

# INTERSOL 2011

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**Environmental Forensics March 28<sup>th</sup> 2011**  
**SOIL POLLUTION AND ENVIRONEMENTAL FORENSICS**  
**SCOPE OF LITIGATIONS, EVIDENCE MANAGEMENT, DAMAGE AND**  
**REMEDIATION**



**Jean Francois DAVID** [jf.david@experts-judiciaires.org](mailto:jf.david@experts-judiciaires.org)  
**Expert près la Cour d'Appel de Versailles**  
**Compagnie Nationale des Experts de Justice en Environnement**  
**Jean-Louis SEVEQUE** [jlseveque@seveque-environnement.fr](mailto:jlseveque@seveque-environnement.fr)  
**Expert près la Cour d'appel d'Amiens**  
**Président de la Compagnie Nationale des Experts de Justice en**  
**Environnement**

**INTERSOL – LYON March 28<sup>th</sup> 2011**

# SUMMARY

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## ☐ SCOPE OF LITIGATIONS

- What are soil pollutions issues
- Where Environment Forensics has to apply

## ☐ PROVIDING AND MANAGING EVIDENCE

## ☐ DAMAGE ASSESSMENT AND REMEDIATION

# What is a polluted site

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- A polluted site is a site which, because of former deposits of waste or infiltration of polluting substances presents a nuisance or a long-lasting risk for people or the environment (French ministry of Environment)
  
- A polluted site, although after remediation scheme has been conducted remains a polluted site
  - Monitoring must be driven on the long range
  - Future breakthrough in environmental (and other) sciences may lead to additional interventions

# FIELD AND SCOPE OF LITIGATION

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- ❑ As the Environmental Liability Directive (ELD) deals with the "pure ecological damage", it is based on the powers and duties of public authorities ("administrative approach") as distinct from a civil liability system which is more appropriate for "traditional damage" (damage to property, economic loss, personal injury).
- ❑ Civil liability system will encompass "traditional damages" pending front of civil courts
- ❑ Anyway an administrative court can be seized in a indirect way by a request concerning private damage
- ❑ So litigation may appear ont both grounds
  - Of environmental liability and environmentally specific issues
  - Of civil liability on common grounds (loss of amenity, value...)

# FIELD AND SCOPE OF ENVIRONMENTAL FORENSICS - LITIGATION

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- Technical advice to courts and tribunals
- Technical advice to plaintiffs
  - Before filing a lawsuit
  - During the process of a law suit
- Technical advice to stake holders / public agencies, before or during a public procedure (hearing, public inquiry)
  - Helping to reach a sound decision
  - Preventing further environmental damages

# INTERVENTION DRIVERS SCHEME OF RELATIONS

| Stake holders<br>Damages            | Labour force | Customer | Media<br>Relay of opinion | Third parties | Government<br>Public agencies |
|-------------------------------------|--------------|----------|---------------------------|---------------|-------------------------------|
| Labour force                        | ⊕            | ×        | ↔                         |               | ↔                             |
| Private property                    | ○ ↔          | ○ ↔      | ↔                         | ○             |                               |
| Public property                     | ↔            | ×        | ↔                         | □             | ⌵ ⬠                           |
| Physical media,<br>air, water, soil |              | ⌵ ↔      | ↔                         | □             | ⌵ ⬠                           |

Compulsory insurance



Communication



Crisis management



Mitigation, remediation



Civil liability

















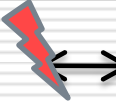




















Absolute liability



Quality improvement  
Operators commitments



# INTERVENTION DRIVERS WHERE ENVIRONMENTAL FORENSICS APPEARS

| Stake holders<br>Damages         | Labour force  | Customer   | Media<br>Relay of opinion  | Third parties   | Government<br>Public agencies  |
|----------------------------------|---|--|--|---|--|
| Labour force                     |    |   |   |   |   |
| Private property                 |    |     |   |    |   |
| Public property                  |     |     |    |     |       |
| Physical media, air, water, soil |   |   |   |     |    |

Compulsory insurance



Communication



Crisis management



Independent expertise



Mitigation, remediation



Civil liability



Quality improvement  
Operators commitments



Court ordered expertise



# ENVIRONMENTAL FORENSICS

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- Related first to litigation
- Litigation occurs mainly
  - When prevention has failed
  - When a consent, a contract has been flawed by lack or improper information, lack of transparency
  - When damages occurred and were left without proper remediation



# INDEPENDANT EXPERTISE

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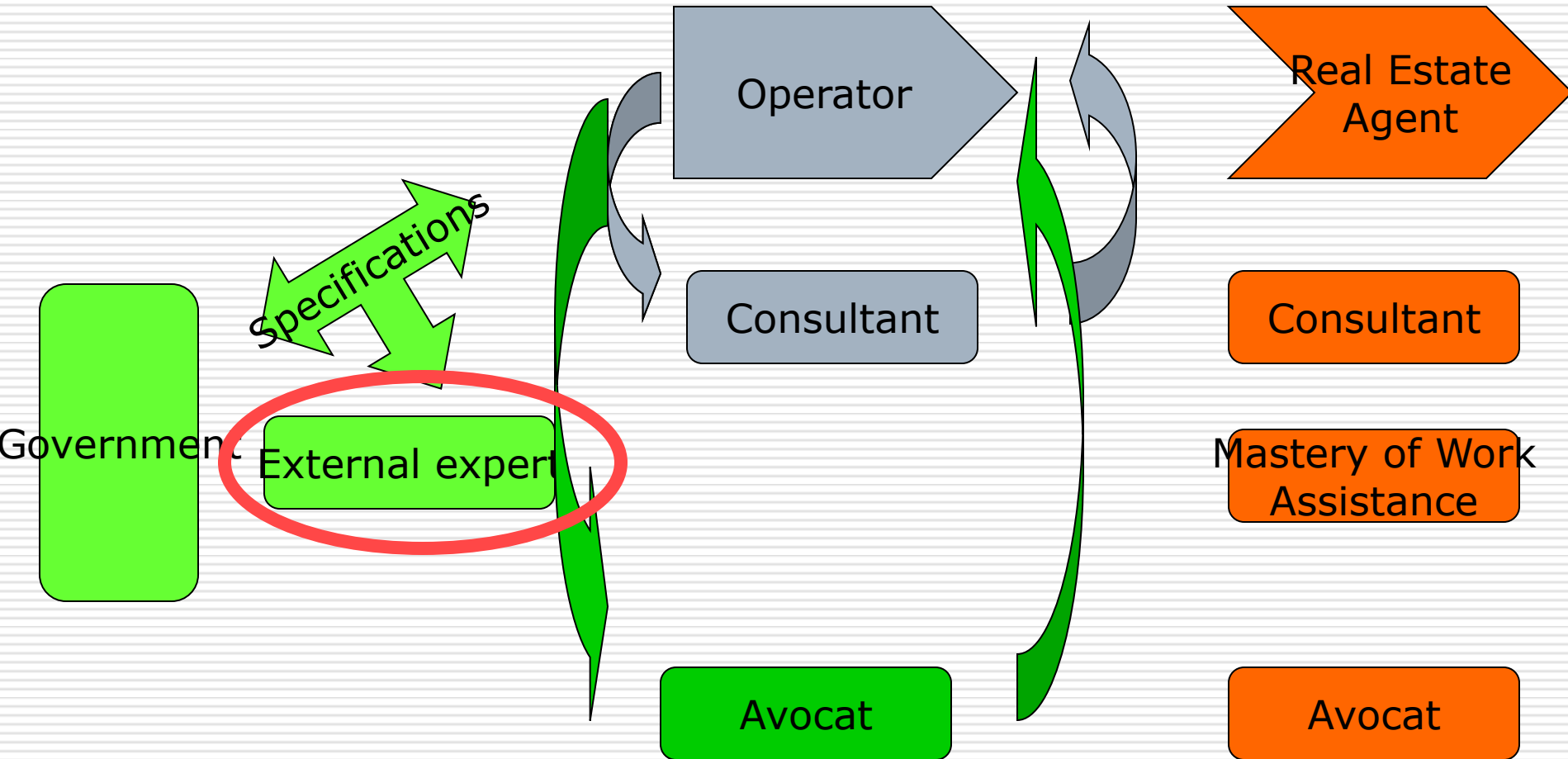
- Prevention process :
  - Environment Impact Statement
  - End of operation Application
  - Intervention during public hearing or public inquiry
- Litigation
  - Independant expert – expert of the Court (Latin system)
  - Expert witness (Anglo saxon system)

# TYPOLOGY OF LITIGATIONS

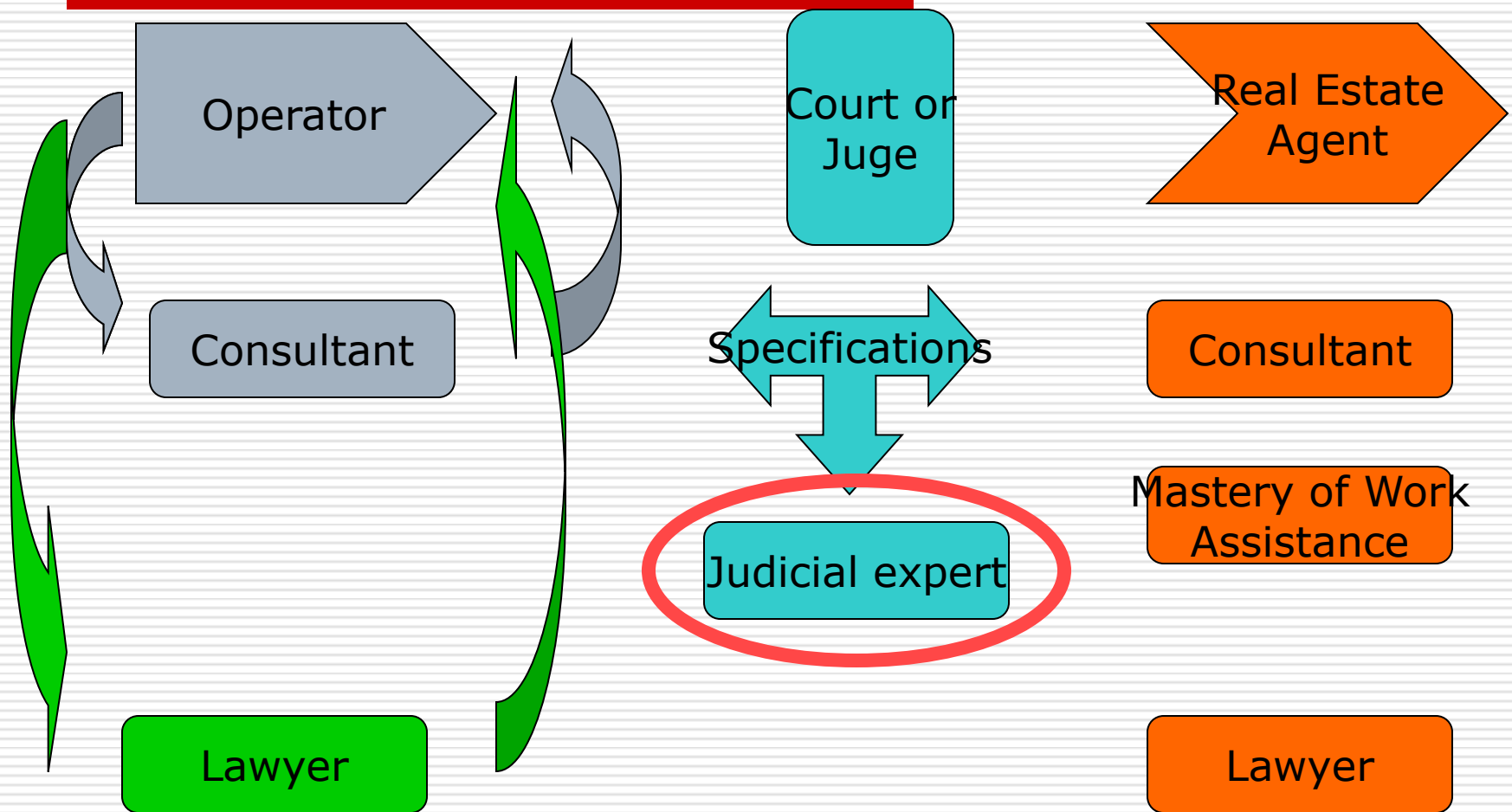
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- Buy and sell, real estate
- Remediate or mitigate
  - An existing pollution
  - A damage occurred (to public or private property)
- Challenge administrative decisions
  - Lack of enforcement, lack of prevention
  - Improper or excessive enforcement

# Environmental Forensics in the process : between Government agency and former operator



# Environmental Forensics in the process : between Operator and Real Estate agent



# SUMMARY

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## □ SCOPE OF LITIGATIONS

- What are soil pollutions issues
- Where Environment Forensics has to apply

## □ PROVIDING AND MANAGING EVIDENCE

## □ DAMAGE ASSESSMENT AND REMEDIATION

# PROVIDING AND MANAGING EVIDENCE : What is environmental expertise

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- Environmental expertise is
  - A Multidisciplinary approach
  - A project by itself with various contributors, inputs, objectives and results
  - An intervention led on a project management basis with
    - Costs
    - Time span
    - Results (answers to provide)
  - Answering two fold issues, both social, technical

# PROVIDING AND MANAGING EVIDENCE

Conducting environmental expertise : « an independant project »

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- Environmental expertise, when needed, is a project inside a more complex operation
- Environmental expertise considered as environmental forensics must
  - Be conducted in an independant way (granting stakeholders both independance and appearances of independance)
  - So be separated from consulting or engineering tasks

# PROVIDING AND MANAGING EVIDENCE :

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- ❑ Checking inputs
- ❑ Issuing specifications for further investigations or technical results
- ❑ Assessing as is situation :
  - Compliance with regulations
  - Compliance with standards and best practices when results are at stake or challenged



# PROVIDING AND MANAGING EVIDENCE :

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- Adding a valuable insight in a generally complex process, helping to overcome discrepancies
- Understanding the general values and constraints of environmental litigation, assessment, remediation, the concept of sustainability

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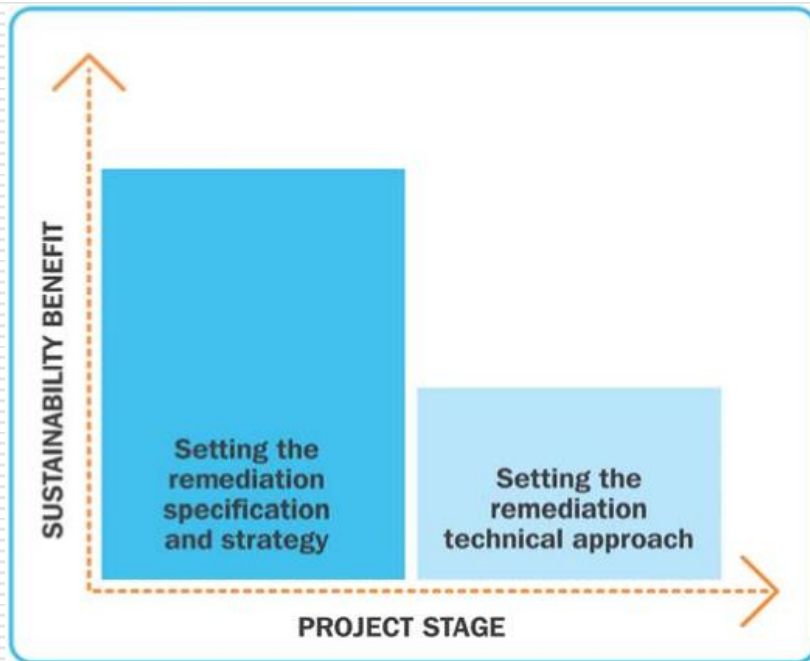
# DAMAGE AND REMEDIATION : Two examples on the ground of sustainability

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- ❑ EUROPEAN EXAMPLE : NICOLE (Network for Industrially Contaminated Soils in Europe) WORKSHOP [www.Nicole.org](http://www.Nicole.org) road map for sustainable Remediation
- ❑ US EXAMPLE : AFCEE (Air Force Center for Engineering and Environment)  
<http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/srt/index.asp> afcee
  - Performance tracking tool
  - Sustainable remediation tool

# EUROPEAN EXAMPLE : ROAD MAP FOR SUSTAINABLE REMEDIATION

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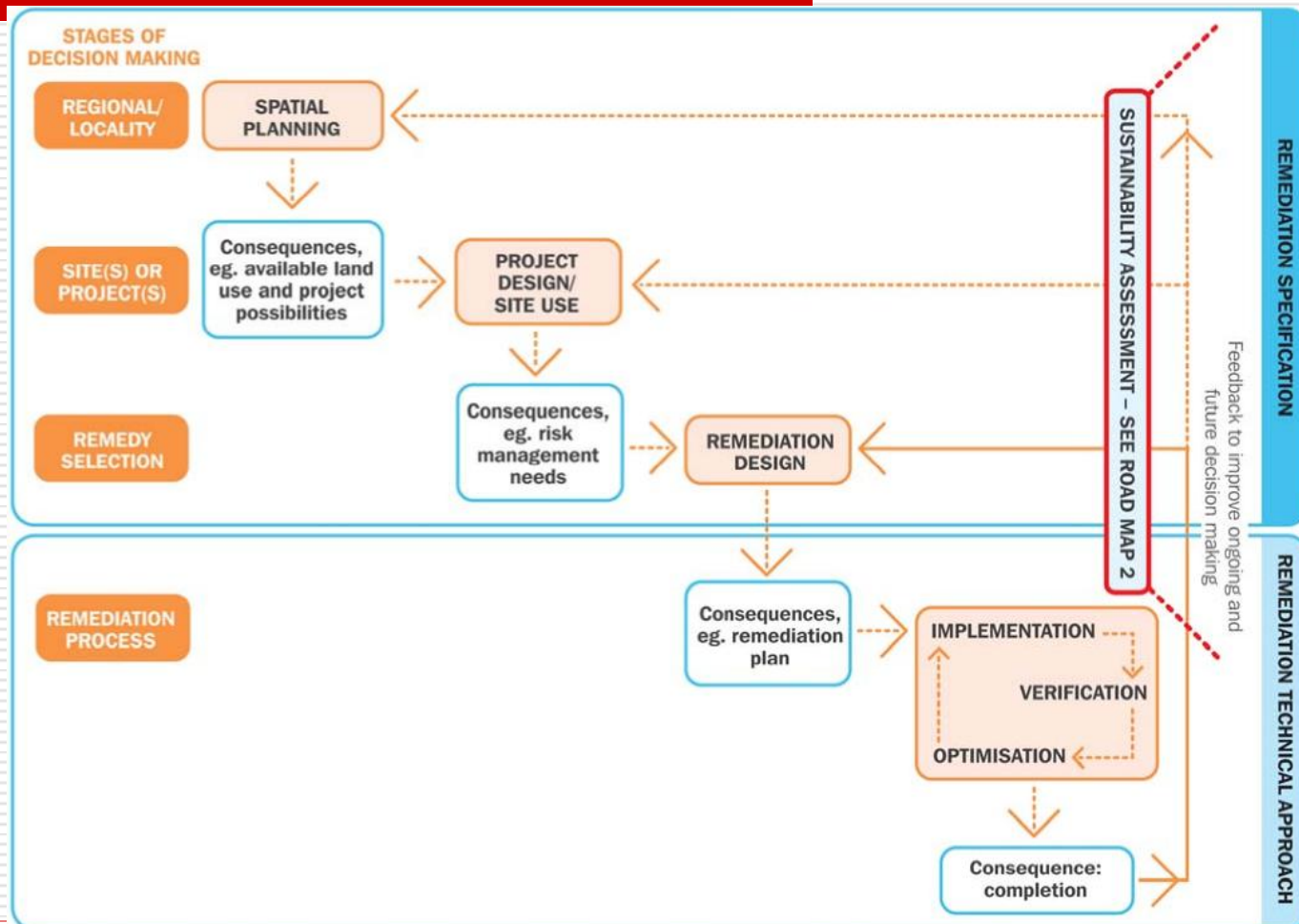
Sustainability gain dependent on the stage of the project at which it is introduced

Similar to the concept of risk management and risk assessment, sustainable remediation can be divided into two inter-related components:

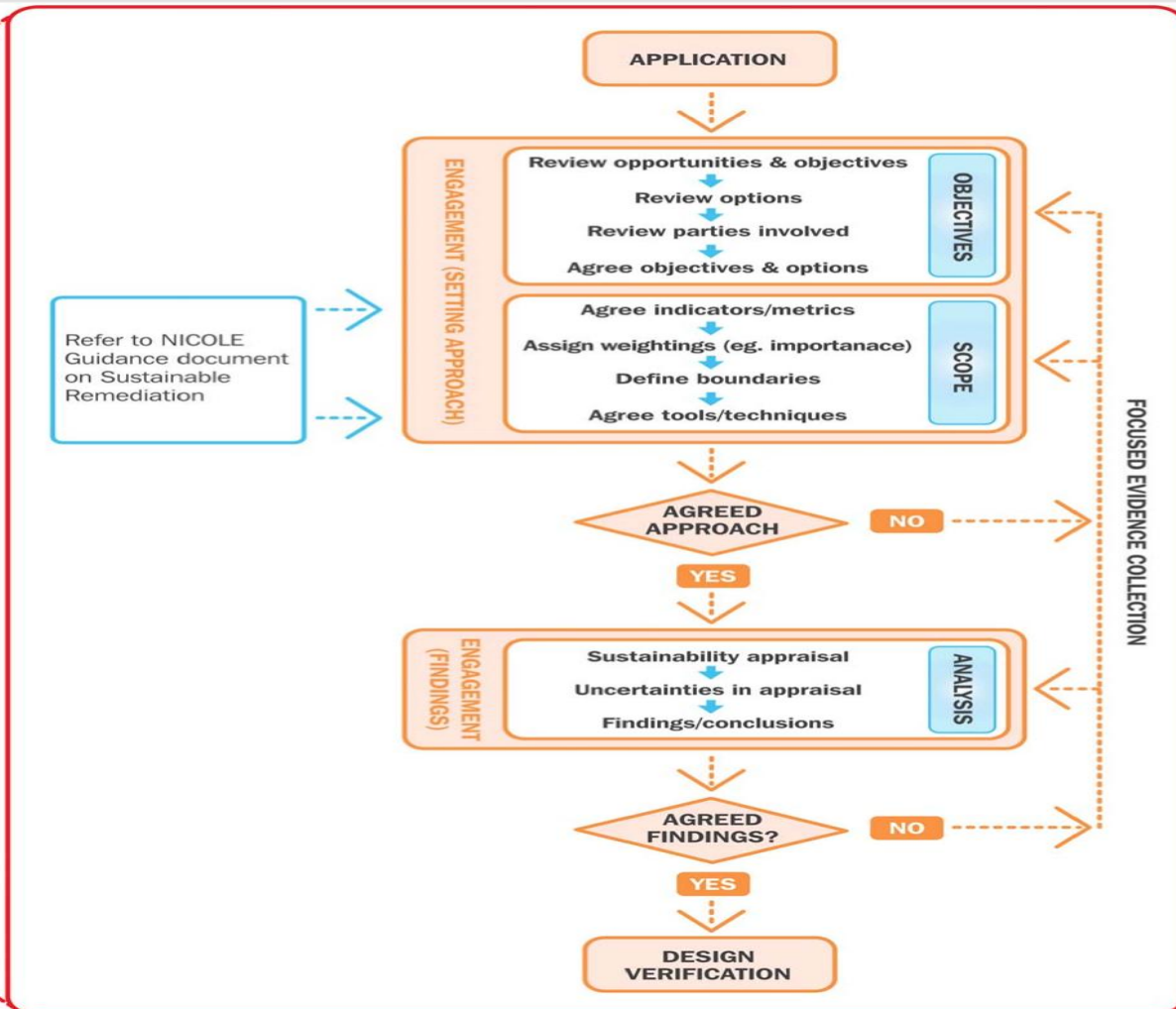
*a. Sustainability management*: the discipline of integrating sustainability assessment into contaminated land management decision making

*b. Sustainability assessment*: the process of gaining an understanding of possible outcomes across all three elements (environmental, social and economic) of sustainable development.

# ROADMAP FOR SUSTAINABILITY MANAGEMENT



# DAMAGE ASSESSMENT & REMEDIATION Sustainability assessment



# DAMAGE ASSESSMENT & REMEDIATION Sustainability assessment

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- ❑ Demonstrating a sustainability gain builds trust and therefore support from stakeholders.
- ❑ Sustainability assessment is a tool used for understanding sustainability impacts and benefits. As sustainability assessment is essentially a *subjective* process, transparency in the sustainability assessment approach greatly improves the chances of agreement between all stakeholders, and an acceptable and durable decision.
- ❑ The sustainability assessment component of NICOLE's Road Map recommends a simple process to help establish an agreed view between the different project stakeholders. It includes two broad stages.

# DAMAGE ASSESSMENT & REMEDIATION Sustainability assessment

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## □ First stage :

- the stakeholders are identified
- the objectives and the scope of the sustainability assessment are agreed with these parties.

## □ Objective setting includes:

- i. making sure that everyone who should be, is involved;
- ii. agreeing the sustainable development opportunities and objectives for the project;
- iii. agreeing the range of possible options that are going to be compared, for example remediation methods;
- iv. setting out a common understanding of purpose (objectives and options).



# DAMAGE ASSESSMENT & REMEDIATION Sustainability assessment

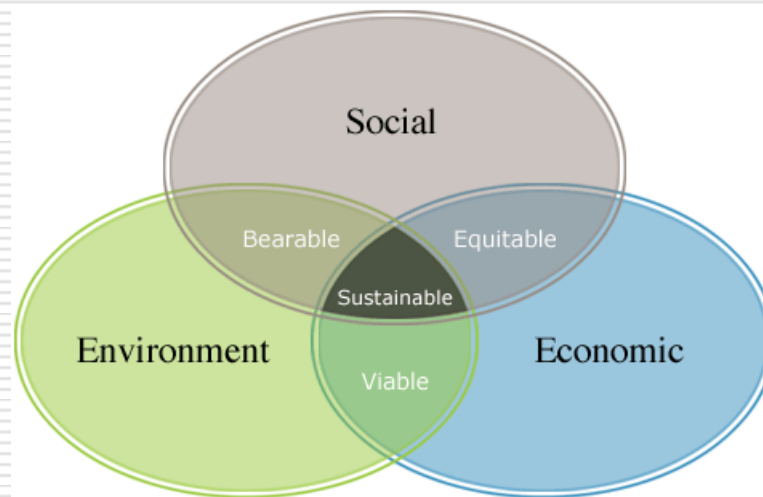
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- ❑ Second stage : the sustainability analysis. This consists of three activities:
  - i. a sustainability appraisal based on the agreed scope and objectives;
  - ii. a review of the uncertainties within the appraisal;
  - iii. ultimately drawing the conclusions or sustainability findings, together with the stakeholders.
- ❑ Finally, a monitoring and verification process should be developed and applied during project execution to demonstrate sustainability, achievement of project objectives and satisfaction of stakeholders.
- ❑ Acknowledgement to be made to NICOLE's Guidance on Sustainable Remediation, where further details are available.

# US EXAMPLE : ROAD MAP FOR SUSTAINABLE REMEDIATION Motivation and Purpose

## Sustainability Language

- UN Bruntland Commission (1987)
  - Defines sustainable development: that which meets present needs without compromising future needs



- UN World Summit (2005) Environmental, social, and economic pillars of sustainability

# Motivation and Purpose

## Definition for Sustainable Remediation

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“A remedy or combination of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources.” (Sustainable Remediation White Paper, *Remediation Journal*, Summer 2009)

More specifically:

1. Minimize or eliminate consumption of energy & other natural resources;
2. Reduce or eliminate releases to the environment, especially to the air;
3. Harness or mimic a natural process;
4. Result in the reuse or recycling of land or otherwise undesirable materials;
5. Encourage the use of remedial technologies that permanently destroy contaminants.

*Key Point:*

How can we easily **apply these principles to real-world situations?**

# Motivation and Purpose

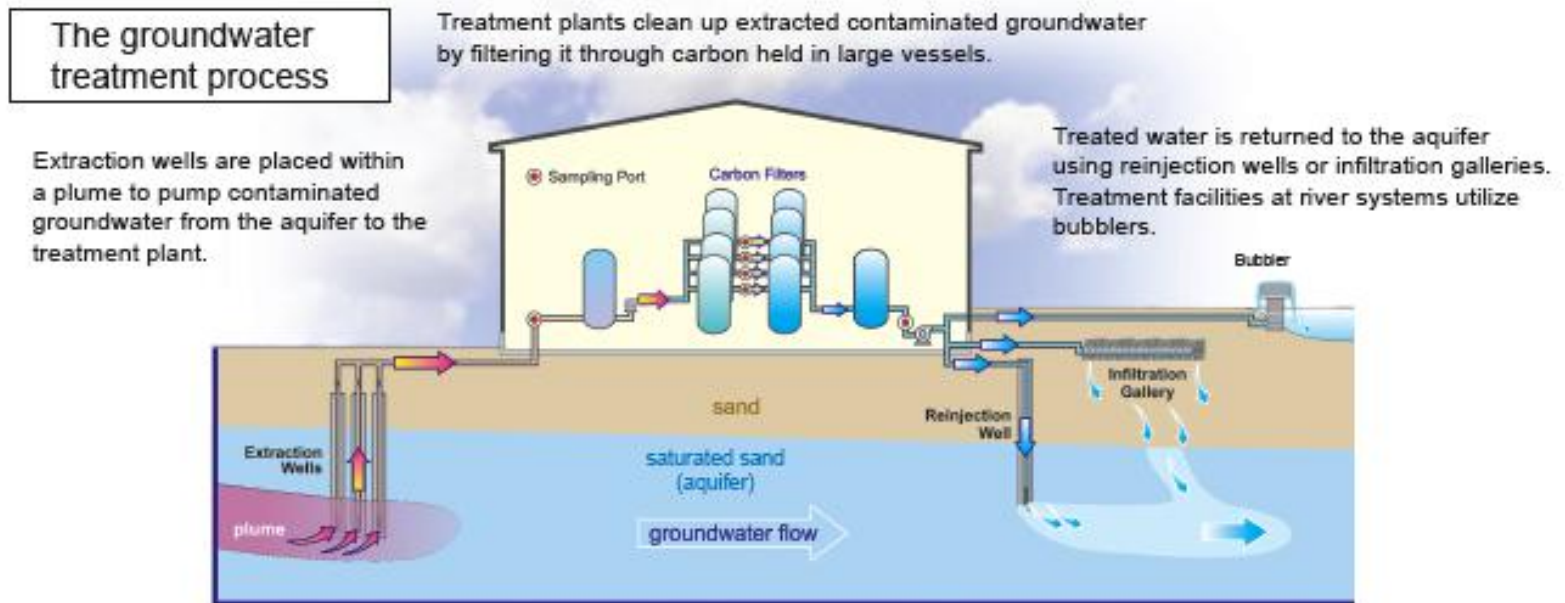
- ❑ New Remediation Paradigm
- ❑ Examples of Existing Metrics
  - CERCLA (Nine Criteria)
  - Risk and Economic Cost
- ❑ Potential Supplemental Metrics
  - Air Emissions
  - Energy Usage
  - Resource Service
  - Materials Consumption



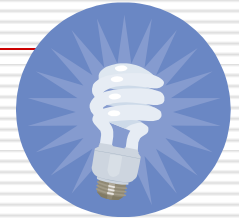
# Motivation and Purpose

## The Problem...

**Historical approach to contaminated sites does not fully consider sustainability concepts. Plus, remediation systems performance not routinely tracked.**



# Motivation and Purpose



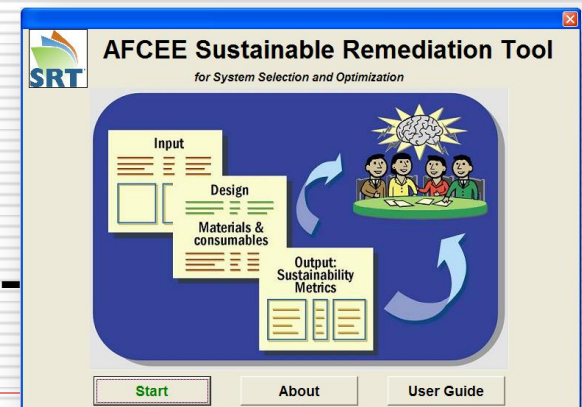
## Solutions...

Develop tools to help AFCEE environmental professionals incorporate sustainability concepts into their remediation decision making process (e.g., PBM, RRM, ERP-O) and track performance:

- i) Plan future remediation implementation
- ii) Optimize operating remediation sites

## Tools...

- ✓ **Performance Tracking Tool (PTT)**
- ✓ **Sustainable Remediation Tool (SRT)**
- ✓ **Alternative Energy Siting Tool**
- ✓ **Environmental Restoration Program-Optimization (ERP-O) Initiative**



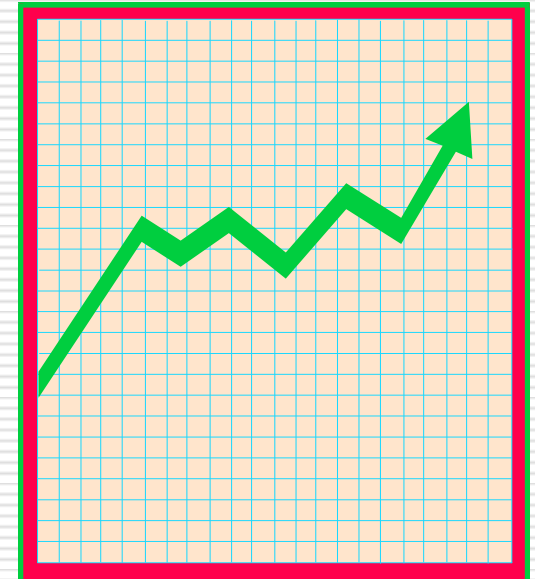
# **US EXAMPLE : ROAD MAP FOR SUSTAINABLE REMEDIATION**



## **PERFORMANCE TRACKING TOOL (PTT)**

# The Performance Tracking Tool – What Is It?

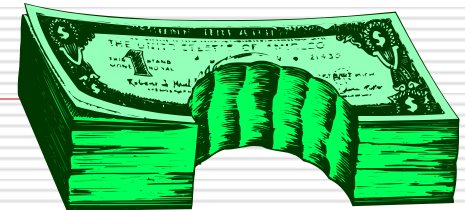
- ❑ The Performance Tracking Tool (PTT)
  - Very general (back of the envelope)
  - Excel 2007 based, mathematical model
  - Evaluates system operation
  - Presents data in a graphical format
- ❑ Initiated in 2004 with goal of finding a faster way of analyzing system performance during Remedial Process Optimization (RPO) reviews





# The Performance Tracking Tool – What Is It For?

- ❑ Assists in answering two key questions:
  - Is contaminant mass being reduced at the appropriate rate?
  - Are costs consistent with projections?
- ❑ Provides input for either optimizing or discontinuing system
- ❑ Goes beyond simply assessing whether contaminants are being removed to evaluate removal efficiency by comparing treatment performance with cost



# Systems Evaluated : until technical solutions

- ❑ The initial version was designed for evaluating pump and treat systems
  - Acknowledgements to Javier Santillan, Marc Gill and Mike Flinn
- ❑ The current version of the PTT adds five additional approaches
  1. Bioslurping
  2. Monitored Natural Attenuation (MNA)
  3. Surfactant Extraction (SurfactX)
  4. Soil Vapor Extraction (SVE)
  5. Dual Phase SVE-P&T Extraction



# Data Population

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## □ Data requirements

- Preliminary (Record of Investigation –RI -, Record of Documents- ROD-)
  - ✓ Interim remedial action costs and mass removed
  - ✓ Estimated contaminant mass, completion schedule and cost
  - ✓ Establishes Performance Objectives Baseline
- Operational (Five Year Reviews, Annual Cost and Performance Reports)
  - ✓ System capital, operation, and maintenance costs
  - ✓ Contaminant and geochemical concentrations, extraction rates, and operating time (alternative – annual mass removed or degraded)

## □ Data are entered into selected areas of the models and embedded algorithms return the results

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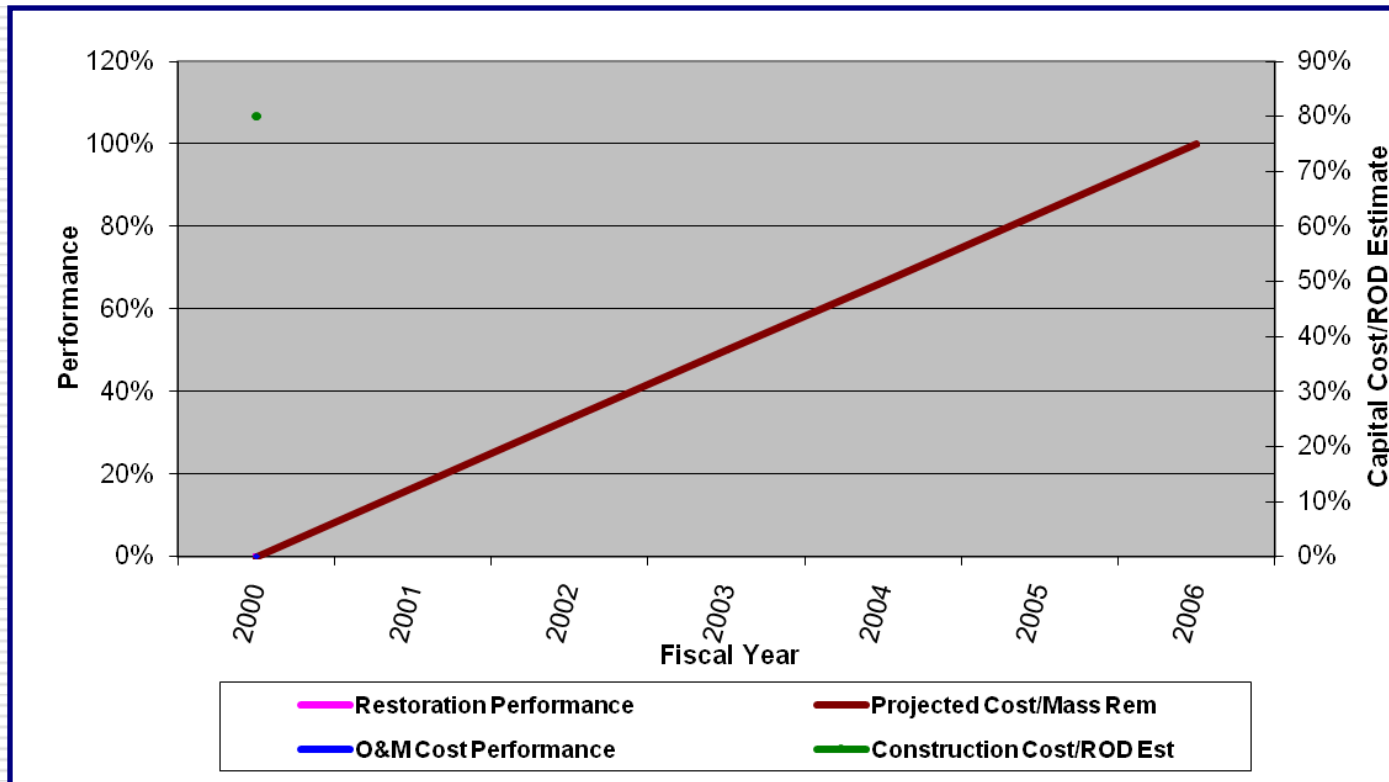
# Data Results

- ❑ Data results are normalized as percentages
  - Focus on performance, not expectations
  - Not distracted by magnitude of data values (same scale)
- ❑ Graphic presentation assists in visualizing system performance
- ❑ Provides preliminary projections for future funding based on system performance



# Graphical Display

## □ Cost and treatment correlated on

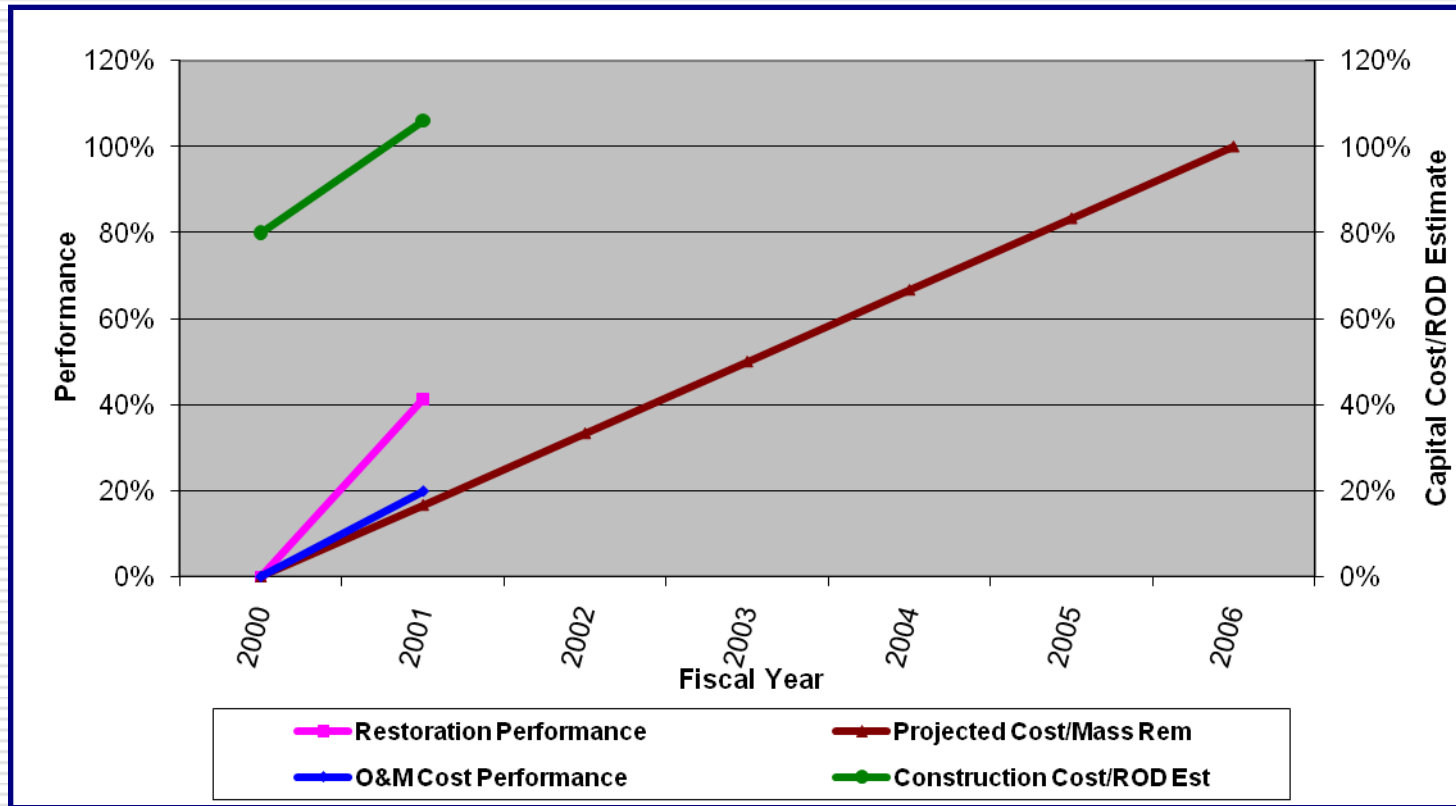


➤ Need several years of data to see trends develop

# Graphical Display

(continued)

## □ Cost and treatment correlated on

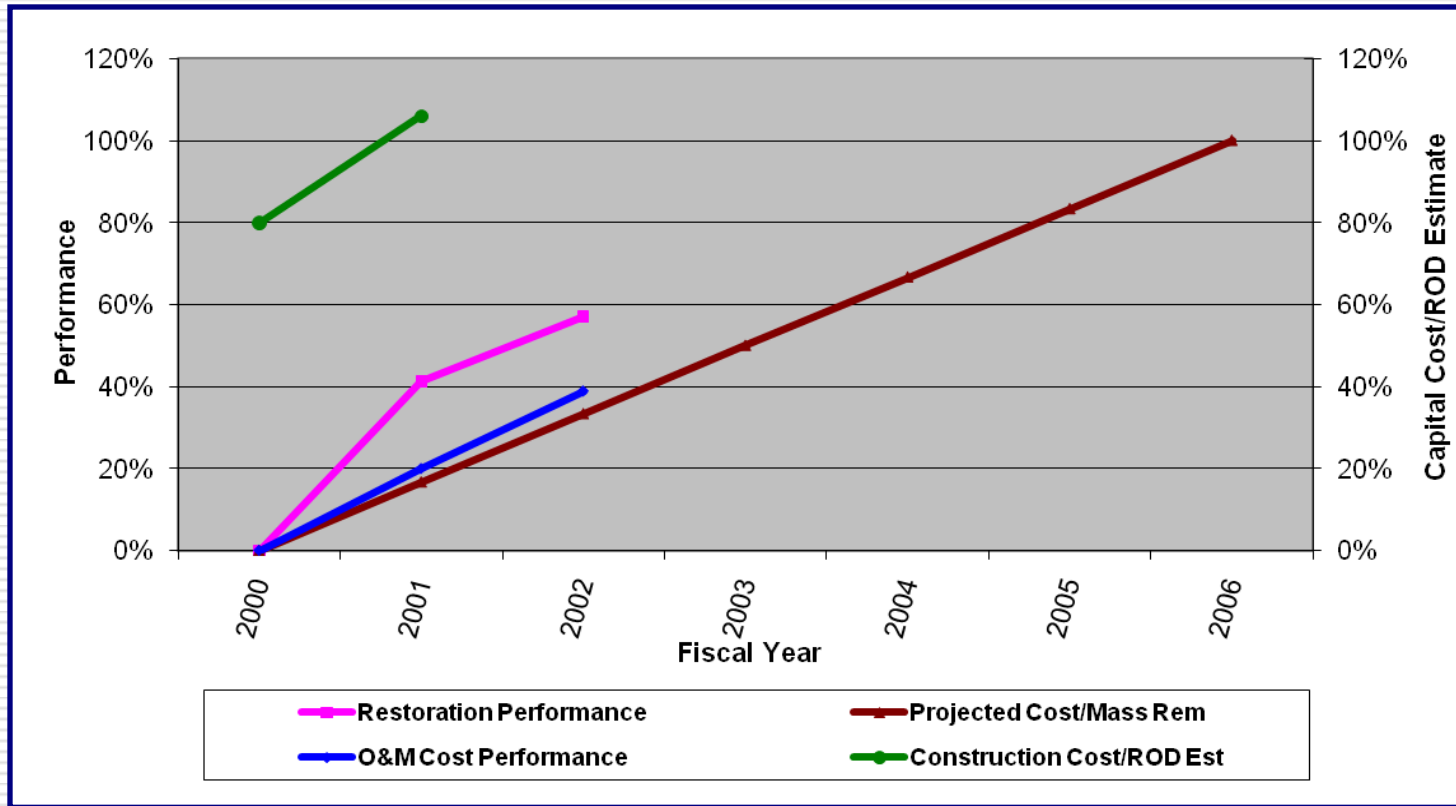


➤ Need several years of data to see trends develop  
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# Graphical Display

(continued)

## □ Cost and treatment correlated on

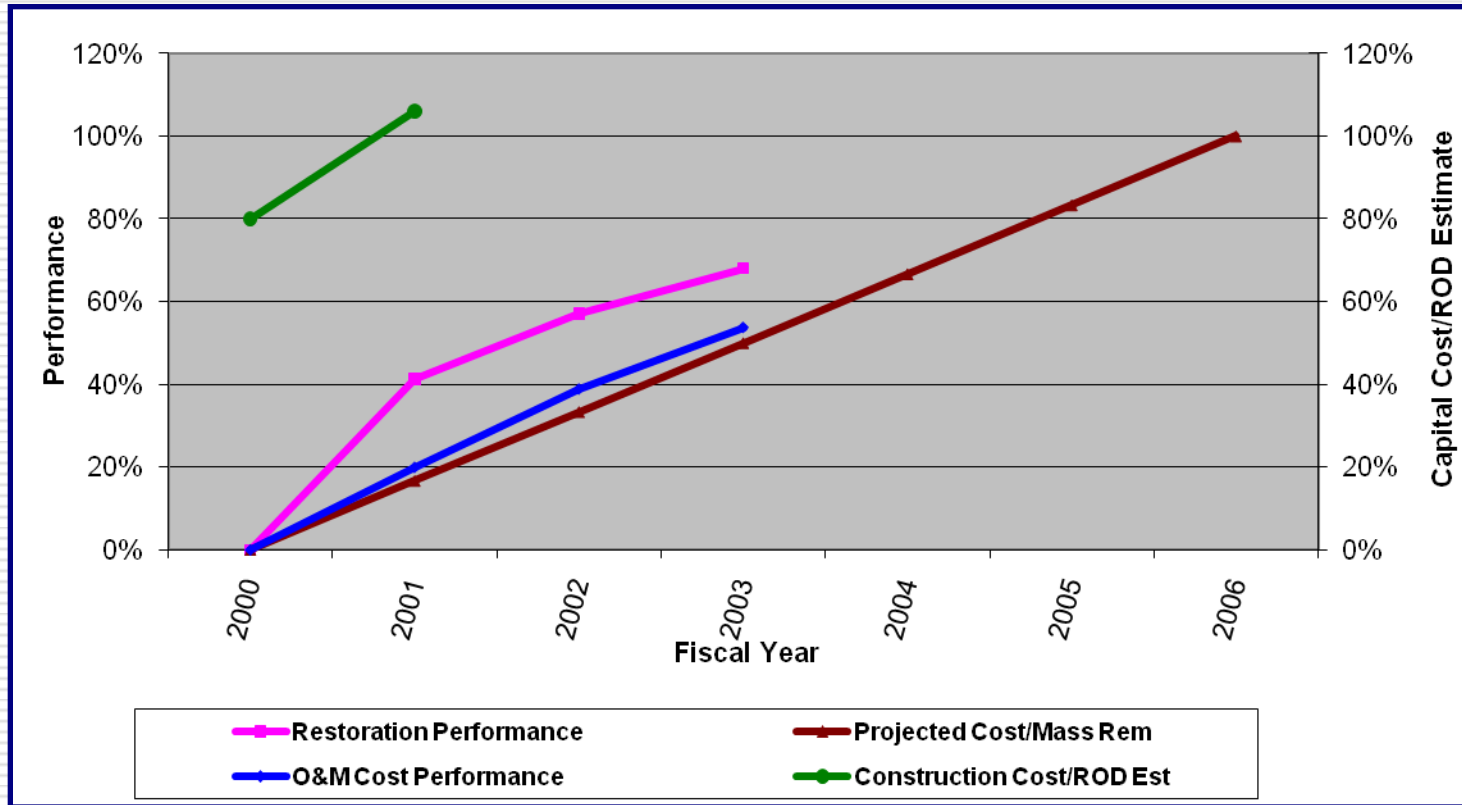


➤ Need several years of data to see trends develop  
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# Graphical Display

(continued)

## □ Cost and treatment correlated on



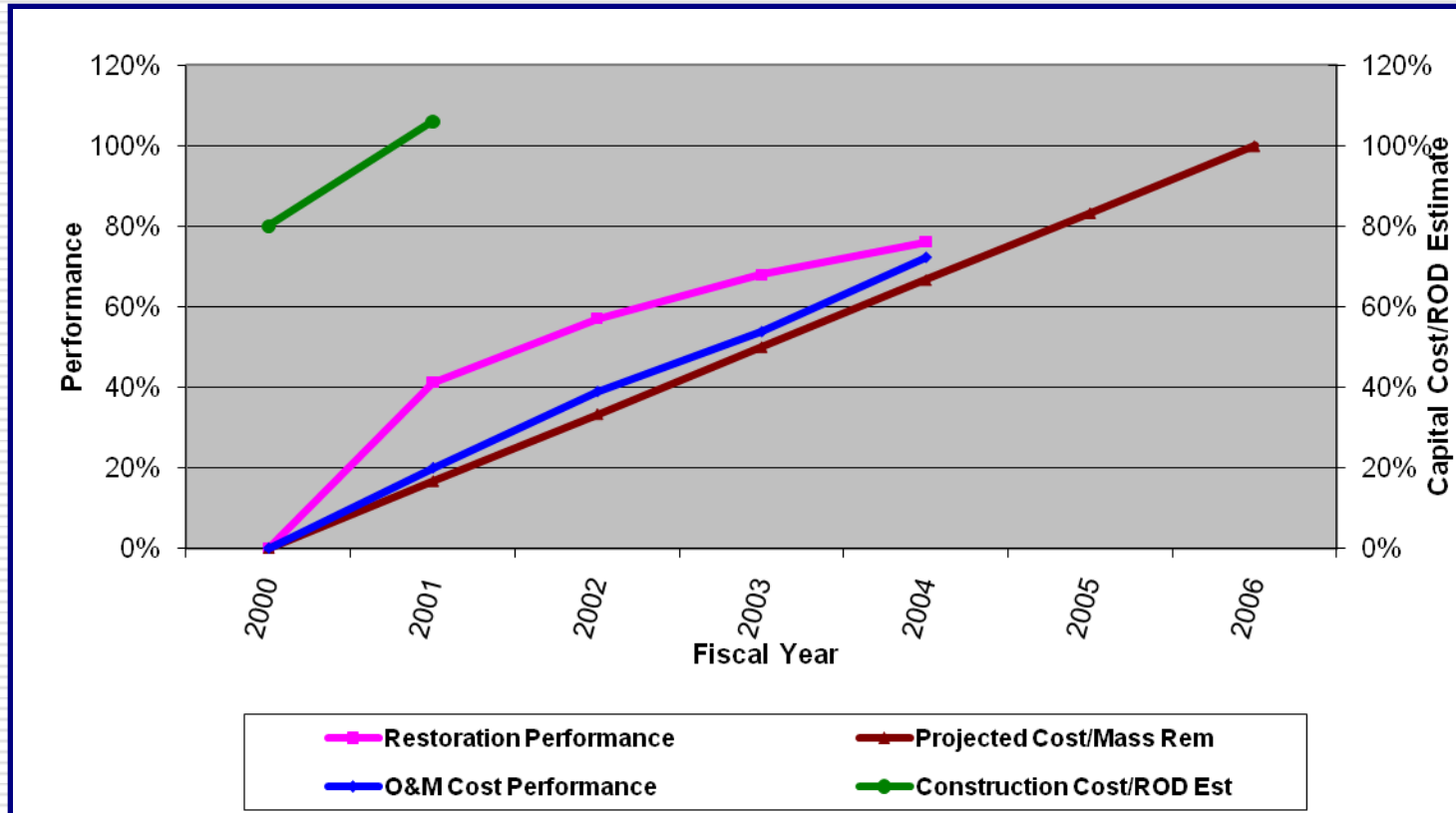
➤ Need several years of data to see trends develop  
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# Graphical Display

(continued)

## □ Cost and treatment correlated on

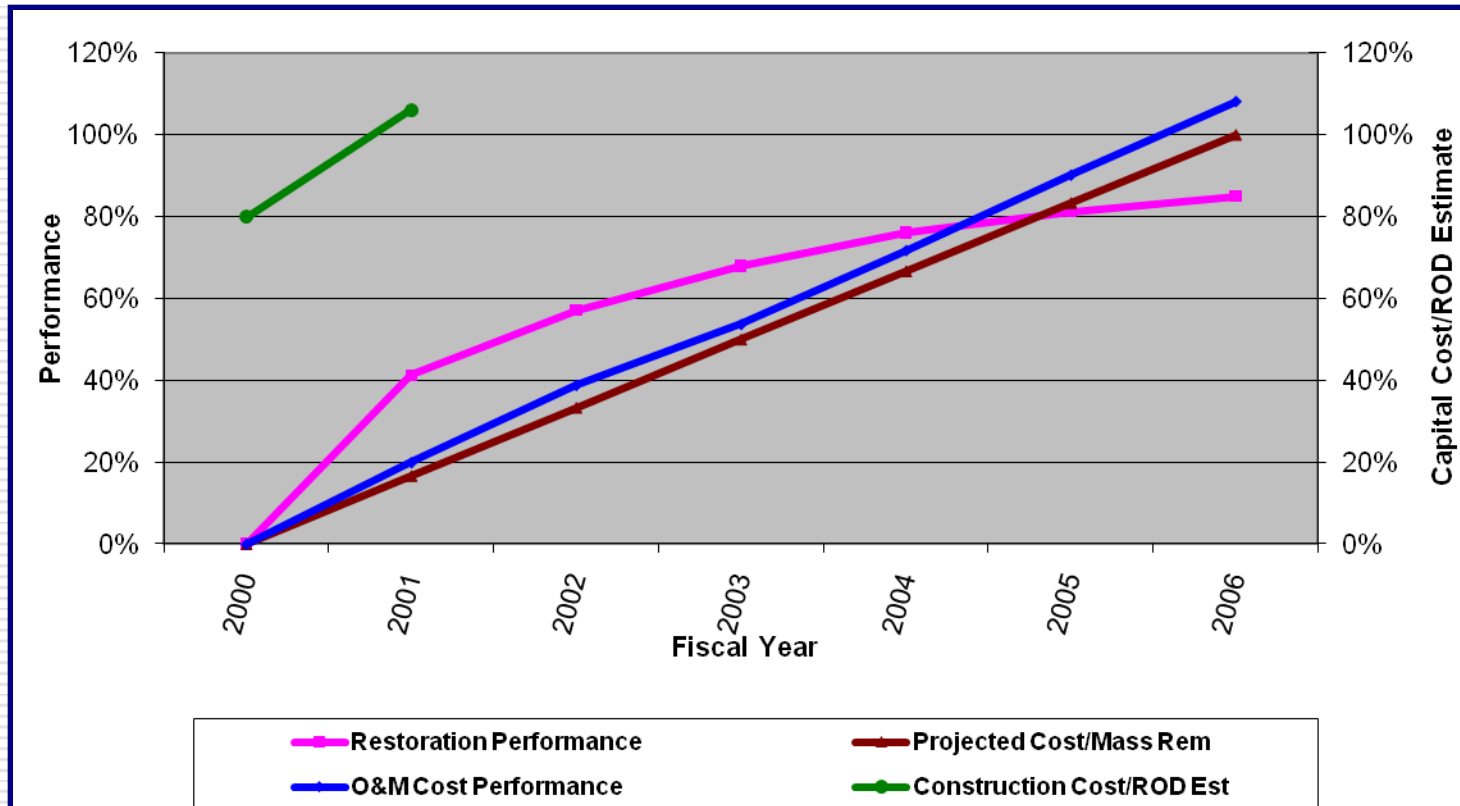


➤ Need several years of data to see trends develop  
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# Graphical Display

(concluded)

## □ Cost and treatment correlated on



➤ Need several years of data to see trends develop  
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# Example 1: P&T – Step 1

- ☐ Chlorinated Solvents Release
- ☐ Decision Document Expectations

| Mass Data Entry Directions: Enter mass data in Mass Calculations worksheet |              |
|--|--------------|
| Interim Action Start Year  | N/A          |
| Interim Action Cost  | N/A          |
| Interim Action Mass Removed  | N/A          |
| Remedy Start Year (from DD)  | 1981         |
| Estimated Mass at Remedy Start (lbs.)                                      | 10,000       |
| Estimated Acreage Impacted   | 200          |
| Acre-ft of Groundwater Impacted  | 1,200        |
| Remedy Completion Year   | 2010         |
| DD Cost-To-Complete (CTC)  | \$ 5,887,000 |
| DD Estimated Capital Costs   | \$ 887,000   |
| DD Estimated O&M Costs   | \$ 5,000,000 |
| Total Capital Costs  | \$ 500,000   |
| Total O&M Costs  | \$ 3,930,917 |

# Example 1: P&T – Step 2

□ Raw data entered and calculated

| Fiscal Year | Avg. Volume Pumped (gpm) | Percent Operational Uptime | Average Annual Concentration ug/l (influent) |                |       |       |      |     |       |    | Total Annual Mass Removed (lb/yr) |
|-------------|--------------------------|----------------------------|--|----------------|-------|-------|------|-----|-------|----|-----------------------------------|
|             |                          |                            | VOCs   | Chloro-benzene | 12DCB | 14DCB | cDCE | PCE | TCE   | VC |                                   |
| 1981        | -                        | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | -     | 0  |                                   |
| 1982        | 400                      | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | 1,000 | 0  | 1,687                             |
| 1983        | 1,155                    | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | 231   | 0  | 1,125                             |
| 1984        | 568                      | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | 251   | 0  | 601                               |
| 1985        | 800                      | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | 201   | 0  | 678                               |
| 1986        | 685                      | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | 180   | 0  | 520                               |
| 1987        | 685                      | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | 159   | 0  | 459                               |
| 1988        | 685                      | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | 138   | 0  | 399                               |
| 1989        | 685                      | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | 117   | 0  | 338                               |
| 1990        | 685                      | 96                         | 0  | 0              | 0     | 0     | 0    | 0   | 96    | 0  | 277                               |
| 1991        | 809                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 76    | 0  | 270                               |
| 1992        | 877                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 55    | 0  | 212                               |
| 1993        | 649                      | 92                         | 0  | 0              | 0     | 0     | 0    | 0   | 35    | 0  | 92                                |
| 1994        | 693                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 32    | 0  | 97                                |
| 1995        | 613                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 32    | 0  | 86                                |
| 1996        | 626                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 29    | 0  | 80                                |
| 1997        | 600                      | 97                         | 0  | 0              | 0     | 0     | 0    | 0   | 25    | 0  | 64                                |
| 1998        | 588                      | 98                         | 0  | 0              | 0     | 0     | 0    | 0   | 21    | 0  | 53                                |
| 1999        | 565                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 15    | 0  | 37                                |
| 2000        | 673                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 12    | 0  | 36                                |
| 2001        | 630                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 13    | 0  | 37                                |
| 2002        | 597                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 12    | 0  | 31                                |
| 2003        | 570                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 11    | 0  | 27                                |
| 2004        | 596                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 11    | 0  | 29                                |
| 2005        | 471                      | 100                        | 0  | 0              | 0     | 0     | 0    | 0   | 12    | 0  | 25                                |
| 2006        |                          |                            |  |                |       |       |      |     |       |    |                                   |
| 2007        |                          |                            |  |                |       |       |      |     |       |    |                                   |
| 2008        |                          |                            |  |                |       |       |      |     |       |    |                                   |
| 2009        |                          |                            |  |                |       |       |      |     |       |    |                                   |
| 2010        |                          |                            |  |                |       |       |      |     |       |    |                                   |

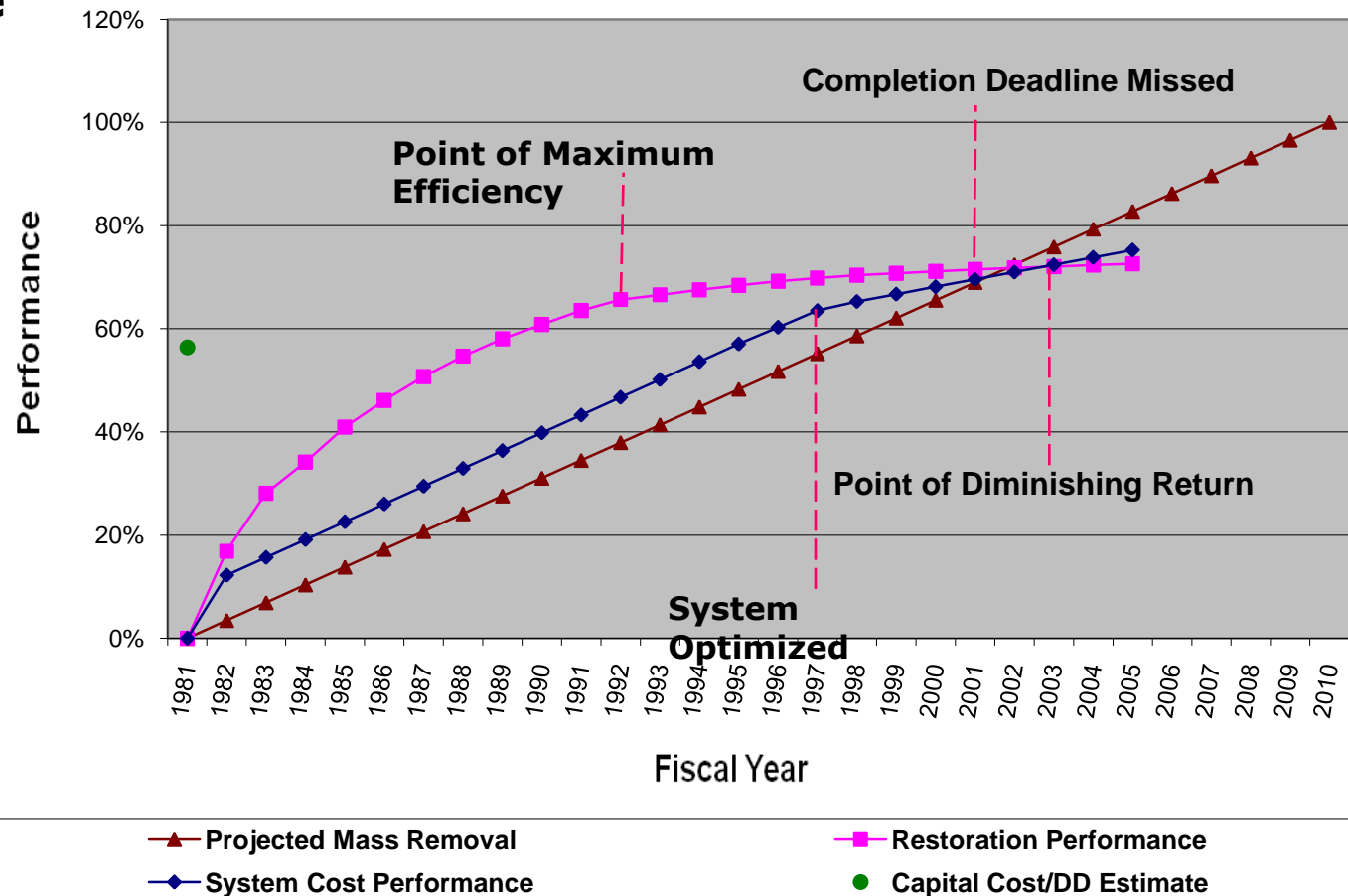
# Example 1: P&T – Step 3

- Capital and O&M costs entered
- Results tabulated

| Fiscal Year | Total Mass Removed per Year (lbs.) | Capital Cost per Year | O&M Cost per Year | Capital Cost as Percent of DD Estimate | O&M as Percent of CTC | Projected System Cost as Percent of CTC | Actual System Cost as Percent of CTC | Projected Mass Removed | Actual Mass Removed |
|-------------|------------------------------------|-----------------------|-------------------|--|-----------------------|---|--------------------------------------|------------------------|---------------------|
| 1981        |                                    | \$ 500,000            | \$ 16,917         | 56%                                    | 0%                    | 0%                                      | 0%                                   | 0%                     | 0%                  |
| 1982        | 1,687                              |                       | \$ 203,000        |  | 4%                    | 15%                                     | 12%                                  | 3%                     | 17%                 |
| 1983        | 1,125                              |                       | \$ 203,000        |  | 7%                    | 18%                                     | 16%                                  | 7%                     | 28%                 |
| 1984        | 601                                |                       | \$ 203,000        |  | 11%                   | 21%                                     | 19%                                  | 10%                    | 34%                 |
| 1985        | 678                                |                       | \$ 203,000        |  | 14%                   | 24%                                     | 23%                                  | 14%                    | 41%                 |
| 1986        | 520                                |                       | \$ 203,000        |  | 18%                   | 27%                                     | 26%                                  | 17%                    | 46%                 |
| 1987        | 459                                |                       | \$ 203,000        |  | 21%                   | 30%                                     | 29%                                  | 21%                    | 51%                 |
| 1988        | 399                                |                       | \$ 203,000        |  | 24%                   | 33%                                     | 33%                                  | 24%                    | 55%                 |
| 1989        | 338                                |                       | \$ 203,000        |  | 28%                   | 36%                                     | 36%                                  | 28%                    | 58%                 |
| 1990        | 277                                |                       | \$ 203,000        |  | 31%                   | 39%                                     | 40%                                  | 31%                    | 61%                 |
| 1991        | 270                                |                       | \$ 203,000        |  | 35%                   | 42%                                     | 43%                                  | 34%                    | 64%                 |
| 1992        | 212                                |                       | \$ 203,000        |  | 38%                   | 45%                                     | 47%                                  | 38%                    | 66%                 |
| 1993        | 92                                 |                       | \$ 203,000        |  | 42%                   | 48%                                     | 50%                                  | 41%                    | 67%                 |
| 1994        | 97                                 |                       | \$ 203,000        |  | 45%                   | 51%                                     | 54%                                  | 45%                    | 68%                 |
| 1995        | 86                                 |                       | \$ 203,000        |  | 49%                   | 55%                                     | 57%                                  | 48%                    | 68%                 |
| 1996        | 80                                 |                       | \$ 190,000        |  | 52%                   | 58%                                     | 60%                                  | 52%                    | 69%                 |
| 1997        | 64                                 |                       | \$ 190,000        |  | 55%                   | 61%                                     | 64%                                  | 55%                    | 70%                 |
| 1998        | 53                                 |                       | \$ 104,000        |  | 57%                   | 64%                                     | 65%                                  | 59%                    | 70%                 |
| 1999        | 37                                 |                       | \$ 84,000         |  | 58%                   | 67%                                     | 67%                                  | 62%                    | 71%                 |
| 2000        | 36                                 |                       | \$ 84,000         |  | 60%                   | 70%                                     | 68%                                  | 66%                    | 71%                 |
| 2001        | 37                                 |                       | \$ 84,000         |  | 61%                   | 73%                                     | 70%                                  | 69%                    | 71%                 |
| 2002        | 31                                 |                       | \$ 84,000         |  | 62%                   | 76%                                     | 71%                                  | 72%                    | 72%                 |
| 2003        | 27                                 |                       | \$ 84,000         |  | 64%                   | 79%                                     | 72%                                  | 76%                    | 72%                 |
| 2004        | 29                                 |                       | \$ 84,000         |  | 65%                   | 82%                                     | 74%                                  | 79%                    | 72%                 |
| 2005        | 25                                 |                       | \$ 84,000         |  | 67%                   | 85%                                     | 75%                                  | 83%                    | 73%                 |
| 2006        |                                    |                       |                   |  |                       | 88%                                     |                                      | 86%                    |                     |
| 2007        |                                    |                       |                   |  |                       | 91%                                     |                                      | 90%                    |                     |
| 2008        |                                    |                       |                   |  |                       | 94%                                     |                                      | 93%                    |                     |
| 2009        |                                    |                       |                   |  |                       | 97%                                     |                                      | 97%                    |                     |
| 2010        |                                    |                       |                   |  |                       | 100%                                    |                                      | 100%                   |                     |

# Example 1: P&T – Step 4

## ■ Performance Graphed



# Example 1: P&T – Step 5

## ■ Future Expenditures Projected

|                            | To Date         | Projected Total Cost | Estimated Total Cost |
|----------------------------|-----------------|----------------------|----------------------|
| System Cost/Acre           | \$ 19,654.59    | \$ 27,077.48         | \$ 29,435.00         |
| System Cost/Acre Foot      | \$ 3,275.76     | \$ 4,512.91          | \$ 4,905.83          |
| Cost/lb Removed by System  | \$ 541.55       | \$ 746.08            | \$ 588.70            |
| System Costs               | \$ 3,930,917.00 | \$ 5,415,496.44      | \$ 5,887,000.00      |
| Mass Removed by System     | 7,259 lbs       |                      |                      |
| Percent of DD Mass Removed | 73%             |                      |                      |
| Total Mass Removed         | 7,259 lbs       |                      |                      |
| Total Remediation Costs    | \$ 3,930,917    |                      |                      |

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# Example 2: Dual Phase – Step 1

- JP Fuel Leak
- Decision Document Expectations

| Mass Data Entry Directions: Enter mass data in Mass Calculations worksheet |              |
|--|--------------|
| Interim Action Start Year  | N/A          |
| Interim Action Cost  | N/A          |
| Interim Action Mass Removed  | N/A          |
| Remedy Start Year (from DD)  | 1991         |
| Estimated Mass at Remedy Start (lbs.)                                      | 250,000      |
| Estimated Acreage Impacted   | 10           |
| Acre-ft of groundwater impacted  | 50           |
| Remedy Completion Year   | 2015         |
| DD Cost-To-Complete (CTC)  | \$ 6,250,000 |
| DD Estimated Capital Costs   | \$ 250,000   |
| DD Estimated O&M Costs   | \$ 6,000,000 |
| Total Capital Costs  | \$ 250,000   |
| Total O&M Costs  | \$ 3,250,000 |



# Example 2: Dual Phase – Step 2

## ■ Raw data entered and calculated

| Fiscal Year | Avg. Volume Pumped (gpm) | Percent Operational Uptime | Average Annual Concentration ug/l (influent) |     |     |      |           | NAPL Recovered (lb/yr) | Total Annual Mass Removed (lb/yr) |
|-------------|--------------------------|----------------------------|--|-----|-----|------|-----------|------------------------|-----------------------------------|
|             |                          |                            | TCE  | DCE | VCI | BTEX | Other VOC |                        |                                   |
| 1991        |                          |                            |  |     |     |      |           |                        |                                   |
| 1992        | 10                       | 95                         | 0  | 0   | 0   | 0    | 0         | 160                    | 160                               |
| 1993        | 10                       | 95                         | 0  | 0   | 0   | 0    | 0         | 125                    | 125                               |
| 1994        | 10                       | 95                         | 0  | 0   | 0   | 0    | 0         | 240                    | 240                               |
| 1995        | 10                       | 95                         | 0  | 0   | 0   | 0    | 0         | 360                    | 360                               |
| 1996        | 10                       | 95                         | 0  | 0   | 0   | 0    | 0         | 395                    | 395                               |
| 1997        | 10                       | 95                         | 0  | 0   | 0   | 0    | 0         | 150                    | 150                               |
| 1998        | 10                       | 95                         | 0  | 0   | 0   | 0    | 0         | 100                    | 100                               |
| 1999        | 10                       | 95                         | 0  | 0   | 0   | 90   | 65        | 360                    | 366                               |
| 2000        | 10                       | 95                         | 0  | 0   | 0   | 30   | 40        | 150                    | 153                               |
| 2001        | 10                       | 95                         | 0  | 0   | 0   | 15   | 40        | 138                    | 140                               |
| 2002        | 10                       | 95                         | 0  | 0   | 0   | 15   | 40        | 266                    | 268                               |
| 2003        | 10                       | 95                         | 0  | 0   | 0   | 15   | 40        | 214                    | 216                               |
| 2004        | 10                       | 95                         | 0  | 0   | 0   | 25   | 40        | 239                    | 242                               |
| 2005        |                          |                            |  |     |     |      |           |                        |                                   |
| 2006        |                          |                            |  |     |     |      |           |                        |                                   |
| 2007        |                          |                            |  |     |     |      |           |                        |                                   |
| 2008        |                          |                            |  |     |     |      |           |                        |                                   |
| 2009        |                          |                            |  |     |     |      |           |                        |                                   |
| 2010        |                          |                            |  |     |     |      |           |                        |                                   |
| 2011        |                          |                            |  |     |     |      |           |                        |                                   |
| 2012        |                          |                            |  |     |     |      |           |                        |                                   |
| 2013        |                          |                            |  |     |     |      |           |                        |                                   |
| 2014        |                          |                            |  |     |     |      |           |                        |                                   |
| 2015        |                          |                            |  |     |     |      |           |                        |                                   |

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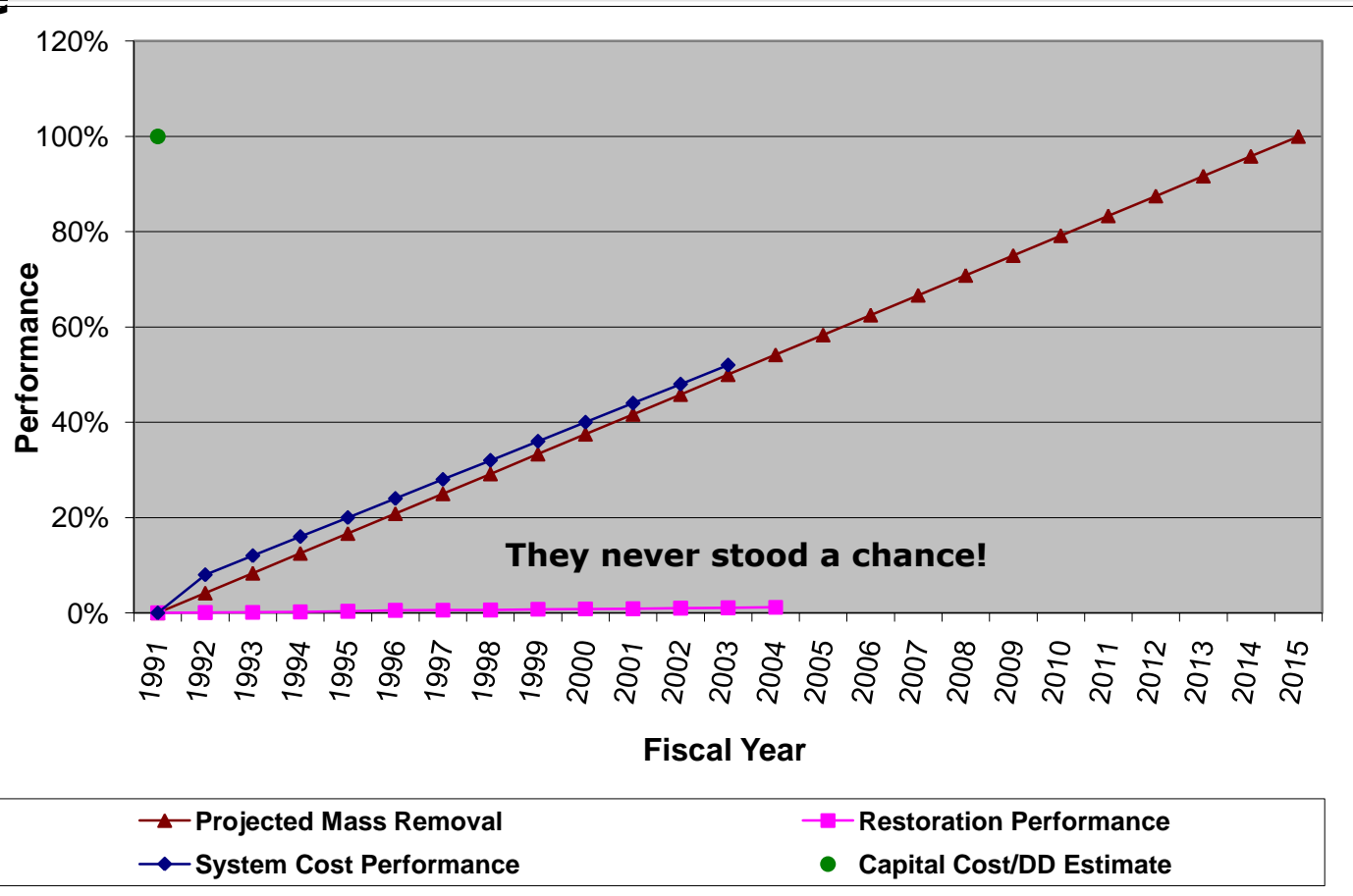
# Example 2: Dual Phase – Step 3

- Capital and O&M costs entered
- Results tabulated

| Fiscal Year | Total Mass Removed per Year (lbs.) | Capital Cost per Year | O&M Cost per Year | Capital Cost as Percent of DD Estimate | O&M as Percent of CTC | Projected System Cost as Percent of CTC | Actual System Cost as Percent of CTC | Projected Mass Removed | Actual Mass Removed |
|-------------|------------------------------------|-----------------------|-------------------|--|-----------------------|---|--------------------------------------|------------------------|---------------------|
| 1991        |                                    | \$ 250,000            |                   | 100%                                   |                       | 0%                                      |                                      | 0%                     | 0%                  |
| 1992        | 160                                |                       | \$ 250,000        |  | 4%                    | 4%                                      | 8%                                   | 4%                     | 0%                  |
| 1993        | 125                                |                       | \$ 250,000        |  | 8%                    | 8%                                      | 12%                                  | 8%                     | 0%                  |
| 1994        | 240                                |                       | \$ 250,000        |  | 12%                   | 12%                                     | 16%                                  | 13%                    | 0%                  |
| 1995        | 360                                |                       | \$ 250,000        |  | 16%                   | 17%                                     | 20%                                  | 17%                    | 0%                  |
| 1996        | 395                                |                       | \$ 250,000        |  | 20%                   | 21%                                     | 24%                                  | 21%                    | 1%                  |
| 1997        | 150                                |                       | \$ 250,000        |  | 24%                   | 25%                                     | 28%                                  | 25%                    | 1%                  |
| 1998        | 100                                |                       | \$ 250,000        |  | 28%                   | 29%                                     | 32%                                  | 29%                    | 1%                  |
| 1999        | 366                                |                       | \$ 250,000        |  | 32%                   | 33%                                     | 36%                                  | 33%                    | 1%                  |
| 2000        | 153                                |                       | \$ 250,000        |  | 36%                   | 37%                                     | 40%                                  | 38%                    | 1%                  |
| 2001        | 140                                |                       | \$ 250,000        |  | 40%                   | 42%                                     | 44%                                  | 42%                    | 1%                  |
| 2002        | 268                                |                       | \$ 250,000        |  | 44%                   | 46%                                     | 48%                                  | 46%                    | 1%                  |
| 2003        | 216                                |                       | \$ 250,000        |  | 48%                   | 50%                                     | 52%                                  | 50%                    | 1%                  |
| 2004        | 242                                |                       | \$ 250,000        |  | 52%                   | 54%                                     | 56%                                  | 54%                    | 1%                  |
| 2005        |                                    |                       |                   |  |                       | 58%                                     |                                      | 58%                    |                     |
| 2006        |                                    |                       |                   |  |                       | 62%                                     |                                      | 63%                    |                     |
| 2007        |                                    |                       |                   |  |                       | 67%                                     |                                      | 67%                    |                     |
| 2008        |                                    |                       |                   |  |                       | 71%                                     |                                      | 71%                    |                     |
| 2009        |                                    |                       |                   |  |                       | 75%                                     |                                      | 75%                    |                     |
| 2010        |                                    |                       |                   |  |                       | 79%                                     |                                      | 79%                    |                     |
| 2011        |                                    |                       |                   |  |                       | 83%                                     |                                      | 83%                    |                     |
| 2012        |                                    |                       |                   |  |                       | 87%                                     |                                      | 88%                    |                     |
| 2013        |                                    |                       |                   |  |                       | 92%                                     |                                      | 92%                    |                     |
| 2014        |                                    |                       |                   |  |                       | 96%                                     |                                      | 96%                    |                     |
| 2015        |                                    |                       |                   |  |                       | 100%                                    |                                      | 100%                   |                     |

# Example 2: Dual Phase – Step 4

## ■ Performance Graphed



# Example 2: Dual Phase – Step 5

## ■ Future Expenditures Projected

|                            | To Date         | Projected Total Cost | Estimated Total Cost |
|----------------------------|-----------------|----------------------|----------------------|
| System Cost/Acre           | \$ 325,000.00   | \$ 27,864,293.68     | \$ 625,000.00        |
| System Cost/Acre Foot      | \$ 65,000.00    | \$ 5,572,858.74      | \$ 125,000.00        |
| Cost/lb Removed by System  | \$ 1,114.57     | \$ 95,559.24         | \$ 25.00             |
| System Costs               | \$ 3,250,000.00 | \$ 278,642,936.83    | \$ 6,250,000.00      |
| Mass Removed by System     | 2,916           |                      |                      |
| Percent of DD Mass Removed | 1%              |                      |                      |
| Total Mass Removed         | 2,916           |                      |                      |
| Total Remediation Costs    | \$ 3,250,000    |                      |                      |

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# Potential Applications

---

- ❑ The PTT can enhance your understanding of system operations and environmental conditions
    - Data from an existing system may be useful when considering whether to install a similar system at a different location
  - ❑ The PTT can assist in decision making
    - Designate system endpoints in ROD
    - System optimization – apply to individual system components
      - ✓ Rehabilitate or abandon less productive extraction points
      - ✓ Increase rates on more productive extraction points
    - Use subsequent results to evaluate the effect of your decisions and adjust accordingly
-

# Summary

---

- ❑ Focus of PTT is on system operation, not site remediation
- ❑ “Back of the envelope” general assessment (Reality Check)
  - Professional judgment or assumptions often required
    - ✓ Cost to complete estimates
    - ✓ Original mass estimates
    - ✓ Area/volume of contamination
  - Results are only as good as the data used
    - ✓ Original (raw) O&M data are best
    - ✓ Summary data are okay
    - ✓ Averaged data are not so hot (loss of data resolution)

# Future Developments

---

- Develop and validate additional technologies
  1. *In Situ* Thermal Treatment
  2. Enhanced *In Situ* Bioremediation
  3. *In Situ* Chemical Oxidation
  4. Permeable Reactive Barriers (ZVI and biowall)
- Create Site System Summary
- Develop multiple system graphing capability

# **US EXAMPLE : ROAD MAP FOR SUSTAINABLE REMEDiation**



## **SUSTAINABLE REMEDiation TOOL**

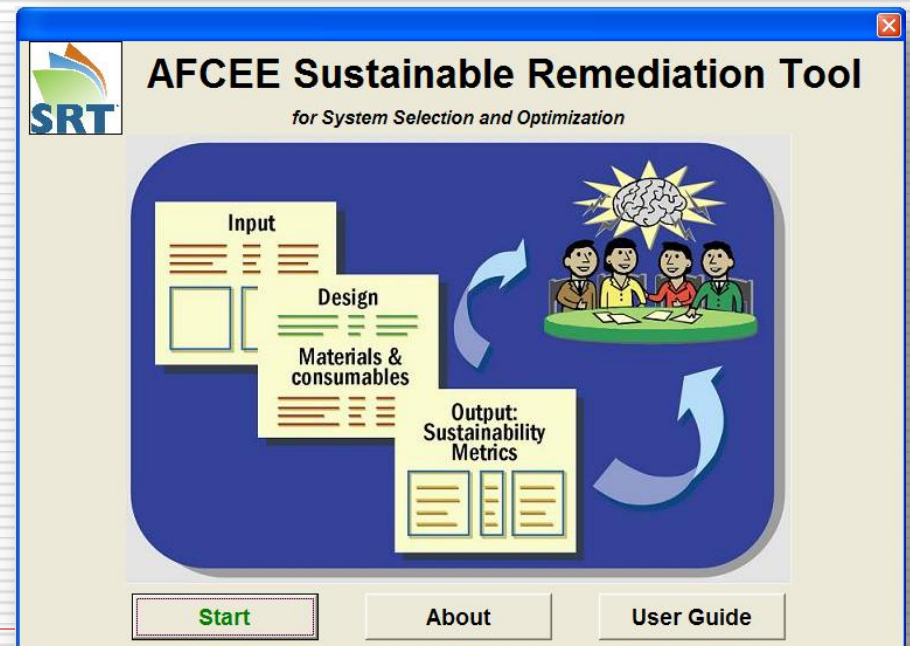


# ***SRT Overview***



## **Project Team**

- **SRT Design and Functionality**
- **SRT Workflow**
- **Hands On Practice**



# ***Acknowledgements : SRT Project Team***

---

- **Air Force Center for Engineering and the Environment**
  - **Erica Becvar**
  
- **AECOM**
  - **Doug Ruppel, John Claypool, Dave Woodward**
  
- **GSI Environmental Inc.**
  - **Chuck Newell, Tiffany Swann, Lila Beckley, Ata Rahman**
  
- **CH2M HILL**
  - **Doug Downey, Paul Favara, Brad Woodard**

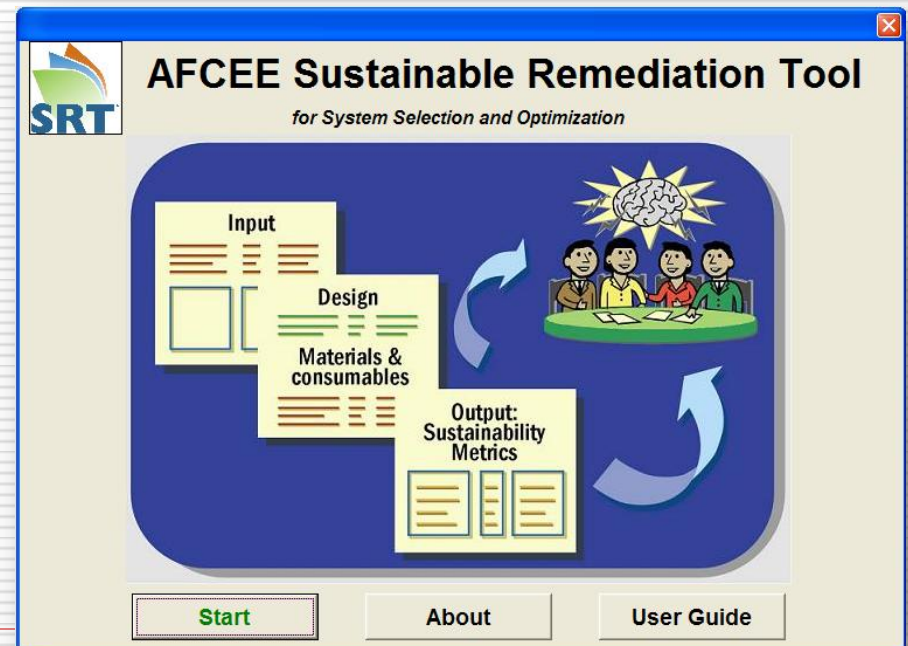
# ***SRT Overview***

- **Project Team**

- ➡ **SRT Design and Functionality**

- **SRT Workflow**

- **Hands On Practice**



# ***SRT Design Principles***

---

- **No replication of design tools (simply calculate metrics)**
- **Develop with tiered approach for parameter inputs**
  - **Easy Tier 1 with Rules of Thumb for technology estimates**
  - **Tier 2 can estimate but not intended to replace design tools**
  - **Allow user override of estimated values at any time to accommodate real design parameters**
- **Include cost as a sustainability metric**

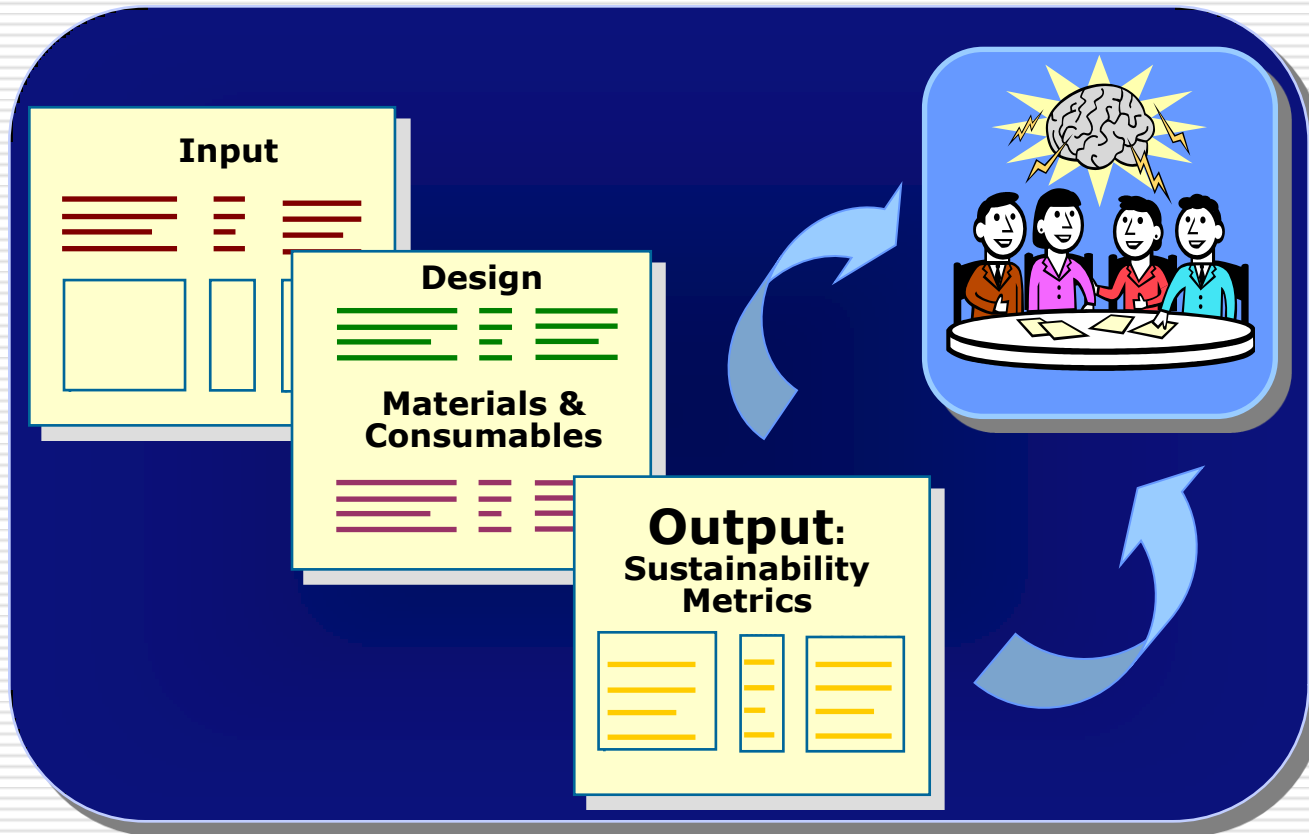
# ***Technologies in the SRT***

- **Excavation**
- **Soil Vapor Extraction (SVE)**
- **Pump and Treat (P&T)**
- **Enhanced Bioremediation**
- **In Situ Chemical Oxidation (ISCO)**
- **Permeable Reactive Barrier (PRB)**
- **Long-term Monitoring (LTM) / Monitored Natural Attenuation (MNA)**
- **Thermal Treatment**

# ***Metrics Estimated by the SRT***

- **Emissions to atmosphere**
  - **CO<sub>2</sub>**
  - **NO<sub>x</sub>**
  - **SO<sub>x</sub>**
  - **PM<sub>10</sub>**
- **Total energy consumed**
- **Change in resource service**
- **Technology cost**
- **Safety / Accident risk**

# ***SRT Structure***



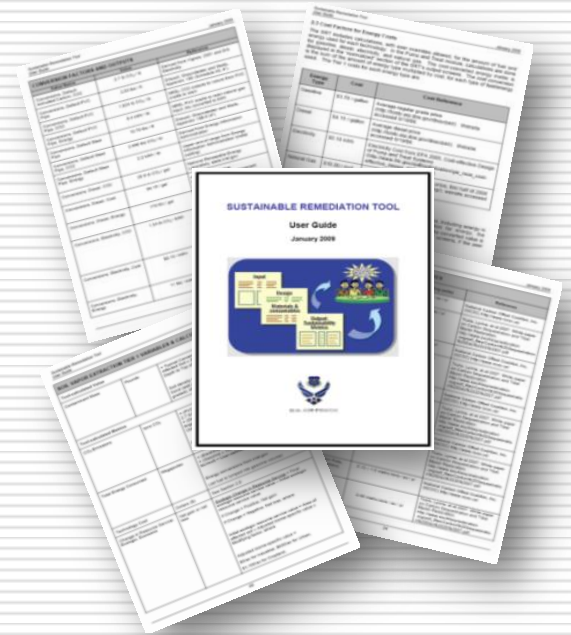
# 2-Tier Framework

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



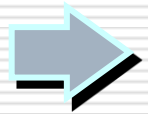
# ***SRT Strengths***

- Evaluates sustainability metrics
- Screens / Compares technologies side-by-side
  - Up to 8 different technologies at once
- Two tier options for user
- Scenarios feature
- Stakeholder roundtable feature
- Capable of using inputs from design tools
- Will have validated costing model (RACER™ - sold on line-) interaction in next release



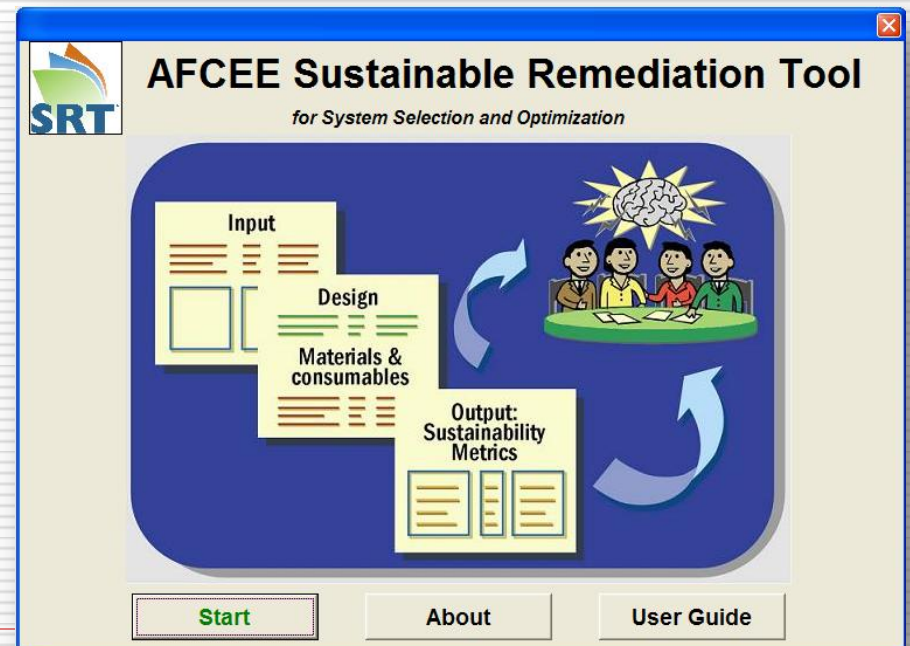
# ***SRT Overview***

- **Project Team**
- **SRT Design and Functionality**



## **SRT Workflow**

- **Hands On Practice**



# SRT General Inputs

SRT rev2\_1.xls [Compatibility Mode] - Microsoft Excel

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## SUSTAINABLE REMEDIATION TOOL

**1. Enter Project Information.**

Site Name:   
 Location:   
 Site/Project Phase for Calculation:   
☒ Tier 1 ☐ Tier 2

**Fuel Costs**

|             |         |           |
|-------------|---------|-----------|
| Gasoline    | \$2.00  | \$/gallon |
| Diesel      | \$2.00  | \$/gallon |
| Electricity | \$0.10  | \$/kWh    |
| Natural gas | \$11.00 | \$/mcf    |

**Instructions:**

= Enter your data here. Click button to the right of the cell for help.  
 = Use this default value or override with **your own**.  
 = Calculated value. You cannot change this.  
 For help, click on the square gray buttons located throughout the SRT.

**New users:** Fill in the boxes as indicated above. Choose Soil or Groundwater. Click buttons on Recommended Flow to proceed through the screens.  
**Advanced users:** Follow Recommended Flow, or click on tabs to navigate.

**2. Choose Environmental Media** ☐

**Soil...**

Recommended flow:

```

graph LR
    Main[Main] --> SoilInput[Soil Input]
    SoilInput --> Excavation[Excavation]
    SoilInput --> SVE[SVE]
    SoilInput --> ThermalTreatment[Thermal Treatment]
    Excavation --> Output[Output]
    SVE --> Output
    ThermalTreatment --> Output
  
```

**...or Groundwater.**

Recommended flow:

```

graph LR
    Main[Main] --> GWInput[GW Input]
    GWInput --> PumpTreat[Pump & Treat]
    GWInput --> EnhancedBioremediation[Enhanced Bioremediation]
    GWInput --> InSituChem[In Situ Chem. Oxidation (ISCO)]
    GWInput --> PRB[Permeable Reactive Barrier (PRB)]
    GWInput --> LTM[MNA]
    PumpTreat --> Output[Output]
    EnhancedBioremediation --> Output
    InSituChem --> Output
    PRB --> Output
    LTM --> Output
  
```

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 21 May 2010

MainScreen InputSoil EXDesign SVDesign ThermalDesign OutputSoil InputGW PTDesign EBDesign ISCODesign PRBDesign MNADesign OutputGW

Ready 100%

# SRT Soil Inputs

SRT rev2\_1.xls [Compatibility Mode] - Microsoft Excel

**SOIL/SOURCE INPUT**

Example Site  
Denver, CO

Area of Affected Soil: 10000 ft<sup>2</sup>  
 Depth to Top of Affected Soil: 0 ft  
 Depth to Bottom of Affected Soil: 15 ft  
 Depth to Groundwater: 25 ft

Soil Type: Sand (well graded)

Contaminant Class: CVOCs  
 Max Concentration: 10 mg/kg  
 Typical Concentration: 1.25 mg/kg

Contaminant mass: 19 lbs

Calculate natural resource service? ☐ Yes ☒ No

**Instructions:**

- = Enter your data here. Click button to the right of the cell for help.
- = Use this default value or override with **your own**.
- = Calculated value. You cannot change this.

Paste Tier 2 Example  
Clear Soil Inputs

**Recommended flow:**

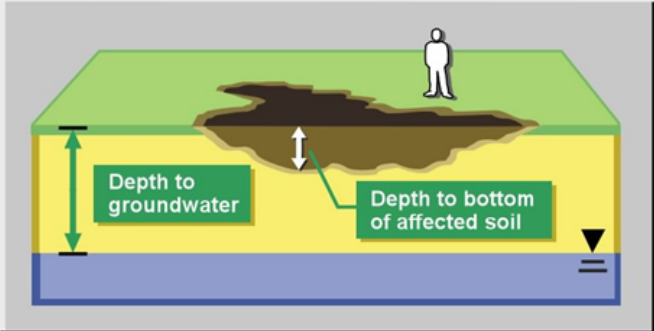
You are here

Main → Input → Next: Choose Technologies

Next: Choose Technologies

- ☒ Excavation
- ☒ Soil Vapor Extraction
- ☒ Thermal Treatment

Results



Depth to groundwater

Depth to bottom of affected soil

MainScreen **InputSoil** EXDesign SVDesign ThermalDesign OutputSoil InputGW PTDesign EBDesign ISCODesign PRBDesign MNADesign OutputG

Ready 95%

# SRT Tier 1 - Excavation

SRT rev2\_1.xls [Compatibility Mode] - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Developer

## EXCAVATION - TIER 1

Example Site  
Denver, CO  
CAPITAL and O&M

### Design for Managing Soil

Airline miles flown by project team (total miles for all travelers) 10000 miles over proj lifetime  
Average Distance Traveled by Site Workers per one-way trip 12 miles one-way  
Trips by Site Workers during construction 400 # over project lifetime  
Trips by Site Workers after construction 20 # over project lifetime

Distance to Disposal (one-way) 300 miles  
Type of Disposal Hazardous

Volume of affected soil 150,000.  
Volume of affected soil 5,556.

Total hours to excavate 140.  
Number of loads for disposal 530.  
Total miles driven for disposal 320,000.  
Total hours for fill dirt placement 55.  
Number of loads of fill dirt 600.  
Total miles driven for fill 12,000.

Instructions:  
= Enter your data here. Click button to the right of the cell for help.  
= Use this default value or override with **your own**.  
= Calculated value. You cannot change this.

Restore Defaults  
Show Inputs

Recommended flow:  
Main → Input → Technology Design → Results

**You are here**

Technology Design

- ☒ Excavation
- ☒ Soil Vapor Extraction
- ☒ Thermal Treatment

<< >>

### Type of Disposal

Waste classification of the contaminated excavated soil should be determined based on chemical analyses, process knowledge, and state and federal regulations. Waste classification will determine the disposal cost. Disposal cost of hazardous waste is generally 10 times more than the cost for disposal of non hazardous waste.

MainScreen InputSoil **EXDesign** SVDesign ThermalDesign OutputSoil InputGW PTDesign EBDesign ISCODesign PRBDesign MNADesign OutputGW

Ready 100%

# SRT Tier 2 - Excavation

SRT rev2\_1.xls [Compatibility Mode] - Microsoft Excel

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## Design Calculations - Excavation

|   |          |                    |   |                                   |
|---|----------|--------------------|---|-----------------------------------|
| Area of Affected Soil                       | 10,000.  | ft <sup>2</sup>    | Volume of affected soil: Area * (Depth to Bottom - Depth to Top of Affected Soil).  | Return to Summary                 |
| Total Thickness of Affected Soil            | 15.      | ft                 |   |                                   |
| Volume of affected soil                     | 150,000. | ft <sup>3</sup>    | Total hours to excavate: Volume of affected soil * soil density * (1 ton / 2000 lbs) * (1/rate of excavation in ton/hr).  | Restore Defaults (Detail Section) |
| Volume of affected soil                     | 5,556.   | cu yd              |   |                                   |
| Soil density                                | 100.     | lb/ft <sup>3</sup> |   |                                   |
| Excavation rate                             | 53.      | tons/hr            |   |                                   |
| Total hours to excavate                     | 140.     | person-hours       |   |                                   |
| Fluff factor (excavated soil)               | 1.15     |                    | Loads for disposal: Volume of affected soil * fluff factor * (1/dump truck volume) * (1 yd <sup>3</sup> / 27 ft <sup>3</sup> unit conversion)   |                                   |
| Dump truck volume for disposal              | 12.      | cu yd              |   |                                   |
| Number of loads for disposal                | 530.     | # loads            |   |                                   |
| Total miles driven for disposal             | 320,000. | miles              | Total miles driven for disposal: Number of loads for disposal * 2 * Distance to disposal (input above).   |                                   |
| Fluff factor (fill)                         | 1.3      |                    | Loads of fill dirt: Volume of affected soil (above) * fluff factor * (1/dump truck volume) * (1 yd <sup>3</sup> / 27 ft <sup>3</sup> ).   |                                   |
| Dump truck volume for moving fill           | 12.      | cu yd              |   |                                   |
| Number of loads of fill dirt                | 600.     | # loads            |   |                                   |
| Fill spread rate                            | 448.5    | cu yd/hr           | Total hours for fill dirt placement, is the sum of: (1) Area (user input) * (1 yd <sup>2</sup> / 9 ft <sup>2</sup> ) / fill spread rate in yd <sup>3</sup> /hr. (2) Number of loads of fill dirt (calculated above) * dump truck volume (above) / rate of water compaction in yd <sup>3</sup> /hr. (3) Total volume of fill dirt / spread & compaction rate in yd <sup>3</sup> /hr. |                                   |
| Water compaction rate                       | 174.3    | cu yd/hr           |   |                                   |
| Spread/compaction rate                      | 654.     | cu yd/hr           |   |                                   |
| Total hours for fill dirt placement         | 55.      | hrs                |   |                                   |
| Distance from site to fill source (one way) | 10.      | miles              | Total miles driven for fill: Number of loads of fill dirt * 2 * Distance from site to fill source.  |                                   |
| Total miles driven for fill                 | 12,000.  | miles              |   |                                   |
| Excavator fuel consumption rate             | 3.       | gal/hr             | Total diesel: (Total hours to excavate & place fill * Excavator fuel consumption rate) + (Total miles driven for disposal * Dump  | Return to Summary                 |
| Dump truck fuel use rate                    | 8        | mpg                |   |                                   |

# SRT Results Screen

SRT rev2\_1.xls [Compatibility Mode] - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Developer

**SOIL/SOURCE RESULTS**

Instructions:

- = Enter your data here.
- = Use this default value or override with **your own**.
- = Calculated value. You cannot change this.

Recommended flow:

Main → Input → Technology → Exit

Show Inputs <<Last Screen

\* Normalize metrics to see more, go back to Inputs to adjust & or go back to Main (Tier 1/2 or GW), or Exit.

**Non-normalized**  
**Calculations in natural units**

|            | Carbon Dioxide Emissions to Atmosphere |                                   | NO <sub>x</sub> *    | SO <sub>x</sub>      | PM <sub>10</sub>      | Total Energy Consumed |            | Technology |    |
|------------|--|-----------------------------------|----------------------|----------------------|-----------------------|-----------------------|------------|------------|----|
|            | tons CO <sub>2</sub>                   | lbs CO <sub>2</sub> per lb contam | tons NO <sub>x</sub> | tons SO <sub>x</sub> | tons PM <sub>10</sub> | Megajoules            | kWh        | dollars    | dk |
| Excavation | 550.                                   | 58,000.                           | 4.4                  | 0.0043               | 0.21                  | 7,200,000.            | 2,000,000. | 2,600,000. |    |
| SVE        | -                                      | -                                 | -                    | -                    | -                     | -                     | -          | -          |    |
| Thermal    | -                                      | -                                 | -                    | -                    | -                     | -                     | -          | -          |    |

\*: See SRT v.2 Known Issues

# ***Conclusions***

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## **Sustainable Remediation Tool (SRT) Distribution**

**Available as free download from US Air Force (AFCEE)**

**[www.afcee.af.mil/resources/technologytransfer/  
programsandinitiatives/sustainableremediation](http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation)**

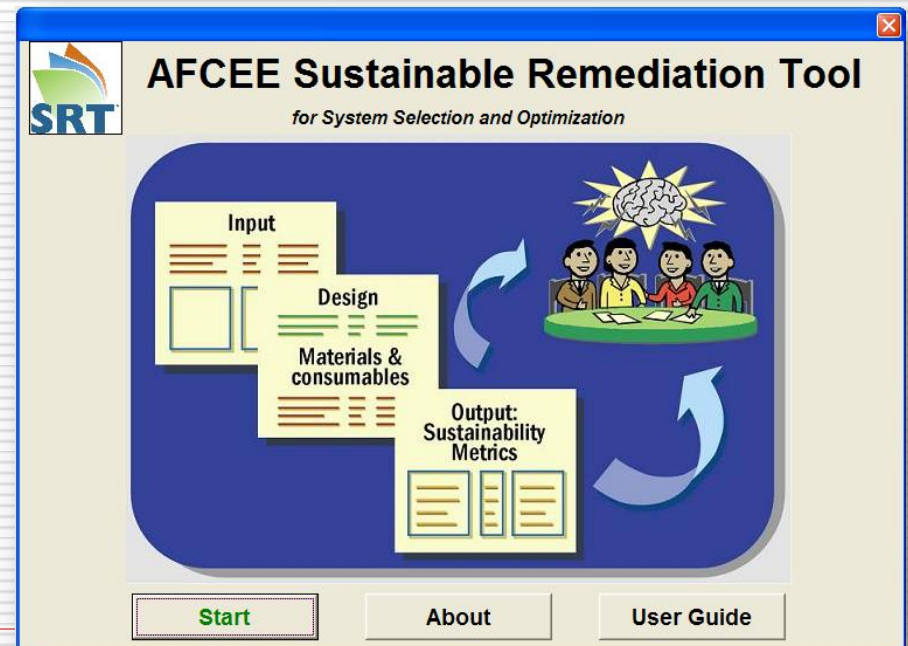




# ***SRT Overview***

- **Project Team**
- **SRT Design and Functionality**
- **SRT Workflow**

 **Hands On Practice**



# Environmental forensics

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- The process
  - Legal
  - Commercial
  - Litigation Court issues
- Actors : Who does what
- Actors who owes what to whom
  - A two fold key point : independance and appearance of independance

# Comparisons

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## □ European roadmap

- Stresses role of the three pillars and social and local (land use) decision
- Allows a wider range of decision, leaves open technical solutions

## □ US tools

- Are more related to binding regulation, although interactive process is one of the conditions
- Are built to support a project management system and track costs, use feedback and provide outlooks so far as possible to decision makers
- Encompass technical solutions in a detailed way, available both to Mastery of work, external expertise, stake holders

# SOIL POLLUTION AND ENVIRONMENTAL FORENSICS

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□ Now, time for questions