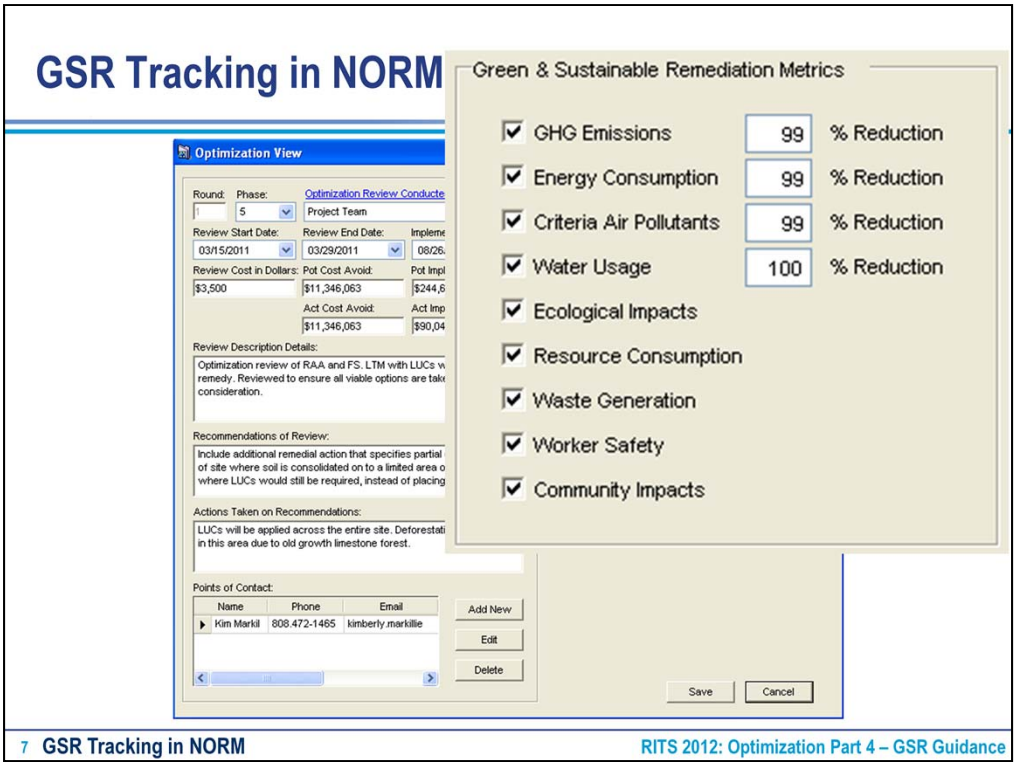

Optimization Policy requires GSR tracking in NORM.

The NORM Optimization Module has been updated to track GSR metrics.

The Optimization Module tracks the following sustainable actions:

- Minimized energy usage and increased energy efficiency
- Maximized recycling, reuse and reduction of materials, including waste
- Preserved natural resources (water)
- Minimized emissions, including greenhouse gases

GSR Tracking in NORM (cont.)

- For Fall 2011, 10 sites reported GSR related information
  - 6 sites reported % reductions for the metrics
- Optimization/GSR Module will ultimately track the following sustainable remedial technologies:
  - Monitored natural attenuation
  - *In situ* bioremediation
  - Engineered wetlands
  - Permeable reactive barriers, including biowalls
  - Stabilization/solidification using soil amendments

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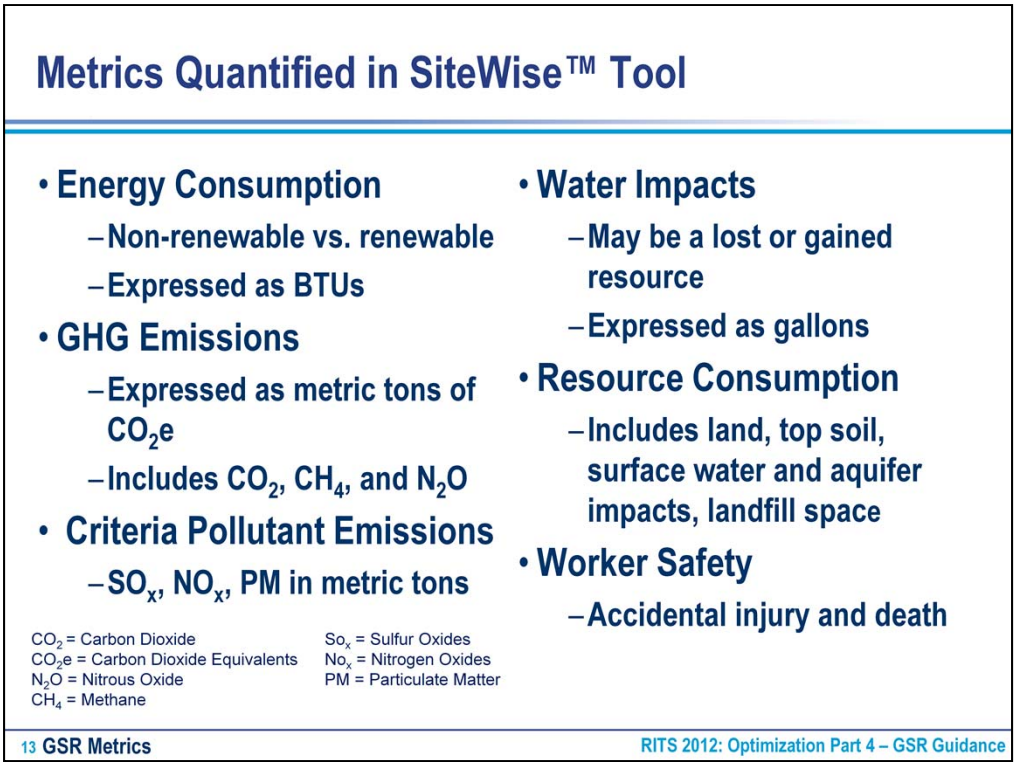
GSR Metrics (Section 2.0)

- Eight GSR metrics identified in the Navy Fact Sheet (2009)
  - Energy consumption
  - Greenhouse gas (GHG) emissions
  - Criteria pollutant emissions
  - Water impacts
  - Ecological impacts
  - Resource consumption
  - Worker safety
  - Community impacts

- List of metrics can be modified to fit specific site circumstances



From NAVFAC GSR Fact-Sheet

"**Energy Consumption: Consumption of energy from nonrenewable** versus renewable sources is an important metric because of the need to conserve the U.S. energy supply and reduce dependence on foreign sources of energy. Energy consumption also results in the generation of greenhouse gases (GHGs). Activities resulting in energy consumption include: on-site electrical use, fuel consumed for on-site equipment and transportation, and energy used for the production of consumables associated with the remedy.

GHG Emissions: Quantification of GHG emissions is also an important metric because of growing concern for climate change. The internationally accepted norm is to consider direct GHGs that include carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) to develop GHG emission inventories. A standard DoD-wide approach for conducting GHG inventories is being developed. On April 17, 2009, the EPA formally declared GHGs as major air pollutants with adverse human health and environmental effects. EPA is considering regulating these gases under the Clean Air Act. Activities that result in GHG emissions include: equipment and electrical use on site; transportation of personnel, material, and equipment; and production of consumables associated with the remedy.

Criteria Pollutant Emissions: Air emission of criteria pollutants, regulated by the Clean Air Act of 1970, can cause smog and adverse health effects such as asthma, bronchitis, lung cancer, and eye irritation. Criteria air pollutants include: sulfur oxides (SOx), oxides of nitrogen (NOx), particulate matter (PM), carbon monoxide (CO), ozone, and lead due to various activities such as transportation, electrical usage, and heavy machinery and equipment use during remedy implementation.

Water Impacts: Water consumption can be evaluated both qualitatively and quantitatively. Water can be a lost resource if water from an aquifer is wasted or conversely as a gained resource if contaminated water is treated and re-injected into the aquifer for beneficial use. In addition, water is consumed to produce electricity and manufacture consumables that may be used during remedial activities"

Resource Consumption: The resource consumption metric tracks consumption of resources that are not specifically identified in other metrics such as landfill space occupied by hazardous and non-hazardous waste produced during remedial action or amount of top soil brought to a site for backfill.

Worker Safety: Worker safety/accident risk is the risk of fatality or injury of carrying out a specific task of a remedial activity. The guiding principle of any activity undertaken by DON is to "operate safely". Therefore, worker safety is crucial and is also a part of NAVFAC's strategic plan. During remedial action operations, higher risk activities include working around heavy equipment and machinery, and transportation."

Metrics Evaluated Outside of SiteWise™ Tool

- Ecological Impacts
  - Invasive species, habitat destruction, ecosystem structure shift
- Community Impacts
  - Noise, traffic, odor, dust

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Metric Calculation Methods and Tools (Section 3.0)

- SiteWise™
- Sustainable Remediation Tool (SRT™)
- Other tools are also available and can be applied in cases where equipment, materials or metrics are not included in SiteWise™ or SRT™
- Net Environmental Benefit Analysis (NEBA)

SiteWise™ and SRT™ were developed to quantify the effects of remedial actions

SiteWise™ GSR Tool

- SiteWise™ developed jointly by Battelle, Navy, and Army Corps of Engineers (USACE)
- Series of Excel™ spreadsheets to calculate the environmental footprint of remediation in terms of sustainability metrics
- User-friendly *streamlined life-cycle analysis (LCA)*
  - Considers *life-cycle impacts* from remedial actions
- Version 2 released to public in June 2011
- Posted to the NAVFAC GSR Portal
  - SiteWise™ is being applied industry wide: Navy, Army, USACE, U.S. EPA, State regulators, and private industry

SiteWise™ Input Sheet and Output Examples

This worksheet allows the user to define material production, transportation, equipment use, and residual handling variables for the remedial alternative
Yellow cells require the user to choose an input from a drop down menu
White cells require the user to type in a value

MATERIAL PRODUCTION — For inputting data for other options in Material Production, please check this box.

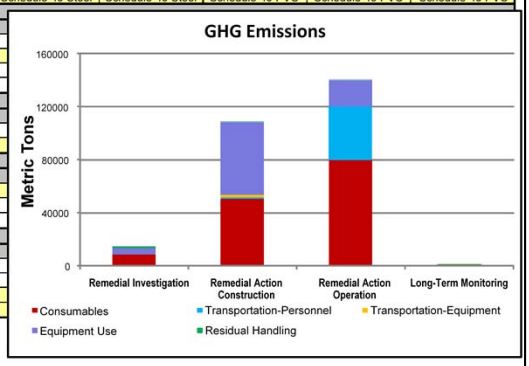
WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5
Input number of wells					
Input depth of wells (ft)					
Choose well diameter (in) from drop down menu	1/2	1/2	1/2	1/2	1/2
Choose material type from drop down menu	Steel	Steel	PVC	PVC	PVC
Choose specific material schedule from drop down menu	Schedule 40 Steel	Schedule 40 Steel	Schedule 40 PVC	Schedule 40 PVC	Schedule 40 PVC

TREATMENT CHEMICALS
- Input number of injection points
- Choose material type from drop down menu
- Input amount of material injected at each point (lbs)
- Input number of injections per injection point

GAC
- Input weight of GAC used (lbs)
- Choose material type from drop down menu

CONSTRUCTION MATERIALS
- Choose material type from drop down menu
- Input area of material (ft^2)
- Input depth of material (ft)

WELL DECOMMISSIONING
- Input number of wells
- Input depth of wells (ft)
- Choose well diameter (in) from drop down menu
- Choose material from drop down menu



Input sheet allows you to build the remedy. White input cells are user input such as number of wells or depth of wells. Yellow input cells are drop down pick-lists such as well diameter or well material type.

The output can be generated for each metric. Various other output examples can be seen throughout this presentation.

SiteWise™ Calculation Sheet

PUMP OPERATION- For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pumps or unused methods

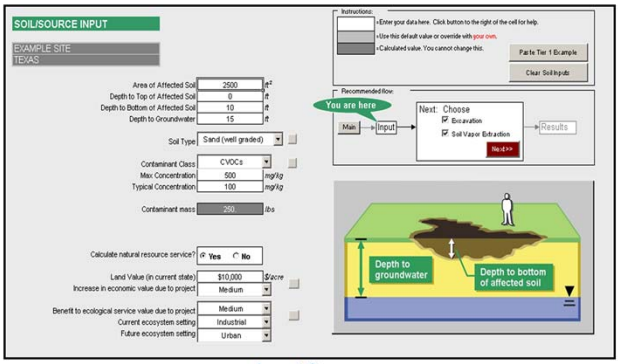
USER INPUT		Pump 1	Pump 2	Pump 3	Pump 4
Method 1 - IF NAME PLATE SPECIFICATIONS ARE KNOWN					
USER INPUT	*Input Pump horsepower (hp)*	0	0	1	5
USER INPUT	*Input Number of pumps operating*	1	0	2	6
USER INPUT	*Input Operating Time for each pump (hrs)*	10	0	3	7
	Input Pump Load	0.8	0.8	0.8	0.8
	Input Pump Motor Efficiency	0.9	0.9	0.9	0.9
Method 2 - IF PUMP HEAD IS KNOWN					
USER INPUT	*Input flow rate (gpm)*	0	0	0	0
USER INPUT	*Input total head (ft)*	0	25	0	0
USER INPUT	*Input Number of pumps operating*	0	1	0	0
USER INPUT	*Input Operating Time for each pump (hrs)*	0	4	0	0
	Input pump Efficiency	0.6	0.6	0.6	0.6
	Input specific gravity	1	1	1	1
	Pump horsepower (hp)	0.00	0.00	0.00	0.00
Method 3 - IF ELECTRICAL USAGE IS KNOWN					
USER INPUT	*Input Pump Electrical Usage (KWh)*	1000	0	0	0
Select Region					
USER INPUT	*Choose Region from Figure 1*	AKGD	AKMS	AZNM	CAMX
	CO_2 emission factor (lb/MWH)	1232	499	1311	724
	CH_4 emission factor (lb/MWH)	0.0256	0.02075	0.01745	0.03024
	N_2O emission factor (lb/MWH)	0.00651	0.00408	0.01794	0.00808
	NOx emission factor (lb/MWH)	2.480	6.791	2.111	0.618
	SOx emission factor (lb/MWH)	1.214	0.526	1.081	0.531
	ENERGY OUTPUT				
	Energy Usage (KWh)	1.0E+03	0.0E+00	4.0E+00	1.4E+02
	Energy Usage (MWH)	1.0E+00	0.0E+00	4.0E-03	1.4E-01
	Energy Usage (BTU)	8.5E+06	0.0E+00	3.4E+04	1.2E+06
	CO_2 OUTPUT				
	CO_2 emission (metric ton)	5.6E-01	0.0E+00	2.4E-03	4.6E-02
	N_2O emission (metric ton CO_2e)	9.2E-04	0.0E+00	1.0E-05	1.6E-04
	CH_4 emission (metric ton CO_2e)	2.4E-04	0.0E+00	6.6E-07	4.0E-05
	NOx and SOx OUTPUT				
	NOx emission (metric ton)	1.1E-03	0.0E+00	3.8E-06	3.9E-05
	SOx emission (metric ton)	5.5E-04	0.0E+00	2.0E-06	3.4E-05

TOTAL FROM PUMP OPERATION	
CO_2 Emission (metric ton)	**6.1E-01**
Energy Used (MWh)	**1.1E+00**
Energy Used (MMBTU)	**9.8E+00**
Water Usage (gal)	**5.8E+02**
NOx Emission (metric ton)	**1.2E-03**
SOx Emission (metric ton)	**5.9E-04**

A benefit of SiteWiseTM is that it is transparent. The calculation sheet with all inputs and assumptions can be viewed.

Sustainable Remediation Tool (SRT™)

- Developed by the Air Force Center for Engineering and the Environment (AFCEE)
- Excel™ based
- Two tiers of analysis with varying levels of detail
- Comprised of modules for various remedy types
  - Soil Remediation
    - Excavation
    - Soil vapor extraction (SVE)
    - Thermal treatment
  - Groundwater Remediation
    - Pump & treat
    - Enhanced bioremediation
    - Permeable reactive barrier (PRB)
    - *In situ* chemical oxidation (ISCO)
    - Long-term monitoring/monitored natural attenuation (LTM/MNA)



Input Screen

NEBA

- Net Environmental Benefit Analysis (NEBA) can be completed to quantify ecological impacts along with risk reduction and remedial costs.
- The units for NEBA are discounted Service Acre Years (dSAYs). It is a detailed calculation, which may be useful for some sites where ecological impacts are an important metric.
- Regardless of NEBA results, risk must be in an acceptable range. (10-4 to 10-6)

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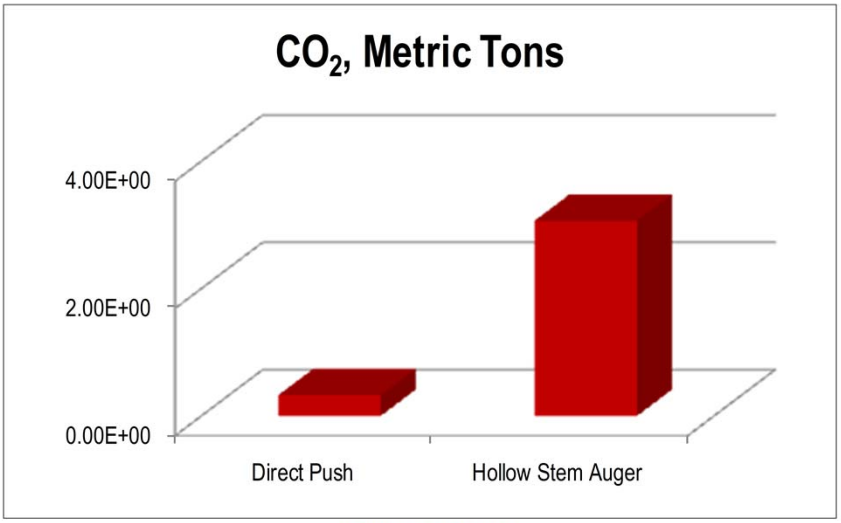
GSR During Site Characterization (Section 4.0)

- Primary impacts
  - Increased GHG and criteria pollutant emissions
  - Consumption of energy
  - Accident risk
- Reduce the site characterization footprint through:
  - Efficient data collection
  - Streamline characterization process
  - Efficient sampling techniques
  - Minimize and manage investigation derived waste (IDW)

Comparison of Direct Push vs. Hollow Stem Auger for 40 Hours



Courtesy of Battelle

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GSR During Remedy Selection (Section 5.0)

- Selecting the most sustainable remedy among those identified results in the greatest opportunity to lower the overall remedy footprint
  - The selected remedy must meet all applicable CERCLA or RCRA criteria
- When conducting a comparative GSR evaluation, ensure that the end point for each alternative is consistent
- In general, remedies that use passive systems and enhance natural processes will be most sustainable

GSR During Remedy Selection (cont.)

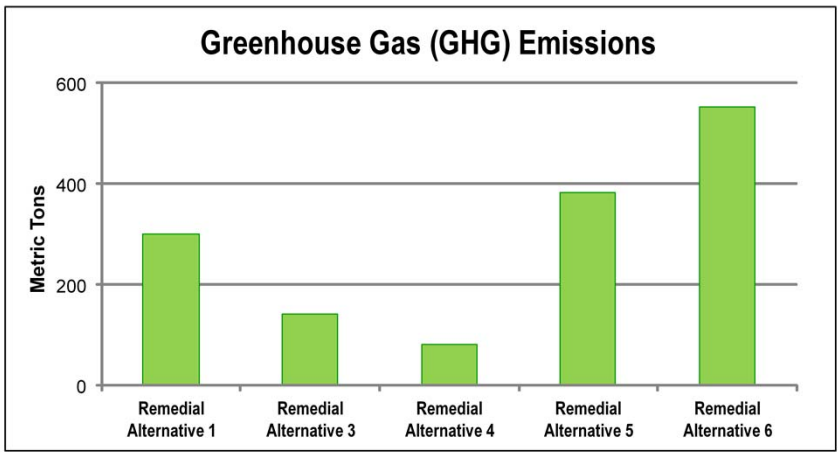
- Use of optimization techniques, such as optimizing remedial action objectives (RAOs), treatment trains, target treatment zones, performance objectives, and exit strategies will result in footprint reduction
- Guidance document includes section on incorporating GSR Metrics into the regulatory framework
- To date, U.S. EPA has not developed guidance for incorporating GSR into remedy selection

GSR During Remedy Selection (cont.)

Sustainability Metrics	Balancing Criteria					Modifying Criteria	
	Long-Term Effectiveness	Reduction in Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability	Cost	State Acceptance	Community Acceptance
Energy Consumption			X		X	X	X
GHG Emissions	X		X			X	X
Criteria Pollutant Emissions	X		X			X	X
Water Impacts/Use	X		X		X	X	X
Ecological Impacts	X		X			X	X
Resource Consumption	X		X		X	X	X
Worker Safety			X		X	X	X
Community Impacts			X			X	X
Cost of Remedy					X		

The guidance document includes this table of Sustainability Metrics mapped against the CERCLA criteria for remedy selection.

SiteWise™ Required During Remedy Selection



Example SiteWise™ Tool Output
Comparative Analysis for GHG Emissions from Remedial Alternatives

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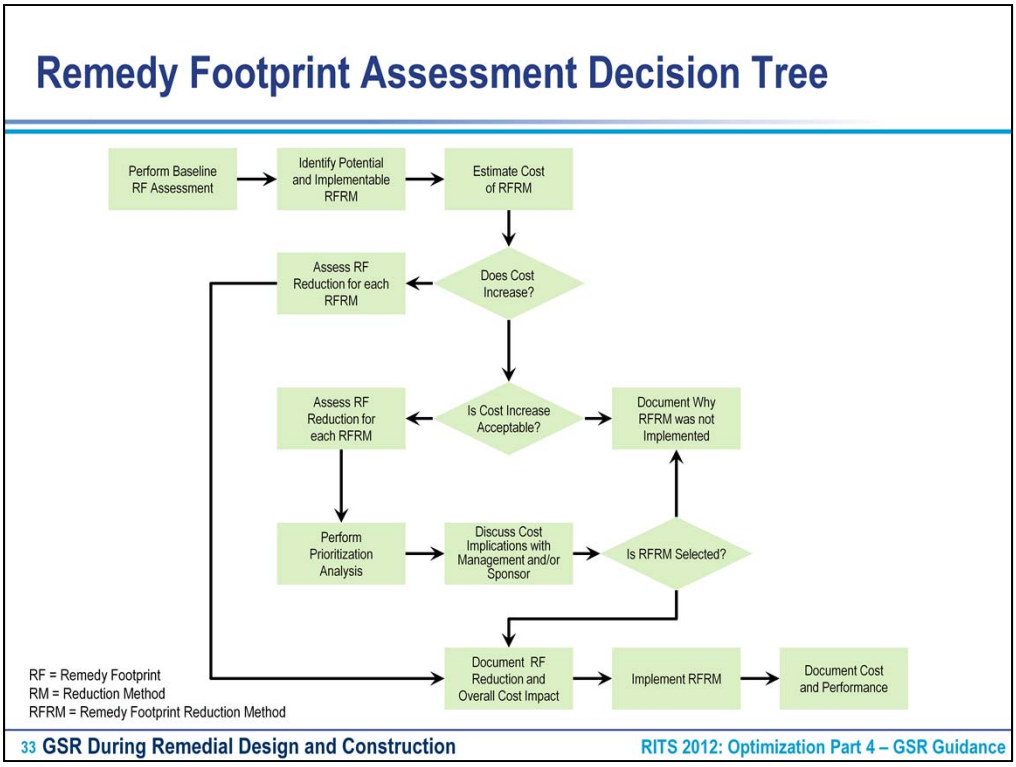
GSR During Remedial Design and Construction (Section 6.0)

- Update sustainability assessment for selected remedy
- Identify high footprint activities in remedial action
- Develop list of potential footprint reduction methods

Perform Cost and Footprint Sensitivity Analysis

- Consider life-cycle cost impacts
  - Footprint reduction methods may result in increased costs initially, but have a reduction in operating costs (e.g., energy, water, materials)
- Prioritize footprint reduction methods for implementation
- Include the selected footprint reduction methods in the remedial design



This decision tree reminds us to prioritize footprint reduction options, document costs, and involve management in footprint reduction method selection as appropriate.

GSR During Remedial Design and Construction (cont.)

- SiteWise™ can assist by comparing the sustainability impacts from various design alternatives
- U.S. EPA has published best management practices (BMPs) for green remediation design
  - Excavation and surface restoration
  - Pump and treat technologies
  - Bioremediation
  - Soil vapor extraction and air sparging
  - Clean fuel and emission technologies

Many Design Inefficiencies Result From:

- Designing for initial site conditions only and not accounting for changes over the lifecycle of the project as concentrations decrease
- Over-designing equipment rather than carefully designing equipment for the intended purpose
- Reducing the up-front costs by installing lower-cost but less energy-efficient devices

Design Inefficiencies Can Result in the Following Sustainability Impacts

- Inefficient power usage by over-sized equipment
- Continuously running equipment
- Unnecessary unit operations
- Excess volume of chemicals injected
- Inefficient injection strategy
- Too many monitoring locations

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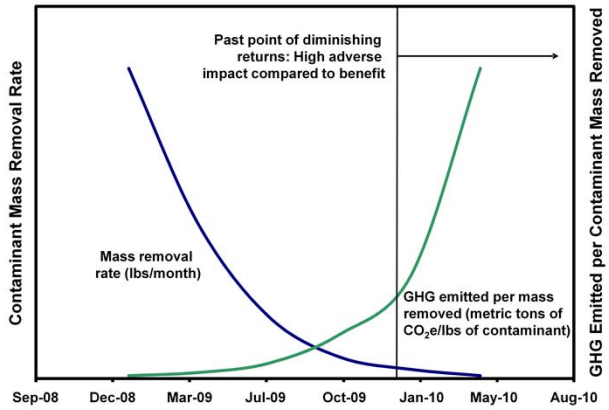
GSR During RA-O and LTMgt (Section 7.0)

- Steps for implementing GSR during RA-O
  - Include GSR as part of periodic optimization review
  - Perform sustainability assessment for existing systems and alternative remedial options
  - Evaluate potential footprint reduction techniques for recommended remedial approach
  - Implement footprint reduction techniques as appropriate
  - Document footprint reduction activities
  - Track contaminant removal with GSR metrics to implement exit strategies and support system shut-down recommendations
- Follow a similar approach for incorporating GSR into optimization of the LTMgt program

GSR in LTMgt includes activities such as passive sampling, telemetry, and monitoring optimization have the greatest sustainability impact on LTM

Performance Objectives and Exit Strategies

- **Establish performance objectives and exit strategies to prevent a system from operating beyond its point of diminishing returns**



Similar figures have been used to look at cost, but looking at sustainability metrics may carry more weight with some team members.

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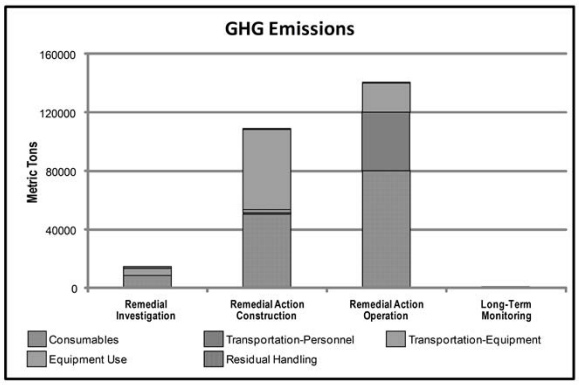
General Footprint Reduction Methods (Section 8.0)

- Identify options that achieve the greatest reduction in the overall footprint, while meeting the remedial goals and minimizing cost impacts
- A baseline sustainability assessment identifies those elements/activities of the remedy with the greatest impacts
- Resources should be focused on activities with the greatest sustainability impacts to ensure the greatest benefit is achieved

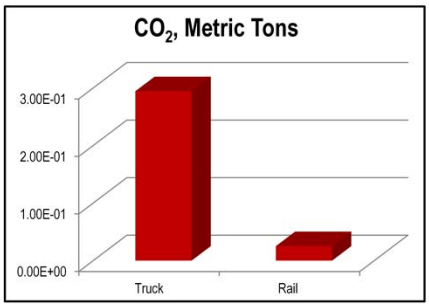
Example SiteWise™ Output

- Demonstrates how a baseline GSR assessment can be used to identify the remedial activities with the greatest sustainability impacts



General Footprint Reduction Methods (cont.)

- Alternative fuels
  - Biodiesel for heavy equipment
  - Electric or hybrid transportation
- Renewable energy
  - Photovoltaics
  - Wind power
  - Recovery of landfill gas
  - Microturbines
- Alternative transportation
  - Use rail transportation if available
- After-treatment technologies for diesel engines
  - Diesel oxidation catalysts
  - Diesel particulate filters
  - Selective catalytic reductions
  - Diesel multistate filters



Comparison of Truck vs. Rail for Transportation of 10 Tons for 100 Miles

General Footprint Reduction Methods (cont.)

- Energy conservation
  - High-efficiency or premium-efficiency motors
  - Proper sizing of equipment
  - Variable frequency drives
  - Pulse operation, e.g., *in situ* air sparging/soil vapor extraction (IAS/SVE)
- Resource conservation and green materials
  - Consider Leadership in Energy and Environmental Design (LEED) guidelines during construction and landscaping activities
  - Refer to green building standards in the DoD Sustainable Buildings Policy
- Improved injection methods for *in situ* remedies
  - A large component of an *in situ* remedy footprint is typically related to the manufacturing of the material consumed
  - Optimize the injection program to efficiently use chemicals and equipment

General Footprint Reduction Methods (cont.)

- Procurement
  - Integrate green objectives and criteria in the contract
  - Example: To the extent practicable, the contractor shall evaluate and implement green remediation strategies and applications in the performance of the requirements of this work assignment to maximize sustainability, reduce energy and water usage, promote carbon neutrality, promote industrial materials reuse and recycling, and protect and preserve land resources.
- Project management
  - Reduce transportation by scheduling simultaneous tasks
  - Employ local contractors and subcontractors
  - Host virtual meetings to avoid unnecessary travel
  - Request electronic submittals

General Footprint Reduction Methods (cont.)

Activity	Impacts	Footprint Reduction Method
Excavation and backfilling	• Soil erosion • Consumption of energy • Transportation of air-borne contaminants • Ecosystem disturbance	• Local disposal facility • On-site treatment and soil reuse • Improved CSM and/or risk analysis to optimize excavation volume
Sediment dredging, dewatering, and disposal	• Emissions of GHGs and criteria air pollutants • Consumption of energy • Ecosystem disturbance	• Passive dewatering rather than mechanical • Hydraulic dredging directly to disposal facility or barge
Transportation of materials and waste	• Emissions of GHGs and criteria pollutants • Consumption of energy • Accident risk, traffic	• Rail transportation • Alternative fuels • After treatment emission controls

The guidance document includes a larger version of this table with more activities addressed.

Footprint Reduction Example NAWS China Lake CA

- Compare operation of two types of solar-powered skimmers
- Vendor estimates that each solar-powered unit saves ~0.15 lbs of CO_2 per hour of continuous operation compared to electrical powered units
- The passive skimmer system will also result in reduced O&M activities compared to the original mobile product recovery system, resulting in additional remedy footprint reductions

Project Background

From 1945 to 1988, fire fighting training was performed at a fire fighting training area (FFTA) located in the southwest portion of Site 44 at the point of interest (POI) 197 Fuel Dump. The FFTA consisted of one pad, where techniques for fighting petroleum fires were practiced. Unburned gasoline, JP-5 fuel, and water would evaporate or flow off the pad and percolate into the surrounding soil. Site 44 also encompasses POI 197, called the "Water Road Fuel Dump," located 750 ft east of the old FFTA. Based on site records and aerial photographs, fuels may have been released at POI 197 in the 1960s and 1970s. Free product is present in monitoring and extraction wells at Site 44. A mobile product recovery system (MPRS) has been utilized for free product recovery at Site 44 since 2000. The Navy performed a pilot test in 2008 to evaluate vacuum-enhanced skimming (VES) and other skimming approaches. Based on the results of the testing, passive skimming was identified as the appropriate technology to address the free product at Site 44. A Remedial Design prepared for the Navy recommended installation of a solar-powered passive skimming system to take advantage of the readily available solar energy.

GSR Evaluation

Several skimmer designs were evaluated prior to selecting two designs for installation. Vendor estimates indicate that each solar-powered unit saves approximately 0.15 pounds of CO_2 per hour of continuous operation compared to traditional electrical powered units. Additionally the passive skimming system will result in reduced O&M activities compared to the MPRS, resulting in further reduction in the remedy footprint associated with personnel travel and site visits.

Footprint Reduction Example Adak Naval Complex AK

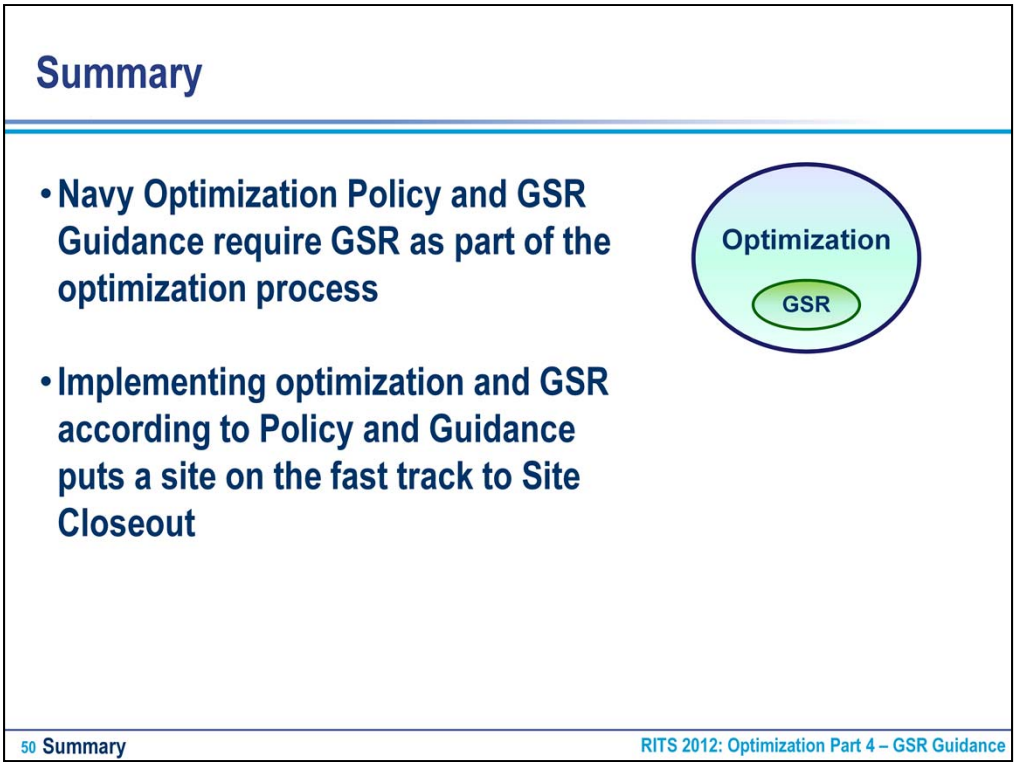
- Three petroleum areas requiring free-product recovery identified in remote locations
- Mobile system constructed including recovery pumps and product storage tanks
- Power not readily available in all locations
- Mobile wind-powered turbines designed to power the recovery system
- Turbines power a 1,000-watt generator that can produce 12 volts of electricity, enough to power the recovery pumps

Project Summary A total of three petroleum areas requiring free-product recovery were identified at the former Adak Naval Complex, AK. Rather than constructing several systems in remote locations, mobile systems were constructed and moved from site to site. Obtaining a power source also presented a challenge for some of the remote site locations. Equipment included in the free-product recovery system was recovery pumps and product recovery and storage tanks. The remote location and severe climate of Adak did not only present challenges, but also opportunities for innovation to design and implement energy efficient and sustainable remedial systems. To address the challenges presented in this case, mobile wind-powered turbines were designed to power the free-product recovery systems.

GSR Strategy Employed Construction of a renewable energy system for operation of a remediation system is often not cost-effective. However, at a remote site such as this where a power source is not always available, the cost of bringing in power lines can off-set the cost of a renewable energy system. At the former Adak Naval Complex, mobile wind turbines were designed and constructed to generate power for the free-product recovery systems. The mobile wind turbines power a 1,000-watt generator that can produce 12 volts of electricity, enough to power the free-product recovery pumps. In addition to eliminating electrical infrastructure costs, wind power is a clean source of energy.

Presentation Overview

- GSR as Part of Optimization
- GSR Tracking in NORM
- GSR Guidance Document
  - GSR Metrics (Section 2.0)
  - Metric Calculation Methods and Tools (Section 3.0)
  - GSR During Site Characterization (Section 4.0)
  - GSR During Remedy Selection (Section 5.0)
  - GSR During Remedial Design and Construction (Section 6.0)
  - GSR During RA-O and LTMgt (Section 7.0)
  - General Footprint Reduction Methods (Section 8.0)
- ► Summary



Incorporate GSR throughout the remedial process

GSR allows you to:

- identify methods for using natural resources and energy efficiently
- reduce negative impacts on the environment
- minimize or eliminate pollution at its source
- reduce waste to the greatest extent possible

GSR improves the remedial action by maximizing the overall environmental benefit while still meeting the existing requirements for site cleanup

Resources

- GSR Web Page
- Provides useful links on available information, case studies, and web tools on sustainable practices for remediation
  - Guidance and Policies
  - SiteWise™
  - Link to other GSR resources including clu-in.org for
    - U.S EPA's Green Primer, 2008
    - U.S. EPA's Superfund Green Remediation Strategy, 2010
    - Various U.S. EPA Green Remediation BMPs