Air Force Center for Engineering and the Environment

Integrity - Service - Excellence

UPDATE: Building *Sustainability* into the Air Force Remediation Process

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AECOM ENVIRONMENT GSI ENVIRONMENTAL CH2MHILL

Sustainability in AF Remediation:

Project Team

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Problem & Solution

The Problem…

Historical approach to contaminated sites does not fully consider sustainability concepts.

A Solution…

Develop tool to help AFCEE environmental professionals incorporate sustainability concepts into their remediation decision making process (*e.g.*, PBEM, RRM, ERP-O) for

i) planning future remediation implementation

ii) optimizing operating remediation sites

Tool will be available as freeware from US Air Force

Context

Of particular interest to DoD is new paradigm for remediation propelled by Executive Order (EO) 13423, January 2007.

Call to operate in "sustainable manner" leaves government environmental restoration professionals with need for tools to help develop sustainable remediation practices.

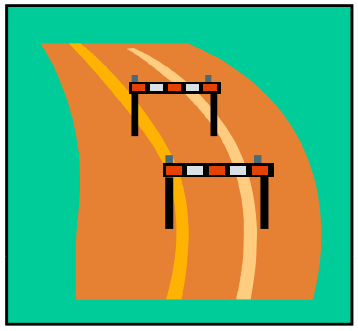
Sustainable: "to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations of Americans" (EO 13423, Bush 2007)

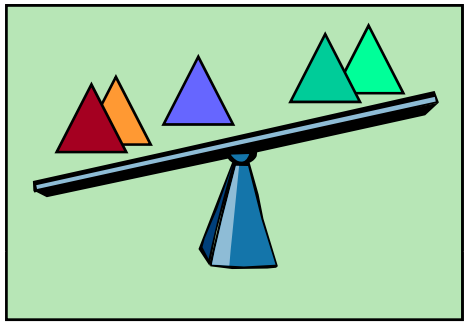
How to Measure Sustainability?

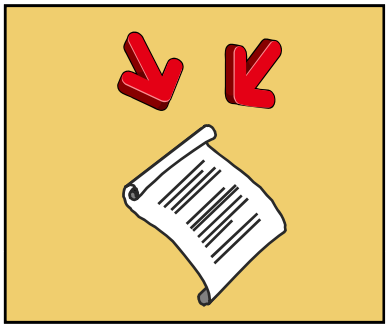
Metrics can quantify sustainability. Requires broad system view combined with detailed, LCA-style approach in which impacts of each process step summed and considered in overall decision-making process.

At present, remedies tend to follow CERCLA Nine Criteria for RIS/FS and Selection of Remedy (40 C.F.R. 300.430(e)(9)(iii)).

Two Threshold	Five Balancing	Two Modifying







Key Issue

The CERCLA Nine Criteria are:

- **Threshold Criteria**
  - **Overall protection of human health and the environment**
  - **Compliance with ARARs**
- **Primary Balancing Criteria**
  - **Long-term effectiveness and permanence**
  - **Reduction of toxicity, mobility, or volume**
  - **Short-term effectiveness**
  - **Implementability**
  - **Cost**
- **Modifying Criteria**
  - **State / Support agency acceptance**
  - **Community acceptance**

Key Issue

However, many of CERCLA Nine Criteria not easily quantifiable or comparable. In order to evaluate sustainability, several new metrics become a part of the remediation process. These include:

- **Carbon dioxide emissions**
- **Energy consumption**
- **Change in resource service**
- **Worker safety**

What the Tool Does

Estimation of modified / new metrics in easy-to-use tool provides way to consider sustainability of various remediation technologies while circumventing time-consuming hand calculations.

Built on Microsoft Excel platform.

Calculates sustainability metrics for specific remediation technologies (additional technologies are currently being added):

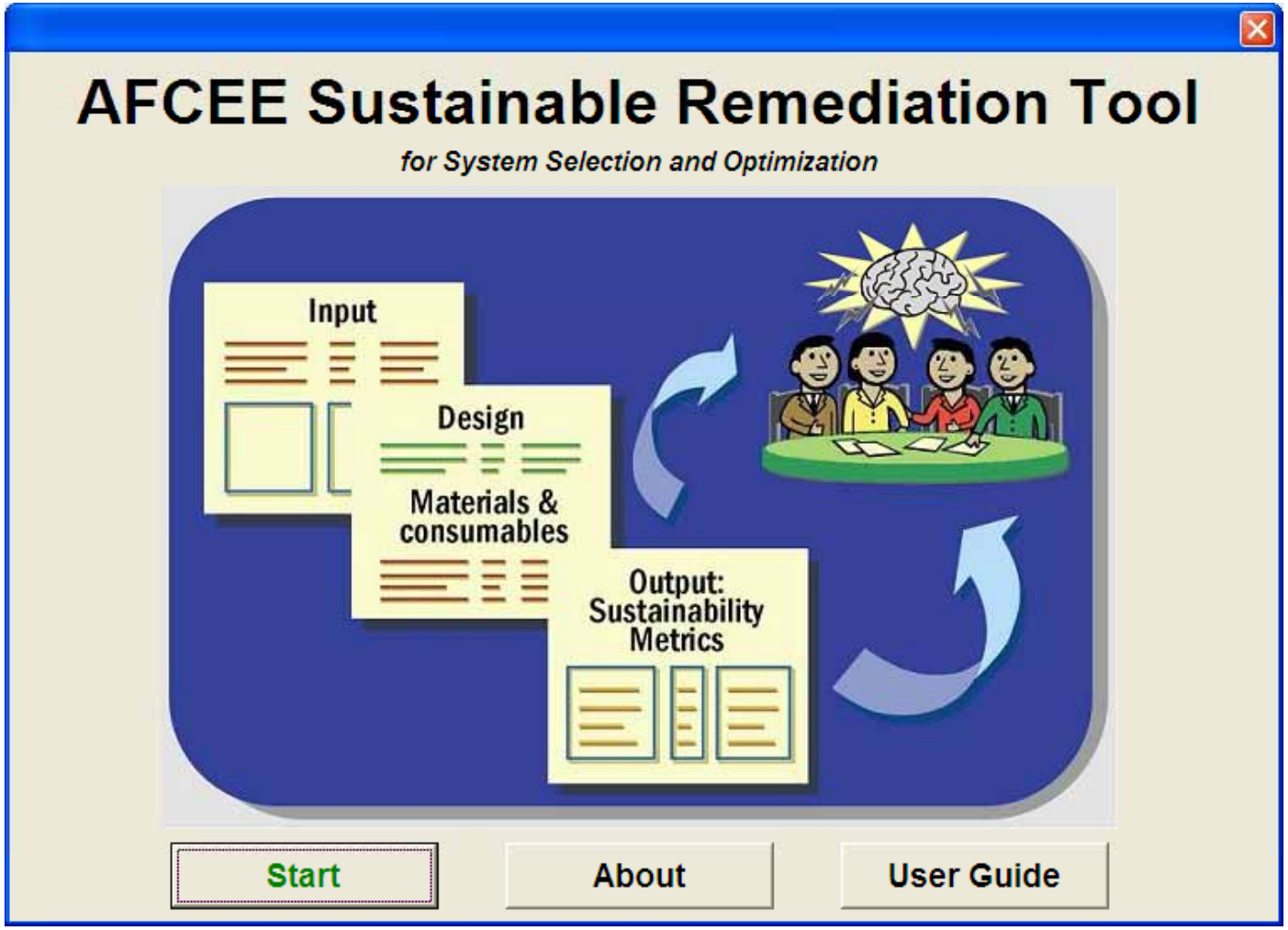
- **Soil Technologies**
  - **Excavation**
  - **Soil Vapor Extraction**
- **Groundwater Technologies**
  - **Pump and Treat**
  - **Enhanced In Situ Bioremediation**

Metric Outputs

SRT sustainability metrics calculated are the following (additional metrics to included are being evaluated):

- **Carbon dioxide emissions to atmosphere**
- **Total energy consumed**
- **Change in resource service**
- **Technology cost**
- **Safety / Accident risk**

SRT Structure

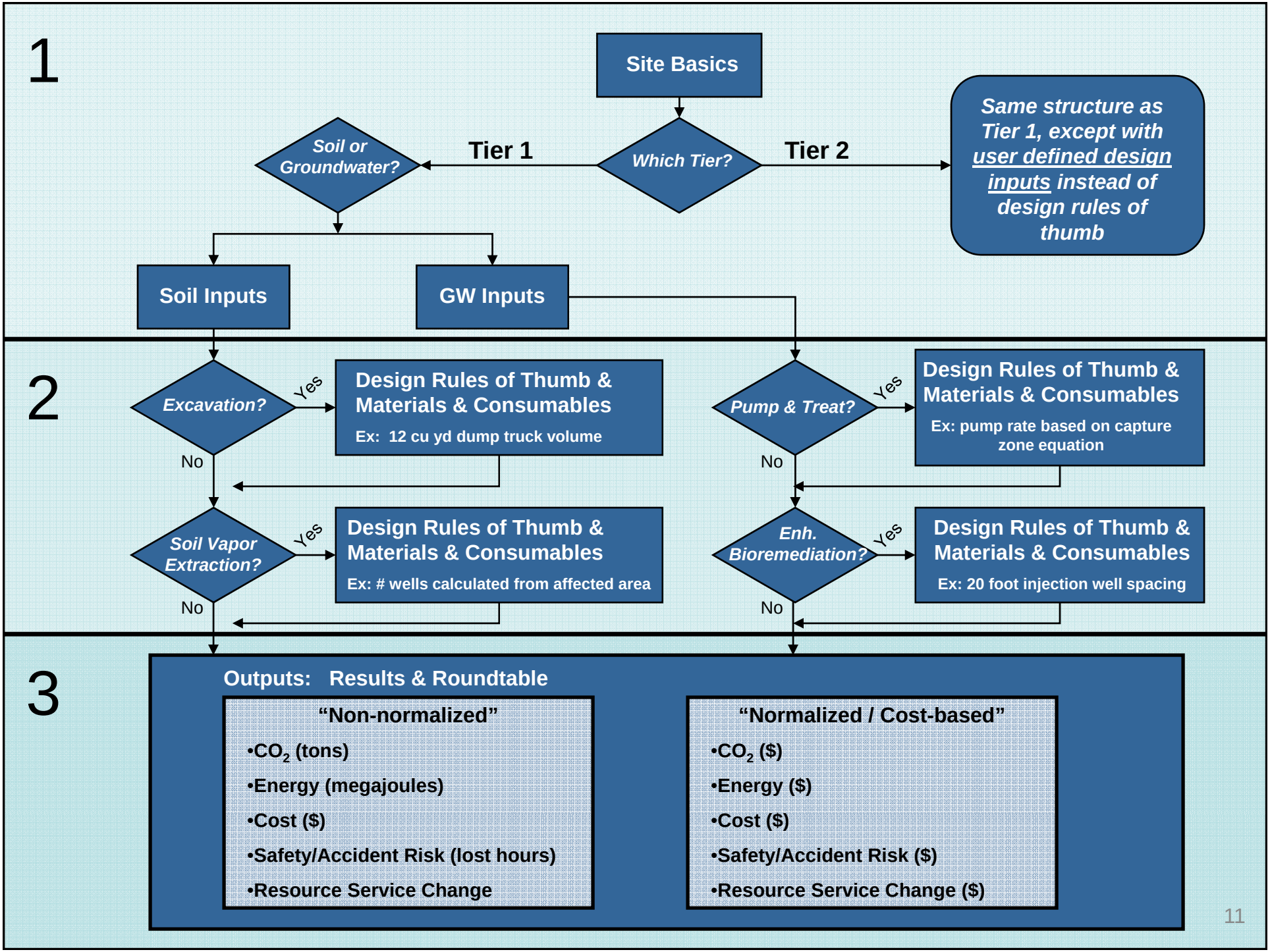


Like RBCA Toolkit!

Tiers of Varying Detail

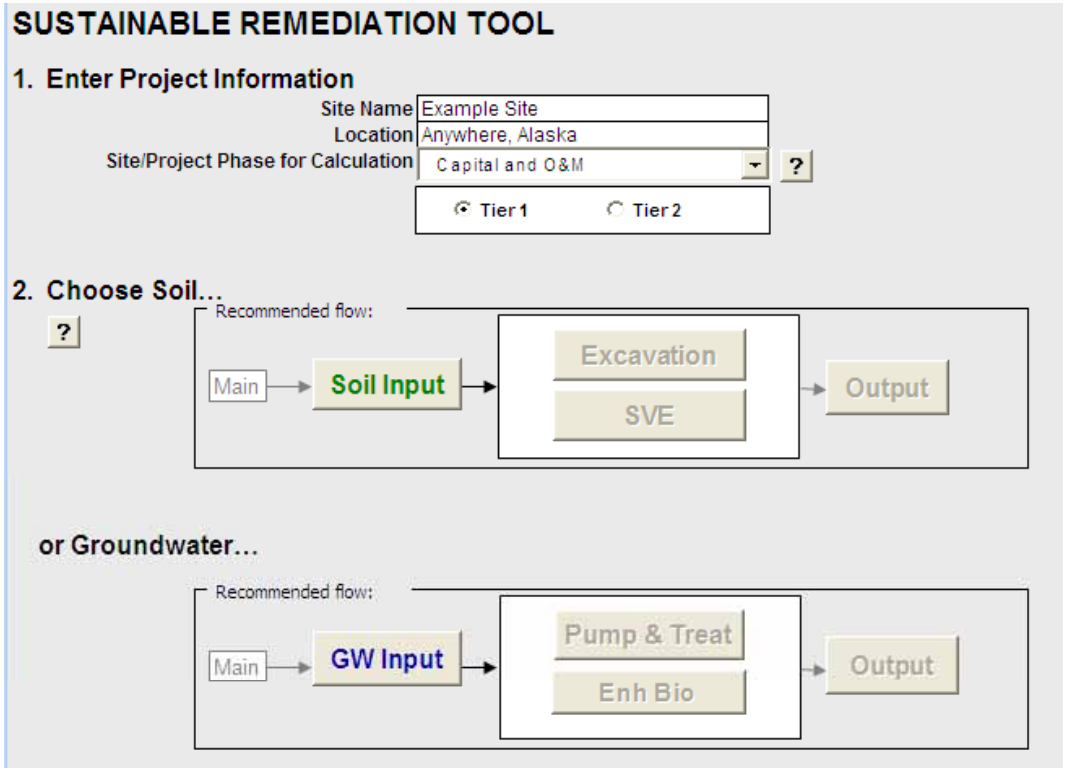
	Tier 1	Tier 2
Calculation Basis:	**"Rules of Thumb"**	**User-entered design information from detailed design**
Time Required:	**1 - 2 hrs**	**1 - 2 days**

Tier 1 Advantages:	Tier 2 Advantages:
✓ Shorter execution than Tier 2 ✓ Extensive built-in defaults ✓ Simpler user inputs ✓ Most appropriate before a Feasibility Study	✓ More site-specific results ✓ More default user-overrides ✓ Most appropriate after a Feasibility Study ✓ More appropriate for optimization of existing systems


1
Site Basics
Which Tier?
Tier 1
Tier 2
Soil or Groundwater?
Same structure as Tier 1, except with user defined design inputs instead of design rules of thumb
Soil Inputs
GW Inputs
2
Excavation?
Yes
No
Design Rules of Thumb & Materials & Consumables
Ex: 12 cu yd dump truck volume
Pump & Treat?
Yes
No
Design Rules of Thumb & Materials & Consumables
Ex: pump rate based on capture zone equation
Soil Vapor Extraction?
Yes
No
Design Rules of Thumb & Materials & Consumables
Ex: # wells calculated from affected area
Enh. Bioremediation?
Yes
No
Design Rules of Thumb & Materials & Consumables
Ex: 20 foot injection well spacing
3
Outputs: Results & Roundtable
"Non-normalized"
•CO_2 (tons)
•Energy (megajoules)
•Cost ($)
•Safety/Accident Risk (lost hours)
•Resource Service Change
"Normalized / Cost-based"
•CO_2 ($)
•Energy ($)
•Cost ($)
•Safety/Accident Risk ($)
•Resource Service Change ($)

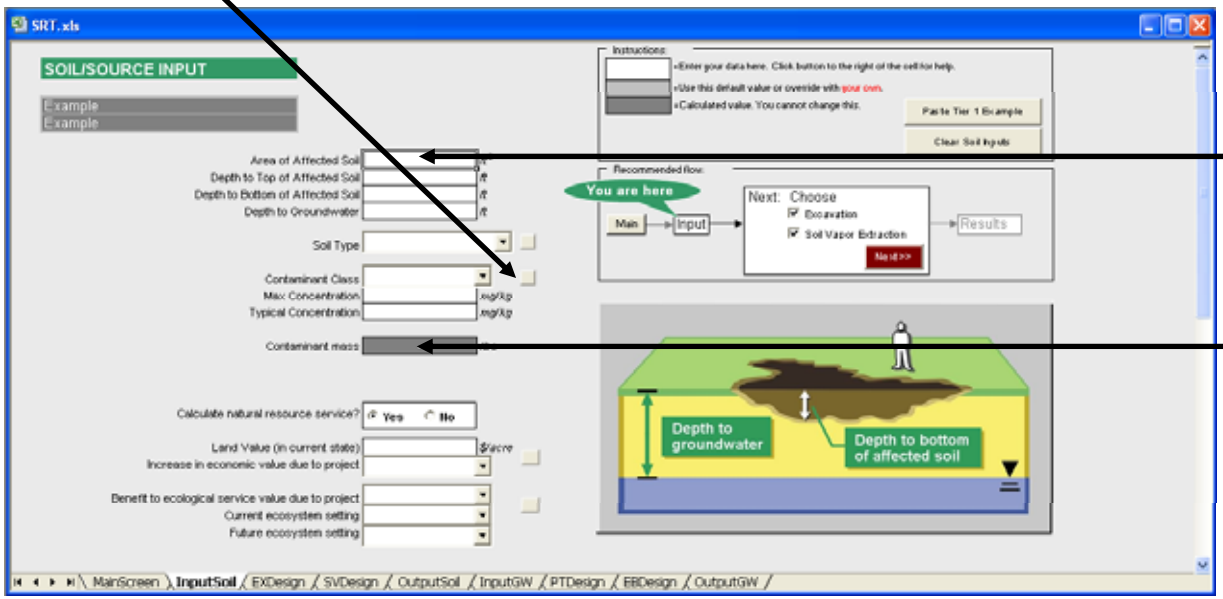
Basic Input Screen

- Once opened and saved, user taken to the **Main Screen**.
  - Enter **Site Name** and **Location**.
  - Choose **Site/Project Phase** for calculation. For an **existing system**, choose "**O&M only**."
  - Choose **Tier 1** or **Tier 2**.



Soil Input Screen

- After choosing Tier 1 or Tier 2, choose **Soil Input** or **Groundwater (GW) Input**.
  - Enter **site data** in **white cells**.
  - See tool **calculated values** in **dark gray cells**.
- Use in-tool **help** anywhere you see this icon.

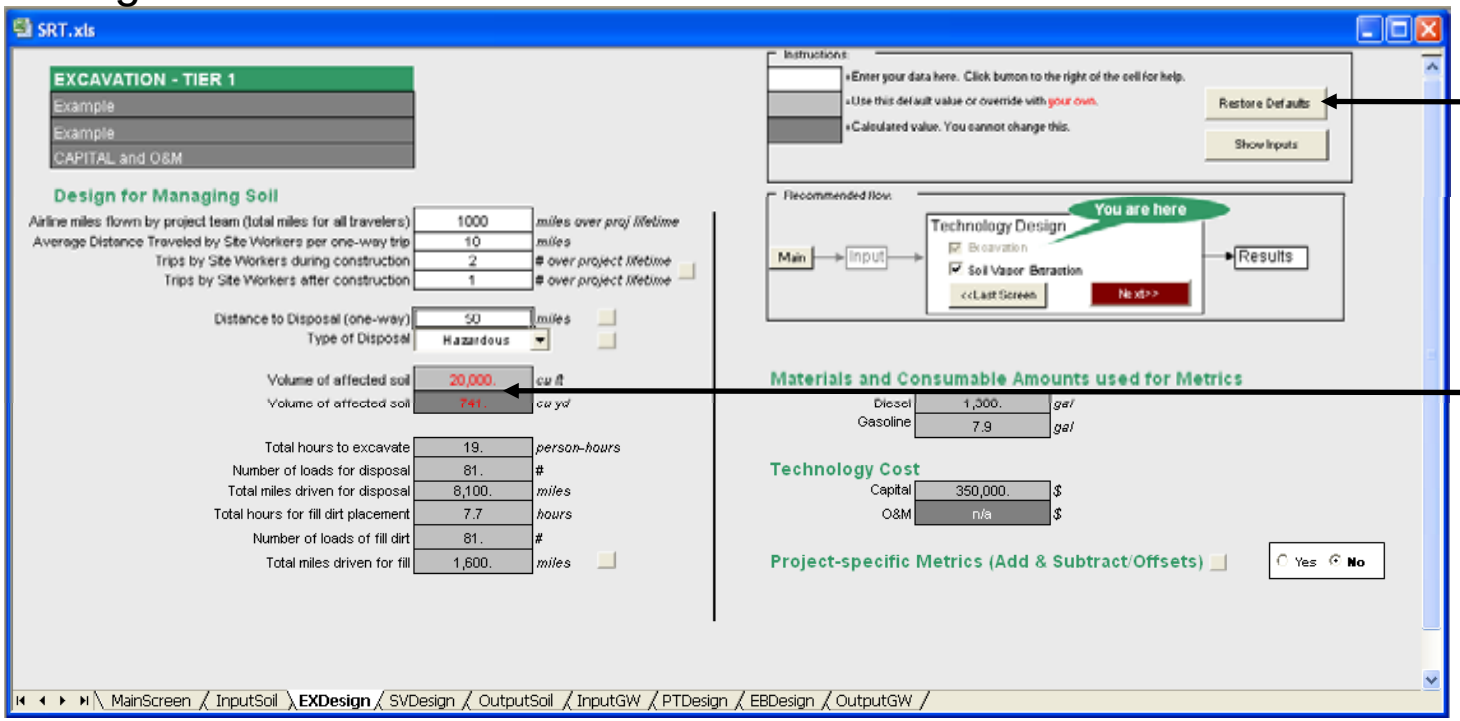


Soil Technology Input Screen

- On each **technology design screen**:

  - Enter **site data** in **white cells** and

  - **Override** any **default** values in **light gray cells**. Overridden defaults and subsequent calculations will turn to red text. Defaults can be restored by clicking "**Restore Defaults**" button.



Example Material Calculation & Conversion

$$2{,}500 \text{ lb PVC} \times \frac{2 \text{ lb } CO_2}{1 \text{ lb PVC}} \times \frac{0.453 \text{ kg}}{1 \text{ lb}} \times \frac{0.001 \text{ metric ton}}{1 \text{ kg}} = 2 \text{ metric tons } CO_2 \text{ emitted}$$

"Non-normalized" natural units

$$\times \frac{\$5}{1 \text{ ton } CO_2} = \$10 \ CO_2 \text{ offset}$$

"Normalized" $ units

Example Consumable Calculation & Conversion

$$100 \text{ gal gas} \times \frac{20.71 \text{ lb } CO_2}{1 \text{ gal gas}} \times \frac{0.453 \text{ kg}}{1 \text{ lb}} \times \frac{0.001 \text{ metric ton}}{1 \text{ kg}} = 1 \text{ metric ton } CO_2 \text{ emitted}$$

"Non-normalized" natural units

$$\times \frac{\$5}{1 \text{ ton } CO_2} = \$5 \ CO_2 \text{ offset}$$

"Normalized" $ units

Energy Consumed Metric Example

$$32 \text{ gal gas} \times \frac{150 \text{ MJ}}{1 \text{ gal gas}} = 4{,}800 \text{ MJ energy}$$

"Non-normalized" natural units

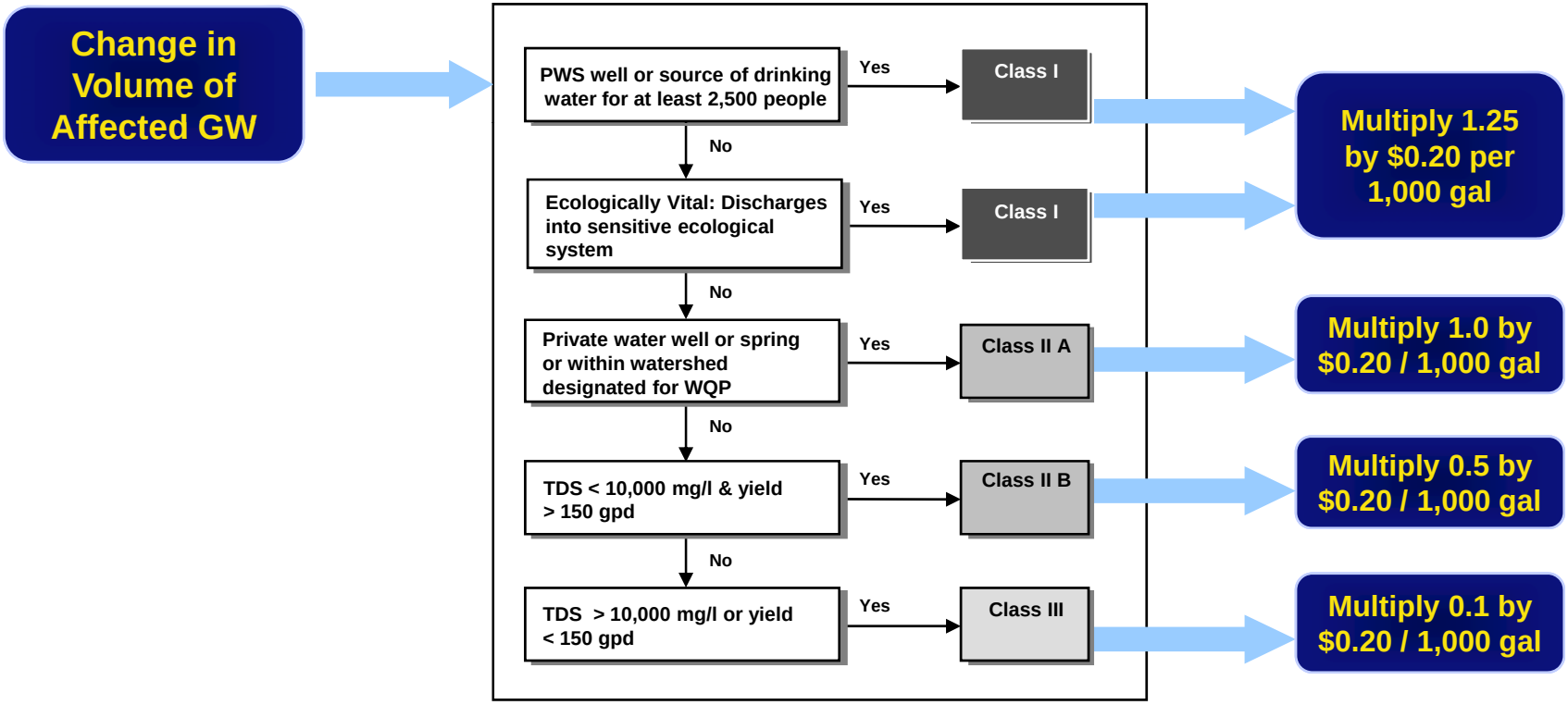
$$32 \text{ gal gas} \times \frac{\$4.00}{1 \text{ gal gas}} = \$128$$

"Normalized" $ units

Resource Service Metric

"Non-normalized" Resource Service metric is based on volume of plume that is restored

"Normalized" Resource Service Groundwater Valuation:



EPA (1986), *Guidelines for Groundwater Classification under EPA Groundwater Protection Strategy, Final Draft.*

Technology Cost Example

"Non-normalized" and "Normalized" units are the same

$$10{,}000\ yd^3 \times \frac{\$400}{1\ yd^3\ Excavation} = \$4{,}000{,}000$$

"Non-normalized" natural units

$$10{,}000\ yd^3 \times \frac{\$400}{1\ yd^3\ Excavation} = \$4{,}000{,}000$$

"Normalized" $ units

Unit costs from Federal Roundtable

Safety / Accident Risk Example

$$(1{,}000 \text{ hrs worked} + 400 \text{ hrs traveled}) \times \frac{2.7 \times 10^{-9} \text{ injuries}}{1 \text{ hr worked}}$$

$$+ (100 \text{ miles traveled}) \times \frac{91 \text{ injuries}}{100{,}000{,}000 \text{ VMT}}$$

$$= 9.5 \times 10^{-5} \text{ injuries}$$

"Non-normalized" natural units

$$\frac{48 \text{ lost hrs}}{1 \text{ injury}} \quad (9.5 \times 10^{-5} \text{ injuries}) \times \frac{\$80}{1 \text{ lost hr}} = \$0.36$$

"Normalized" natural units

Risk of non-fatal injuries derived from the US Bureau of Labor, 2006

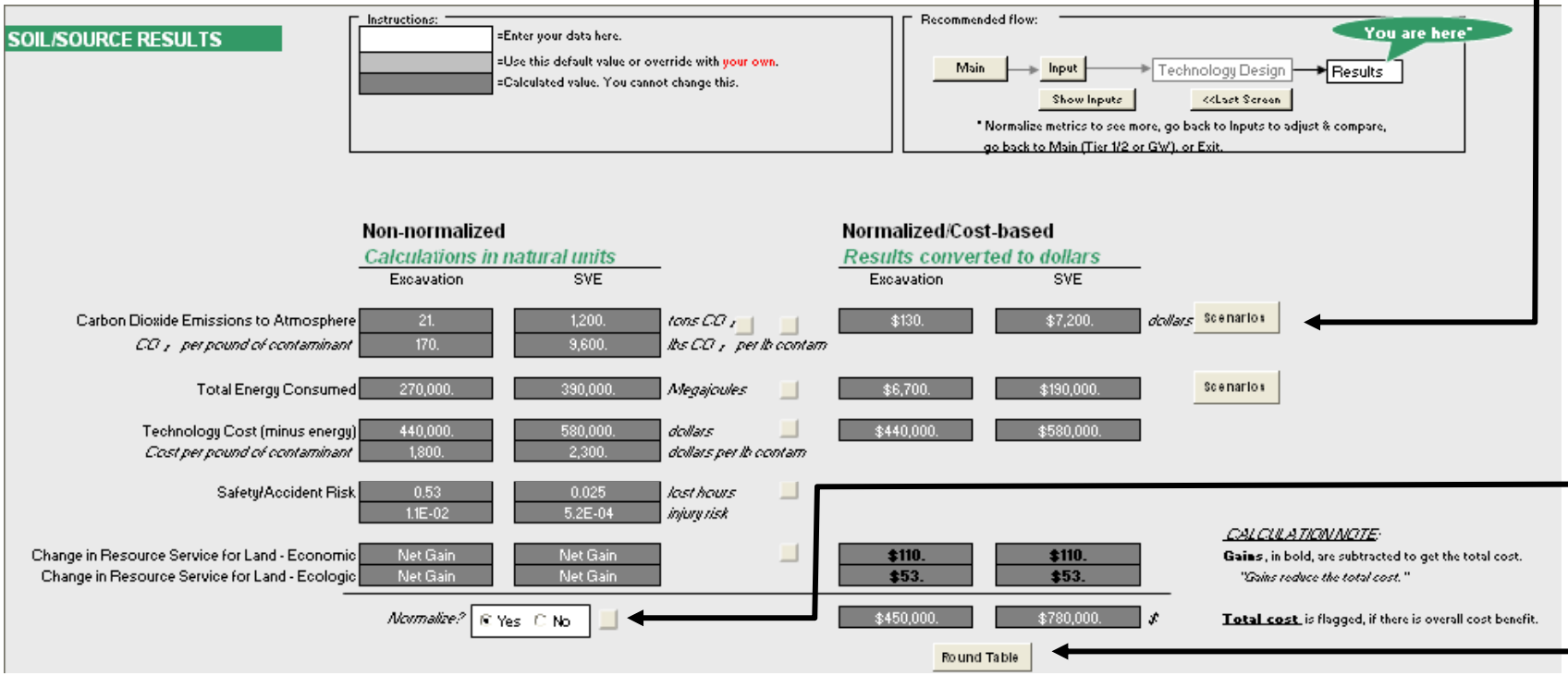
Output Screen

Example: Output Screen for Soil Technologies

- To view metrics in **Normalized** format, click "**Yes**" radio button.

- To access **CO_2 Scenarios** feature, click "**Scenarios**" button next to CO_2 emissions output. To access **Energy Scenarios** feature, click "**Scenarios**" button next to Energy metric output.

- To access **Stakeholder Roundtable**, click the "**Roundtable**" button.



Considering the Future: Scenario Planning

Technique used by many businesses to prepare for unknown. Forecasting wide variety of plausible futures allows businesses to plan for uncertainty element of future investments or of long-term projects. Premise – not to predict what will happen but to prepare for any possible future.

Can be applied to sustainability concepts and to remediation as sustainability considers requirements of both present and future generations and because many remediation systems operate for many years.

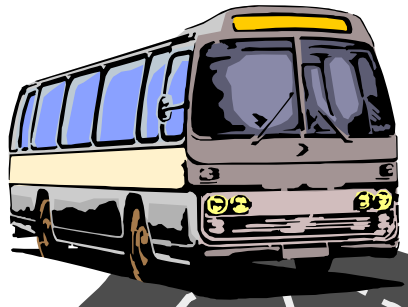
SRT applies scenario to:

- **Cost of CO_2 emission offsets**
- **Cost of energy**

Future Scenarios Feature

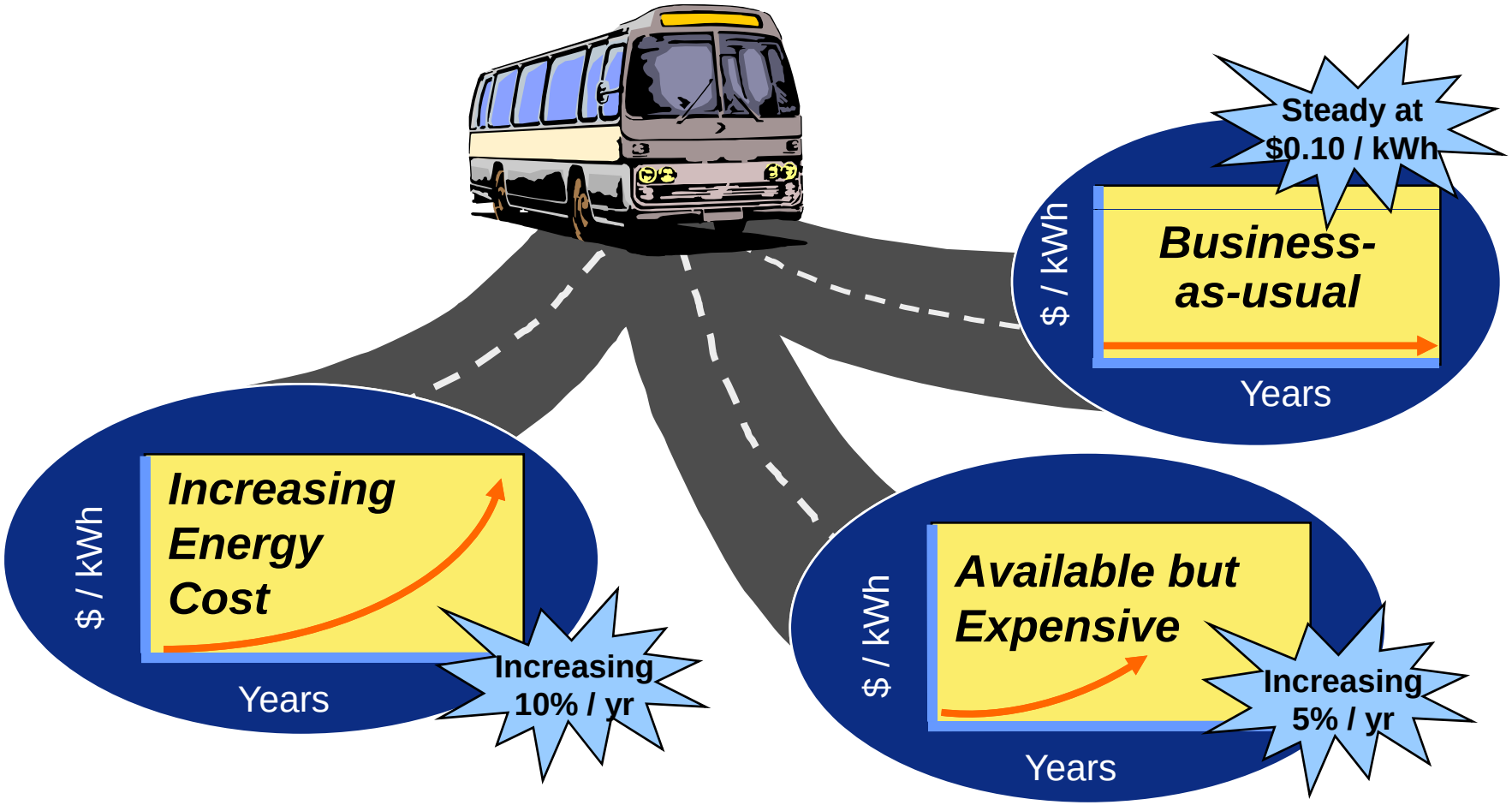
CO_2 Scenarios

***Key Point**: SRT users can consider the long-term costs of projects given various CO_2 and energy cost scenarios.*



Future Scenarios Feature

Energy Scenarios



Future Scenarios Feature

EXAMPLE:
CO_2 Scenarios and Net Present Value Calculations

Using a given capitalization rate, the tool calculates the net present value of CO_2 offset costs in three different future scenarios.

NPV CALCULATION - CARBON DIOXIDE EMISSIONS (Normalized; 100 years max)

Capitalization Rate	0.03	
Business as Usual	6	$ per ton per year (base rate)
Bank of America	40	$ per ton per year
Carbon Constrained World	0.15	increase after Year 1 (Year 1 uses base rate).

PUMP AND TREAT[1]

Capital phase	260	tons CO2
O&M phase	1200	tons CO2 per
Duration	47	years

	Business as Usual	Bank of America	Carbon Constrained World
No NPV:	$340,000	$2,300,000	$34,000,000
NPV[3]:	$180,000	$1,200,000	$11,000,000

Capitalization Rate

CO_2 Scenario Values

Net Present Value Calculations

[1] Pump & Treat calculations assume all PVC, Steel, Diesel, and capital-phase gasoline are used in capital phase; all other materials and fuel are used in O&M phase.

Reaching a Consensus Among Stakeholders

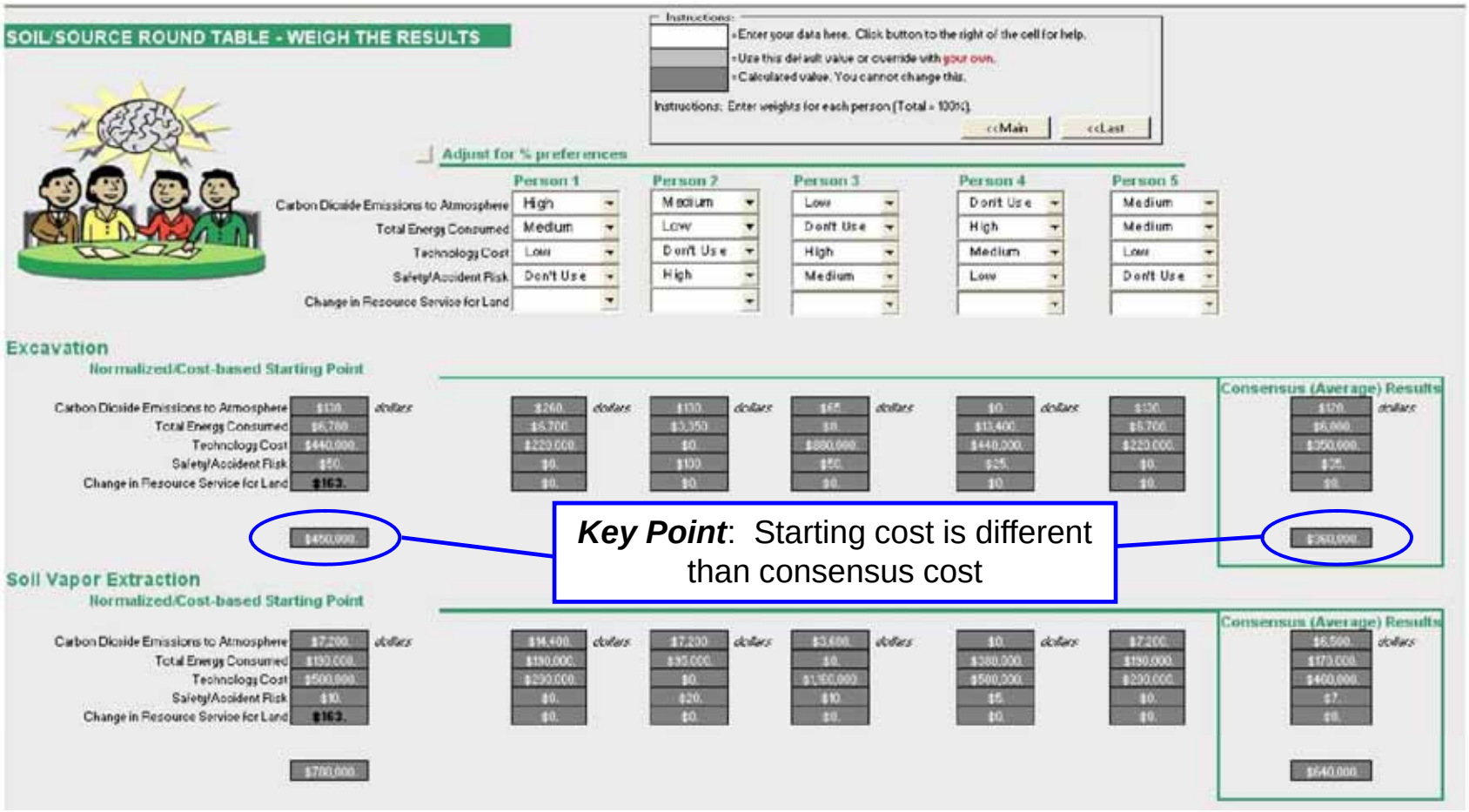
Challenge – Reaching consensus from diverse group of perspectives.

Different people value different metrics in various ways.

Stakeholder Roundtable feature facilitates group agreement. Up to five parties can rank each of five metrics. Tool averages each normalized metric according to users' rankings. Users can see consensus normalized values for each metric (and the summed consensus value).

Consensus output intended to facilitate group communication. Is not intended to give "right" answer to the weighing of sustainability metrics.

Stakeholders Roundtable Example



For Further Information

AFCEE ERP-O Website:

www.afcee.af.mil/resources/restoration/rpo/index.asp

AFCEE Sustainable Remediation Web Site:

www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremeditation

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