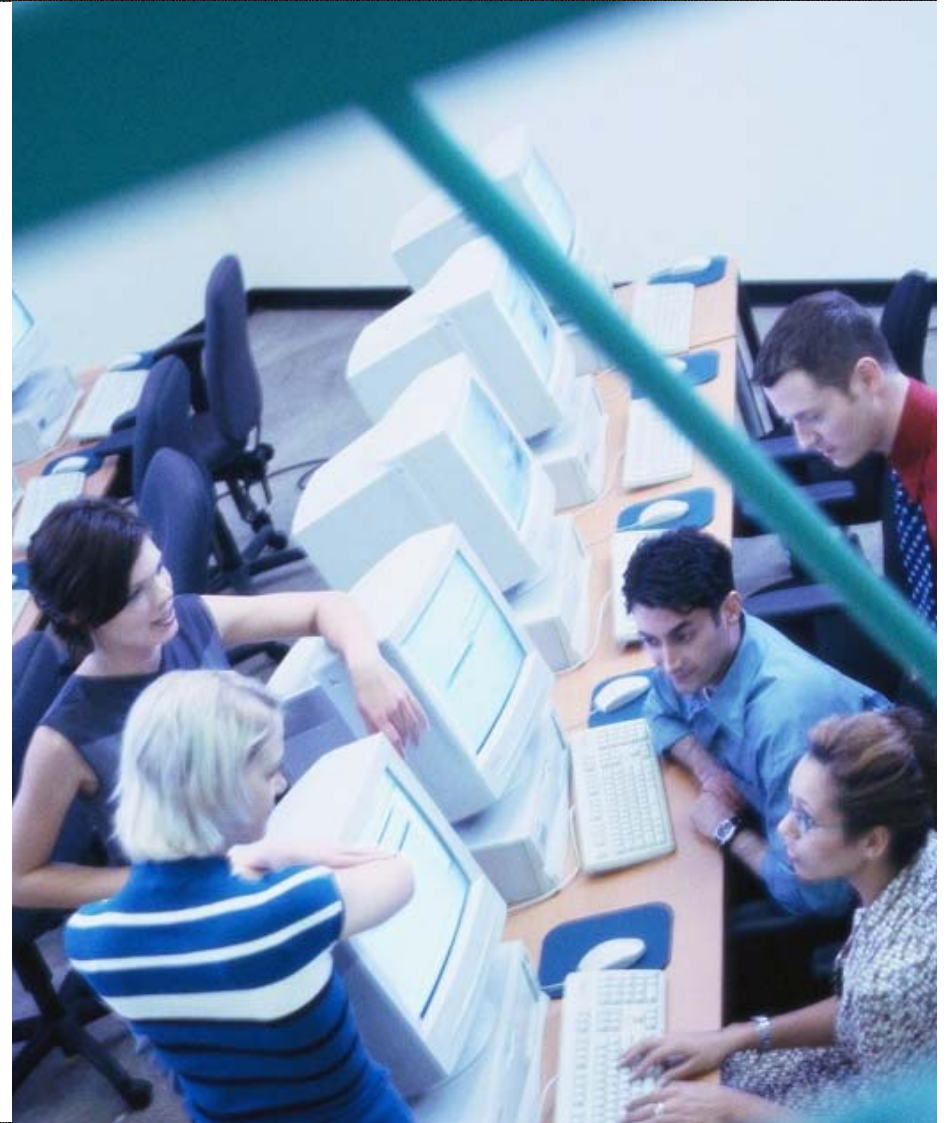


The Varied Landscape of Tools for Green and Sustainable Remediation

Justin Kelley

Overview of this Session

- Introduction
- Summary of the tools available
- Considerations when selecting tools
- Deep Dive on 3 publicly available tools
 - Sitewise
 - SRT
 - AECOM Holistic Tool
- Comparison of the tools
- Takeaways



Components of Sustainable Remediation



ECONOMIC

Remedial actions that reduce site risks & provide economic benefits.

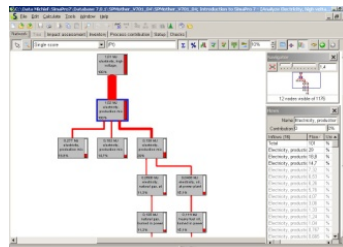
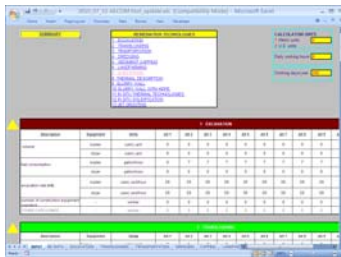
ENVIRONMENTAL

Technologies, approaches & designs that reduce the environmental footprint of site cleanup.

SOCIAL/COMMUNITY

Community engagement & adaptive reuse that provides a benefit to the community.

Off-the-Shelf Tools for Selecting Metrics & Completing Environmental Footprint Calculations



- Public Domain/Freeware
 - Sustainable Remediation Tool (**SRT™**)
 - **SiteWise™**
 - Green Remediation Evaluation Matrix (Cal DTSC)
 - Illinois Greener Cleanup Matrix
 - AFCEE Performance Tracking Tool
 - EPA Region 9 Green Remediation Analysis

Off-the-Shelf Tools for Selecting Metrics & Completing Environmental Footprint Calculations

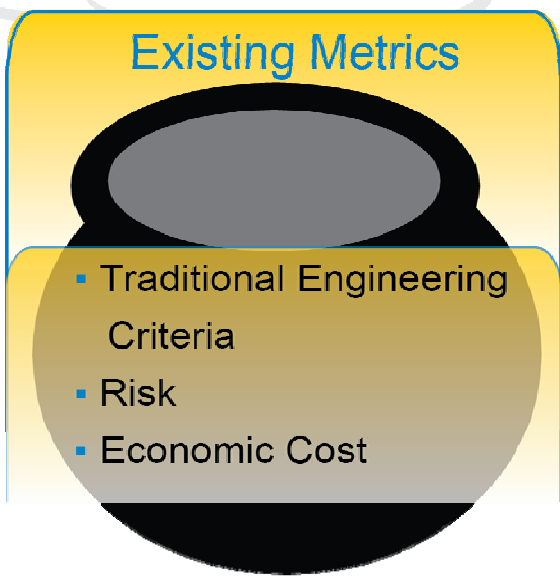
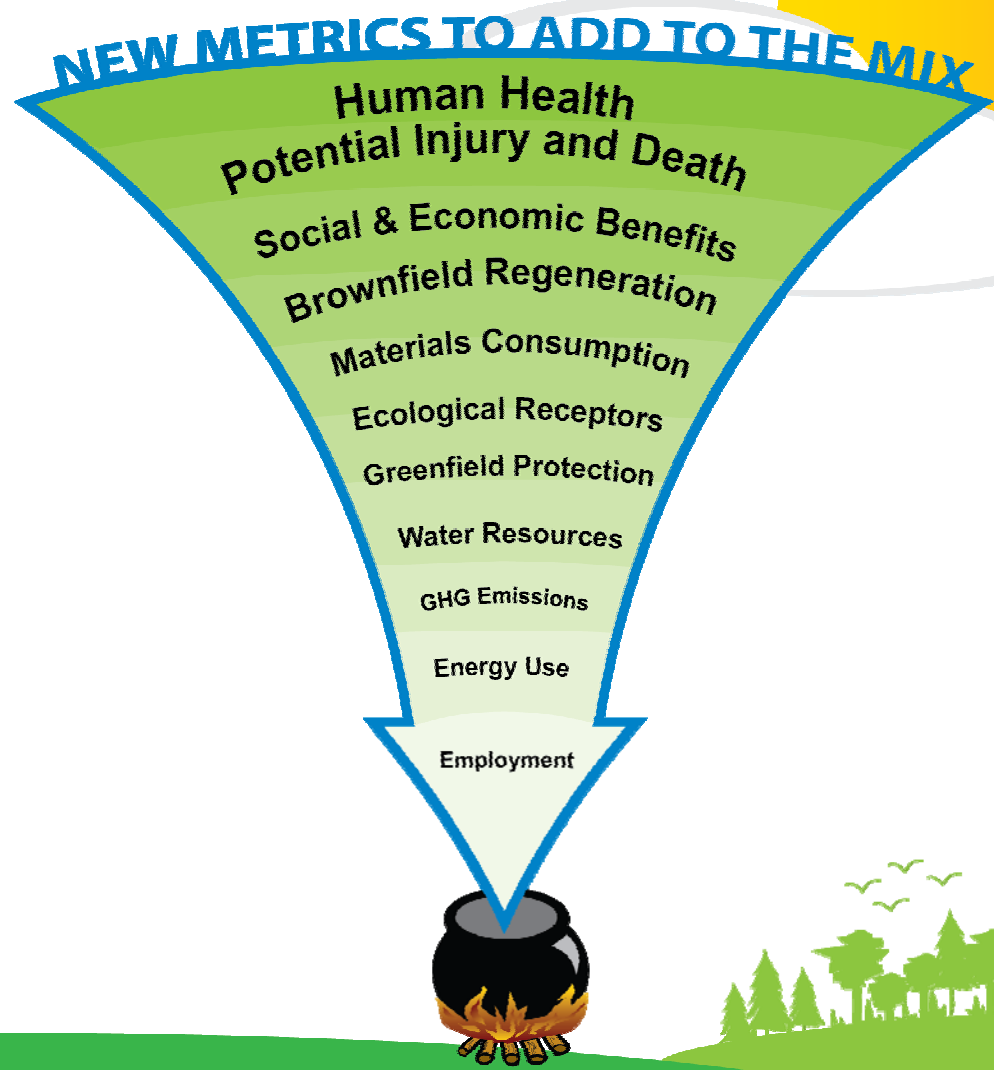
- Proprietary Tools
 - **AECOM GSRx BMP Tool**
 - **AECOM Holistic Tool**
 - Arcadis BalancE3
 - BP Sustainability Assessment Tool
 - **Golder GoldSET**
 - Haley and Aldrich – Sustainable Remediation Assessment Tool
 - Malcolm Pirnie Clean Me Green
 - **PWGSC SD Tool**
- Lifecycle Assessment (LCA) Tools
 - Gabi
 - Simapro
- **ADDITIONAL TOOLS ARE IN DEVELOPMENT!**

Usage Considerations in Selecting or Designing a Tool

- Scope of Footprint Analysis
 - Single site
 - Enterprise/portfolio wide
- Frequency of Footprint Analysis
 - One-time for a feasibility study
 - Quarterly/annually for Corporate or regulatory reporting
- Level of skill/training required to use the tool
- Resource constraints
 - Financial/budget
 - Timeframe



Which metrics, how to measure?



New Metrics Represent Externalities Not Generally Considered By Current Process

Example Metrics Used in Various Evaluation Tools

- Safety (risk of remedy)
 - Risk of death/injury in traffic accident
 - Risk from fugitive dust (due to particulate matter, contaminants)
- Natural resources impacts
 - Groundwater, surface water, natural resources
 - Effects of dredging or capping
 - Relationship to Natural Resources Injury, Damages
- Energy use
 - Conservation, alternative sources, energy independence
 - Moving contaminants from one place to another
- Economics
 - Cost, effect on home prices, redevelopment, etc.
- Greenhouse Gas Emissions
 - CO₂ , NO_x , CH₄

Common Environmental Metrics: Positives and Negatives

Core Element	Evaluate Negatives	Evaluate Positives
1. Energy	Total energy use: natural gas (BTU), electricity (kWh), fuel (gallons)	Renewable energy applied (KWh saved by solar, wind, geothermal, biomass energy)
2. Air	Total air pollutants, GHG emissions (CO ₂ e), dust	GHG emission reductions (CH ₄ to CO ₂)
3. Water	Total water use (gallons or liters)	Water recovery (gallons or liters)
4. Land	Total land disturbed (acres); noise and lighting disturbances	Land reuse (acres/; ecosystems enhanced)
5. Materials & Waste	Waste generated (tons)	Materials reused (tons)

SiteWise™ Tool

- What is SiteWise™
 - Series of Excel spreadsheets to calculate impacts of remediation in terms of sustainability metrics
 - Originally developed by Battelle but further development was performed jointly with the Navy and USACE in a collaborative effort
 - Tool available to the public as a freeware
- Tool Framework
 - Remedial technologies are broken down into activities or modules
 - User builds-up overall remedy using different modules as appropriate
 - Building block approach optimizes tool flexibility
 - Tool can be used for a variety of remedial technologies, portions of technologies, or individual actions

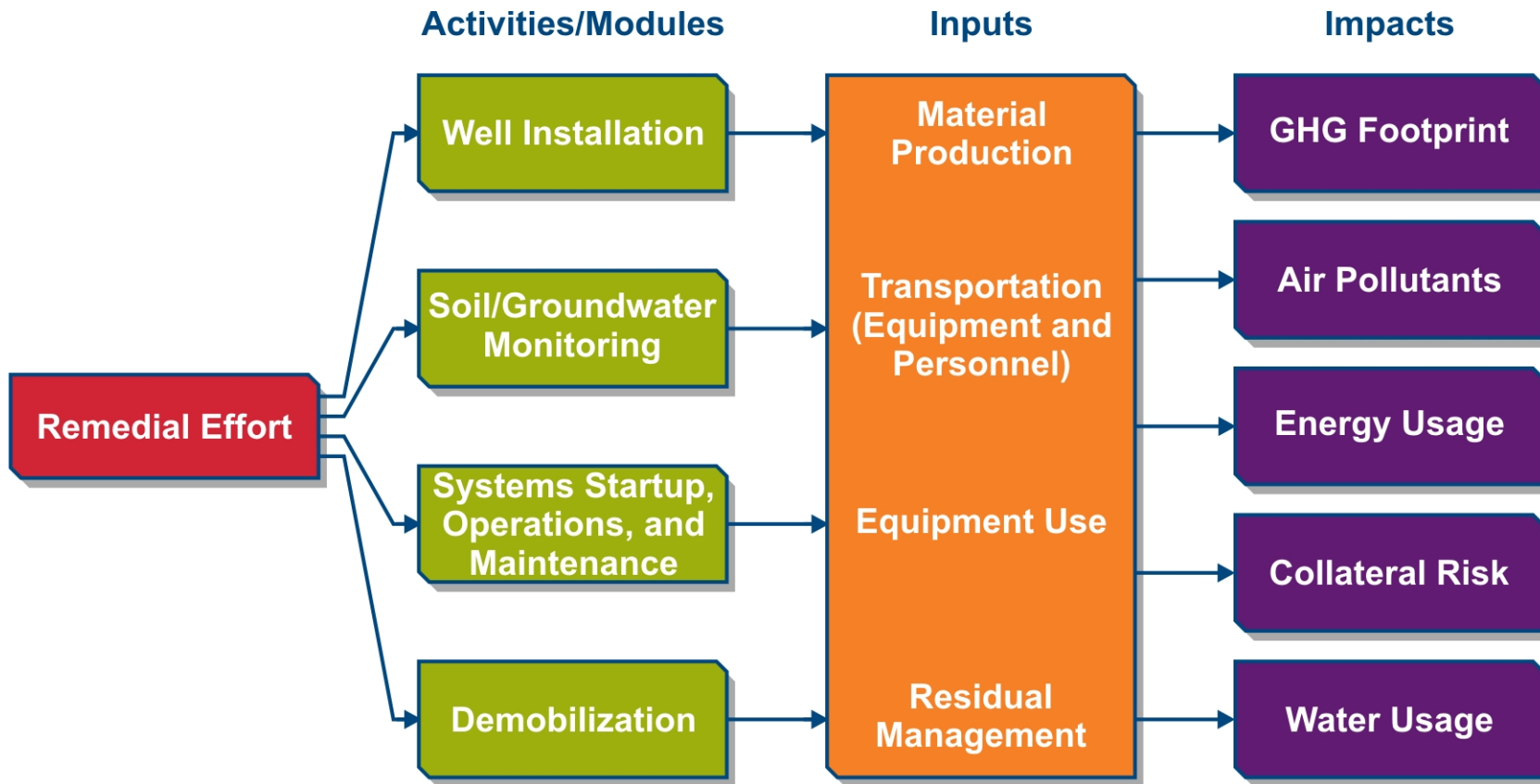
SRT™ Tool

- What is SRT™
 - Series of Excel spreadsheets to calculate impacts of remediation in terms of sustainability metrics
 - Developed by AECOM/GSI for AFCEE for use on its sites
 - Released to the public as a freeware
- Tool Framework
 - Series of 8 technologies selected based on AFCEE's frequency of application
 - Tiered approach
 - Tier 1 – Designed to be completed in 1-2 hours using “rules of thumb”
 - Tier 2 – Designed to be completed in 1-2 days with user defined inputs
 - Version 3 just released
 - Links AECOM's RACER™ software to allow for direct input to SRT

AECOM Holistic Tool™

- What is the AECOM Holistic Tool™
 - Series of Excel spreadsheets to calculate impacts of remediation in terms of sustainability metrics
 - Originally developed by AECOM Italy for use on an initial project site
 - Tool has been expanded to include additional technologies for use on additional project sites
 - Proprietary Tool
- Tool Framework
 - Remedial technologies are broken down into activities or modules
 - User builds-up overall remedy using different modules as appropriate
 - Building block approach optimizes tool flexibility
 - Tool can be used for a variety of remedial technologies, portions of technologies, or individual actions

Battelle SiteWise™ Tool Framework



Battelle SiteWise™ Interface

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 <i>Input Pump horsepower (hp)</i>	0	0	1	5
USER INPUT <i>Input Number of pumps operating</i>	1	0	2	6
USER INPUT <i>Input Operating Time for each pump (hrs)</i>	10	0	3	7
<i>Input Pump Load</i>	0.8	0.8	0.8	0.8
<i>Input Pump Motor Efficiency</i>	0.9	0.9	0.9	0.9
Method 2 - IF PUMP HEAD IS KNOWN				
USER INPUT <i>Input flow rate (gpm)</i>	0	0	0	0
USER INPUT <i>Input total head (ft)</i>	0	25	0	0
USER INPUT <i>Input Number of pumps operating</i>	0	1	0	0
USER INPUT <i>Input Operating Time for each pump (hrs)</i>	0	4	0	0
<i>Input pump Efficiency</i>	0.6	0.6	0.6	0.6
<i>Input specific gravity</i>	1	1	1	1
<i>Pump horsepower (hp)</i>	0.00	0.00	0.00	0.00
Method 3 - IF ELECTRICAL USAGE IS KNOWN				
USER INPUT <i>Input Pump Electrical Usage (KWh)</i>	1000	0	0	0
Select Region				
USER INPUT <i>Choose Region from Figure 1</i>	AKGD	AKMS	AZNM	CAMX
<i>CO₂ emission factor (lb/MWH)</i>	1232	499	1311	724
<i>CH₄ emission factor (lb/MWH)</i>	0.0256	0.02075	0.01745	0.03024
<i>N₂O emission factor (lb/MWH)</i>	0.00651	0.00408	0.01794	0.00808
<i>NO_x emission factor (lb/MWH)</i>	2.480	6.791	2.111	0.618
<i>SO_x emission factor (lb/MWH)</i>	1.214	0.526	1.081	0.531
ENERGY OUTPUT				
<i>Energy Usage (KWh)</i>	1.0E+03	0.0E+00	4.0E+00	1.4E+02
<i>Energy Usage (MWh)</i>	1.0E+00	0.0E+00	4.0E-03	1.4E-01
<i>Energy Usage (BTU)</i>	8.5E+06	0.0E+00	3.4E+04	1.2E+06
CO₂ OUTPUT				
<i>CO₂ emission (metric ton)</i>	5.6E-01	0.0E+00	2.4E-03	4.6E-02
<i>N₂O emission (metric ton CO₂ e)</i>	9.2E-04	0.0E+00	1.0E-05	1.6E-04
<i>CH₄ emission (metric ton CO₂ e)</i>	2.4E-04	0.0E+00	6.6E-07	4.0E-05
NO_x and SO_x OUTPUT				
<i>NO_x emission (metric ton)</i>	1.1E-03	0.0E+00	3.8E-06	3.9E-05
<i>SO_x emission (metric ton)</i>	5.5E-04	0.0E+00	2.0E-06	3.4E-05
TOTAL FROM PUMP OPERATION				
<i>CO₂ Emission (metric ton)</i>	6.1E-01			
<i>Energy Used (MWh)</i>	1.1E+00			
<i>Energy Used (MMBTU)</i>	9.8E+00			
<i>Water Usage (gal)</i>	5.8E+02			
<i>NO_x Emission (metric ton)</i>	1.2E-03			
<i>SO_x Emission (metric ton)</i>	5.9E-04			

SRT™ Tool Framework

Framework: Tiers of Varying Detail

	Tier 1	Tier 2
Calculation Basis:	“Rules of Thumb”	User-entered detailed design
Time Required:	1 - 2 hrs	1 - 2 days
	Tier 1 Advantages	Tier 2 Advantages
	<ul style="list-style-type: none">✓ Shorter execution than Tier 2✓ Extensive built-in defaults<ul style="list-style-type: none">✓ Simpler user inputs✓ Most appropriate before an Feasibility Study (FS)	<ul style="list-style-type: none">✓ More site-specific results✓ More default user-overrides✓ Most appropriate after an FS<ul style="list-style-type: none">✓ More appropriate for optimizing existing systems

SRT™ Tool Interface

PUMP AND TREAT - TIER 2

Case Study

Northeastern US

O&M

Design for Managing Groundwater

Airline miles flown by project team (total miles for all travelers)	140000	miles over proj lifetime
Average Distance Traveled by Site Workers per one-way trip	30	miles one-way
Trips by Site Workers during construction	1200	# over project lifetime
Trips by Site Workers after construction	12220	# over project lifetime

Remediation Design (Purpose)

Duration (must be <100 years) years

Tier 2: Change
Calculated Values
(dark gray boxes)

Total pumping rate gpm

Number of wells #

Length of manifold ft

Treatment Method

Beginning Plume Mass kg

Ending Plume Mass kg

Original Plume

Plume Area	880.	acres
Plume Length	13,000.	feet
Plume Volume	1,700.	million gallons
Dissolved Mass	330.	kg

After Project

Plume Area	190.	acres
Plume Length	6,100.	feet
Plume Volume	380.	mil gals
Dissolved Mass	15.	kg

AECOM Holistic Tool™ Interface

Stressors	Units									<u>Total</u>	
		EXCAVATION	TRANSPORTATION	THERMAL TREATMENT	LANDFARMING TREATMENT	TRANSPORTATION	BACKFILLING	SHEETPIILING			
<i>Gas emissions</i>											
CO ₂	kg	1.4E+06	6.6E+05	4.7E+07	1.1E+05	6.6E+05	7.0E+05	3.0E+04	50,900	t	
CO	kg	6.0E+04	2.5E+03	1.1E+04	3.2E+02	2.5E+03	6.0E+04	1.9E+04	136		
NO _x	kg	4.9E+04	9.4E+03	4.2E+04	1.3E+03	9.4E+03	4.9E+04	1.6E+04	159		
SO _x	kg	6.8E+02	1.0E+02	1.6E+04	1.9E+01	1.0E+02	7.0E+02	2.0E+02	18		
<i>Work accidents</i>											
expected number of accidents	-	3.4E+00	1.8E-02	2.7E+00	2.7E+00	1.8E-02	3.4E+00	4.4E-01	12.2	-	
expected number of deadly accidents	-	1.0E-02	9.1E-04	8.2E-03	4.1E-04	9.1E-04	1.0E-02	1.3E-03	0.031		
<i>Dust emissions</i>											
E _{PM10}	kg	5.6E+06	1.0E+05	5.1E+01	4.3E-01	1.0E+05	5.6E+06	4.6E+05	11,300	t	
E _{PM2.5}	kg	7.8E+05	1.0E+04	7.1E+00	6.0E-02	1.0E+04	7.8E+05	6.4E+04	1,600		
<i>Energy consumption</i>											
mechanical/combustion/electrical energy	MJ	2.0E+07	3.7E+06	7.8E+08	1.6E+06	3.7E+06	1.0E+07	1.9E+05	8.20E+08	MJ	
<i>Water consumption</i>											
groundwater and superficial water	m ³	2.6E+05	-	-	1.3E+05	-	-	1.5E+04	394,000	m ³	
<i>Carbon footprint</i>											
oak wood										450	ha
agricultural land										623	

Background and Functionality

Comparison Factor/Attribute	<i>SRT</i>	<i>SiteWise</i>	<i>Holistic Tool</i>
Sponsoring / Funding Organizations	AFCEE	USACE; USN	AECOM
Developing Organizations	AECOM (Prime) Subs: GSI Environmental CH2M Hill	Battelle	AECOM
Platform / Environment	MS Excel	MS Excel	MS Excel
Number of Workbooks	1	37	16
Work Flow Within the Tool	Menu-driven UI	Self-navigate	Self-navigate

Background and Functionality (continued)

Comparison Factor/Attribute	<i>SRT</i>	<i>SiteWise</i>	<i>Holistic Tool</i>
Analyzes Multiple Alternatives Simultaneously	Yes (up to 4)	Yes (up to 6)	Yes (up to 13)
Remedial Technology Scope/Applicability	Focused on 8 remedial technologies (Primary AFCEE uses)	Not limited to any given remedial technology	Focused on 12 remedial technologies
User Guide	Yes	Yes	Yes
Help System	Yes	No	No
Current Version	2.1	1.0	1.1
Availability	Freeware	Freeware	Proprietary

Typical Uses and Applications

Applications of the Tool	<i>SRT</i>	<i>SiteWise</i>	<i>Holistic Tool</i>
Feasibility Studies	X	X	X
Remedial Process Optimization	X	X	X
Five Year Reviews	X	X	
Baseline Reporting/Disclosure	X	X	

Lifecycle Stages When the Tools Can Be Used

Lifecycle Stage	<i>SRT</i>	<i>SiteWise</i>	<i>Holistic Tool</i>
Preliminary/Initial Assessment	X		
Site Inspections	X	X	
Remedial Investigations	X	X	
Feasibility Studies	X	X	X
Remedy Selection & Decision	X	X	X
Remedial Design	X	X	
Remedial Construction	X	X	
Operations & Maintenance	X	X	
Long-term Management/Monitoring	X	X	
Site Closeout			

Environmental Metrics Evaluated by the Tools

Metric	<i>SRT</i>	<i>SiteWise</i>	<i>Sima Pro</i>	<i>Holistic Tool</i>
Carbon Dioxide (CO2) Emissions	X	X	X	X
Nitrogen Oxides (NOx) Emissions	X	X	X	X
Sulfur Oxides (SOx) Emissions	X	X	X	X
Particulate Matter (PM) Emissions	X	X	X	X
Energy Consumption	X	X	X	X
Water Consumption		X	X	
Landfill				X
Change in Groundwater Resource Service	X			
Change in Ecologic Resource Service of Land	X		X	
Carbon "footprint"	X		X	X

Social & Economic Metrics Evaluated by the Tools

Metric	<i>SRT</i>	<i>SiteWise</i>	<i>Sima Pro</i>	<i>Holistic Tool</i>
<i>Social Factors</i>				
Worker Safety/Construction Accident Risk	X	X	X	X
<i>Economic Factors</i>				
Technology Construction / Implementation Cost	X			
Technology Operation & Maintenance Cost	X			
Change in Economic Resource Value of Land	X			
Change in Economic Resource Value of Groundwater	X			
Variable Cost scenarios for Carbon offsets	X			
Variation of Energy cost over remedial lifecycle	X			

Remedial Technologies Addressed Within the Tools

Remedial Technology	<i>SRT</i>	<i>SiteWise</i>	<i>Holistic Tool</i>
Excavation	X	N/A	X
Road transport	X	N/A	X
Barge transport		N/A	X
Sediment dredging		N/A	X
Sediment capping		N/A	X
Landfarming		N/A	X
Sheetpiling		N/A	X
Thermal desorption		N/A	X
Slurry wall		N/A	X

Remedial Technologies Addressed Within the Tools

(continued)

Remedial Technology	<i>SRT</i>	<i>SiteWise</i>	<i>Holistic Tool</i>
In situ thermal technologies	X	N/A	X
In-situ stabilization / solidification (ISS)		N/A	X
Jet grouting		N/A	X
In-situ Chemical Oxidation (ISCO)	X	N/A	X
Enhanced Bio	X	N/A	X
LTM/MNA	X	N/A	X
Soil Vapor Extraction (SVE)	X	N/A	X
Permeable Reactive Barriers (PRBs)	X	N/A	

Output Format & Content

Comparison Factor/Attribute	<i>SRT</i>	<i>SiteWise</i>	<i>Holistic Tool</i>
Metrics in Natural Units	X	X	X
Metrics in "Normalized" Units	X		X
Comparitive Graphs and Charts	X	X	X
US Units	X		X

Takeaways

- Chicken and the Egg
 - Metrics & remedial technologies sometimes dictate which tool to use
 - Tools sometimes dictate which metrics will be considered
- Different tools require a different level of effort to use
- Most tools have not been designed with portfolio management in mind
- The tool is not as important as the inputs and understanding going into the development of the site
- Tools can help identify the key aspects of a project that can improve your sustainability metrics and drive innovative ideas
- Tool selection is site specific. Should be based on the project needs/phase/remedial technology – Some tools are limited by the technology selected
- Customized tools can be a better approach based on the organization's needs.



Thank You

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